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Development of a New Technology Venture Balanced Scorecard Derived from Critical Factors that Impact Product Quality

Zella Jackson Hannum
Western Michigan University, zella@sti.net

DEVELOPMENT OF A NEW TECHNOLOGY VENTURE BALANCED SCORECARD DERIVED FROM CRITICAL FACTORS THAT IMPACT PRODUCT QUALITY

by

Zella Jackson Hannum

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WE HEREBY APPROVE THE DISSERTATION SUBMITTED BY

Zella Jackson Hannum

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David M. Lyth, Ph.D.
Dissertation Review Committee Chair

Tarun Gupta, Ph.D.
Dissertation Review Committee Member

Leonard Lamberson, Ph.D.
Dissertation Review Committee Member

John R. Lloyd, Ph.D.
Dissertation Review Committee Member

APPROVED

Dean of The Graduate College

Date June 2012

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Can a department manager who launches technologically advanced products use a performance measurement tool to improve product quality? Business environments where technologically advanced products are launched to the market for the first time, known as new technology ventures (NTV's), have lagged behind in adoption of measures that drive product quality. NTV's have been slow to adopt such measures due to a lack of research that would substantiate the impact of any proposed performance management systems. Thus, the development of an effective and useful tool that measures and drives product quality performance in NTV environments, which has usable visual displays—would be a significant advancement. This research devised a scorecard to enable NTV managers to attain project-level product quality goals.

Scorecard development required (1) identification of management practices that impact product quality, (2) incorporation of these factors into a balanced scorecard, and (3) evaluation of this newly devised tool. Two studies were employed to accomplish these goals.

The first study used multiple linear equations to predict critical factors that drive product quality. Data were collected from experienced NTV managers using a previously validated survey instrument. The data analyses demonstrated significant correlations with measures of product quality management practices and product quality performance.

Scorecard design methodology defined in the literature was used to convert the identified product quality management practices into performance measures.

The second study required the development and test of a valid and reliable measure of scorecard performance capability and usability. Data were collected from experienced NTV managers using this measure. It demonstrated significant correlations with measures of scorecard performance capability and managers' decision to use the scorecard. This evaluation determined managers deemed the scorecard a usable tool and it would aid them in making effective product quality management decisions.

This scorecard is designed as a template for indigenous modification and may be quickly incorporated into a variety of new technology product development environments so NTV managers can guide their teams toward higher quality products. This may have a positive influence on launch rates of technologically advanced products since superior product quality has been positively correlated with launch success.

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I wish to dedicate this work to my cherished brother, Melvin Jackson, Jr., the one man that I have loved all of my life. Many years deceased, yet always remembered. His spirit lives on in me. My oldest brother, more than anyone else, would have known how far I have come. Sometimes inspiration comes from a memory.

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CHAPTER I

INTRODUCTION

Introduction to the Problem

New Technology Ventures Lag Behind in Performance Management Adoption

The title of Kaplan and Norton's 1992 seminal article, "The Balanced Scorecard; Measures that Drive Performance," identifies the primary goal of a balanced scorecard—*performance management* (Kaplan & Norton, 1992). In addition, it is widely recognized that performance management is used to promote goal congruence and influence managers' decisions (Otley, 1999). Numerous business sectors have adopted performance management systems such as the balanced scorecard. In fact, the balanced scorecard is one of the mostly widely used strategic management tools ranked highly effective (Kaplan & Norton, 2001b; Chenhall, 2005). However, business environments where technologically advanced products are launched to the market for the first time, known as new technology ventures (NTVs), have lagged behind in adoption of measures that drive product quality. NTVs have been slow to adopt such measures due in part to a lack of research that would substantiate the impact of any proposed performance management systems. Thus, the development of an effective and useful scorecard that measures and drives product quality performance in new technology venture (NTV) environments, which has usable visual displays, would be a significant advancement. In particular, an effective and useful NTV *Product Quality Management* (PQM) Balanced Scorecard would enable NTV managers to attain project-level product quality goals (Adams, Bessant, & Phelps, 2006;

O'Connor & De Martino, 2006; O'Connor, Paulson, & De Martino, 2008; Schramm, 2008; Kelley, 2009).

Scorecard as Innovation in NTV Environment

This scorecard is an innovation. There has been a dearth of performance measures in the new technology venture sector (O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009). While technological innovation has played a significant role in America's economic expansion, there has been a lack of vocabulary for and measurement of the new technology venture sector. Such measurement has proven difficult because firms in this sector are highly heterogeneous and marked by heroic management and engineering efforts. These efforts are guided by overarching first-to-market imperatives that tend to drive chaotic ad hoc early-generation processes in rapid response environments. And yet, economic development specialists and technologists contend it is important to devise a viable method to systematically assess processes and management practices in the new technology venture environment, particularly as it relates to continuous process improvement and product quality (Adams et al., 2006; Schramm, 2008). This research addressed these performance measure research imperatives with its development of an NTV scorecard to aid managers in making decisions that impact product quality.

NTV Adoption Challenges

Performance measurement systems that incorporate continuous process improvement (CPI) have been adopted extensively within mature industries characterized by established engineering design processes. Moreover, continuous process improvement has become a success imperative that achieves efficient, high quality results. In particular, products engineered using standardized engineering design processes that are defined, measured, analyzed, continuously improved and controlled yield high quality products. Evidence supports that CPI *has* improved product and business performance in many industries and business sectors. However, new technology venture firms that use first of its kind engineering design processes, lag behind in adopting this imperative. A review of the literature has determined that extensive continuous process improvement initiatives have *not* been widely adopted by new technology ventures.

A plethora of continuous process improvement frameworks exist, and the extent to which NTV managers use them is not well understood. In fact, evidence suggests NTV managers spend minimal resources toward engineering design process improvement. The resistance to CPI adoption has been attributed to the perception of insufficient payoff and protracted timelines that may result in a rapid response environment driven by an overarching first-to-market imperative. In addition, a first-to-market imperative drives a tendency toward heroic management of chaotic ad hoc processes in these rapid response NTV environments.

The concept of process improvement, which was developed in the quality movement, requires that the existing process be stabilized. It then becomes predictable, and its capabilities become amenable to analysis and improvement. Continuous process improvement occurs when the cycle of stabilizing, assessing, and improving a given process becomes institutionalized (Davenport & Short, 1990). Because of these characteristics, it could be argued that the process stabilization imperative of CPI is at odds with firms that engage in NTV development. This is due to the very nature of an NTV process, which is a first of its kind process that may require extensive redesign until the new technology and resultant product are deemed viable.

In fact, simple new product development processes that have no new technology requirements *may struggle* to justify the up-front CPI costs in a first generation process because early design changes may be easily and readily made without sacrificing product viability or quality. In sharp contrast, the highly complex engineering design processes characteristic of NTV development environments *may easily* justify the up-front costs associated with CPI initiatives, because their configuration management is confounded by even small design changes early in the development life cycle (Campbell, 1989; Macala, 1996). Perhaps the more complex the process, the more important it is to install stable engineering design processes early in the development life cycle. While this is well understood in general, its applicability in the NTV sector is less clear. However, evidence does exist that highly technologically complex engineering design processes do justify the up-front costs associated with CPI initiatives and is documented in the aerospace, telecommunications and engineering to order (ETO) environments (Griffin, 1997; Chapman, O'Mara, Rouchi, & Corso, 2001; MacCormack & Verganti, 2003; Brun & Saetre, 2008).

The questions that arise from this discussion and are addressed as part of this research are (1) Will CPI initiatives that work in aerospace and telecommunications arenas prove applicable in the new technology venture sector? and (2) Can the added expense in a first of its kind engineering design process be justified early while the ease and cost of design changes are low? If the answer to these questions is "yes," then a usable performance management system would provide a tool toward this aim.

Alternatively, must NTV managers wait for a later threshold to spend resources on CPI after the process has become more stable? If the answer is to this question is "yes," then a performance management system would not prove useful. Figure 1 depicts the inverse relationship between ease of design changes vs. cost of design changes over time (Newman, Lavelle, & Eschenbach., 2009).

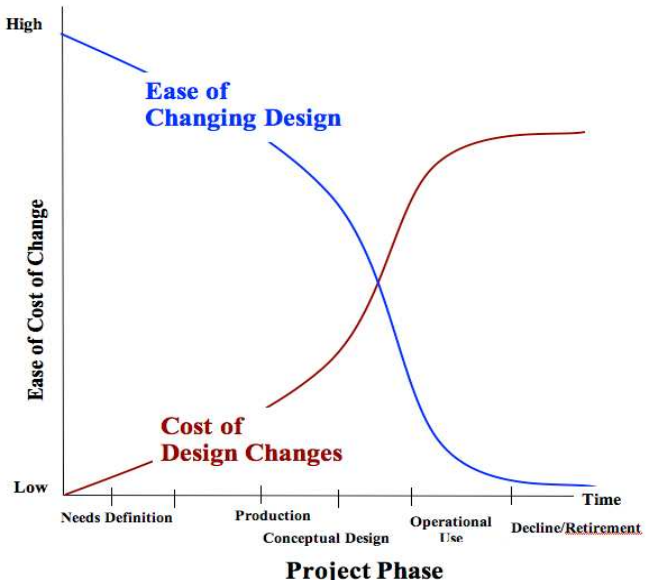

Figure 1. Life-Cycle Design Change Costs vs. Ease of Change (Newman et al., 2009)

Primary Focus of Research

The primary focus of this research was to develop a performance management system known as a balanced scorecard that measures and drives product quality performance—to enable NTV managers attain project-level product quality goals. If successful, the resultant NTV *Product Quality Management* Balanced Scorecard would serve as an effective and usable scorecard template for indigenous modification.

An effective and usable scorecard used by NTV managers to make better product quality management (PQM) practice decisions is projected to have five outcomes. An increased likelihood that engineering design changes would be made when

1. Ease of change is highest;
2. Cost of change is lowest; and
3. The likelihood of confounding design errors due to complexity is lowest.

In addition,

4. Strong product quality goal congruency would result between the NTV department level manager and top management that would result in
5. Enhanced product quality, and
6. Increased successful launch rates.

The scorecard will be designed for quick incorporation into a variety of new technology product development environments so NTV managers could begin to guide their teams toward higher quality products. As indicated in the list above, these leadership endeavors guided by the scorecard may have a positive influence on launch rates of technologically advanced products since superior product quality has been positively correlated with launch success.

CHAPTER II

LITERATURE REVIEW

Distinguishing the NTV Environment

Important Domain Distinctions

An extensive body of knowledge exists for the new product development (NPD) domain. It is distinguished from new technology development as characterized in the literature and ascribed to in this research. Significantly, the NPD arena has widely adopted CPI and performance measurement systems such as the balanced scorecard. Thus, it is important for this discussion to briefly examine the two domains and how they differ. This affords clearer scrutiny on the problem under investigation that arose out of the NTV environment, as well as the research objectives set forth to solve said problem. The distinctions and definitions for both the NPD and NTV domains are articulated below.

NPD Domain Definitions

“Non-radical innovation” has been used in the literature to describe new product development (NPD). NPD experts have, in fact, determined the importance of achieving best practices for managing NPD during the manufacturing ramp-up from prototype to full-scale production. In these cases, a new product typically involves a *refinement* of an existing product that has *low* impact on the market in terms of offering: (1) new benefits of marginal value, (2) insignificant (i.e., 5 times or less) improvement in known benefits, or (3) insignificant reduction (i.e., 30% or less) in cost (Cooper, Edgett, & Kleinschmidt, 2004b, 2004c; Kahn, Barczak, & Moss, 2006).

In addition, non-radical innovations require the firm *refine* a mature manufacturing process to produce refinement-based products as well as modify mature marketing and sales strategies.

These late generation processes and strategies have been previously devised, and may have been finely honed from using appropriate continuous process improvement (CPI) initiatives. Significantly, CPI initiatives have typically proven to have had significant positive impact on product quality (Cooper et al., 2004b, 2004c; Kahn et al., 2006). NPD products include the following types of refinements: (1) new model car with a 10% improvement in gas mileage, (2) new laser printer that is 20% smaller and uses 15% less ink, (3) new laptop that is 10% smaller and 20% faster.

NTV Domain Definitions

In contrast, the terminology "radical innovation" has been used to describe a new technology venture (NTV), a recognized body of knowledge. NTV experts have yet to determine the importance of achieving best practices for managing NTV during the manufacturing ramp-up from prototype to full-scale production. In these cases, a NTV generates *first of its kind* products and technologies that have *high* impact on the market in terms of offering: (1) wholly new benefits, (2) significant (i.e., 5 to 10 times or more) improvement in known benefits, or (3) significant reduction (i.e., 30% to 50% or more) in cost (Ansoff, 1957; Booz-Allen & Hamilton, Inc., 1982; Leifer, O'Connor, Colarelli, & Rice, 2001, O'Connor & De Martino, 2006). In addition, a radical innovation requires the firm to develop a first of its kind manufacturing process to produce the new tech-based product as well as devise first generation marketing and sales strategies. These first generation processes and strategies are indigenously devised, newly invented, and situation specific. They have been expressly developed or adapted to facilitate the launch of the new technology (Ansoff, 1957; Booz-Allen & Hamilton, Inc., 1982; Leifer et al., 2001; O'Connor & De Martino, 2006).

NTV products include the following types of radical innovations depicted in Table 1: (1) mobile 3-D (Newitz, 2010), (2) engineered stem cells (Singer, 2010), (3) social TV (Bulkeley, 2010), and (4) jet-pack like GadJet (Editors, 2010).

Table 1. *Examples of Current Radical Innovations*

Radical Innovations	Firms	Description
Mobile 3-D	3M Nintendo Nvidia N4D	Engineer new auto stereoscopic 3-D displays for mobile multimedia devices such as Smart Phones®. Requires new software design that synthesizes 3-D scenes from existing 2-D video by estimating depth. Engineer new hand held device design then first of its kind manufacturing process, and devise first of its kind user interface (Newitz, 2010).
Engineered Stem Cells	iPerian Cellular-Dynamics George Daley Shinya-Yamanaka Fate-Theraputics	Engineer process design to produce induced pluripatent stem cells (iPS) cells; the starting ingredient to produce a variety of human body cells. Engineer first of its kind process design: precise combination of chemicals, agitation, and temperature that transforms iPS cells into heart cells, for example. Note: iPS cells are effective substitute for embryonic stem cells since can reproduce prodigiously and develop into any cell type in human body (Singer, 2010).
Social TV	Intel Motorola BT Clipsync MIT	Devise device that seamlessly combines social networks that boost live TV viewership with passive TV viewing. Engineer new device design interfaces so (1) viewers easily link with friends, (2) carriers, networks, and contract providers can easily provide personalized programming, and (3) said firms can hold audiences vs. losing to competition such as Hulu's internet streaming (Bullkeley, 2010).
Jet-Pack GADJET	Martin Aircraft	Prototype device powers fans to lift and fly an individual for 30 minutes at up to 97 kilometers per hour. Flyers control pitch and roll with one hand; throttle and yaw with the other hand. Includes a parachute. Engineer first if its kind transport and first of its kind manufacturing process to produce GadJet so emergency personnel can reach remote areas quickly and efficiently (Editors, 2010).

Contrasts Between NPD and NTV Manufacturing Environments

Recognize both non-radical and radical innovations must pass a battery of commercialization viability tests for these new products to formally transfer to the commercialization department. For the NPD or non-radical, these viability tests strive to determine how, when, and where the refined manufacturing ramp-up will occur, typically at an *existing manufacturing facility*. Recall that analysts have observed these late generation manufacturing processes may have been devised previously, and may have been finely honed from using appropriate continuous process improvement (CPI) initiatives over a period of time. Importantly, CPI initiatives have typically proven to have had significant positive impact on product quality (Cooper et al., 2004b, 2004c; Kahn et al., 2006).

The NPD manufacturing environment is depicted in Figure 2 and portrays the following recognized sub-domains: commercialize, standardize, refine existing manufacturing process, optimize, and verify. Note that the second sub-domain is "standardize," and because standardized manufacturing processes are in place, it is straightforward to incorporate CPI initiatives. Similarly, the third sub-domain is "refine existing manufacturing process"; this is where the design engineering team can readily make process improvements.

In sharp contrast, the radical innovation or NTV, viability tests must determine if the innovative product is even marketable and if the engineering design is practical to produce on a large scale as well as numerous other considerations. Once these considerations are satisfied, a new manufacturing plant must be designed and built using newly engineered manufacturing requirements. The NTV team first determines the requirements and specifications of the radically innovative product, creates a first of its kind engineering design, then engineers the first of its kind manufacturing process, and oversees the construction of the *newly designed manufacturing*

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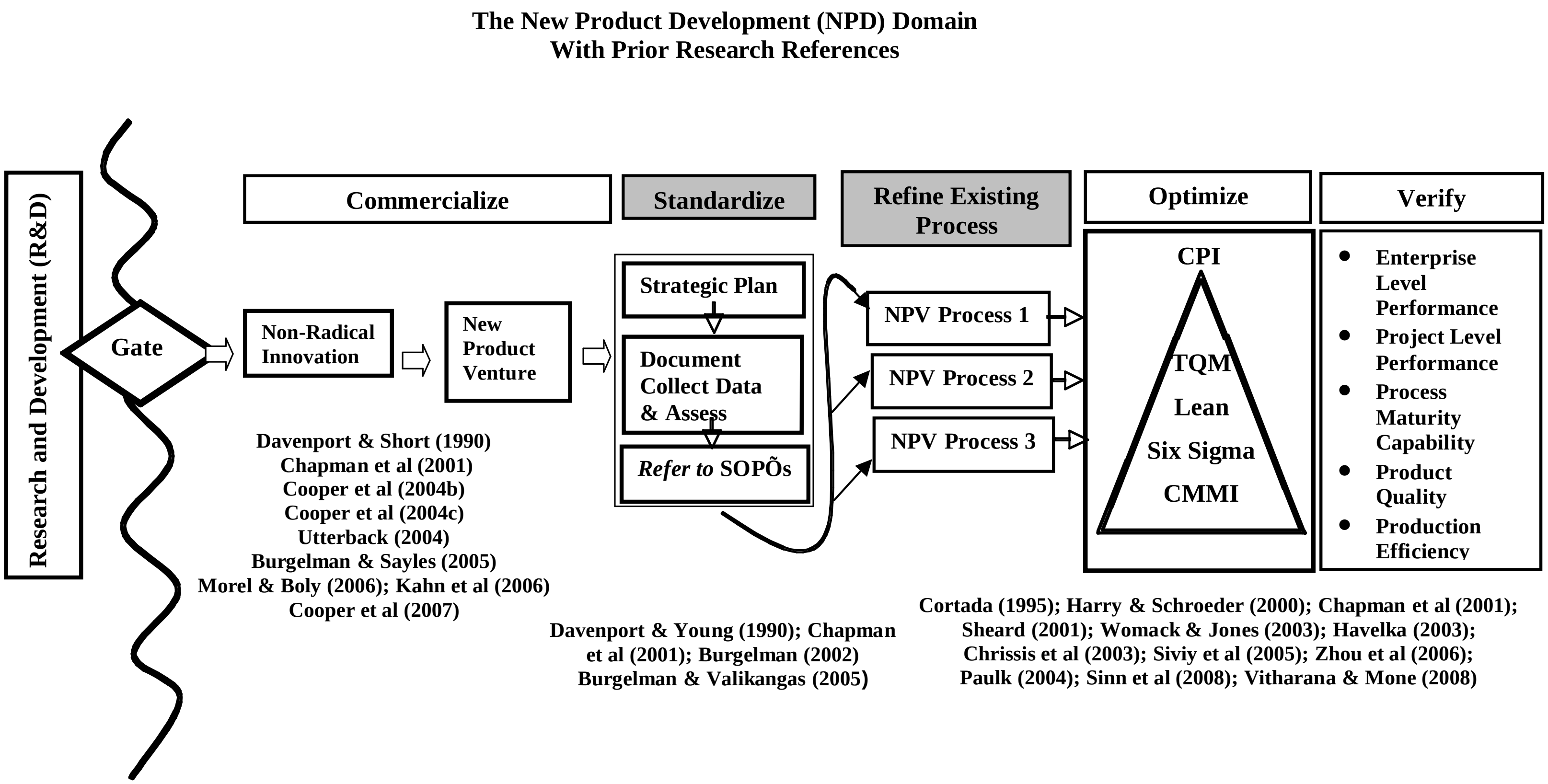


Figure 2. NPD Domains with References

facility. Thereafter, the NTV team is responsible for the evolutionary engineering design process improvement of this first generation radically innovative product and its manufacturing process.

Recent NTV researchers have proposed that to better manage innovation, managers should initiate programs that include practices for managing the NTV process, itself. In particular, case study research has produced evidence that CPI initiatives may be justified and could significantly improve NTV product quality (Leifer et al., 2001; O'Connor & De Martino, 2006; Kelley, 2009). Yet the NTV sector has lagged behind in adopting CPI initiatives.

NTV Manufacturing Environment and Identified Research Gap

A newly commercialized radical innovation is a new technology venture (NTV) (Ansoff, 1957; Booz-Allen & Hamilton, Inc., 1982; Leifer et al., 2001; O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009). Recognize that most professionally managed NTV's undergo viability tests that strive to determine if the (1) innovative product is marketable, and (2) if the engineering design is practical to produce on a large scale as well as numerous other considerations. Once these considerations are satisfied, a new manufacturing plant must be designed and built using newly engineered manufacturing requirements. The NTV team then creates a first of its kind engineering design process, determines the requirements and specifications of the radically innovative product, engineers the first of its kind manufacturing process, and oversees the design and construction of the *newly designed manufacturing facility*. Thereafter, the NTV team is responsible for the evolutionary engineering design process improvement of this first generation radically innovative product and its manufacturing process. A radical innovation requires the firm to develop a first of its kind manufacturing process to produce the new tech-based product as well as devise first generation marketing and sales strategies. These first generation processes and strategies are indigenously devised, newly invented and situation specific. They have been expressly developed or adapted to facilitate the launch of the new technology (Ansoff, 1957; Booz-Allen & Hamilton, Inc., 1982; Leifer et al., 2001; O'Connor & De Martino, 2006).

Gaps in Literature

Recognize the literature review revealed that prior research of the NTV environment has relied primarily on the qualitative case study method. In addition, research on process improvement as a critical driver of new technology product quality has *not* been systematically examined. These two characteristics constitute a significant gap in the research.

This study is aimed at understanding the impact of process maturity on product quality. In particular, what product quality management practices drive product quality in the NTV environment? The goal of this research is not to capture all the radical innovation activity in each company surveyed but to understand the impact process maturity has on product quality in the NTV domain.

The use of an easy-to-administer, time-efficient, economical assessment tool vs. the arduous, time-consuming, expensive-to-administer case study tool that currently dominants research in this sector *addresses one identified gap*. Therefore, if this study's instrument demonstrates criterion validity in the NTV environment, it will equip researchers with a tool that may enable expansive research aimed to improve processes in the new technology venture sector and thereby improve new technology product quality. In addition, the study investigates product quality management practices that incorporate engineering design process improvement. Because this has not been studied systematically in the NTV environment before, it *addresses the second identified gap*.

The NTV manufacturing environment is depicted graphically in Figure 3 and portrays the following recognized sub-domains: commercialize, design and build first of its kind manufacturing process, standardize, optimize, and verify. Additionally, the identified gap in the

The New Technology Venture (NTV) Manufacturing Environment Domain
With Identified Gap and Prior Research References

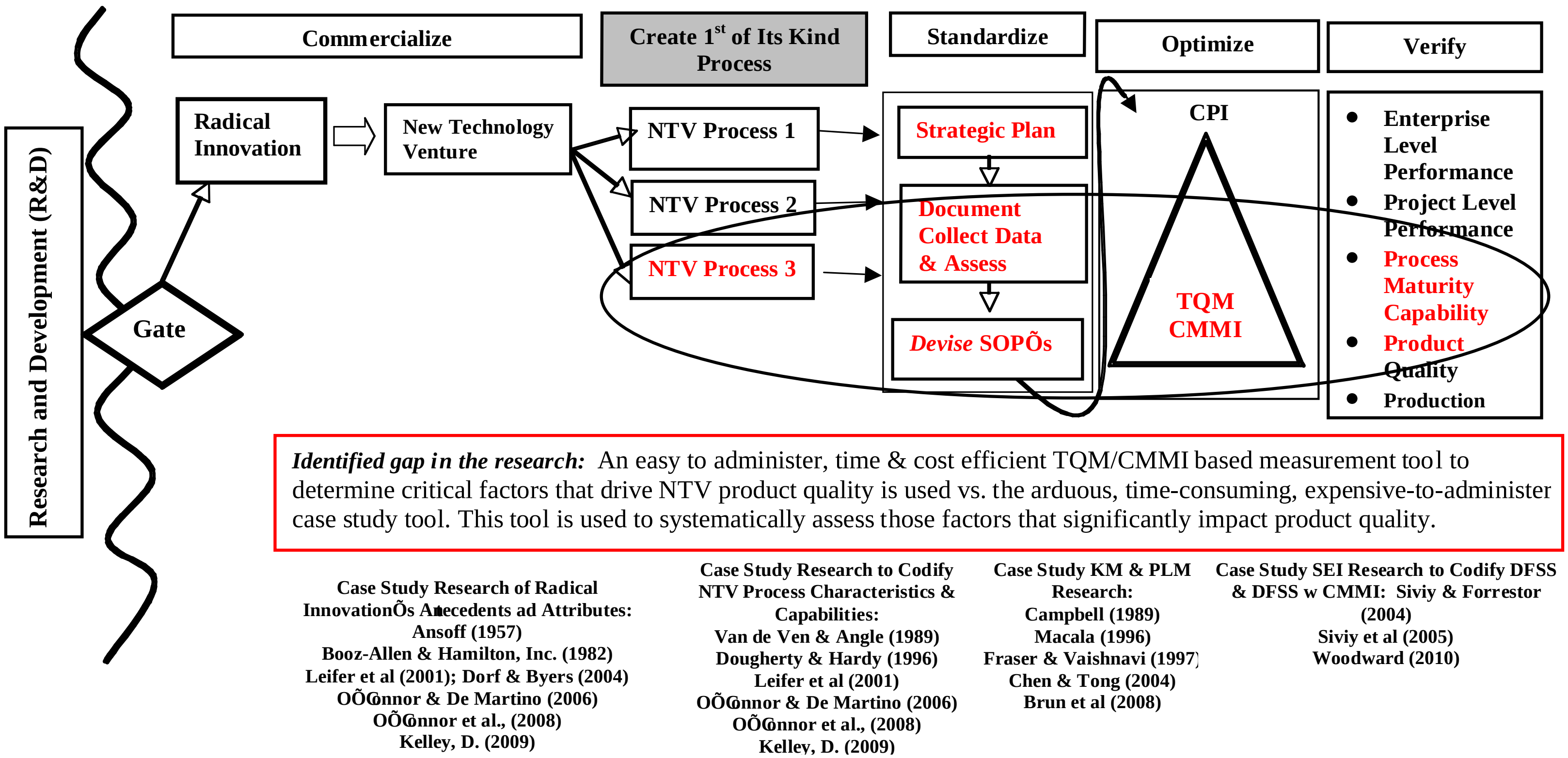


Figure 3. NTV Manufacturing Environment with Identified Gap and Prior Research References

research is delineated. Significantly, these five NTV sub-domains differ from the NPD environment; the second step is “design and build the first of its kind manufacturing process.” This is in sharp contrast to the NPD environment with its second step, “standardize.” Herein lies a fundamental difference between the two environments that brings the use of recognized CPI initiatives in the NTV environment into question. Will CPI adoption improve NTV engineering design processes and resultant product quality? If so, would a performance management system known as a balanced scorecard provide NTV managers guidance on how to effectively manage product quality management practices?

Measures of New Technology Ventures

Systematic Measures

Measures of new technology ventures are a subset of the larger body of knowledge known as innovation management measurement. Analysts (Adams et al., 2006) sought to identify the systematic assessment tools available to those wishing to measure the successful management of innovation. They conducted an extensive review and analysis of these tools and found the following measures were used:

1. Team Climate Inventory (Anderson & West, 1996, 1998) to assess an organizational climate supportive of the innovative process.
2. KEYS instrument for assessing the work environment for creativity (Amabile, Conti, Coon, Lazenby, & Herron, 1996).
3. Number of patents organization generates per specified time period (Griliches, 1990).
4. R&D expenditures as a measure of innovation management capability (Parthasarthy & Hammond, 2002).

5. Technical Innovation Audit (Chiesa, Coughlan, & Voss, 1996), which measures concept generation, product development, process innovation, and technology acquisition.
6. Innovative Behavior Measure (Scott & Bruce, 1994) and Innovation Potential Indicator (Patterson, 2003) both measure individual innovative behaviors.

Subjective Measures

Additionally, a host of subjective measures were examined that would prove valuable to those choosing the case study method—but would have no systematic assessment value. Unfortunately, these researchers concluded that *both* the quantitative and subjective measures they reviewed tend to be abstract, with little consideration given to the use of measures as a management tool in the day-to-day context of managing innovation. Importantly, the Advisory Committee on Measuring Innovation in the 21st Century Economy (Schramm, 2008) determined there was a significant need for researchers to develop firm-level and industry-level measures of innovation that would enable systematic assessment. Recognize that *none* of the aforementioned measurements is designed to measure the critical factors that drive NTV product quality management. Moreover, this researcher sought to find an assessment tool that could be implemented systematically, and become a management tool in the day-to-day context of managing the commercialization of new technology products. Thus, the new technology venture product quality management instrument (NTV PQMI) was chosen because it directly addresses the research question at hand.

Previously Validated Systematic Assessment Instrument Used

This research project uses the previously validated NTV PQMI (a TQM/CMMI based measurement tool) that has been shown capable of determining the critical factors that drive quality. The instrument was minimally modified and is being used to test its viability in the NTV environment.

Recognize that the instrument was devised for the expressed purpose of being used in the public domain; funds were provided by a grant from Earl V. Snyder Innovation Research Center at Whitman School of Management, Syracuse University (Vitharana & Mone, 2008). Public use instruments such as the (1) Corporate Entrepreneurship Assessment Instrument (Hornsby et al., 2002), (2) Thermal Environment Survey (BSR/ASHRAE Standard 55P), (3) SERVQUAL a multiple-item scale for measuring consumer perceptions (Parasuraman, Zeithaml, & Berry, 1988), and the (4) Global Adult Tobacco Survey (Gajalakshmi et al., 2003) are often designed using public funds or endowments. Their purpose is often to assist in the adoption of standard measures. Such was the case with this instrument (Vitharana & Mone, 2008).

Case Study Method Dominates NTV Research

Additionally, prior radical innovation case study research to date has focused on the organizational structures and competencies within firms that repeatedly launch new technology. In particular, researchers Leifer, Rice, and O'Connor sought to determine what organizational structures and firm level competencies drove product quality, as well as project level and enterprise level performance (Leifer et al., 2001; O'Connor & De Martino, 2006; Kelley, 2009). These research projects were all qualitative case studies. Additional case study research conducted by Van de Ven, Angle, Dougherty, and Hardy sought to determine methods for studying innovation processes and to define characteristics of innovative processes within firms that had a track record of innovation (Van de Ven, Angle, & Poole, 1989; Dougherty & Hardy, 1996).

Strategic engineering management tools such as knowledge management (KM) and product line management and engineering (PLME) have also been qualitatively studied using the case study method (Campbell, 1989; Macala, 1996; Chen & Tong, 2004). In addition, KM's derivative, formal engineering specification methods, also known as ambiguity reduction (Fraser & Vaishnavi, 1997; Brun & Saetre, 2008), have been examined using the case study method. Pertinent prior research also includes the case study examination of new product development tools such as design for six sigma (DFSS), as well as six sigma and CMMI combined, in order to obtain optimal new product process results (Siviy & Forrestor, 2004; Siviy, Penn, & Harper, 2005; Woodford, 2010). These case studies sought to codify significant attributes of NPD and NTV environments, the products themselves, the organizational structures and their launch strategies that demonstrated each tool's successful implementation.

While the case study body of work on radical innovation has *not* provided a systematic measurement tool that can be used on a day-to-day basis, it *has* provided operational definitions that this research project has incorporated.

Definitions

Prior case study research has established a recognized definition for a new technology venture (NTV) and a new technologically advanced product. These definitions are used in this study and delineated below.

1. A *new technology venture (NTV)* engages in preparing a new technologically advanced product for release to its final consumer for the first time with a first to early generation production process.
2. A *new technologically advanced product* may be software or hardware (e.g., device, machinery, vehicle, etc.) a formulation (e.g., chemical, pharmaceutical, etc.) or delivery mechanism (e.g., Bluetooth, Internet, cloud computing, etc.) and is one that offers wholly new benefits; specifically:

- Significant (5 to 10 times or more) improvement in known benefits; or
- Significant (30% to 50% or more) reduction in cost.

A variety of terms have been used to define a new technologically advanced product. For example, “radical innovation” is another term for this. Likewise, “newly commercialized radical innovation” is used to mean new technology venture (Ansoff, 1957; Booz-Allen & Hamilton, Inc., 1982; Leifer et al., 2001; O’Connor & De Martino, 2006; O’Connor et al., 2008; Kelley, 2009). However, the terms used consistently throughout the present study are “new technologically advanced product” and “new technology venture.”

A previously validated survey instrument was employed to investigate experienced NTV managers’ perceptions of the impact of CPI management practices on product quality. The instrument is based on the capability maturity model integrated (CMMI) CPI framework with overarching total quality management (TQM) principles (Vitharana & Mone, 2008).

CMMI arose out of the aerospace industry; and a review of the literature indicates it may prove particularly applicable to the NTV sector. Both the aerospace and NTV sectors share highly technologically complex, first of their kind processes with overarching rapid speed-to-market imperatives. Thus, it was hypothesized that CMMI may prove applicable to the NTV sector. A CPI applicability evaluation was performed and established that this hypothesis was tenable (Hannum & Lyth, 2010). A synopsis of the evaluation is provided in the next section.

Determining Applicable CPI Tools to Improve NTV Processes—Overview

Mature organizations use continuous process improvement (CPI) practices that have improved product and business performance in many industries and business sectors. However, CPI practices have not been widely adopted in the new technology venture (NTV) sector. Firms in the NTV sector have rapid response environments guided by overarching first-to-market imperatives. Heroic efforts and chaotic ad hoc processes also characterize these firms. However, CPI adopting sectors such as the aerospace industry with similar environments, market imperatives, and characteristics have tested the myriad of CPI initiatives and found the application of the Capability Maturity Model Integrated (CMMI) framework valuable when striving to improve product and business performance. This success has led to the consideration of CMMI's applicability to the NTV sector. This section examines CPI initiatives, including CMMI, and investigates whether CMMI is a plausible framework that can be applied to the NTV sector. This section also describes how and why new technology ventures may benefit from the adoption of CMMI. A CPI framework applicability evaluation is conducted to establish CMMI's plausible application to the NTV sector. This may provide the impetus for further research to test its validity as a tool to improve success rates of new technology ventures.

CPI Historical Perspective

At the turn of the last century, Frederick Taylor revolutionized the workplace with his prescriptions of work organization, task decomposition, and job measurement to increase organizational productivity and efficiency (Taylor, 1911). Today, after years of evolutionary improvements to Taylor's basic ideas, continuous process improvement (CPI) initiatives routinely improve product and business performance in many industries (Harry & Schroeder, 2000; Harter, Krishnan, & Slaughter, 2000; Davenport, Harris, Delong, & Jacobson, 2001; Amaratunga, Sarshar, & Baldry, 2002; Harter & Slaughter, 2003; Kristensen & Westlund, 2004; Paulk, 2004; Rahman & Bullock, 2005; Hutchinson, 2006; Bailey, Bilke, Xia, Rodchua, & Sinn, 2006). But a full century later, firms that engage in the development and commercialization of new technologies have yet to embrace CPI widely. These firms have rapid response environments guided by overarching first-to-market imperatives. Heroic efforts and chaotic ad hoc processes also characterize these firms. All CPI frameworks specifically address these latter two characteristics.

While the NTV sector lacks wide CPI adoption, other industries with similar environments, market imperatives, and characteristics have examined and tested the myriad of CPI initiatives and found the application of the Capability Maturity Model Integrated (CMMI) framework valuable when striving to improve product and business performance. These industries are aerospace, telecommunications, and engineering-to-order (ETO) industries (Griffin, 1997; Phillips & Shrum, 2000; Chapman et al., 2001; MacCormack & Verganti, 2003; Brun & Saetre, 2008; Veldman & Klingenberg, 2009). All of these adopting sectors were once, and could arguably still be considered to be, new technology ventures. The success of CMMI CPI initiatives in these industries has led to the consideration of CMMI's applicability to the NTV sector.

The New Technology Venture Sector

R&D departments routinely devise revolutionary technologies that must be deemed commercially viable. Once a new technology passes a battery of commercialization viability tests, it formally passes into the hands of the new technology venture (NTV) management team. The NTV team is charged with the evolutionary process improvement of a first- or early-generation new technology venture process. The steps to ensure this new process achieves the best outcomes are depicted in the SIPOC diagram in Figure 4 below. SIPOC is a six sigma acronym for Suppliers, Inputs, Process, Outputs, Customers.

A plethora of continuous process improvement frameworks exist, and the extent to which NTV managers use them is not well known. In fact, evidence suggests NTV managers spend minimal resources toward process improvement due to the perceived effort, insufficient pay-off and protracted timelines that compete unsuccessfully with first-to-market imperatives (Verworn, Herstatt, & Nagahira, 2006; Brun & Saetre, 2008). This section examines CPI initiatives, including CMMI, and investigates whether CMMI is a plausible framework that can be applied to the NTV sector to achieve justifiable process improvements in highly complex, first-to early-generation processes. A CPI framework applicability evaluation is conducted to make this determination. Should a proven tool like CMMI become widely adopted in the NTV sector, it may be used to improve the success rates of new technology ventures.

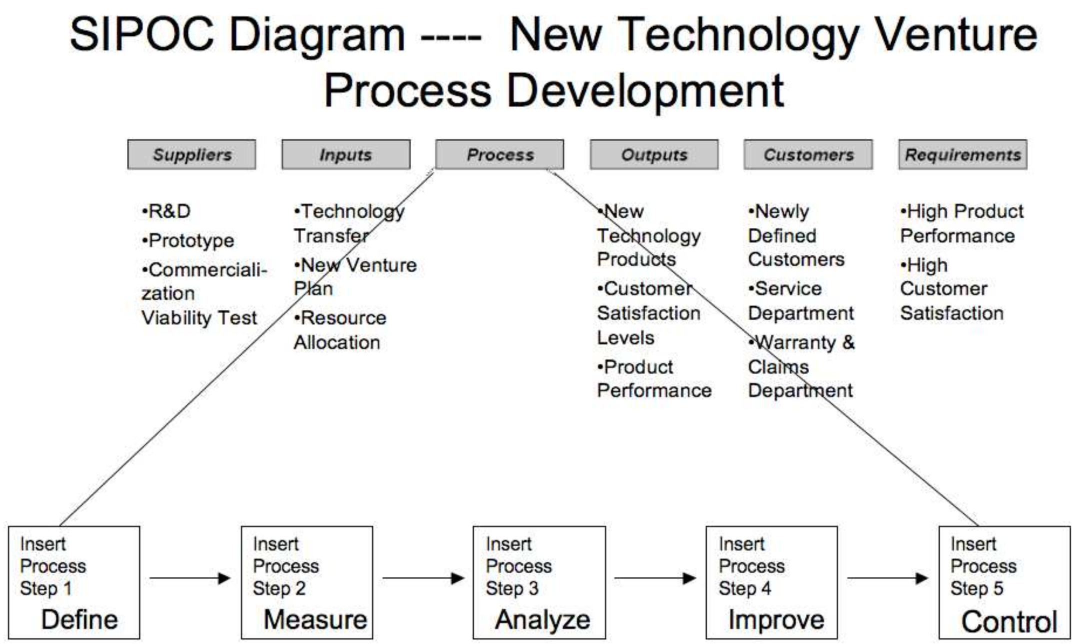


Figure 4. SIPOC Diagram of Generic NTV Process (Simon, 2010)

CMMI Defined

CMMI is a CPI framework that evaluates how efficiently a firm is able to design, manufacture, and deliver technology products. This is achieved in two fundamental steps. First, an appraisal is conducted to determine the relative maturity of the new technology development process. Second, once the maturity level is determined, CMMI provides a forward stepwise methodology that guides process managers and engineers toward initiatives that result in more mature processes. CMMI's five process maturity levels are initial, repeatable, managed, and optimizing. Each level is defined in Table 2.

Table 2. *Characteristics of the Five Process Maturity Levels*

1. *Initial*	The process is characterized as ad hoc, and occasionally even chaotic. Few processes are defined; Success depends on individual and sometimes heroic effort.
2. *Repeatable*	Basic project management processes are established to track cost, schedule, and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications.
3. *Defined*	The process for both management and engineering activities is documented, standardized, and integrated into a standard new technology development process for the firm. All projects use an approved, tailored version of the firm's standard NTV development process for developing new technology.
4. *Managed*	Detailed measures of the NTV development process and product quality are collected and used effectively. Both the NTV development process and products are quantitatively understood and controlled.
5. *Optimizing*	Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.

(Paulk, Curtis, Chrissis, & Weber, 1993)

NTV Sector Values High Product Quality and Efficient Processes

The new technology venture sector has seen and contributes to increasingly demanding global markets and an accelerating pace of technological change. These have led researchers and practitioners to recognize that firms engaging in new technology ventures need to compete on both product quality and product development speed to achieve the first-to-market objective. Firms that achieve high product quality, and are first-to-market, anticipate that these competitive advantages may result in higher business performance (Porter, 1998).

Researchers have put forth models to improve performance that tend to focus on the management of the new technology venture. However, these models address the identification of phases, integration of different phases and project team autonomy (Chapman et al., 2001), rather than on the continuous improvement of the new technology venture process itself. While firms engaging in new product development share, the first-to-market objective evident in the NTV sector, they also tend to have product families that clearly justify CPI. In contrast, new technology ventures often use a first- or early-generation process with unproven product or business-level viability. Thus, it would be of interest to learn if the up-front investment of time and resources required by CPI result in a justifiable payoff for firms engaging in new technology ventures as evidenced in the aerospace, telecommunications, and ETO sectors. If this study confirms these results, it could be used to support the use of the CMMI CPI framework in the new technology venture sector and achieve systematic product and business performance improvements. In turn, practitioners will be equipped with a rigorously, time-tested tool to aid in the systematic increase of successful new technology launch rates.

Key Concepts

Framework

A number of continuous process improvement models and standards that have a variety of issuing bodies, scopes, architectures, and rating methods were reviewed. In addition, frameworks have been devised with both *externally* and *internally* derived criteria (Paulk, 2004). Externally derived frameworks include

- Malcolm Baldridge National Quality Award criteria (Baldridge, 1987)
- Standards such as ISO 9000 (Quality Management Systems – Requirements) (ISO9001, 2000)

Internally derived frameworks include

- Total Quality Management (TQM) (Crosby, 1979; Juran, 1992; Deming, 1994)
- Lean (Womack & Jones, 2003)
- Six sigma (Harry & Schroeder, 2000)
- Process Improvement models such as CMMI (Chrissis, Konrad, & Shrum, 2003)

Process

A process is the logical organization of people, materials, energy, equipment, and procedures into work activities designed to produce a specified end result (Pall, 1987). Recall that the specified end result for the NTV sector is a first of its kind product produced using a first generation manufacturing process. *This first generation process is indigenously devised, newly invented and situation specific.* It will have been expressly developed or adapted to facilitate the launch of the new technology (Ansoff, 1957; Booz-Allen & Hamilton, Inc., 1982; Leifer et al., 2001; O'Connor & De Martino, 2006).

Process Stabilization

The concept of continuous process improvement, which was developed in the quality movement, requires that the existing process be stabilized. It then becomes predictable, and its capabilities become accessible to analysis and improvement. Continuous process improvement occurs when the cycle of stabilizing, assessing, and improving a given process becomes institutionalized (Davenport & Short, 1990). However, it could be argued that the process stabilization imperative of CPI is at odds with firms that engage in NTV development, since by its very nature such a process is a first- to early-generation process that may require extensive redesign until the new technology and resultant product are deemed viable. In fact, simple new product development processes that have no new technology requirements *may struggle* to justify the up-front CPI costs in a first generation process because early design changes may be easily and readily made without sacrificing product viability or quality. In sharp contrast, the highly complex processes characteristic of NTV development environments *may easily* justify the up-front costs associated with CPI initiatives, because their configuration management is confounded by even small design changes early in the development life cycle (Campbell, 1989; Macala, 1996). Perhaps the more complex the process, the more important it is to install stable processes early in the development life cycle. Evidence that highly complex processes may justify the up-front costs associated with CPI initiatives is documented in the aerospace, telecommunications and ETO environments (Griffin, 1997; Chapman et al., 2001; MacCormack & Verganti, 2003; Brun & Saetre, 2008). It would be of interest to know if those CPI initiatives that work in these arenas prove applicable in the NTV development sector.

CPI Frameworks' Applicability to Specified Industries and Sectors

The selection and implementation of a CPI framework to a particular industry or sector is often predicated on historical best practices, top management policy and/or government dictum. For CPI initiatives installed for the first time, a recognized schema has been adopted by both the defense and commercial industries and is known as a CPI framework applicability evaluation (Paulk, 2004; Chen & Tong, 2004; Zhou, He, & Gao, 2006; Sinn, Chandler, Bailey, & Mattis, 2008). In addition, recognize that a number of models and standards exist, which are focused on continuous process improvement, and which are applicable in a variety of specified industries and business functions. Most have their roots in the management and improvement of manufacturing processes but have evolved to accommodate a variety of settings including administrative, service, healthcare, financial institutions, among others to great success. Generalization of these continuous improvement frameworks has been proven to be effective in organizations ranging from manufacturing to service committed to continuous improvement (Sinn et al., 2008). However, each framework must be reviewed to determine its applicability to a particular organizational environment. For this reason the CPI applicability evaluation begins with a review of the literature.

First, the evaluator assesses historical and potential future applications in order to select an appropriate subset of applicable CPI frameworks for further investigation. Second, the evaluator maps these applicable frameworks in order to reveal nesting relationships. Third, the evaluator determines which CPI framework has the most broadly based and finely tuned framework because it may then be used with confidence. Lastly, the evaluator performs a contextual analysis. The evaluator assesses the most broadly based, finely tuned CPI framework within the setting in which it is to be applied (Paulk, 2004; Chen & Tong, 2004; Zhou et al., 2006; Sinn et al., 2008).

Literature presents attributes of effective continuous process improvement that leads to high product quality, process performance, and business performance. In particular, the value of frameworks such as (1) TQM, (2) lean, (3) six sigma, and (4) capability maturity model integrated (CMMI) have been widely acknowledged (Cortada, 1995; Harry & Schroeder, 2000; Clark, 2000; Harter et al., 2000; Issac, Chandrasekharan, & Anantharman, 2003). However, certain CPI frameworks have proven more applicable than others given the needs and nature of a particular industry sector. A continuous process improvement (CPI) framework applicability evaluation was conducted to determine if capability maturity model integration (CMMI) and total quality (TQM) based tools devised for the aerospace defense industry may be used in the commercial new technology venture sector.

The resultant examination of prior research, mapping to determine scoping differences, and contextual analysis determined that CMMI and TQM based tools devised for the aerospace defense industry were applicable to the commercial new technology venture sector (Johnson & Brodman, 2000; Amaratunga et al., 2002; Ramanujan & Kesh, 2004; Doss & Kamery, 2006; Hutchinson, 2006; Veldman & Klingenberg, 2009; Hannum & Lyth, 2010). The peer-reviewed evaluation may be viewed: http://nciia.org/sites/default/files/conf2010papers/jackson.pdf.

The next section details the CPI framework applicability evaluation.

CPI Applicability Evaluation

A CPI framework applicability evaluation begins with a review and synthesis of the literature. This synthesis revealed core broad-based, yet interrelated CPI frameworks. In particular, TQM, lean, six sigma, CMMI, ISO 9000, and the Baldridge Award, along with the more generic practices of strategic planning, assessment, data collection, documentation, and the development of standard operating procedures, form a foundational core of broad-based inter-related areas resident in continuous process improvement initiatives. All of these recognized performance improvement frameworks began in a particular industry or business sector such as manufacturing or aerospace software development, and evolved over the ensuing years into models for organizational performance improvement for many types of organizations. These include for-profit entities in manufacturing, technology development, service, healthcare, education, as well as non-profit organizations (Sinn et al., 2008). The frameworks and generic practices, with their predecessor and inter-relationships, are depicted in the Figure 5.

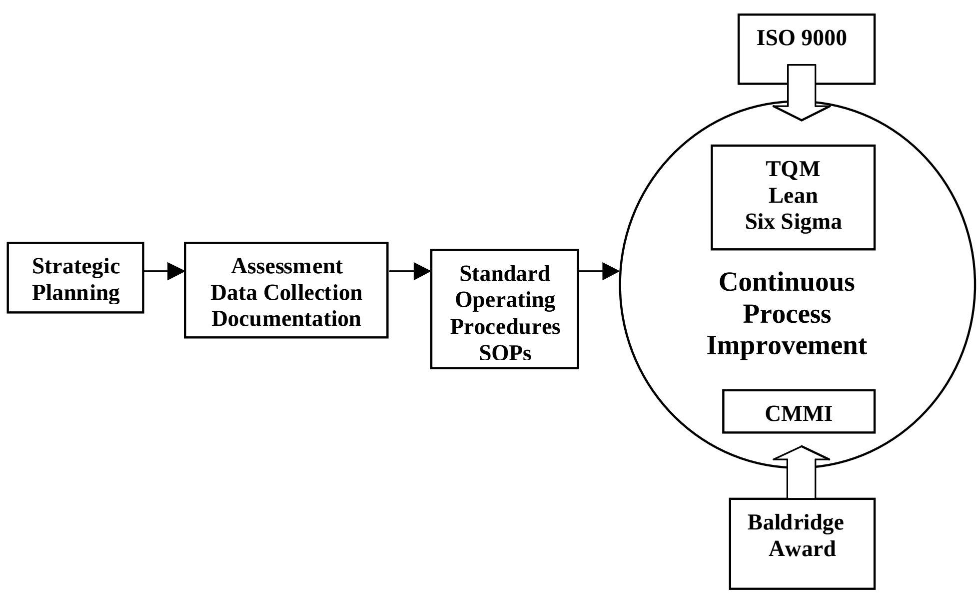


Figure 5. Core Areas Used to Achieve Continuous Process Improvement

Antecedents of Strategic Planning

Strategic planning has always been part of the vision-determining mechanism and guide for the future for all continuous process improvement frameworks. Strategic planning's essential attribute is that a firm must become increasingly systematized using a fundamental methodology that assesses and determines the direction of work to be pursued for improvements and changes.

Strategic planning is generally tied to change and improvement, based on a vision for the future. The future and vision being discussed in this case are tied to systems for assessing directions related to change and improvement within the context of broad quality systems. Data must be collected and documented in ways that are appropriate to the specific missions of continuous process improvement. Strategic planning affords a systematic approach to setting goals for the future, determining appropriate measures for success, and planning for needed resources. It is to this end that an appropriate, applicable, and useful framework should be selected given the myriad of options (Burgelman, 2002).

Assessment, data collection, and documentation are antecedents to strategic planning and integral components of the early phases of all continuous process improvement initiatives. Once a strategic plan is in place, it is incumbent to each firm's leaders and managers to capture knowledge to ensure efficiency and select an appropriate continuous process improvement framework (Burgelman, 2002). Standard operating procedures (SOPs) are a core component of any continuous process improvement framework. They are the minimum outcome from any strategic plan that insists its organization's leaders assess, collect data and document results for some form of analysis that may provide insight into continuous process improvements. SOPs fulfill a number of pervasive needs found in major quality, organizational and continuous process improvement systems. The SOPs form the basis for implementation of the quality system in all continuous process improvement initiatives and provide steps to follow in disciplined ways to accomplish all functions of the program. Broadly noted, SOPs may take different forms and include written work instructions, flow charts, examples, process maps, and other procedural documentation, which can be accessed and used by all of the firm's participants.

Varying Deployments of Strategic Planning Into CPI

The specific ways in which a strategic plan, assessment, data collection, documentation and SOP practices have been deployed and integrated into each continuous process improvement framework varies. Each framework has its own architects, set of issuing bodies, and standardization entities. Some frameworks rely on externally derived criteria vs. internally derived criteria; some have an intra-relationship focus vs. an inter-relationship focus; some have project success imperatives vs. enterprise level success imperatives. All the frameworks examined in this research originated in a particular context for a specific industry and business function. All have expanded to a wide spectrum of industries and business functions. This section reviews and synthesizes the existing literature base in the Malcolm Baldridge framework, ISO 9000, TQM, lean, six sigma, and capability maturity model integrated (CMMI) to determine the most applicable CPI framework with which to assess new technology venture (NTV) development processes.

1. The Malcolm Baldridge National Quality Award criteria were externally developed in 1988 as a model for managing quality in a manufacturing organization and recognize achievements in quality and business performance. This framework examines both intra and inter-relationships in both for-profit and non-profit entities, and is considered to be an enterprise level framework. The U.S. National Institute of Standards and Technology in the Department of Commerce launched the award in 1987 to encourage U.S. companies to publicize successful quality and improvement strategies, to adopt total quality management, and to encourage competitiveness.

Examiners assess their own externally derived criteria and allocate points in seven major areas. Unfortunately, applicant information is confidential. Thus, the required confidentiality agreements ensure that the link between award criteria and resultant product/business performance remains inaccessible and other firms have no reliable way to replicate results. Lastly, the award criteria have been revised and improved over the ensuing years and have evolved into a model for organizational performance for many types of organizations. Significantly, this evolutionary course has occurred for every recognized performance improvement framework.

2. ISO 9000 (Quality Management Systems), like the Baldridge Award, has externally derived criteria. This framework is an extensive suite of standards dealing with quality management systems, and can be used for external quality assurance purposes. Formerly biased towards a manufacturing environment, the 2000 release removed much of the manufacturing bias and has subsequently been adopted by a wide variety of industries and functions. It addresses the organizational context of processes (inter-relationships) and the enterprise level viewpoint such as profitability, market share, and the like. Sector-specific variants, such as QS9000 and TL9000, provide recommendations for adopting ISO9001 in specific environments, the automotive and telecommunications industries, respectively. Unfortunately, ISO 9000 only defines minimum qualifications a firm needs to achieve for certification (Bamford & Deibler, 1993) and lacks substantial support for continuous improvement (Coallier, 1994). The ISO suite of standards originated in manufacturing and was first narrowly applied then later became widely accepted.
3. The lean framework derives its criteria internally and has a focus on identifying and eliminating waste. The eleven waste categories are: defects, overproduction, queue time, transportation, processing waste, inventory, waste of motion, talent,

complexity, redundancy and communication (Sinn et al., 2008). Its focus is intra-organizational with departmental, functional, with enterprise level performance imperatives. Lean practices make use of the experience and intuition of experts to solve problems. In practice, its commonly used tools include single-piece flow, pulling System (billboards), Just In Time (JIT), Value Chain Management, TPM (Total Production Maintenance), SMED (Quick Die Change), the balanced production lines, prevent errors, workplace Organization (Workplace organization), 5S, customer value flow analysis, motion analysis, Jidoka (automation), prevention of errors, more employee training (Zhou et al., 2006). Lean originated in manufacturing, was first narrowly applied and then later became widely accepted.

4. Similarly, TQM and its more precise derivative, six sigma have internally derived criteria as well, but systematically identifies and measures variation, defects, and waste for elimination to achieve sustained improvements. Six sigma is based on the overarching philosophical tenants of TQM and statistics. Six sigma uses quantifiable indicators and analysis with minimal dependence on the experience and intuition of experts to solve problems. In practice, it combines many traditional statistical methods and tools such as QFD (Quality Function Deployment), FMEA (Failure Mode and Effects Analysis), SPC (statistical process control), MSA (Measurement System Analysis), ANOVA (analysis of variance), DOE (design of experiments), regression analysis, hypothesis testing, and so on (Zhou et al., 2006). Six sigma's focus is intra-organizational with enterprise level performance imperatives. TQM and six sigma each originated in manufacturing were first narrowly applied and then later became widely accepted.

5. The capability maturity model integrated (CMM1) framework requires each firm derive its own set of continuous process improvement criteria. As mentioned in the

introduction, each maturity level has defined characteristics whereby each firm's distinctive set of procedures is assessed to determine if it has one of the following levels of process maturity: (1) initial, (2) repeatable, (3) defined, (4) managed, and (5) optimizing. Level 1 is indicative of low process maturity; level 5 is indicative of high process maturity. Its focus is intra-organizational with departmental, functional and enterprise level performance imperatives. Software Engineering Institute (SEI) originally developed it and its first application provided a well-defined approach to continuous software process improvement in the aerospace industry (Harter et al., 2000; Manzoni & Price, 2003). Aerospace hardware developers (e.g., jets and its sub-components) adopted CMMI due of its success in the aerospace software industry. Additionally, due to CMMI's comprehensive nature, more industries, firms, and business functions outside of the aerospace software/hardware industry have begun to use the CMMI framework to achieve continuous process improvement. These include education, medical and biotech, administration, distance learning, university Ph.D. programs, facilities management, automotive, and generic new product development, among others. Empirical evidence supports the contention that CMMI has demonstrated its appropriateness and applicability in a wide spectrum of settings (Johnson & Brodman, 2000; Amaratunga et al., 2002; Ramanujan & Kesh, 2004; Doss & Kamery, 2006; Hutchinson, 2006; Veldman & Klingenberg, 2009).

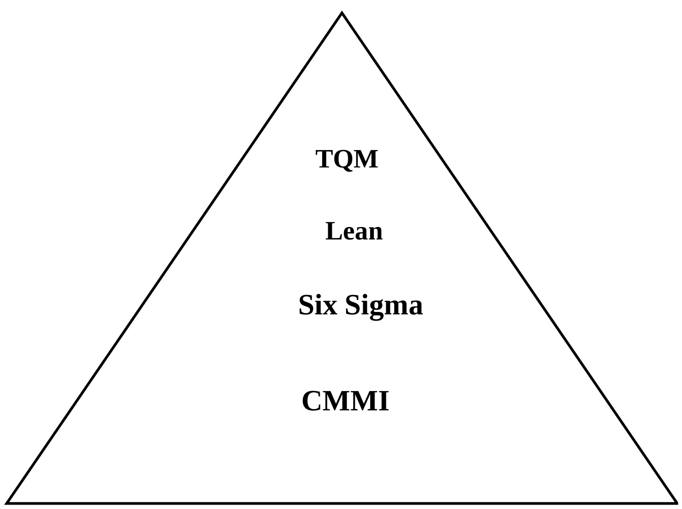
A review of the literature revealed that CMMI provides *more* comprehensive guidance for improving processes than TQM, lean, and six sigma. Lastly, CMMI's applicability and usefulness is rapidly broadening into more business sectors just as has occurred with all the other recognized frameworks.

The literature review also revealed that only the four *internally* derived CPI frameworks should be considered further due to the unique and indigenous nature of NTV environments.

Likewise, NTV environments use first generation manufacturing processes and therefore no externally derived standard has yet to come about. To wit, TQM, lean, six sigma, and CMMI are examined further. The next step in the evaluation is a procedure known as mapping. This requires that these four frameworks be mapped to reveal nested relationships and thereby identify the most broadly based and finely tuned method. The most broadly based, finely tuned method may be best used with confidence. Thus, the CPI engineer may determine a specific CPI framework that is applicable for a given process. In short, the most nested framework that provides the best CPI operational methods may be selected and implemented with confidence (Paulk, 2004; Chen & Tong, 2004; Zhou et al., 2006; Sinn et al., 2008).

Mapping and Nesting

Scholars and practitioners have long recognized that while each framework had its own genesis, they have each evolved to accomplish a single outcome: continuous process improvement. Consequently, the process of mapping CPI frameworks to determine nesting relationships has become routine in some industries. The aerospace industry, for example, routinely maps CPI frameworks, since various governing agencies and customers may require multiple certifications when competing for Department of Defense contracts (Sheard, 2001). As such, the aerospace industry has devised methods to evaluate the applicability and usefulness of CPI initiatives. Recognize that the use of CPI is *voluntary* for new technology ventures (NTV) in the commercial sector and *compulsory* in the aerospace industry. However, this distinction may make the aerospace industry’s method of CPI analysis for applicability and usefulness more valuable since it is both rigorous and time-tested. In the commercial NTV sector, each firm decides whether to engage in CPI at all. And if the firm engages in CPI, it typically controls both the CPI appraisal and improvement programs. Therefore, the purpose of mapping CPI frameworks in this context is only to justify the use of the most applicable yet comprehensive framework for the continuous process improvement of new technology ventures, and not to serve outside governing bodies. In particular, recognize that because the NTV sector uses first- or early-generation processes indigenous to each firm, this study concerns itself only with CPI frameworks that have internally derived criteria. Therefore, TQM, lean, six sigma, and CMMI are the focus of this study's scrutiny due to the internally derived nature of these frameworks and their successful applications in aerospace, telecommunications, and engineering to order (ETO) sectors. These CPI frameworks and their nesting relationships are depicted in Figure 6.



CPI Framework's Objectives

- **Style of management aimed at achieving long-term continuous process improvement by linking product quality to customer satisfaction**
- **Identify & eliminate waste**
- **Identify, eliminate waste, defects and variation to 99.9997% defect free**
- **Identify and strengthen process capabilities to achieve level 5 maturity: continuous process improvement**

Figure 6. CPI Framework's Objectives and Nesting Relationships (Paulk, 2004; Sinn, Chandler, Bailey, & Mattis, 2008)

The selection and implementation of a voluntarily employed CPI framework is best determined by its applicability and usefulness, as established by (further) examination of prior research, mapping to examining scoping differences, and conducting contextual analyses (Paulk, 2004; Sinn et al., 2008). These examinations and analyses were performed and it was determined that CMMI's broader framework (compared to lean and six sigma) and contextual suitability, combined with TQM’s overarching philosophical tenets would be most applicable to the new technology venture sector.

Lean production and six sigma management have commonalities that include culture pursuit, ultimate objectives, continuous process improvement, requirement to understand the role of the employee toward success and strategic requirements (Zhou et al., 2006). In contrast, the two frameworks’ differences include the model of operation and management, recommended starting points and methods to solve the problem, implementation steps, focus of specific implementations and training, cognition of financial effect, process improvement strategies, and specific concerns. These differences, however, are not antagonistic but complementary. If integrating and applying the two, a firm’s business process will continuously improve and thereby be more responsive to changing market conditions while maintaining the strongest competitive advantages (Chen & Tong, 2004). Table 3 depicts generic lean and TQM/Six sigma process components and maps their complementary attributes, thus illustrating how the lean framework nests within TQM/Six sigma (Sinn et al., 2008).

When evaluating multiple frameworks to determine applicability and usefulness, an organization faces a number of challenges. First, the scope of different frameworks is likely to differ, with some amount of overlap that must be addressed. Interpreting the framework with the broader scope from the perspective of the framework with the narrower scope is usually appropriate. For example, an organization using CMMI and six sigma should interpret the six sigma practices from the perspective of CMMI (Paulk, 2004). This mapping of requirements in one framework to the requirements in the other may reveal nesting. For example, the broader-scope framework will provide more detailed requirements and guidance on implementing parts of the narrower framework. Although there may be specific points in the narrower framework that are neglected in the broader, satisfying the more detailed framework’s requirements can be considered *prima facie* evidence that the narrower framework’s equivalent requirements are satisfied. Therefore, mapping to reveal nesting is one effective way of addressing framework applicability.

Table 3. *How Lean Maps Within TQM/Six Sigma*

TQM/Six Sigma Attribute	Characteristic of TQM/Six Sigma Attribute	How to Accomplish	Complementary Lean activity
Define	Define the process and the project	Map process	Use the process map to identify all process steps.
Measure	Determine step timing, activity costs, flow distances, process parameters	Measure using best practice methods	Determine current time and develop target time for all steps
Analyze	Analyze every measurement for waste, value and opportunity	Deep Dive the data	Determine the delta and analyze root cause.
Improve	Target the high waste measurements and develop a process to mitigate	Try Something – Make a substantiated change; avoid analysis paralysis	Understand and develop and implement improvement strategies for each step of the work process.
Control	Ensure process discipline and that the organization does not slip back to the old way/habit	Instill process discipline through leadership; Have visible management attentive to continuous improvement	Ensure that the gains are sustained through management audits and visible management.

(Paulk, 2004; Sinn, Chandler, Bailey, & Mattis, 2008)

Contextual Analysis

Another way of addressing framework applicability is to determine the contextual requirements for each specific setting. For example, a tenth generation process derived for a product family may find a six sigma CPI framework fits best while a first generation process may find a CMMI CPI framework fits best. This might be the case because six sigma strives to remove large variation based upon an established baseline that already exists. In contrast, CMMI may begin its assessment with no initial baseline in place. CMMI then is a more logical choice to use for the assessment of first-to-early generation processes found in NTV environments. Consequently, CMMI's broader framework and contextual suitability, combined with TQM's overarching philosophical tenets are used to measure the CPI in this new technology venture study. Recognize that *six sigma maps within CMMI* in the same way that lean maps within six sigma. This nested relationship is depicted in the Table 4 (Sinn et al., 2008).

Conclusions

Continuous process improvement (CPI) has improved product and business performance in many industries and business sectors. However, it has not been widely adopted in the new technology venture (NTV) sector. The literature review sought to establish the plausibility of the CMMI CPI framework as a viable tool to improve complex, first generation NTV processes. The review investigated how and why CMMI, which arose out of the aerospace industry, might prove particularly applicable to the NTV sector. Both the aerospace and NTV sectors share highly complex, first- or early-generation processes with overarching rapid speed-to-market imperatives. And since CMMI initiatives *have* improved aerospace processes, it was hypothesized that they may improve NTV processes. A CPI framework applicability evaluation was conducted to establish CMMI's plausible application to the NTV sector. This section detailed this evaluation, which examined prior research, mapped initiatives to determine scoping differences, and analyzed contexts. The evaluation's results established that CMMI is a plausible CPI framework that may be a viable tool when applied to the NTV sector. Consequently, the researcher has incorporated a proven TQM/CMMI based measurement instrument to measure six critical factors and their impact on product quality in the NTV sector.

Table 4. *CMMI Maps and Nests Within TQM/Six Sigma*

Low Maturity → **High Maturity**

Six Sigma Requirements	**Level 1** Initial	**Level 2** Managed	**Level 3** Defined	**Level 4** Quantitatively Managed	**Level 5** Continuous Optimizing
Define	Undefined process and project and yet performed; Ad hoc and chaotic process performance led via heroic efforts	Infrastructure in place to support process; Broadly defined process descriptions in place	Infrastructure in place to support process; Precise standardized process descriptions in place	Firm and projects have quantitative objectives for product quality and process performance; These are based on customer needs and process implementers	Firms and projects have quantitative understanding of common causes of variation inherent in processes; Continually revised firm level quantitative process-improvement objectives in place
Measure	No meaningful measurements of timing, activity costs, flow distances, and process parameters	Measure against process descriptions	Measure against tailored set of firm's precise, standardized processes according to own guidelines rigorously produced	Measure quality and process performance in statistical terms; for selected sub-processes, detailed measures of process performance are collected and statistically analyzed	Use measurement methods described in level 4; Effects are measured and evaluated against quantitative process improvement objectives
Analyze	No analysis of waste, value & opportunities	Crisis driven passive analysis; no detailed measures available thus minimal opportunities to analyze meaningful data	Some proactive analysis; uses understanding of interrelationships of process activities and detailed measures of processes	Diligent, proactive statistically sound analysis of quality and process data repository…	Analyze as in level 4; Both the defined processes and the firm's set of standard processes are targets of measurable improvement activities
Improve	No target of high waste measurements and no processes are devised to mitigate	Only produce outputs per process descriptions; much re-work, scrap, inefficiency, poor quality tolerated	Produce outputs per standardized process descriptions; some re-work, scrap, inefficiency, poor quality tolerated	…That support fact-based decision-making. Special causes of process variation are identified and, where appropriate the sources of special causes are corrected to prevent future occurrences	Use fact-based decision-making to continually improving using innovative and technological improvements by addressing common causes of process variation
Control	No controls and no process discipline is ensured	Controls in place as adherence to process descriptions	Controls in place as adherence to standardized process descriptions; lead to the qualitatively predictability of process performance	Controls lead to the quantitatively predictability of process performance via incremental improvements	Controls lead to quantitatively predictability of process performance via continuous improvement; Addresses common causes of process variation and changes process[a]

[a] To shift the mean of the process performance or reduce the inherent process variation experienced

(Paulk, 2004; Sinn, Chandler, Bailey, & Mattis, 2008)

The first study reported in this dissertation will determine which, if any, of six critical factors identified in the previously validated and reliable CMMI/TQM based instrument (Vitharana & Mone, 2008) have a statistically significant impact on product quality performance. If research results confirm these factors impact product quality, this instrument will equip NTV practitioners with a new tool that incorporates (1) the well accepted overarching TQM philosophical tenets combined with (2) the rigorously, time-tested CMMI methods for achieving CPI. These frameworks have lead to significant process and product quality performance improvements in the aerospace sector. Importantly, should NTV managers adopt this new tool, they may anticipate similar process and product quality improvements.

CHAPTER III

RATIONALE AND OBJECTIVES

Rationale

Engineering managers charged with launching technologically advanced products to the market for the first time have little guidance from traditional performance measurement systems. A measurement system designed to aid engineering managers with making more effective process improvement decisions that impact product quality would be a significant advancement. Such measurement has proven difficult because firms in this sector are highly heterogeneous and marked by heroic management efforts. Economic development specialists contend it is important to devise a viable method to assess processes and management practices systematically in this environment, particularly as it relates to continuous process improvement and product quality, to improve future ventures.

The primary focus of this research was to devise an effective and usable performance measurement tool, since it may enable managers to improve the product quality of technological innovations.

Given the importance of innovation, and the fact that managing the quality of new technologically advanced products is essential to the success of each new venture, a newly devised scorecard, which was effective and usable would be a significant advancement. Because this scorecard was designed as a template for indigenous modification, it can be incorporated quickly into a variety of fast-paced new technology product development environments. NTV managers grounded in continuous process improvement practices will be able to incorporate this tool confidently in order to guide their teams toward higher quality products. This, in turn, may have a positive influence on the successful launch rates of technologically advanced products since superior product quality has been positively correlated with launch success.

Scorecard Development Requirements

The development of a balanced scorecard for project-level new technology managers requires (1) identification of management practices that impact product quality, (2) incorporation of these factors into a balanced scorecard, and (3) evaluation of this newly devised balanced scorecard. Two studies were employed to accomplish these goals.

Objectives

This research project built on process capability maturity theory and was comprised of two studies. The objective of the first study was to determine critical factors that drive product quality. It used multivariate equations to predict critical factors that drive product quality. Data were collected from experienced NTV managers using a previously validated survey instrument. When the data analyses demonstrated significant correlation with measures of product quality management practices and product quality performance, the critical factors were incorporated into the performance measurement tool, known as the balanced scorecard.

Recognized design methodology grounded in the literature was used to establish a solid framework from which to build the tool. This provided the best platform from which to launch its evaluation. Therefore, scorecard design methodology defined in the literature was used to convert the identified product quality management practices into performance measures.

The objectives of the second study were twofold. First, the development and test of a valid and reliable measure of scorecard performance capability and usability was needed. This was required because no such instrument existed in the literature. The second objective of this study was to evaluate the newly devised scorecard. Data were collected from experienced NTV managers using this measure. It was projected that the instrument would demonstrate significant correlation with measures of scorecard performance capability and managers' decision to use the scorecard. This evaluation determined that managers deemed the scorecard to be a usable tool and that it will aid them in making effective product quality management decisions.

This tool was developed with a desire to enable managers to lead initiatives that improve the product quality of technological innovations.

In summary, this research was comprised of a five-step systematic methodology that investigated product quality management practices in the new technology venture departments. Effective product quality management practices were (1) identified, and (2) incorporated into a scorecard. The resultant scorecard was (3) designed, (4) made operational, and (5) evaluated.

CHAPTER IV

METHODS AND PROCEDURES

The methods and procedures section includes (1) schema, (2) participants, (3) sample size, (3) criteria for participation, (4) procedures, and (5) measures for two pilot studies and two full-scale studies.

Study One

Schema

The development of a valid and reliable survey instrument involves numerous steps that take considerable time. However, when using an instrument that has been shown valid and reliable, this process may be streamlined. The schema devised by Gliem and Gliem (2003), Mulvenon and Turner (2003), Pett, Lackey, and Sullivan (2003), as well as Radhakrishna (2007) was followed:

- Conduct extensive literature review of prior research to ascertain applicability of selected measurement instrument.
- Identify target audience and devise procedures to solicit respondents.
- Seek Human Subjects Institutional Review Board (HSIRB) review and obtain response prior to soliciting potential respondents.
- Use appropriate expert(s) to confirm face validity remains intact.
- Articulate hypotheses; delineate independent and dependent variables as linked to refined measurement instrument.

- Compute readability test(s) after revisions. Confirm resultant grade level corresponds to the target audience.
- Use previously validated instrument whereby face, content, and construct validity were previously established (Vitharana & Mone 2008).
- Conduct pilot study (15 respondents).
- Establish reliability from the pilot study using Cronbach's alpha (α); appropriate revisions may be made to the instrument until α >.70 (Nunnally, 1978).
- Establish criterion validity using multiple linear regression.
- Conduct full- scale study (100–125 respondents).
- Establish reliability from the pilot study using Cronbach's alpha (α); appropriate revisions may be made to the instrument until α >.70 (Nunnally, 1978).
- Establish criterion validity using multiple linear regression.
- Conduct multivariate regression analysis; report and analyze appropriate statistics (e.g., coefficient of determination (adjusted R^2), F and p values and thereby
- Determine if the NTV PQMI reliably predicts product quality in the new technology venture sector, and if it
- Establish a correlation between process management, management commitment, employee education and training, customer focus, quality metrics, and employee responsibility.

Participants

Participants for the pilot study were current and recent managers of new technology venture processes with three or more years of experience within the last five years. These managers were identified and recruited from the following sources: (1) National Consortium of

Innovators and Inventors Alliance (NCIIA); (2) McAllen Economic Development Corporation, a firm networked with new technology ventures on the third coast; (3) American Society of Engineering Managers (ASEM); (4) Kaufmann Foundation; (5) AimWest; and (6) Paragon Recruiting. Recognize additional participants for the larger study included contacts from: (1) networking with Dr. Lyth and Dr. Lloyd, academic leaders in the new technology venture sector; (2) InfoGroup, the nation's leading compiler of business information; and (3) Industrial Research Institute (IRI), the nation's leading association of companies and federal laboratories working to enhance the effectiveness of technological innovation.

This research sought variety in the number of industries studied, the size of the companies, their reputation for past innovativeness, and the age and structure of NTV functions. Companies and their NTV managers were qualified for inclusion in the research sample based on their declared intent to evolve their capability for managing their radical innovation processes. This was cross-referenced with pre-screened professional organization affiliations (e.g., NCIIA and IRI) and public documentation such as company web sites and/or stockholders' annual reports. Finally, a subset of members of these firms who were willing to complete surveys and participate in interviews ultimately self-selected to be the final participants in the pilot test as well as the full-study.

Sample Size

When testing a newly developed survey instrument, the sample size for a full-scale study should have a minimum of 10 respondents per item. However, when using an instrument that has been shown valid and reliable—as was the case for this study—a smaller sample size may prove sufficient. This is particularly justified when there are several marker variables with high Cronbach's alpha values that are greater than .80, which was true in this case. Lastly, it is recommended that the sample size of a full-scale study be six to ten times the size of its pilot study (Tabachnick & Fidell, 2001; Pett et al., 2003). Consequently, the pilot study sample size was computed to be 15 and the full-scale sample size was 100. Also, Cohen (1992) established that for a multiple linear regression model with six predictors, a sample size of 97 was sufficient for a medium (13%) effect. The full scale study collected data from 102 respondents, which exceeds Cohen's threshold. Note that confirmation of sample size was re-visited whenever additional statistical analyses were performed on the full-scale study's data set; this lower bound of 100 was met for all sets of criterion used for each analysis method selected.

Criteria for Participation

Participants in the surveys were new technology venture managers who (1) managed the launch of a new technology venture for a minimum of three years within the last five years (Vitharana & Mone, 2008), and (2) worked in an environment where job titles and responsibilities were clearly defined (Naranjo, 2009). Participants also confirmed that their new technology products offered: (1) wholly new benefits, (2) significant (i.e., 5 to 10 times) improvement in known benefits, or (3) significant reduction (i.e., 30 to 50%) in cost (Leifer et al., 2001). Fifteen managers completed the NTV PQMI as participants of the pilot test for study one. Data were compiled from their responses, and then analyzed.

Procedures

Qualitative Evaluation of Proven Measurement Instrument

A qualitative evaluation of the Vitharana and Mone's (2008) measurement instrument's revisions was completed. Recognize this study modified only the job title and otherwise maintained the original survey intact (Vitharana & Mone 2008). Statistical expert, Naranjo examined the modified survey and expressed confidence in its statistical data gathering capability for those new technology venture environments where job titles and responsibilities were clearly defined (Naranjo, 2009). Thus, all 15 pilot study respondents confirmed their job titles and responsibilities were clearly defined.

Human Subjects Institutional Review Board Approvals Obtained

Human Subjects Institutional Review Board (HSIRB) review was requested. All required documentation was provided to the HSIRB office. A survey and methodology “approval not needed” letter was sent from the HSIRB office. The letter was received prior the March 2010 National Consortium of Innovators and Inventors Alliance (NCIIA) Conference. Thus, the researcher recruited potential NTV PQMI survey respondents for this pilot study, and the full-scale study, at the NCIIA Conference. In addition, the peer reviewed paper that ascertained CMMI’s applicability to the NTV environment and reproduced in the literature review section of this dissertation was presented at that same conference.

Readability Test

The readability of the refined instrument was computed using the Flesch-Kincaid Grade Level formula to ensure the reading level was appropriate for all recruited survey respondents:

$$0.39\left(\frac{total\ words}{total\ sentences}\right)+11.8\left(\frac{total\ syllables}{total\ words}\right)-15.59$$

Equation 1. Flesch-Kincaid Grade Level Formula

The resulting value from this formula is a number that corresponds with a grade level. For example, a score of 8.2 would indicate that the text is expected to be understandable by an average student in 8th grade, which is usually around ages 13–14 in the United States of America

(Kincaid, Fishburne, Rogers, & Chissom, 1975). The grade level obtained for the survey used in study one is shown in the Results section.

Survey Methods Researched and Utilized

Survey methods for study one were researched to determine the methods that produce the highest quality responses while also are proven to be efficient and cost-effective. This pilot test used the mixed-mode survey method to collect data on the 15 new technology venture sector respondents. Surveys of establishments such as business, government, and organizations have shown to produce consistent, high quality responses. This is particularly the case when researchers seek factual information regarding situations and assessments of an establishment (de Leeuw 2005; Greene, Speizer, & Witala, 2008). For example, mixed-mode survey approaches are widely used by the Bureau of Labor Statistics and when researchers survey businesses seeking data regarding the business and or its operations. Therefore, an establishment mixed-mode survey method was justified for this dissertation research project since it was seeking data from respondents exclusively on business operations and not personal/sensitive information on the respondents, themselves. Lastly, there are three additional reasons researchers cite for using the mixed-mode survey method for establishments: (1) it increases the likelihood of participation, (2) it reduces the cost of the survey research, and (3) it increases the speed of completion (Turner, Lessler, & Gfroerer, 1992; Dillman & Christian, 2003; de Leeuw 2005; Greene et al., 2008). The establishment mixed-mode survey protocols used for this pilot test and the full- scale study are summarized in Table 5.

The electronic survey method was the primary data collection mode. The specific benefits of this mode included all of the above benefits of mixed-mode plus it (1) increased candid responses due to respondents' anonymity, and (2) responses were obtained directly from the individuals under study. An overview of the described procedural approach is delineated in Table 5.

Table 5. *Survey Data Collection Protocols for (1) Pilot Study and (2) Full-Scale Study*

Step	Experimental Treatment	Description
1	Pre-screen	Phone call to referral to ascertain if potential respondent fits NTV managerial expertise criteria.
2	Introduction	Phone call to remaining list of prospective respondents to introduce researcher and reconfirm that he/she fits criteria. Confirm if candidate has the time and willingness to complete the survey via phone at a future mutually convenient time.
3 4	e-mail Link	Most respondents went to link; E-mail confirmed respondents to remind them of the date and time previously set in introductory phone call. Invitees are informed on the first page of on-line survey of HSIRB 'approval not need' status, WMU contact information, study's purpose, and description of the survey with NTV and NTV product definitions.
4	e-mail Link, again	E-mail link to each respondent one day ahead of those requiring a phone appointment #1.
5	Phone Appointment #1	Complete all or part of the survey with respondent as time permits. Reschedule follow-up phone appointment as needed.
6	Phone Appointment #2	Complete remaining portion of survey as time permits. May require a third phone appointment; reschedule accordingly. Continue with this experimental treatment protocol until obtain fifteen completed pilot study survey instruments.
7	Direct to Web	Once study is completed, return to experimental treatment #1 and continue to #6. For those respondents who prove exceedingly busy and/or prefer the solitude and self-administering qualities of completing the survey on-line, the link is provided yet again, which is followed up with an e-mail reminder for the individual to complete the survey at their earliest possible convenience. Continue with this protocol until the appropriate number of surveys is completed.
8	Final e-mail	Send an e-mailed "thank you for your participation" note.

Measures

Survey Instrument

Vitharana and Mone developed a survey instrument for software development managers for use in the aerospace and telecommunications industries (Vitharana & Mone, 2008). This measurement instrument known as the Software Quality Management Instrument (SQMI) was designed with CMMI and TQM tenets embedded in its structure. Because the CPI applicability evaluation determined that CMMI's finely focused assessment lens (compared to lean and six sigma) and contextual suitability, combined with TQM's overarching philosophical tenets would be an applicable CPI framework in the NTV sector, the SQMI was used in this research project. Thus, this research project strove to expand the application of Vitharana and Mone's instrument into the new technology venture sector.

The SQMI was minimally modified for the NTV sector and renamed the NTV Product Quality Management Instrument (NTV PQMI). This modified instrument was used to measure the critical factors that determine NTV product quality in both the pilot and full-scale studies. This instrument has been previously tested in the aerospace and telecommunications industries. Consequently, its reliability and validity was previously established in analogous arenas. This study modified only the department name and job title; otherwise the survey remains entirely intact. Statistical expert Naranjo examined the modified survey and expressed confidence in its statistical data gathering capability for those NTV environments where job titles and responsibilities are clearly defined (Naranjo, 2009). Lastly, the minimally modified version of Vitharana and Mone's (2008) new product quality rating and process improvement scale (NTV PQMI) was tested empirically in a pilot study to determine if it is a reliable measurement tool for the new technology venture sector and to establish criterion validity. Results were analyzed to determine that the full-scale study was justified.

Instrument Measures Six Critical Factors

This research used the NTV PQMI measurement instrument and postulated that six factors significantly impact product quality: (1) process management, (2) education and training, (3) customer focus, (4) management commitment, (5) quality metrics, (6) employee reponsibility (Vitharana & Mone, 2008). Both the original measurement instrument and its minimally modified twin examine the impact of these same six critical factors. These items were measured using a five-point Likert scale that ranged from 1 = *strongly disagree* to 5 = *strongly agree*. Each of the six constructs, also known as hypothesized factors, is discussed below.

Process Management. Process management is the practice of managing the new technology venture engineering design development process. Process management increases visibility into the new technology process, and therefore helps reduce process variations, enhance the predictability of new technology product quality, and facilitates process improvement (Harter et al., 2000; Havelka, 2003; Ravichandran & Rai, 2000). The critical nature of the NTV process is further highlighted in the capability maturity model (CMM) and its derivative capability maturity model integrated (CMMI). CMMI was designed to assist software and hardware developing firms identify their current process maturity and, as a result, select strategies for process improvement (Paulk et al., 1993). Advocates attest that process maturity is linked to the quality of the product developed (Cook & Campbell, 1979; Blaydon, Keogh, & Evans, 1999; Cooper et al., 2007). TQM identifies continuous process improvement as a precursor for developing quality products (e.g., Juran, 1992). Process management is further highlighted in new technology ventures (Van de Ven, Angle, & Poole, 1989; Dougherty & Hardy, 1996; Leifer et al., 2001; O’Connor & De Martino, 2006). In particular, O’Conner and De Martino (2006) advocate a more proactive approach to constantly improving the new technology process. These authors prescribe a process management strategy that involves the use of process benchmarking, configuration management, inspections and reviews, testing, CASE tools, standards and guidelines, defect prevention and analysis, statistical process control, and reuse. Sample items might include “NTV processes are documented,” “a comprehensive testing program is utilized to validate the NTV process,” and “NTV process is emphasized over expediency.” The process management construct with its complete set of items (survey statements) is listed in Table 6. Recognize that for each item, a response on a 5-point Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree) was solicited.

Table 6. *Multi-Item Statement to Measure NTV Managers’ Perception of Adherence*

	Item	Strongly Disagree				Strongly Agree
1.	NTV processes are documented.	1	2	3	4	5
2.	NTV processes utilized in practice are compared against ideal processes.	1	2	3	4	5
3.	NTV processes of other organizations (e.g., competitors) are benchmarked.	1	2	3	4	5
4.	NTV processes are continuously improved.	1	2	3	4	5
5.	Top management emphasizes process quality in relation to product quality.	1	2	3	4	5
6.	Configuration management techniques are utilized throughout the NTV development Process.	1	2	3	4	5
7.	Inspections and reviews are utilized in verifying various NTV process documents (e.g., requirements specification, design specification, code, etc.).	1	2	3	4	5
8.	A comprehensive testing program is utilized to validate the NTV process.	1	2	3	4	5
9.	Statistical methods (e.g., control charts, variation analysis, etc.) are used to control the NTV process.	1	2	3	4	5
10.	Computer-aided NTV Process engineering (CASE) tools are utilized in the NTV development process.	1	2	3	4	5
11.	Defect prevention is emphasized over defect detection.	1	2	3	4	5
12.	NTV process defects are thoroughly analyzed.	1	2	3	4	5
13.	NTV process reuse is emphasized.	1	2	3	4	5
14.	NTV process is emphasized over expediency.	1	2	3	4	5

Management Commitment. This construct refers to top NTV management commitment to developing quality products. Vitharana and Mone (2008) identify the need for management commitment to quality in terms of, staffing, and providing the necessary leadership to create an overall quality culture. Sample items might include top NTV "assumes responsibility for quality performance" and "is evaluated on quality performance." The management commitment construct with its complete set of items (survey statements) is listed in Appendix A.

Education and Training. This construct refers to provisioning of quality related education and training for NTV personnel and management. Vitharana and Mone (2008) determined that experts in the aerospace and telecommunications industries concur on the need to provide both managers and product developers with the necessary education and training in quality, statistical techniques, and metrics as a prerequisite to building quality products. Radical innovation experts in the NTV environment likewise concur (Van de Ven, Angle, & Poole, 1989; Dougherty & Hardy, 1996; Leifer et al., 2001; O'Connor & De Martino, 2006). Sample items might include, "quality-related training is provided for NTV personnel" and "resources are provided for quality-related education and training." The education and training construct with its complete set of items (survey statements) is listed in Appendix A.

Customer Focus. This construct refers to the practice of focusing on customers for whom the product is developed. The literature emphasizes the need to achieve total customer satisfaction through studying customer wants and needs, gathering customer requirements, and measuring customer satisfaction. Product quality aspirations are more likely to be achieved with a greater emphasis on customer satisfaction, which is often assessed with customer surveys. Experts in the aerospace and telecommunications industries concur that customer satisfaction should be the main focus of all quality improvement efforts, which is consistent with TQM's emphasis on customer focus. The aforementioned authors jointly advocate the use of structured techniques to elicit customer needs during the early requirements analysis phase, feedback reports to get customers involved throughout the entire new technology venture development process, and surveys to measure customer satisfaction during the subsequent operational phase.

Sample items might include “customer requirements are completely elicited in developing the NTV produce” and “customer requirements are traced and referred back to throughout the NTV development process.” The customer focus construct with its complete set of items (survey statements) is listed in Appendix A.

Quality Metrics. The discipline of NTV product quality metrics entails identifying various attributes that need to be measured and determining how to measure them in developing quality products. (Cooper et al., 2007) identifies three types of software metrics: product metrics (e.g., customer satisfaction), process metrics (e.g., defects identified during code inspections), and project metrics (e.g., scheduling). Product quality metrics give NTV management the ability to make informed decisions, must be cost effective and easily understood (Van de Ven, Angle, & Poole, 1989; Dougherty & Hardy, 1996; Leifer et al., 2001; O’Connor & De Martino, 2006). The foregoing authors identify attributes of a sound quality metrics program as the availability and utilization of quality metrics, collection and analysis of data regarding quality, utilization of statistical techniques in analyzing data regarding quality, and coupling of quality metrics with the NTV development process. Sample items might include, quality metrics “are utilized” and “are tightly coupled with the NTV development process.” The quality metrics construct with its complete set of items (survey statements) is listed in Appendix A.

Employee Responsibility. The TQM philosophy requires employee empowerment as well as total employee involvement and commitment. Employee empowerment is defined as sharing power and increasing autonomy throughout the organization (e.g., Juran, 1992). Rahman and Bullock (2005) contend that besides hard TQM factors such as statistical testing, soft TQM factors such as employee commitment to quality play a key role in quality management. Personnel practices such as the use of teams and employee feedback, and the evaluation of processes instead of people are claimed to facilitate the development of quality NTV products

(Van de Ven, Angle, & Poole, 1989; Dougherty & Hardy, 1996; Leifer et al., 2001; O'Connor & De Martino, 2006). O'Connor and De Martino (2006) argue that employees themselves must act as quality champions. These experts identify the need to implement quality teams, get employees involved in product quality matters, and reward them for their efforts. Sample items might include, NTV personnel are "held responsible for quality performance" and "rewarded for quality performance." The employee responsibility construct with its complete set of items (survey statements) is listed in Appendix A.

The six constructs (e.g., critical factors) of NTV product quality management identified are grounded in the literature and have been extrapolated from the previously validated measurement tool devised by Vitharana and Mone (2008) for use in the new technology venture sector. The objective of this research was to determine the impact of these critical factors on product quality in the NTV environment. These six constructs were delineated as the independent variables being measured.

Establishment of Instrument Reliability and Validation

One important objective of the full-scale study was to evaluate the modified instrument (NTV PQMI) determined to be reliable from the pilot study. This component of the research project sought to determine if the NTV PQMI was, in fact, a reliable and valid measure of the critical factors of new technology venture product quality *using data compiled from the larger sample size of 100 or more*. The six constructs, quality performance measures and the variable relationships with tested hypotheses were delineated. This structure remained the same for the pilot study and the full-scale study.

The full-scale schema exercised was as follows: (1) re-establish reliability, (2) re-establish face and content validity, (3) conduct principal component analysis, (4) re-establish criterion validity, and (5) re-test the regression models. Note that the face and content validity, as well as the construct validity, were previously established based on the work of Vithrana and Mone (2008). This five-step schema is described below.

Cronbach's Alpha

Cronbach's alpha values were computed to determine internal consistency using data collected from the full-study's 102 respondents. Recall, this measures the internal consistency of items within each critical factor and was used to assess and establish reliability.

The first test performed on both the pilot and full-scale studies' data sets was this test for reliability. Cronbach's alpha assessed the six hypothesized critical factors in the new technology venture environment. This section defines Cronbach's alpha.

Recognize a survey instrument that will always elicit consistent and reliable responses even if questions were replaced with other similar questions is deemed reliable. In particular, when a variable generated from such a set of questions returns a stable response, then the variable is said to be reliable. Cronbach's alpha is an index of reliability associated with the variation accounted for by the true score of the "underlying construct." Construct is the hypothetical variable that is being measured (Hatcher, 1994); these have been previously defined in this pilot test as: (1) process management, (2) management commitment, (3) education and training, (4) customer focus, (5) quality metrics, (6) employee responsibility.

Cronbach's equation for alpha is as follows:

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\Sigma Vi}{Vtest}\right)$$

Equation 2. Cronbach's Alpha Basic Equation

- *n* = number of questions
- *Vi* = variance of scores on each question
- *Vtest* = total variance of overall scores (not %'s) on the entire test

Alpha ranges in value from 0 to 1 and may be used to describe the reliability of factors extracted from dichotomous and/or multi-point formatted questionnaires or scales (i.e., rating scale: 1 = poor, 5 = excellent). The higher the score, the more reliable the generated scale is. Nunnally (1978) has indicated 0.7 to be an acceptable reliability coefficient but lower thresholds are sometimes used in the literature.

Validation

Three types of validity were considered to re-establish validity: content, construct, and criterion. These are content validity, construct validity, and criterion validity and are defined below.

Content Validity

Content validity is the extent to which scale items represent the universe from which they are drawn (Cronbach, 1951, 1971). Recall that the content validity was established through review of literature and evaluation of the initial instrument by a group of researchers and industry experts. Significantly, the instrument had its content validity previously established (Vithrana & Mone, 2008).

Construct Validity

Construct validity is the extent to which an instrument measures the theoretical construct it is supposed to measure (Cook & Campbell, 1979). The construct validity of the instrument was assessed in terms of convergent validity, which refers to the extent to which multiple measures of a construct concur with each other. In addition, discriminant validity was assessed. This refers to the extent to which different measures of a single construct are distinct from each other (Campbell & Fiske, 1959). Both convergent and discriminant validity were previously established by Vitharana and Mone (2008). These two elements established construct validity.

Criterion Validity

Criterion validity is the extent to which an instrument estimates present performance or predicts future performance (Nunnally, 1978). Examination of the coefficients of determination for the factors and quality performance assessed the criterion validity of the instrument. Because it was difficult to obtain comparable objective measures across different types and sizes of firms in the sample, a set of self-reported subjective measures was chosen as a proxy for new technology quality performance. This is consistent with Saraph, Benson, and Schroeder (1989), who also used subjective measures due to the difficulty in obtaining viable objective measures. Moreover, new technology product quality has been shown to affect user satisfaction, and therefore user satisfaction may be used as a substitute measure for quality (DeLone & McLean, 1992). Lastly, these measures are consistent with the original measurement tool validated by Vitharana and Mone (2008).

Regression

The regression models were first tested in the pilot study and then re-tested and validated in the full scale study (see equations 3, 4, and 5). If a non-linear relationship were to result then the data would have been transformed, then tested again. If necessary other methods would have been employed to ascertain the most appropriate model that explains the relationships governed by the data collected. An appropriate model must establish a statistically significant relationship between dependent variables and independent variables. Otherwise the use of principal component analysis would not have been justified on the full-scale study. See the Results section.

The regression models were used to determine if they adequately explain the relationships between the independent variables (e.g., process management) and each of three dependent variables (product quality). The pilot study used multiple linear regression because it is a viable model for this type of research. Specifically, it collects numerical rankings that model the independent variables for each of six constructs and uses the quality measures' mean for the dependent variable. One purpose of the pilot study was to validate the regression models as an investigative step to justify moving forward to the full-scale study.

Principal Component Analysis

The goal of Principal Component Analysis (PCA) is to derive a relatively small number of components that can account for the variability found in a relatively large number of measures. Scree plots are generated for examination to determine those factors that explain greater than 70% of the data's variance.

Recognize that PCA additionally incorporates multiple linear regression. This made PCA particularly applicable to the full-scale study's data set and this research project's objectives. Note that measures that are strongly associated with the factors in a model were chosen in this study, rather than those that would be a random sample of potential measures (Kim & Muller, 1978a, 1978b; Hatcher, 1994; De Coster, 1998).

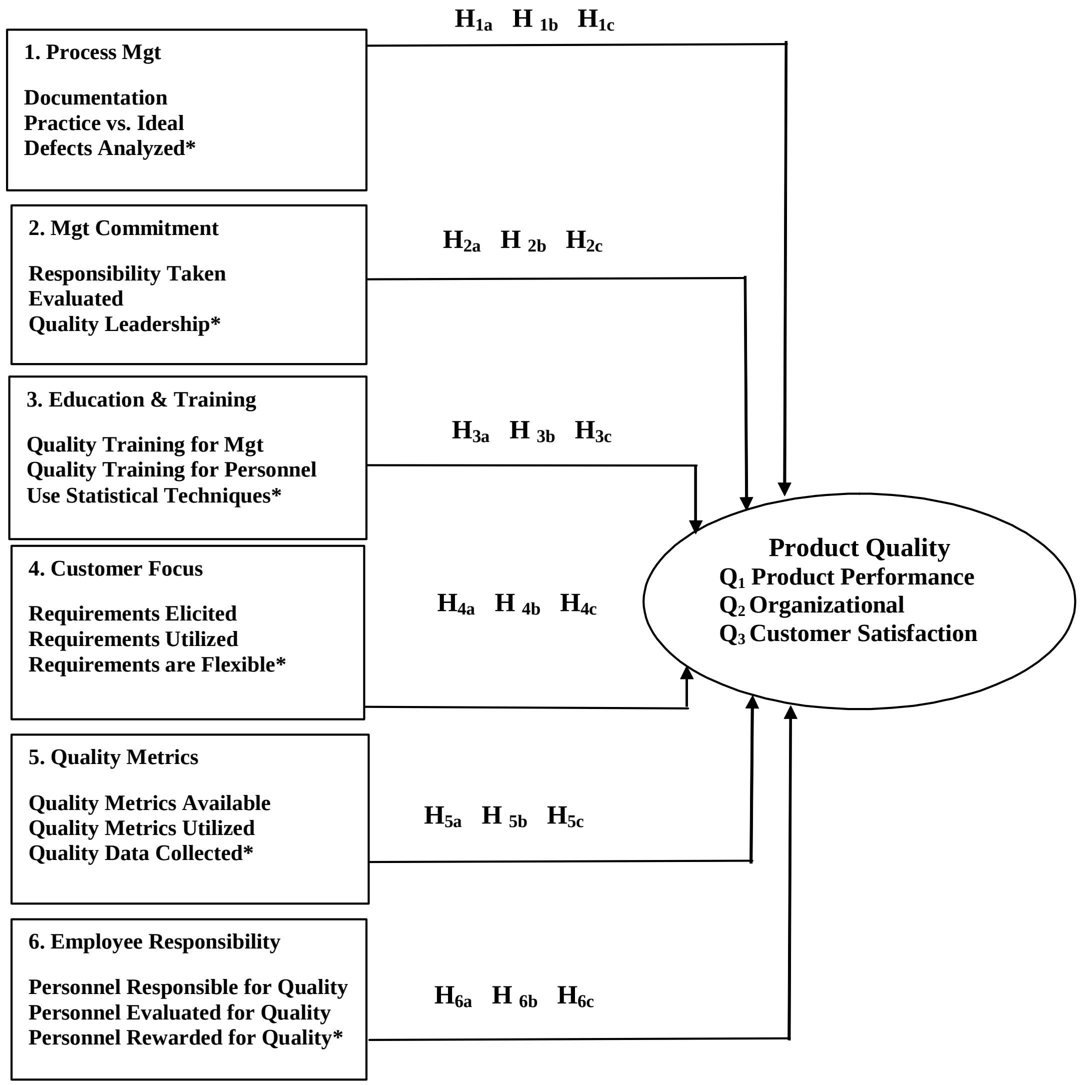
Independent Variable Relationships and Hypotheses Measured by Survey Instrument

The new technology venture product quality management instrument (NTV PQMI) measures NTV managers' perception of adherence to engineering quality management best practices. The following schematic displays the six hypothesized critical factors and their relationship to the three product quality measures. A table that delineates the six constructs' hypothesized relationships to the three quality measures follows this schematic (Figure 7).

The NTV PQMI

Measures

NTV Managers' Perceptions of Adherence to Engineering Quality Management Best Practices Using TQM and CMMI Frameworks



*Complete list of items appears in Appendix A.

Figure 7. NTV PQMI Measures Engineering Managers' Perceptions

Variable Relationships with Tested Hypotheses

These six independent variables were designed determine their impact on product quality in the NTV environment. These hypothesis tests are delineated in Table 7.

Table 7. *Variable Relationships with Tested Hypotheses*

Test 1: Determine Independent Variable NTV Process Management effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H.1a	Dept Quality Measured vs. Industry Standards	Multiple Regression	No Correlation ($p > 0.05$)	Firms that effectively manage NTV processes yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or process management is an insignificant factor
H.1b	Org Quality Measured vs. Industry Standards	Multiple Regression	No Correlation ($p > 0.05$)	Firms that effectively manage NTV processes yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or process management is an insignificant factor.
H.1c	Customer Satisfaction Measured	Multiple Regression	No Correlation ($p > 0.05$)	Firms that effectively manage NTV processes yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or process management is an insignificant factor.

Test 2: Determine Independent Variable Management Commitment effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H.2a	Dept Quality Measured vs. Industry Standards	Multiple Regression	No Correlation ($p > 0.05$)	Firms that have high management commitment yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or management commitment is an insignificant factor.
H.2b	Org Quality Measured vs. Industry Standards	Multiple Regression	No Correlation ($p > 0.05$)	Firms that have high management commitment yield higher quality products	Missing variables expressed in error term, measurement error, small sample size, or management commitment is an insignificant factor.
H.2c	Customer Satisfaction Measured	Multiple Regression	No Correlation ($p > 0.05$)	Firms that have high management commitment yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or management commitment is an insignificant factor.

Table 7—Continued

Test 3: Determine Independent Variable Education and Training effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H.3a	Dept Quality Measured vs. Industry Standards	Multiple Regression	No Correlation ($p > 0.05$)	Firms that have high levels of quality related education and training yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or quality-related education and training is an insignificant factor.
H.3b	Org Quality Measured vs. Industry Standards	Multiple Regression	No Correlation ($p > 0.05$)	Firms that have high levels of quality related education and training yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or quality-related education and training is an insignificant factor.
H.3c	Customer Satisfaction Measured	Multiple Regression	No Correlation ($p > 0.05$)	Firms that have high levels of quality related education and training yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or quality-related education and training is an insignificant factor.

Test 4: Determine Independent Variable Customer Focus effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H.4a	Dept Quality Measured vs. Industry Standards	Multiple Regression	No Correlation ($p > 0.05$)	Firms that have high levels of customer focus when devising product requirements yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or customer focused requirements is an insignificant factor.
H.4b	Org Quality Measured vs. Industry Standards	Multiple Regression	No Correlation ($p > 0.05$)	Firms that have high levels of customer focus when devising product requirements yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or customer focused requirements is an insignificant factor.
H.4c	Customer Satisfaction Measured	Multiple Regression	No Correlation ($p > 0.05$)	Firms that have high levels of customer focus when devising product requirements yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or customer focused requirements is an insignificant factor.

Table 7—Continued

Test 5: Determine Independent Variable Quality Metrics effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H.5a	Dept Quality Measured vs. Industry Standards	Multiple Regression	No Correlation (p > 0.05)	Firms that have high levels of product quality measurements, data, and analysis yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or product quality measurements, data, and analysis is an insignificant factor.
H.5b	Org Quality Measured vs. Industry Standards	Multiple Regression	No Correlation (p > 0.05)	Firms that have high levels of product quality measurements, data, and analysis yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or product quality measurements, data, and analysis is an insignificant factor.
H.5c	Customer Satisfaction Measured	Multiple Regression	No Correlation (p > 0.05)	Firms that have high levels of product quality measurements, data, and analysis yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or product quality measurements, data, and analysis is an insignificant factor.

Test 6: Determine Independent Variable Employee Responsibility effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H.6a	Dept Quality Measured vs. Industry Standards	Multiple Regression	No Correlation (p > 0.05)	Firms that have high levels of employee responsibility that is evaluated and rewarded yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or employee responsibility that is evaluated and rewarded is an insignificant factor.
H.6b	Org Quality Measured vs. Industry Standards	Multiple Regression	No Correlation (p > 0.05)	Firms that have high levels of employee responsibility that is evaluated and rewarded yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or employee responsibility that is evaluated and rewarded is an insignificant factor.
H.6c	Customer Satisfaction Measured	Multiple Regression	No Correlation (p > 0.05)	Firms that have high levels of employee responsibility that is evaluated and rewarded yield higher quality products.	Missing variables expressed in error term, measurement error, small sample size, or employee responsibility that is evaluated and rewarded is an insignificant factor.

Dependent Variable Relationships and Hypotheses Measured by Survey Instrument

The quality performance measures used are the three dependent variables. These are depicted in Table 8.

Table 8. *Three Dependent Variables*

Q_1	• New technology product quality performance of the new technology venture department was measured during the past 3 years and compared to industry standards.
Q_2	• Overall organizational quality (NTV and non-NTV) performance was measured during the past 3 years and compared to industry standards.
Q_3	• Customer satisfaction with product quality was measured, evaluated, and acted upon during the past 3 years.

Each respondent was asked to rate, based on his or her perception, the three performance measures on a five-point Likert scale ranging from “very low” to “very high.” The quality performance measures, Q_1, Q_2, and, Q_3 delineated above, are the three performance measures that were used to assess criterion validity in the full-scale study one, given that the pilot provided statistically justified results. Note that Q_1, Q_2, and Q_3 are expressed as dependent variables in equations 3, 4, and 5.

Multiple Linear Regression Model

A multiple linear regression model was developed to test the pilot study’s data set to determine if it adequately explained the relationship between the independent variables (e.g., process management) and dependent variables (product quality). The data collected was used to test and validate the following multiple linear regression models:

$$Q_1 = ß_0 + ß_1 * PM + ß_2 * MC + ß_3 * ET + ß_4 * CF + ß_5 * QM + ß_6 * ER + \varepsilon$$

Equation 3. Regression Model 1

$$Q_2 = ß_0 + ß_1 * PM + ß_2*MC + ß_3 *ET + ß_4 *CF + ß_5 *QM + ß_6 *ER + \varepsilon$$

Equation 4. Regression Model 2

$$Q_3 = ß_0 + ß_1 * PM + ß_2*MC + ß_3 *ET + ß_4 *CF + ß_5 *QM + ß_6 *ER + \varepsilon$$

Equation 5. Regression Model 3

Where

$ß_0$= intercept; $ß_{1,}$ $ß_2$, $ß_3$, $ß_{4,}$ $ß_{5,}$ $ß_6$ = Partial Regression Coefficients; ε = random error term

Q_1, Q_2, Q_3 = the three product quality measures (dependent variables)

PM, MC, ET, CF, QM, and ER = the six constructs (independent variables)

Legend:

PM = Process management; MC = Management Commitment; ET= Employee Education

CF = Customer Focus; QM = Quality Metrics; ER = Employee Responsibility

The constant $ß_0$ is called the intercept and the coefficients $ß_{1,}$ $ß_2$, $ß_3$, $ß_{4,}$ $ß_{5,}$ and $ß_6$ are the parameter estimates for the variables PM, MC, ET, CF, QM, and ER, respectively. The ε is the error term; it is the residual that cannot be explained by the variables in the model. Most of the assumptions and diagnostics of multiple linear regression focus on the assumptions of ε. It is assumed when building a multiple linear regression model that the error term is normally distributed with a mean of zero and a standard deviation of σ^2, N $(0,\sigma^2)$. An examination of the standardized residuals plots provided graphical evidence to investigate these and other underlying critical assumptions associated with building the viable model.

Stepwise Regression

The full-scale study's data set was analyzed using stepwise regression. While few explicit guidelines exist for determining stepwise regression sample size (Baggaley, 1983), Guadagnoli and Velicer (1988) reviewed several studies that concluded that absolute minimum sample sizes, rather than subject to item ratios, are most relevant. These studies range in their recommendations from an *n* of 50 (Barrett & Kline, 1981) to 400 (Aleamoni, 1976). In addition, Brooks and Barcikowski (1999) used a cross-validation methodology to determine the strength of predictor coefficients when using stepwise regression. Given 15 to 16 predictors in the final stepwise model with an unadjusted R^2 is greater than .70 (which is the case in the present study), a sample size of 96 to 102 was appropriate to project a precision efficacy of .80. The sample size for the full-scale study was chosen to be greater than 100, which is more than double Barrett and Kline's (1981) minimum sample size and satisfies Brooks and Barcikowski's (1999) criteria.

Stepwise regression finds the "best" regression model. It uses a partial F test criterion to examine a model with any number of explanatory variables; in this case 54. An important feature of this stepwise process is that an explanatory variable that has entered into the model at an early stage can subsequently be removed, once other explanatory variables are considered. Variables were added and/or deleted from the regression model at each step of the model-building process. The step-wise procedure terminated with the selection of the best-fitting model. See the Results section.

- Additionally, the model was tested for multicollinearity, correlation, and outliers: This was done in Minitab® A VIF of 5 or less was used to ensure low correlation.
- The output from the Best Subsets test was examined to eliminate those factors with minimal influence and retain those with strong influence on the quality response variables.
- The fit of the model was tested by examining the R-sq adjusted value after each iteration to see if it was greater than o.50.

The examination of the residuals of the final model established the resultant model's validity; the "iid" assumptions of linear regression were validated as described in the Results section.

Justification of the Full Scale Study

The pilot study computed Cronbach's alpha values for each of the six constructs to establish the instrument's internal consistency also known as reliability. In addition, regression was employed using the multiple linear regression models to test and validate the model. Both the reliability and regression tests were used to justify the full-scale study.

Additional Measures Used for Full Scale Study

Statistical Analysis Tools Used

The full-scale study employed statistical analysis tools specific to the study's research goals and the a priori characteristics defined for each data set. To begin a discussion of statistical analysis tools used in this research, definitions used are first delineated.

Definitions

- Variate—a weighted combination of variables.
- Multiple linear regression—a method to find the best combination of weights (i.e., ß coefficients).
- Non-metric data—data that are either qualitative or categorical in nature.
- Metric data—data that are quantitative, and interval or ratio in nature.
- Latent variables—variables that cannot be measured directly but must be estimated with a combination of measured variables.

- Observed—used synonymously with the word “measured.”

What the NTV PQMI Survey Instrument Measures

The NTV PQMI survey measures managers’ perceptions of adherence (scaled from 1 to 5) to product quality management attributes (scaled from 1 to 5). In addition, this research collected a single data set characterized by multiple, latent, metric independent (six critical factors) and multiple, latent, metric dependent variables (three quality measures). Also, some degree of correlation was presumed in the observed and measured independent variables due to the holistic nature of product quality management practices (Isaac et al., 2004). These measures and hypothesized relationships were fully delineated. Recognize a goal of this research project was to determine those critical factors (independent variables) that have a statistically significant impact on the product quality measures (dependent variables). Importantly, it was these data characteristics and the research goals that determined the selection of the statistical analysis tools.

Key Concepts

Data form and quality must be assessed in order to determine an appropriate MSA tool. The form of the data refers to whether the data are non-metric or metric. The quality of the data refers to how normally distributed the data are. Recognize regression, principal component analysis (PCA) and PCA factor analysis methods are sensitive to the linearity, normality, and equal variance assumptions of the data. Examinations of distribution, skewness, and kurtosis are helpful in examining distribution. Also, it is important to understand the magnitude of missing values in observations and to determine whether to ignore them or impute values to the missing observations.

Another data quality measure is outliers, and it is important to determine whether the outliers should be removed. If they are kept, they may cause a distortion to the data; if they are eliminated, they may help with the assumptions of normality. It is important the researcher understands what the outliers represent. Consequently, boxplots and the normality plot were generated; then examined for outliers.

Multiple Regression Analysis

Multiple regression is the most commonly utilized multivariate technique. It examines the relationship between a *single* metric dependent variable and two or more metric independent variables. The first study's variable relationships are characterized by three dependent variables. Each dependent variable is hypothesized to have a correlation with six constructs.

Multiple regression analysis technique relies upon determining the linear relationship with the lowest sum of squared variances; therefore, assumptions of normality, linearity, and equal variance are carefully observed. The beta coefficients (weights) are the marginal impacts of each variable, and the size of the weight can be interpreted directly. Multiple regression is often used as a forecasting tool.

PCA Details

Recall the purpose of PCA is to derive a relatively small number of components that can account for the variability found in a relatively large number of measures. Recognize that principal components are defined simply as linear combinations of the measurements, and so will contain both common and unique variance. Principal component analysis (PCA) is a statistical technique used to reduce the number of factors that explain all of the variance in the model, combine factors as appropriate to delineate the underlying factor structure. In the full-scale study, PCA was used to derive the smallest number of components that accounted for greater than 70% of the variability found in the survey data.

A principal component is defined as a linear combination of optimally weighted observed variables. Consequently, a linear relationship must exist between independent variables and dependent variables in order to use this test. Therefore, results from the pilot study were an important preliminary investigative step. PCA is a statistical approach that can be used to analyze interrelationships among a large number of variables and to explain these variables in terms of their common underlying dimensions (factors). PCA condenses the information contained in a number of original variables into a smaller set of dimensions (factors) with a minimum loss of information (Hair, Anderson, Tatham, & Black, 1992). Importantly, a scree plot is generated to aid in the interpretation of what determines "most" of the variance (Cattell, 1996).

Few explicit guidelines exist for determining PCA sample size (Baggaley, 1983). Guadagnoli and Velicer (1988) review several studies that conclude that absolute minimum sample sizes, rather than subject to item ratios, are most relevant. These studies range in their recommendations from an *n* of 50 (Barrett & Kline, 1981) to 400 (Aleamoni, 1976). Significantly, Vitharana and Mone (2008) used a sample size of 125. Consequently, the minimum sample size for the full-scale study was chosen to be 100, which is double Barrett and Kline's (1981).

Now, recall that the NTV PQMI survey measures managers' perceptions of adherence (scaled from 1 to 5) to product quality management attributes (scaled from 1 to 5). In addition, this research project collected a single data set characterized by multiple, latent, metric independent (six critical factors) and multiple, latent, metric dependent variables (three quality measures). These measures have hypothesized linear relationships. The goal of this research was to determine those critical factors (independent variables) that have a statistically significant impact on the product quality measures (dependent variables). These data set characteristics and research objectives aligned with the PCA factor analysis method. Notably, the PCA factor analysis incorporated regression modeling as an integral component to provide researchers a full explanation of the data.

The ultimate goal of study one was to collect the full-scale survey data and devise a model that adequately explains and can predict those critical factors that drive product quality in the new technology venture environment. Prior to conducting the full-scale study, a pilot study was conducted. Multiple linear regression was used because it collects numerical rankings that model the independent variables for each of six constructs. The mean quality measure for each of three dependent variables was used. This pilot study statistical analysis was used to determine if sufficient evidence existed to justify the full-scale study.

The hypotheses indicated there may be a statistically significant relationship between the six critical factors (independent variables) previously discussed and each of the product quality measures (dependent variables). The investigative schema began with the development of a multiple regression model that substantiated these hypotheses. Note that principal component analysis was performed only on the full-scale study's data set and provided a more comprehensive examination of that data set. The full-scale study's data set had to be greater than or equal to 100 to confidently use the full array of inferential statistics.

The new technology venture product quality measurement instrument (NTV PQMI) was used to measure managers' perceptions within firms engaged in radical innovation. This TQM/CMMI based tool was originally devised by Vitharana and Mone (2008) and minimally modified for use in this research project. The data were compiled and coded to enable the construction of an effective model that determines which factors affect product quality. Notable differences between the pilot study's data set and the full-scale study's data set are size and type. The pilot study used a sample of convenience comprised of 15 experienced NTV managers. The full-scale study used a random sample of over 100.

Recall that the NTV PQMI survey measures managers' perceptions of adherence (scaled from 1 to 5) to product quality management attributes (scaled from 1 to 5), collected a single data set characterized by multiple, latent, metric independent (six critical factors) and multiple, latent, metric dependent variables (three quality measures), assumes there is some degree of correlation among measured independent variables. The goal of this research project was to determine which, if any, of the six critical factors (independent variables) had statistically significant impact on the three product quality measures (dependent variables). For this reason, PCA, which incorporates multiple regression modeling, was employed.

Concluding Remarks

The full-scale study used stepwise regression and principal component analysis to identify the scorecard elements. The pilot study used multiple linear regression; the data set was too small to use principal component analysis.

Scorecard Development

The development of a balanced scorecard for project-level new technology managers requires the identification of critical factors that impact product quality, the incorporation of these factors into a balanced scorecard, and an evaluation of this newly devised tool. This section discusses the recognized procedures used in this study to develop the balanced scorecard.

Background

Traditional management systems lack the ability to link a firm's long-term strategy with its short-term actions. The balanced scorecard management system devised by Kaplan and Norton (1992) addresses this deficiency with a schema that begins with a firm's vision that is translated into plans comprised of the following four elements: (1) perspective framework,

(2) objectives, (3) key performance indicators (KPI's), and (4) strategic views. These four elements are depicted as a narrative and comprise the performance management system known as the balanced scorecard. Each of the scorecard elements is periodically scored and results are reported. The results may be reported in written report form. Results may also be provided in the form of data displays such as graphs, raw data tables, and gauges.

The process to design and implement a balanced scorecard narrative was first defined and depicted by Kaplan and Norton in their 1992 seminal article, "The Balanced Scorecard—Measures that Drive Performance." This balanced scorecard arose out of research that studied twelve firms deemed to be at the leading edge of performance management. The result of this research was a set of measures that would give top managers a fast but comprehensive view of the business. It was hypothesized that tracking performance using this view would increase the likelihood that the firm would achieve its goals (Kaplan & Norton, 1992). Since that time, Kaplan and Norton and other performance measurement experts have developed a body of work comprised of research that has substantiated and further refined the original 1992 guidelines.

BSC Definition, Function, and Framework

The Balanced Scorecard (BSC) is a performance management system that enables standard business units (SBUs) such as a department or division, to clarify their

- Vision
- Strategy, and
- Translate them into action.

The BSC's function is to solicit feedback concerning internal business processes and external outcomes to continuously improve strategic performance and results.

The BSC provides a framework of performance measurements that help managers focus on what should be

- Measured, and
- Completed in order to
- Execute the Standard Business Unit's (SBU's) strategies.

(Kaplan & Norton, 1992; Letza, 1996; Hitt, Keats, & DeMarie, 1998; Otley, 1999; Kaplan & Norton, 2001a, 2001b; Davis & Albright, 2004; Papalexandris, Ioannou, Prastacos, & Soderquist, 2005; Chenhall, 2005; Agostino & Arnaboldi, 2012).

BSC's Main Function. The main function of performance measurement is for a firm to achieve its mission. It does this with stated objectives that are measured and tracked. In turn, these measures are periodically reported to management for possible intervention whenever measures indicate. Management intervention may occur when performance is lacking, as well as, when objectives are achieved. A schematic of performance management's main function is depicted in Figure 8.

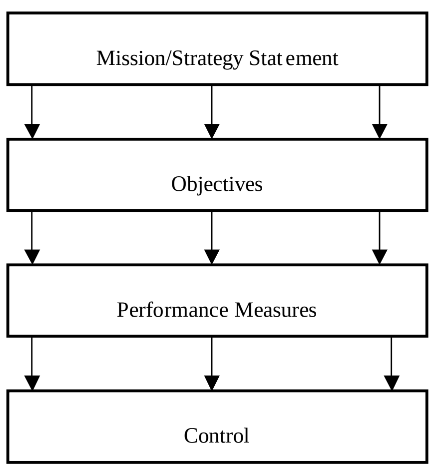


Figure 8. Performance Measurement's Main Function (Letza, 1996)

Kaplan and Norton's Original Perspective Framework. Kaplan and Norton derived a framework from their initial research study comprised of (1) customer perspective, (2) internal perspective, (3) innovation and learning perspective, and (4) financial perspective. The over-arching idea was that these specific four perspectives, known as the perspective framework, provided top management a limited yet comprehensive view of the firm's performance. Figure 9 depicts these four perspectives. It was projected that tracking these key aspects would guide the firm to overall success. Both research findings and the literature provided substantiation for these assertions (Maskell, 1991; Eccles & Pyburn, 1992; Letza, 1996; Hitt et al., 1998). Importantly, research results have provided evidence that scorecard use increases the likelihood that a firm will achieve its goals over the twenty-year period since the scorecard was first introduced (Davis & Albright, 2004; Self, 2004; Chenhall & Langfield-Smith, 2007), which, in part, provided the motivation for this research.

Scorecard Benefits

The scorecard guards against sub-optimization by forcing senior managers to consider all the important operational measures together. It alerts them to improvement in one area being achieved at the expense of another, or an objective being badly met.

The scorecard puts strategy and vision at the center. Traditional measurement systems have a control bias, that is, they specify the particular actions they want employees to take and then measure to see whether or not the employees have taken these actions—they try to control behavior. The balanced scorecard, on the other hand, assumes that people will adopt whatever action is necessary to arrive at these goals. Senior managers know what the end result should be, but not necessarily how to arrive at that result. This can be a very powerful motivator for managers to perform to the best of their ability. Performance control systems can serve two purposes, to measure and to motivate (Mintzberg, 1991). In addition, the elements of the different perspectives can be likened to benchmarking which has been defined as the art of establishing superior performance by identifying gaps in performance and emulating the best practices which help close them (Zairi & Ahmed, 1999).

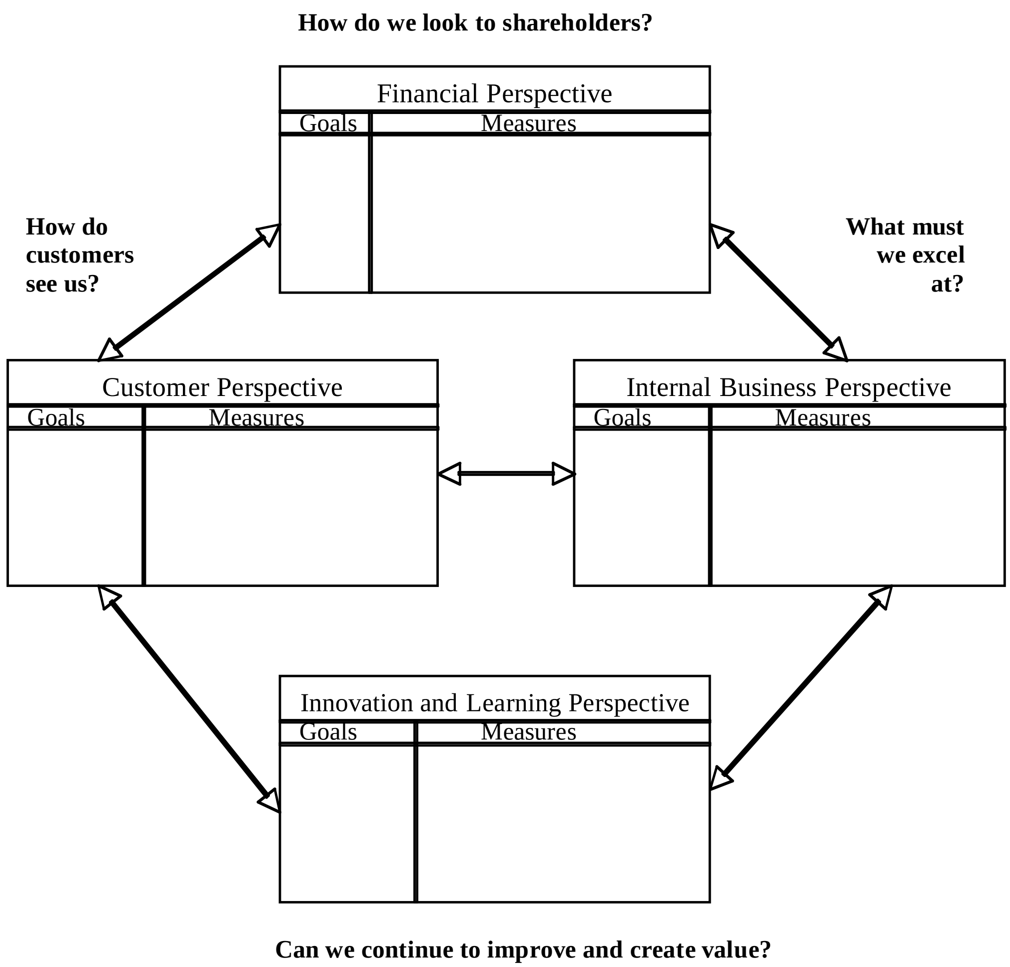


Figure 9. The Four Perspectives that Comprise Original Perspective Framework (Kaplan & Norton, 2001a)

The Scorecard Development Process

The BSC development process differs according to whether the scorecard is intended for use by an individual firm or across an entire business sector. These will be addressed separately.

For the Individual Firm

A balanced scorecard derived indigenously starts first with top management examining available resources, meeting with owners and other appropriate stakeholders to determine a realistic corporate-level vision, set of objectives, and action plans. These remain flexible since all levels of management and personnel are ultimately involved in devising the final vision, set of objectives and their associated business unit-level action plans. Recognize this participation clarifies the vision and builds a consensus among all involved that agrees to support the organization's strategy. As a result, the firm translates its vision and mission into business unit-level action plans that has an operational balanced scorecard. Thus, all personnel know the final aim of the firm (vision) and the specific actions required in order to achieve that aim (mission). In addition, this process ensures that: (1) all levels of the firm understand the long-term corporate-level strategy and divisional, departmental and individual objectives are aligned with it; (2) a stronger commitment from all personnel is achieved; and (3) the likelihood that the firm's long-term goal is accomplished is thereby significantly enhanced (Kaplan & Norton, 1992, 1996c; Olve, Roy, & Wetter, 1999; Cobbold & Lawrie, 2002; Bergeron et al., 2004; Hendricks, Menor, & Wiedman, 2004).

Embedded in this overall strategy are three on-going activities: communication and education, goal setting, and the linking of rewards to performance measures. This enables companies to integrate their business and financial plans. Significantly, the balanced scorecard management system forces managers to construct strategic plans simultaneously with resource allocation budgeting decisions.

A firm that develops its own indigenous scorecard must first: (1) translate the firm's vision into operational objectives; (2) involve the individuals whose performance is being measured; (3) devise action initiatives that are specific to a business unit (e.g., at the departmental level); (4) communicate and link action plans cross-functionally; and (5) set periodic feedback mechanisms in place that (6) allow managers to reset goals and plans as their business units move forward to achieve stated objectives.

Once one cycle of this business planning process is completed, managers and staff will have (1) set targets for the long-term objectives in all scorecard perspectives, (2) identified the strategic initiatives required, and (3) allocated the necessary resources to achieve those initiatives. In addition, managers and personnel are fully equipped to monitor their progress in the achievement of strategy in the light of recent performances (Kaplan & Norton 2001a, 2001b; Ahn, 2001; Akkermans & van Oorschot, 2005; Papalexandris et al., 2005; Burney & Swanson, 2010).

Because many companies operate in a turbulent environment with complex strategies that though valid when they were launched, may lose their validity as business conditions change. Thus, the Kaplan and Norton (1992) balanced scorecard management system affords strategic on-going learning, since it consists of gathering feedback, testing the hypotheses on which strategies were based, and making the necessary periodic adjustments. This is a non-trivial point. Since traditionally, companies have used the monthly or quarterly meetings between corporate and division executives to analyze the most recent period's financial results and then try to understand why some objectives were not achieved. In stark contrast, the balanced scorecard with its causal relationships defined between performance drivers and objectives, allows corporate and business unit executives to use their periodic review sessions to evaluate the validity of the unit's strategy and the quality of its execution. This has proven to be a significant advancement over traditional management systems (Kaplan & Norton, 1992, 1996c; Olve et al., 1999; Cobbold & Lawrie, 2002; Bergeron et al., 2004; Hendricks et al., 2004).

The performance drivers and their causal relationships are depicted in Figure 10. These are important because the system inherently has results that are periodically reported which are scored against targets and stated objectives. These periodic results drive the immediate revision of management and personnel action plans. Action plans are readily revised at each evaluation since the performance drivers are understood to be gauges of how well the firm is operating against stated objectives. It is important to note that performance drivers are precisely where managers and their personnel will intervene should results be sub par. This makes performance drivers critical to the firm's ultimate success due to their *direct* influence on the business outcomes (Kaplan & Norton 2001a, 2001b; Ahn, 2001; Akkermans & van Oorschot, 2005; Papalexandris et al., 2005; Burney & Swanson, 2010).

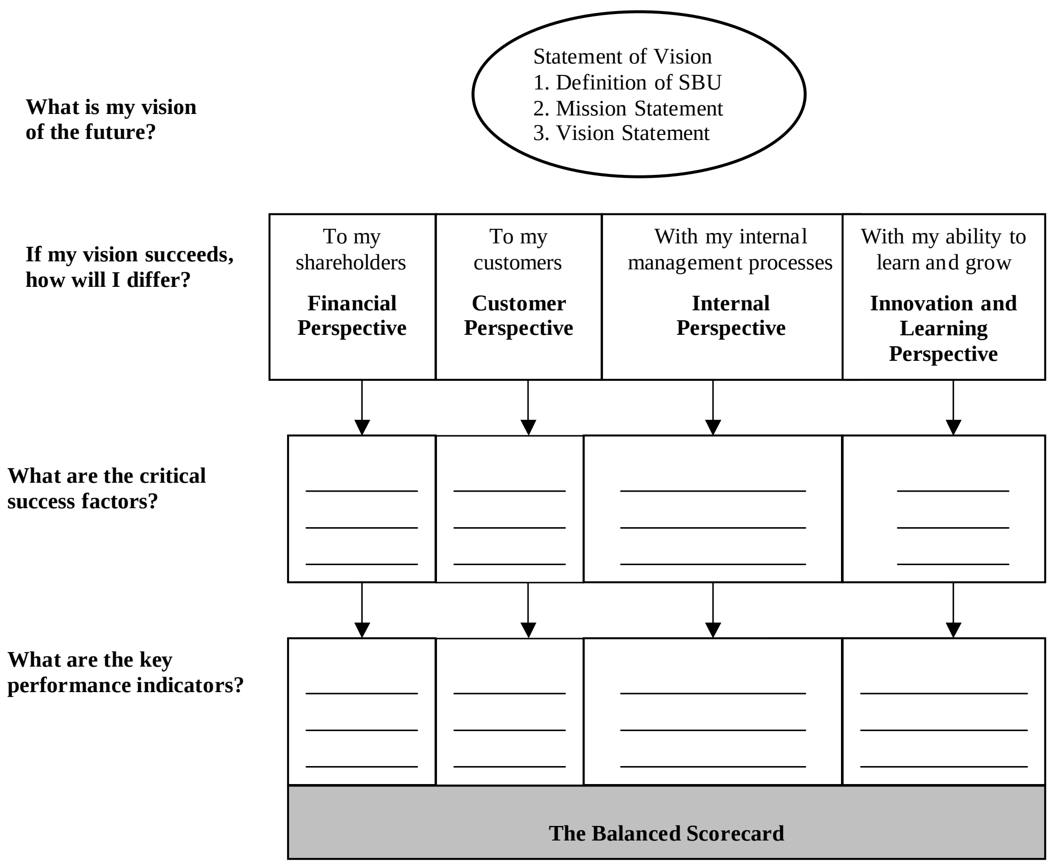


Figure 10. Linking Measurements to Strategy (Kaplan & Norton, 1993)

Thus, the balanced scorecard management system incorporates causal relationships that impact strategic goals. Moreover, performance drivers' results are periodically evaluated, which ensure that adjustments are made so that critical, planned business results are accomplished. In short, the balanced scorecard alerts managers to areas where performance deviates from expectations so they can focus their attention on these areas, and trigger performance improvements through justified resource allocation changes (Kaplan & Norton 2001a, 2001b; Ahn, 2001; Akkermans & van Oorschot, 2005; Papalexandris et al., 2005; Burney & Swanson, 2010).

For the Business Sector

Scorecards developed for a specific business sector have been introduced as a way for individual firms to quickly adopt the effective balanced scorecard system. As early as 1993, Kaplan and Norton offered a balanced scorecard (BSC) template that was adopted by several collaborating firms as a way for them to quickly incorporate this tool after indigenous modification (Kaplan & Norton, 1993). The BSC originators acknowledged that the precise format of the scorecard was a business sector and/or company specific issue (Letza, 1996). Since that time, performance measurement researchers began devising both business sector as well as company specific balanced scorecards. The process to develop a business sector BSC mirrors the process that had been devised and refined by its originators and subsequent specialists (Kaplan & Norton 2001a, 2001b; Ahn, 2001; Akkermans & van Oorschot, 2005; Papalexandris et al., 2005; Burney & Swanson, 2010). A major task facing the performance measurement researcher is to determine the critical factors that impact the industry sectors' standard business unit (SBU).

The NTV Balanced Scorecard

As previously discussed, a study was conducted to identify the critical factors that drive product quality critical in the new technology venture environment. This study employed an electronic survey methodology using a previously validated product quality management instrument that had been shown capable of determining the critical factors that drive quality. A model was built by measuring experienced new technology venture managers' perceptions of potential drivers of product quality using this instrument. These resultant critical factors were incorporated into the NTV *Product Quality Management* Balanced Scorecard. These factors, once in scorecard form, articulated the archetypal NTV measures for indigenous modification.

The BSC scorecard development process is depicted in Figures 11 and 13. Figure 12 depicts the electronic survey's role as part of the NTV sector's scorecard development process. The survey also accomplished steps 1, 2, and 3 of Figure 11. Steps 4, 5, and 6 were done indigenously.

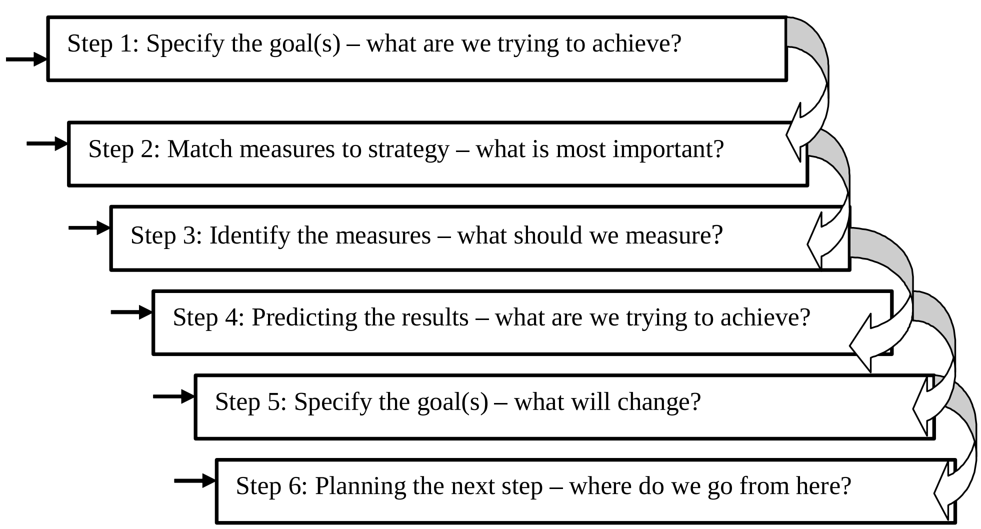


Figure 11. Scorecard Development: Six-Step Methodology (Vitale et al., 1994)

The NTV Product Quality Management Balanced Scorecard Perspective Framework that was tested in the first study is depicted in Figure 12. Only those factors that demonstrate statistically significant correlations with the quality performance variables were retained.

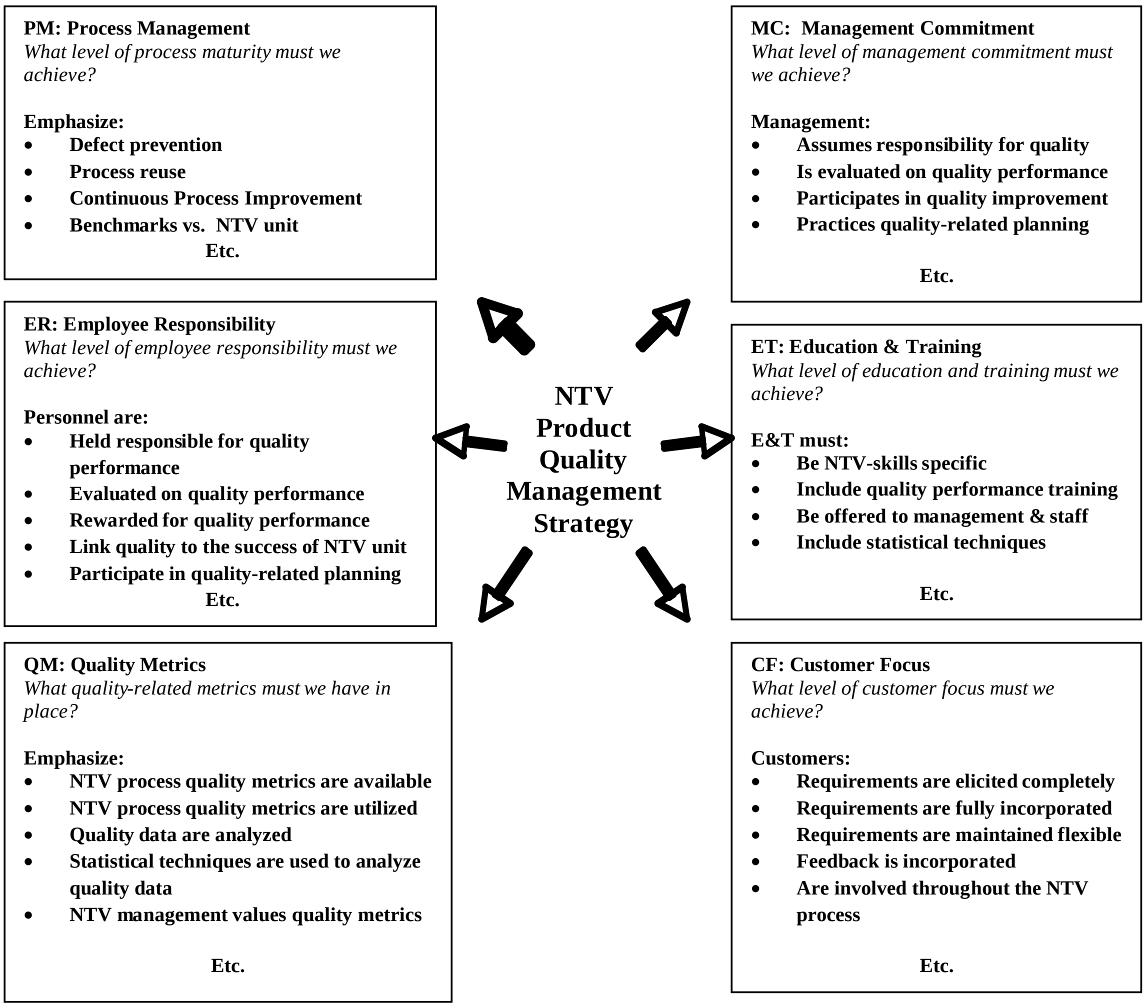


Figure 12. NTV PQM Balanced Scorecard Perspective Framework

Industry Experts Provide Input

The development of a business sector scorecard requires that industry experts be involved in order to establish the face and content validity of the scorecard elements and displays. This research accomplished the iterative process of the scorecard's development by convening a panel of NTV sector experts to assess the initial scorecard. This panel was charged with evaluating the scorecard's face and content validity to accomplish the iterative process depicted in Figure 13.

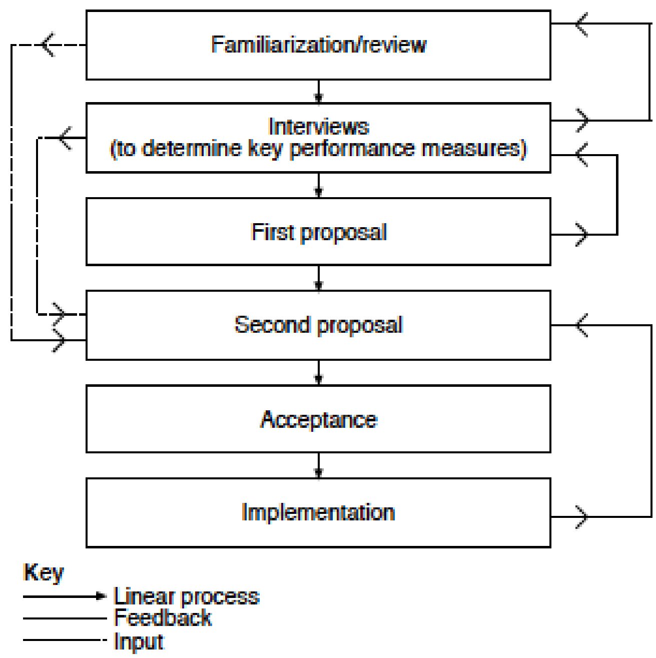


Figure 13. Iterations in Identifying Key Performance Measures (Letza, 1996)

Proposed NTV Product Quality Management Balanced Scorecard

The proposed NTV product quality management balanced scorecard that was tested in the first study is depicted in Table 9; it uses the six critical factors from the NTV PQMI. As previously mentioned, the study using the NTV PQMI established a statistically significant causal relationship between these (or fewer) critical factors and product quality. Thus, the study's results provided an archetypal narrative template for the NTV managers so they may devise appropriate targets and engage their personnel in actions that influence product quality.

Table 9. *Proposed NTV Product Quality Management Balanced Scorecard*

NTV Product Quality Perspective	Objectives	Key Performance Measures	Initiatives	Results
1. Process Management 2. Management Commitment 3. Education & Training 4. Customer Focus 5. Quality Metrics 6. Employee Responsibility				

Data Display Design

Data display of this information was devised using prescribed protocols. Cognitive fit theory was incorporated to ensure that the prescribed and subsequently incorporated data displays made the scorecard easy to read and interpret.

A review of prior research on cognitive fit revealed that enhanced accuracy and speed of judgment occurs when the processes used to derive the data from the display format match those that best support the decision/task solution at hand. Presenting a problem in a way that facilitates problem solution is one of the most effective ways to aid a decision maker (Libby, 1981; Kotovsky, Hayes, & Simon, 1985; Narayan & Vessey, 1994; Khatri et al., 2006). Thus, these considerations were taken into account in developing the display formats for the scorecard.

An analysis of the task and data display characteristics was undertaken in order to enhance the likelihood of a match or cognitive fit. Substantial research has been conducted on the types of multi-attribute judgment tasks that involve the presentation of multiple variables over multiple time periods; these correspond to the types of data displays that were examined for inclusion in the scorecard (Libby, 1981; Kotovsky et al., 1985; Narayan & Vessey, 1994; Khatri et al., 2006).

NTV Balanced Scorecard Evaluation

The NTV Product Quality Management Balanced Scorecard is designed to help improve the quality of management decisions. Evaluation of the scorecard design was performed to determine how useable the tool will be for the experienced NTV managers.

The Scorecard Design & Evaluation Survey Instrument was developed using recognized procedures (Netemeyer, Bearden, & Sharma, 2003; Desselle, 2005). Experienced NTV managers ranked the importance, usefulness, and display usability on a six-point Likert scale: 1 = Strongly Disagree; 2 = Mostly Disagree; 3 = Slightly Disagree; 4 = Slightly Agree; 5 = Mostly Agree; 6 = Strongly Agree. It was hypothesized that a manager who ranks the scorecard elements highly will rank the scorecard's usability highly. An electronic survey methodology was employed to gather the data necessary to test the hypothesis. More on this is provided in the next section.

Scorecard Development Process Summary

Study one strove to determine those critical factors that drive product quality. The results were transformed into a criteria based scorecard. The process to develop this scorecard followed recognized procedures. Because the relationship between critical factors and quality performance measures has been established, the newly devised scorecard may aid the NTV managers in justifying the additional resources necessary to improve their processes. The following are the four steps to design a scorecard management system (Kaplan & Norton, 1996c):

1. Translate the vision into operational goals;
2. Communicate the vision and link it to individual or specific process performance;
3. Transform cause and effect into criteria based targets;
4. Have feedback, learn, and adjust the strategy accordingly.

As discussed, this goes beyond the simple task of identifying a small number of process measures, and requires that NTV managers use the process maturity scorecard as a decision-making tool to integrate the broader NTV management process. The NTV critical factors that drive product quality provide a set of product quality management practices that can be converted into key performance indicators that are then linked to strategic views. This becomes the scorecard narrative. Displays such as graphs, raw data tables, and gauges were also devised to constitute the scorecard displays. Once devised, the NTV scorecard, including the displays, was evaluated to determine its potential efficacy as a tool for practicing new technology venture professionals.

Study Two

Determining the Scorecard's Usability

The balanced scorecard development process resulted in the design of the NTV *Product Quality Management* Balanced Scorecard. The (1) extraction of the statistically significant constructs and (2) transforming of these parameters into a criterion-based balanced scorecard decision-making tool has accomplished this. Once designed, this newly devised NTV scorecard was evaluated to (3) determine its usability. Study two's methods and procedures that were used to develop the survey instrument, and the statistical analysis tools used to evaluate the data, are detailed herein.

The fifteen critical factors derived from study one were incorporated into a performance measurement tool, the balanced scorecard, so new technology venture (NTV) managers can manage those engineering design process improvement practices determined to drive product quality. The NTV *Product Quality Management* Balanced Scorecard was designed to guide NTV managers toward justified decisions that result in improved processes and higher quality products. NTV project-level managers may use this tool routinely to assess product quality management practices as part of a new tech business sector strategy exemplified with the vision: "Become an industry leader in product quality."

NTV Balanced Scorecard Evaluation

The NTV *Product Quality Management* Balanced Scorecard was designed to help improve the quality of management decisions. The scorecard design was evaluated to determine how useable the tool is to the experienced NTV managers.

The Scorecard Design & Evaluation Survey Instrument was developed using recognized procedures (Netemeyer, Bearden, & Sharma, 2003; Desselle, 2005). Experienced NTV managers ranked the importance, usefulness, and display usability on a six-point Likert scale: 1 = Strongly Disagree; 2 = Mostly Disagree; 3 = Slightly Disagree; 4 = Slightly Agree; 5 = Mostly Agree; 6 = Strongly Agree. It was hypothesized that a manager who ranks the scorecard elements highly will rank the scorecard's usability highly. An electronic survey methodology was employed to gather the data necessary to test the hypothesis.

The methods and procedures section includes (1) schema, (2) participants, (3) sample size, (4) criteria for participation, and (5) procedures for two pilot studies and two full-scale studies.

Schema

The development of a valid and reliable survey instrument involves numerous steps that take considerable time. The schema devised by Gliem and Gliem (2003), Mulvenon and Turner (2003), Pett et al. (2003), as well as Radhakrishna (2007) was followed:

- Conduct extensive literature review of prior research to ascertain if a gold standard measurement instrument exists in the public domain.
- Incorporate study one's using results (i.e., of scorecard product quality management practices) into the scorecard design and user evaluation (SD & UE) instrument.
- Identify target audience and devise procedures to solicit respondents.
- Seek an HSIRB review and obtain response prior to soliciting potential respondents.
- Convene a panel of experts to confirm face and content validity.
- Articulate hypotheses; delineate independent and dependent variables as linked to refined measurement instrument.
- Compute readability test once devised. Confirm resultant grade level corresponds to the target audience.
- Conduct pilot study (15 respondents).
- Establish face, content, and construct (i.e. both convergent and discriminant) validity.
- Establish reliability from the pilot study using Cronbach's alpha (α); appropriate revisions may be made to the instrument until $\alpha > .70$ (Nunnally, 1978).
- Establish criterion validity using multiple linear regression.
- Conduct full- scale study (150 + respondents).
- Establish criterion validity using multiple linear regression.

- Conduct multiple linear regression analysis; report and analyze appropriate statistics (e.g., coefficient of determination (adjusted R^2), F and p values and thereby
- Determine if the Scorecard Design and User Evaluation Instrument (SD & UE) reliably predicts scorecard use to scorecard elements' perceived importance, usefulness, and usability toward effective management of product quality management practices. For example, if a manager ranked the first key scorecard element, perspective framework, as important to effectively manage an NTV department (independent variable), then it was hypothesized the manager would choose to use the scorecard (dependent variable).
- Ultimately establish a correlation between all, or a statistically significant subset of the scorecard elements, which includes: perspective framework, objectives, key performance indicators (KPI's), displays of KPI's, and strategic views.

The NTV scorecard and user evaluation survey sought to answer, "What balanced scorecard elements drive usability for NTV managers?" The associated tactics that addressed this question are delineated below.

Participants

Participants for the pilot study were current and recent managers of new technology venture processes with three or more years of experience within the last five years. These managers were identified and recruited from the following sources: (1) National Consortium of Innovators and Inventors Alliance (NCIIA); (2) McAllen Economic Development Corporation, a firm networked with new technology ventures on the third coast; (3) American Society of Engineering Managers (ASEM); (4) Kaufmann Foundation; (5) AimWest; and (6) Paragon Recruiting. Additional participants for the larger study included contacts from: (1) networking with Dr. Lyth and Dr. Lloyd, academic leaders in the new technology venture sector;

(2) InfoGroup, the nation's leading compiler of business information; and (3) Industrial Research Institute (IRI), the nation's leading association of companies and federal laboratories working to enhance the effectiveness of technological innovation.

This research sought variety in the number of industries studied, the size of the companies, their reputation for past innovativeness, and the age and structure of NTV functions. Companies and their NTV managers were qualified for inclusion in the research sample based on their declared intent to evolve their capability for managing their radical innovation processes. These factors were cross-referenced with pre-screened professional organization affiliations (e.g., NCIIA and IRI) and public documentation such as company web sites and/or stockholders' annual reports. Finally, a subset of members of these firms that were willing to complete surveys and to participate in interviews ultimately self-selected as the final participants in the pilot test as well as in the full study.

Sample Size

When testing a newly developed survey instrument, the sample size for a full-scale study should have a minimum of 10 respondents per item. It is recommended that the sample size of a full-scale study be six to ten times the size of its pilot study (Tabachnick & Fidell, 2001, Pett et al., 2003). Consequently, the pilot study sample size was set at 15 and the full-scale sample size was 150. Also, Cohen (1992) established that for a multiple linear regression model with five predictors, a sample size of 91 was sufficient for a medium (13%) effect. The full-scale study collected data from 151 respondents, which exceeds Cohen's threshold. Note that confirmation of sample was re-visited whenever additional statistical analyses were performed on the full-scale study's data set; this lower bound of 150 was met for all sets of criterion used for each analysis method selected.

Criteria for Participation

Participants in the surveys were new technology venture managers who (1) managed the launch of a new technology venture for a minimum of three years within the last five years (Vitharana & Mone, 2008), and (2) worked in an environment where job titles and responsibilities were clearly defined (Naranjo, 2009). Participants also confirmed that their new technology products offered: (1) wholly new benefits, (2) significant (i.e., 5 to 10 times) improvement in known benefits, or (3) significant reduction (i.e., 30 to 50%) in cost (Leifer et al., 2001). Fifteen managers completed the survey instrument as participants in the pilot test. Data were compiled from their responses and analyzed.

Procedures

Human Subjects Institutional Review Board Approvals Obtained

Human Subjects Institutional Review Board (HSIRB) review was requested. All required documentation was provided to the HSIRB office. A survey and methodology "approval not needed" letter was sent from the HSIRB office. The letter was received prior the March 2010 National Consortium of Innovators and Inventors Alliance (NCIIA) Conference. Thus, the researcher recruited potential NTV PQMI survey respondents for this pilot study, and the full-scale study, at the NCIIA Conference. In addition, the peer reviewed paper that ascertained CMMI's applicability to the NTV environment and reproduced in the literature review section of this dissertation, was presented at that same conference.

Readability Test

The readability of the refined instrument was computed using the Flesch-Kincaid Grade Level formula to ensure the reading level was appropriate for all recruited survey respondents:

$$0.39\left(\frac{total\ words}{total\ sentences}\right)+11.8\left(\frac{total\ syllables}{total\ words}\right)-15.59$$

Equation 6. Flesch-Kincaid Grade Level Formula

The resulting value from this formula is a number that corresponds with a grade level. For example, a score of 8.2 would indicate that the text is expected to be understandable by an average student in 8th grade, which is usually around ages 13–14 in the United States of America (Kincaid et al., 1975). The grade level obtained for the survey used in study one is shown in the results section.

Survey Methods Researched and Utilized

Survey methods for study one were researched to determine the methods that produce the highest quality responses while also are proven to be efficient and cost-effective. This pilot test used the mixed-mode survey method to collect data on the 15 new technology venture sector respondents. Surveys of establishments such as business, government, and organizations have shown to produce consistent, high quality responses. This is particularly the case when researchers seek factual information regarding situations and assessments of an establishment (de Leeuw 2005; Greene et al., 2008). For example, mixed-mode survey approaches are widely used by the Bureau of Labor Statistics and when researchers survey businesses seeking data regarding the business and or its operations. Therefore, an establishment mixed-mode survey method was justified for this dissertation research project since it was seeking data from respondents exclusively on business operations and not personal/sensitive information on the respondents, themselves. Lastly, there are three additional reasons researchers cite for using the mixed-mode survey method for establishments: (1) it increases the likelihood of participation, (2) it reduces the cost of the survey research, and (3) it increases the speed of completion (Turner et al., 1992; Dillman & Christian, 2003; de Leeuw 2005; Greene et al., 2008). The establishment mixed-mode survey protocols used for this pilot test and the full- scale study are summarized in Table 10.

Table 10. *Survey Data Collection Protocols for (1) Pilot Study and (2) Full-Scale Study*

Step	Experimental Treatment	Description
1	Pre-screen	Phone call to referral to ascertain if potential respondent fits NTV managerial expertise criteria.
2	Introduction	Phone call to remaining list of prospective respondents to introduce researcher and reconfirm that he/she fits criteria. Confirm if candidate has the time and willingness to complete the survey via phone at a future mutually convenient time.
3	e-mail Link	Most respondents went to link; E-mail confirmed respondents to remind them of the date and time previously set in introductory phone call. Invitees are informed on the first page of on-line survey of HSIRB ‘approval not need’ status, WMU contact information, study’s purpose, and description of the survey with NTV and NTV product definitions.
4	e-mail Link, again	E-mail link to each respondent one day ahead of those requiring a phone appointment #1.
5	Phone Appointment #1	Complete all or part of the survey with respondent as time permits. Reschedule follow-up phone appointment as needed.
6	Phone Appointment #2	Complete remaining portion of survey as time permits. May require a third phone appointment; reschedule accordingly. Continue with this experimental treatment protocol until obtain fifteen completed pilot study survey instruments.
7	Direct to Web	Once study is completed, return to experimental treatment #1 and continue to #6. For those respondents who prove exceedingly busy and/or prefer the solitude and self-administering qualities of completing the survey on-line, the link is provided yet again, which is followed up with an e-mail reminder for the individual to complete the survey at their earliest possible convenience. Continue with this protocol until the appropriate number of surveys is completed.
8	Final e-mail	Send an e-mailed “thank you for your participation” note.

The electronic survey method was the primary data collection mode. The specific benefits of this mode included all of the above benefits of mixed-mode plus it: (1) increased candid responses due to respondents' anonymity, and (2) responses were obtained directly from the individuals under study. An overview of the described procedural approach is delineated in Table 10.

Key Scorecard Elements

The five key elements of the NTV *Product Quality Management* Balanced Scorecard are: (1) perspective framework, (2) objectives, (3) key performance indicators (KPI's), (4) display of KPI's, and (5) strategic views. It is these elements that will be evaluated by the survey instrument.

Construction of Scales, Importance, Usefulness and Usability

Since there was no comprehensive instrument available to measure product quality management practices from the viewpoint of project-level new technology managers, a new instrument was developed. A four-part procedure was developed and followed to devise this product quality management instrument:

1. Items (e.g., critical factors that impact product quality) were identified from Phase-one's statistical analyses results.
2. A six-point Likert scale was devised to have equal intervals for a balanced summated attitudinal scale (Desselle, 2005).
3. Face, content, construct, and criterion validity will be assessed.
4. Reliability will be assessed.

Verification of Instrument Validity and Reliability

The following steps were taken to verify the Scorecard Design and Evaluation Survey Instrument's validity and reliability.

Validity

Four types of validity are generally considered to validate a survey instrument:

1. Face,
2. Content,
3. Construct, and
4. Criterion.

Face validity establishes an instrument's ease of use, clarity, and readability. A team of NTV management experts from industry and academia will evaluate the instrument. The panel of experts will comprise individuals with expertise in new technology venture management, which is the area this instrument was designed to measure. The panel of experts will assess the NTV *Product Quality Management* Balanced Scorecard via an electronic assessment. The experts will judge the survey's appearance, relevance and representativeness of its elements positively, which will establish face and content validity (Netemeyer et al., 2003; Desselle, 2005).

Content validity is the extent to which scale items represent the arena from which they are drawn (Cronbach, 1951). The instrument in the present study had its content validity established from (1) the results of phase-one's study, which determined the critical factors that drive product quality. In addition, an evaluation of the initial instrument by a team of experts and researchers further established its content validity.

Construct validity establishes the survey instrument's ability to actually measure the constructs it was developed to measure. It is an evaluation of an instrument's ability to relate to other variables or the degree to which it follows a pattern predicted by a theory (Netermeyer et al., 2003; Desselle, 2005). The present survey's construct validity was established using factor analysis to establish the factors' convergence, and unidimensionality. This test utilizes the covariance existing between responses to the items in order to group them together into "factors" or domains. Items may load onto other domains. However, factor analysis may also reveal that certain items do *not* load onto any of the domains, thus providing justification for their deletion from the model (Desselle, 2005). The items in the present study were evaluated to determine whether they load onto the domains previously hypothesized when constructing the scale.

Convergence, sometimes denoted as *convergent validity*, is accepted when factorial loads are higher than 0.50 in the final iteration of factor analysis (Nunnally, 1978). Factor analysis was performed iteratively using the 0.5 guideline. The last iteration provided a final unique solution set of items that explained more than 60% of data variation.

Unidimensionality, sometimes denoted as *discriminant validity*, is demonstrated by a single factor solution identified during factor analysis. This was established and demonstrated by the final unique solution's sorted rotated factor loadings and communalities table. Therefore, each of the final factors measured a unique aspect of that construct.

An additional condition of *construct validity* is statistical significance. P-values < 0.05 indicate statistical significance. P-values were derived from multivariate statistical analyses. Multiple linear regression was used to compute p-values of the original five constructs that comprised the model's independent variables.

Criterion Validity

Criterion validity determines the extent to which an instrument estimates present performance or predicts future performance (Nunnally, 1978). Usability was determined by the decision of respondents to actually use the scorecard under examination. It was hypothesized that if an experienced NTV manager respondent strongly agreed to use the scorecard, then this would indicate a strong degree of scorecard usability. Multiple regression results were used to examine the p-value, corresponding coefficient of determination (i.e., unadjusted $R^{2)}$ and the more conservative measure, adjusted R^2. These results indicated that the instrument has a high degree of criterion validity.

Reliability

Each construct's Cronbach's alpha coefficient was used to assess reliability because it is the most frequently used tool for this purpose (Pedhazur & Schmelkin, 1991). The guideline for this test is the coefficient must be above 0.7 in order to establish the instrument's reliability (Nunnally, 1978). In this case, the Cronbach's alpha values were computed for: (1) perspective framework; (2) objectives; (3) key performance indicators (KPI's), display of KPI's, and strategic views.

Measures

Key Concepts

Data form and quality must be assessed in order to determine an appropriate MSA tool. The form of the data refers to whether the data are non-metric or metric. The quality of the data refers to how normally distributed the data are. Regression, principal component analysis (PCA) and PCA factor analysis methods are sensitive to the linearity, normality, and equal variance assumptions of the data. Examination of distribution, skewness, and kurtosis is helpful in examining distribution. Also, it is important to understand the magnitude of missing values in observations and to determine whether to ignore them or impute values to the missing observations.

Another data quality measure is outliers, and it is important to determine whether the outliers should be removed. If they are kept, they may cause a distortion to the data; if they are eliminated, they may help with the assumptions of normality. It is important the researcher understands what the outliers represent.

Multiple Regression Analysis

Multiple regression is the most commonly utilized multivariate technique. It examines the relationship between a *single* metric dependent variable and two or more metric independent variables. The second study's variable relationships were characterized by one dependent variable. This dependent variable was hypothesized to have a correlation with five constructs.

Multiple regression analysis technique relies upon determining the linear relationship with the lowest sum of squared variances; therefore, assumptions of normality, linearity, and equal variance are carefully observed. The beta coefficients (weights) are the marginal impacts of each variable, and the size of the weight can be interpreted directly. Multiple regression is often used as a forecasting tool.

PCA Factor Analysis

Factor analysis is an extension of PCA, also known as PCA factor analysis. This analysis is employed to (1) verify the data set's factor structure, and as a (2) data reduction method. It is employed on a data set of greater than 50. PCA factor analysis steps include: (1) data collection, (2) generation of the correlation matrix, (3) extraction of initial factor solution, (4) rotation and interpretation, and (5) construction of factor loadings to use in further analyses. Factor loading can be thought of as coefficient of determination as they are the percent variance explained by the variable (Desselle, 2005).

The PCA factor analysis method is based on the common factor model, which proposes that each observed response is influenced partially by underlying common factors and partially by underlying unique factors. The strength of the link between each factor and each measure varies, such that a given factor influences some measures more than others.

Factor analysis examines the pattern of correlations (or covariances) between the observed measures. Measures that are highly correlated (either positively or negatively) are likely influenced by the same factors, while those that are relatively uncorrelated are likely influenced by different factors.

This research strove to determine which constructs have the most influence on product quality responses in a predicted way. Consequently, PCA factor analysis was performed on the full-scale study's data set.

The PCA factor analysis output tabularizes the extracted factors orthogonally (which means they are uncorrelated) and their eigenvalues. The Kaiser (1960) criterion provides that only eigenvalues > 1 are retained. This means that these loadings represent a correlation between that item and the overall factor; like Pearson correlations, they range from –1 to 1. Note that this first generated table provides the "un-rotated factor matrix" with factor loadings that represent a correlation between each item and the overall factor. Recognize that this first table tends to provide factor loadings heavily onto one factor. Consequently, this first solution is rotated to produce—the "rotated factor matrix"—which has factor loadings distributed between the retained factors. This subset of factor explains most of the variance and constitutes a good model (e.g., > 60%).

Now, recall that the survey measured managers' perceptions of the scorecard elements' importance, usefulness, and display usability (scaled from 1 to 6) as it relates to their decision to use the scorecard (scaled from 1 to 6). In addition, this research project collected a single data set characterized by multiple, latent, metric independent (five critical factors) and multiple, latent, metric dependent variables (one performance measure). These measures have hypothesized linear relationships. The goal of this research was to determine those critical factors (independent variables) that have a statistically significant impact on the product quality measures (dependent variables). These data set characteristics and research objectives aligned with the PCA factor analysis method. Notably, the PCA factor analysis incorporated regression modeling, as an integral component to provide researchers a full explanation of the data.

The ultimate goal of study two was to collect the full-scale survey data and devise a model that adequately explains and can predict those scorecard elements deemed important, useful, and usable for NTV managers in order to make effective product quality management decisions. Prior to conducting the full-scale study, a pilot study was conducted. Multiple linear regression was used because it is a viable model since it collects numerical rankings that model the independent variables for each of five constructs. The mean usability measure for the dependent variable was used. This pilot study statistical analysis was employed to determine if sufficient evidence existed to justify the full-scale study.

The hypotheses indicated there may be a statistically significant relationship between the five critical factors (independent variables) previously discussed and usability (dependent variable). The investigative schema began with the development of a multiple regression model to substantiate these hypotheses. PCA factor analysis was performed and provided a more comprehensive examination of the full-scale data set (which must be greater than 50 in order to use inferential statistics confidently).

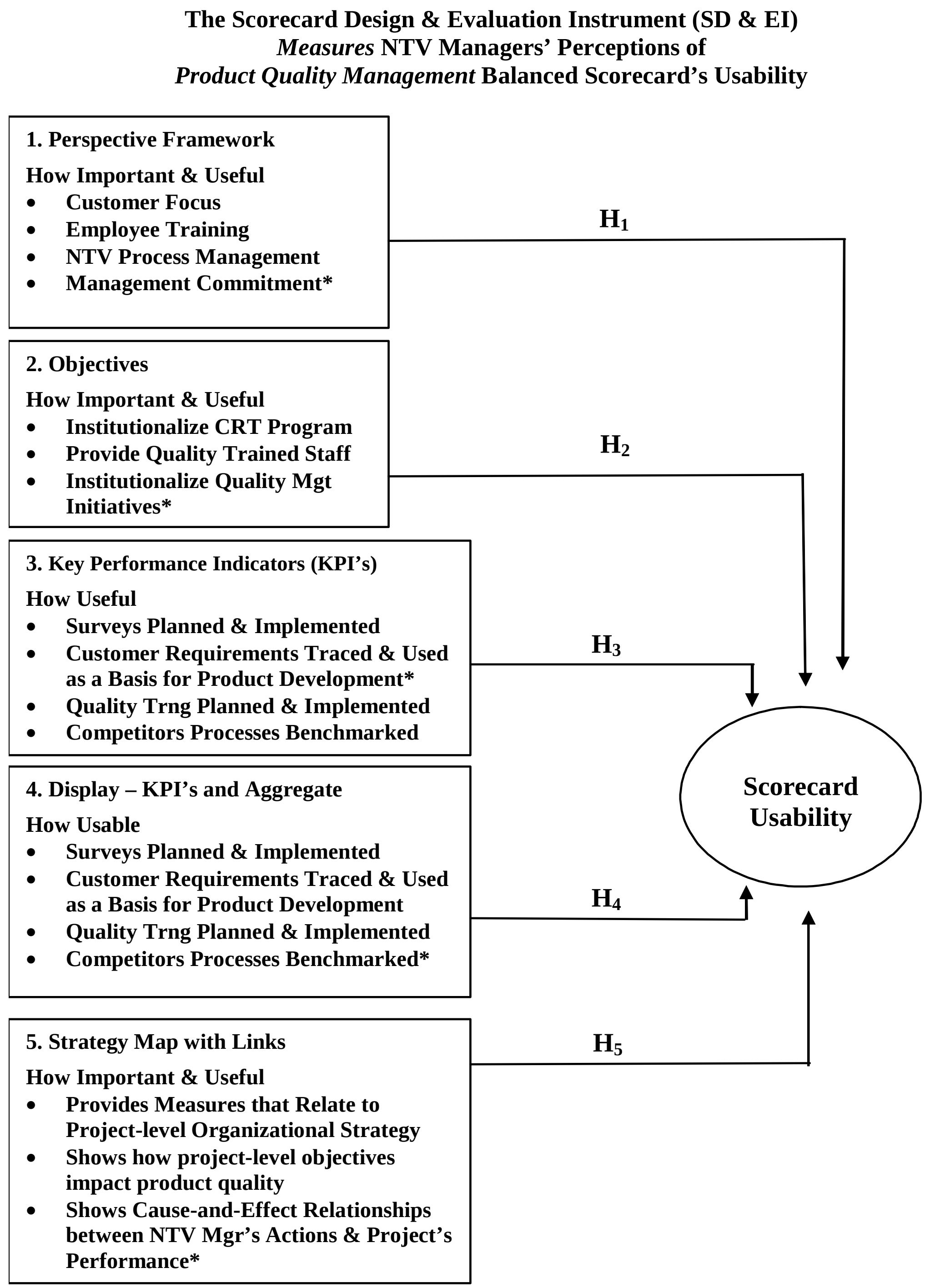
The scorecard design and user evaluation survey was used to measure managers' perceptions within firms engaged in radical innovation. Notable differences between the pilot study's data set and the full-scale study's data set were size and type. The pilot study used a sample of convenience comprising of 15 experienced NTV managers. The full-scale study will use a random sample of over 100.

The survey collected a single data set characterized by multiple, latent, metric independent (five scorecard elements) and multiple, latent, metric and a single dependent variable (usability), and assumed there was some degree of correlation among measured independent variables. Also, because the goal of this research project was to determine which, if any, of the five scorecard elements (independent variables) have a statistically significant impact on the usability of the scorecard (dependent variable), PCA factor analysis, which incorporates multiple regression modeling, was selected and implemented on the full-scale study.

The evaluation portion of study two sought to answer the question, "What balanced scorecard elements comprised of product quality measures, drive usability for NTV managers and engineers?" The five hypotheses were delineated as presented in Figure 14. In addition, Figure 15 is a schematic of the Scorecard Design & User Evaluation Instrument's hypotheses and their relation to the dependent variable, scorecard usability.

Research question: What balanced scorecard product quality measures drive usability for NTV managers and engineers?
Hypotheses: An NTV *Product Quality Management* Balanced Scorecard that has:
1. Important and useful perspective framework – is more usable for managing product quality practices
2. Important and useful objectives – is more usable for managing product quality practices
3. Useful key performance indicators – is more usable for managing product quality practices
4. Important and useful Strategy Maps with Links – is more usable for managing product quality practices
5. Usable Data Displays – is more usable for managing product quality practices

Figure 14. Phase Two Research Question and Hypotheses



*Complete list of items depicted in Appendix E

Figure 15. Scorecard Design & User Evaluation Instrument

Variable Relationships with Tested Hypotheses

The five independent variables below were designed to determine if a relation exists between their effectiveness and the perceived usability of the newly devised NTV scorecard (dependent variable). Effectiveness was defined as important, useful and useable for making PQM decisions. These hypothesis tests are delineated in Table 11.

Table 11. *Variable Relationships with Tested Hypotheses*

Test 1: Determine Independent Variable Perspective Framework effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H. 1	Usability Vs. Non-usability	Multiple Regression	No Correlation ($p \geq 0.05$)	NTV managers perceive the derived perspective framework is effective and useful.	Missing variables expressed in error term, measurement error, small sample size, or perspective framework is an insignificant factor.

Test 2: Determine Independent Variable Objectives effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H. 2	Usability Vs. Non-Usability	Multiple Regression	No Correlation ($p \geq 0.05$)	NTV managers perceive the derived objectives are effective and useful.	Missing variables expressed in error term, measurement error, small sample size, or strategy link is an insignificant factor.

Test 3: Determine Independent Variable Key Performance Indicators (KPI's) effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H. 3	Usability Vs. Non-Usability	Multiple Regression	No Correlation ($p \geq 0.05$)	NTV managers perceive the derived KPI's are effective and useful.	Missing variables expressed in error term, measurement error, small sample size, or strategy link is an insignificant factor.

Test 4: Determine Independent Variable Displays of KPI's and Aggregate View effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H. 4	Usability Vs. Non-Usability	Multiple Regression	No Correlation ($p \geq 0.05$)	NTV managers perceive the designed Displays of KPI's and Aggregate are effective and usable.	Missing variables expressed in error term, measurement error, small sample size, or strategy link is an insignificant factor.

Test 5: Determine Independent Variable Displays of Strategy Map with Links effect on

	Dependent Variables	Test Method	Null Hypotheses	Reject	Accept
H. 2	Usability Vs. Non-Usability	Multiple Regression	No Correlation ($p \geq 0.05$)	NTV managers perceive the designed Displays of Strategy Map with Links are useful.	Missing variables expressed in error term, measurement error, small sample size, or strategy link is an insignificant factor.

Regression

A multiple linear regression model was used to determine if it adequately explains the relationship between the independent variables (i.e., perspective framework, objectives, key performance indicators (KPI's), data displays of KPI's and aggregate view, data displays of strategy map with links and dependent variable (usability). This is a viable model since it collects numerical rankings that model the independent variables for the scorecard elements and their potential relationship with the scorecard's usability. The data collected were used to test and validate the following multiple linear regression model:

$$U = ß_0 + ß_1 * PF + ß_2 * OBJ + ß_3 * KPI + ß_4 * DIS\text{-}KPI + ß_5 * SVIEWS + E$$

where

$ß_0$= intercept; $ß_{1,}$ $ß_2$, $ß_{3,}$ $ß_3$, $ß_{4,}$ $ß_5$ = Partial Regression Coefficients; ε = random error term

U = the usability measure (dependent variable)

PF, OBJ, KPI, DIS-KPI, and SViEWS = scorecard elements (independent variables)

and

PF = Perspective Framework;

OBJ = Objectives;

KPI = Key Performance Indicators

DIS-KPI=Display of KPI's;

SViEWS = Strategic Views

Equation 7. Regression Model Scorecard

Concluding Remarks

A survey instrument entitled, Scorecard Design & User Evaluation Instrument (SD & UE) was devised to measure NTV managers' perception of the scorecard's elements' importance, usefulness, and usability, as well as its displays' usability to enable them in effectively managing product quality. The SD & UE instrument was then pilot tested, and the data were collected and analyzed. The pilot study was used primarily to confirm that the instrument has sufficient internal consistency and that a linear relationship existed between the independent variables and dependent variable. The full study was performed to establish the usefulness of the NTV PQM Balanced Scorecard for new technology venture managers.

CHAPTER V

RESULTS AND DISCUSSIONS

Study One

Overview

This study strove to determine if continuous process improvement practices have a statistically significant positive impact on product quality in the new technology venture environment. If this supposition were to be proven correct, the statistically significant product quality management practices would be converted into performance measurement indicators and incorporated into a scorecard. This scorecard would provide NTV managers a tool that would enable them to make better product quality management decisions in new technology venture environments. Study one was broken into two segments; a pilot study and a full-scale study. The pilot study's results are reported below.

Readability

Microsoft Word was used to verify word and line count; an Excel spreadsheet was used to tally and confirm syllable count as well as compute the grade level. The NTV PQMI contains 527 total words and 54 total sentences (without headings) as well as 1128 total syllables. Using equation 1, it was determined the NTV PQMI is written at 12.15 or slightly above a 12^{th} grade reading level which is for around ages 17-18 in the United States of America. It was confirmed that all 15 pilot study respondents had education levels that exceeded the 12^{th} grade. Pools of participants were previously identified and are summarized in the participants' section. Because the full-study participants were engineers and scientists with at least three years of management experience in the new technology venture environment, the reading level was deemed appropriate.

Pilot Study

Regression

Initial Regression Analysis Using Baseline Equation

The initial regression analysis commenced using all of the independent variables; process management (PM), management commitment (MC), education and training (ET), customer focus (CF), quality metrics (QM) and employee responsibility (ER).

Normal Probability Plot

First examination of the normal probability plot depicted in Figure 16 revealed an approximate straight line and provided graphical evidence of the probable linear relationship between the independent variables and dependent variable.

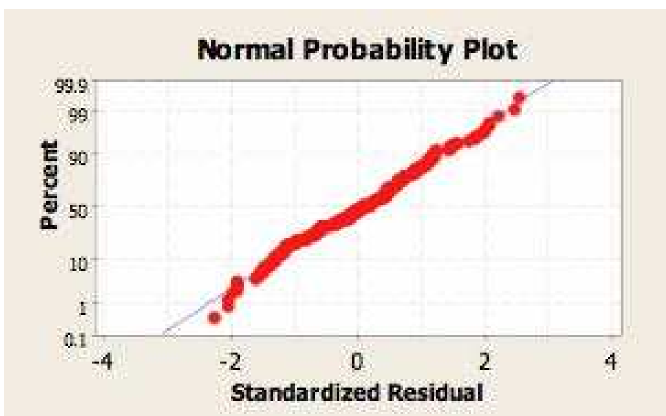


Figure 16. Normal Probability Plot

In short, because the normal probability plot approximates a straight line, normality is tenable and further examination of the regression model is therefore justified. Tables 12 and 13 depict the regression results. Figure 17 is the four-in-one residuals plots for quality measures, Table 14 provides the best subsets regression results, and Figure 18 is the boxplots of the six hypothesized critical factors.

Baseline Regression Equation with Diagnostic Output

The regression equation is:

$$Q_M = 0.208 + 0.0674\ PM + 0.0915\ MC - 0.0295\ ET + 0.373\ CF + 0.295\ QM + 0.159\ ER$$

Table 12. *Factors and Their Respective P and VIF Values*

Factor		P	VIF
Process Management	PM	0.033	1.253
Management Commitment	MC	0.011	1.470
Education and Training	ET	0.590	3.501
Customer Focus	CF	0.000	1.726
Quality Metrics	QM	0.000	6.297
Employee Responsibility	ER	0.019	6.939
	S = 0.438894 R-Sq = 83.6% R-Sq(adj) = 83.1%		
	PRESS = 41.3318 R-Sq(pred) = 82.63%		

Table 13. *Analysis of Variance*

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	6	198.793	33.132	172.00	0.000
Residual Error	203	39.103	0.193		
Total	209	237.896			

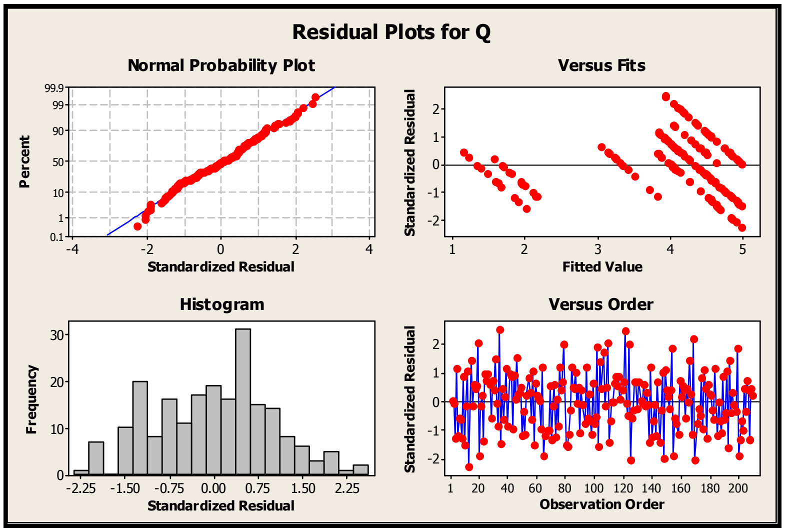


Figure 17. Four in One Residuals Plots for Quality Measures

Table 14. *Best Subsets Regression*

Best Subsets Regression: Q_M versus Process Mgt, (PM), Mgt Commitment (MC), Education and Training (ET), Customer Focus (CF),Quality Metrics (QM), and Employee Responsibility (ER)

Response is Q

Vars	R-Sq	R-Sq(adj)	Mallows Cp	S	PM	MC	ET	CF	QM	ER
1	66.5	66.3	208.3	0.61941					X	
1	65.6	65.4	218.8	0.62724				X		
1	62.6	62.4	256.3	0.65429						X
1	47.2	46.9	446.2	0.77718			X			
1	29.0	28.7	670.8	0.90111		X				
2	82.0	81.8	18.0	0.45455				X	X	
2	80.9	80.7	32.1	0.46877				X		X
2	75.6	75.3	97.6	0.52979			X	X		
2	69.7	69.4	170.6	0.59041		X			X	
2	69.1	68.8	177.1	0.59548	X			X		
3	82.7	82.5	11.2	0.44651				X	X	X
3	82.6	82.4	12.4	0.44772		X		X	X	
3	82.4	82.1	15.4	0.45084	X			X	X	
3	82.1	81.9	18.5	0.45407			X	X	X	
3	81.3	81.1	28.6	0.46432		X		X		X
4	83.2	82.9	7.7	0.44182		X		X	X	X
4	83.1	82.8	8.7	0.44288	X	X		X	X	
4	83.0	82.7	9.6	0.44382	X			X	X	X
4	82.7	82.4	13.2	0.44760			X	X	X	X
4	82.7	82.3	14.0	0.44841		X	X	X	X	
5	83.5	83.1	5.3	0.43813	X	X		X	X	X
5	83.2	82.8	9.6	0.44273		X	X	X	X	X
5	83.1	82.7	10.6	0.44381	X	X	X	X	X	
5	83.0	82.6	11.6	0.44490	X		X	X	X	X
5	81.9	81.4	25.9	0.45980	X	X	X	X		X
6	83.6	83.1	7.0	0.43889	X	X	X	X	X	X

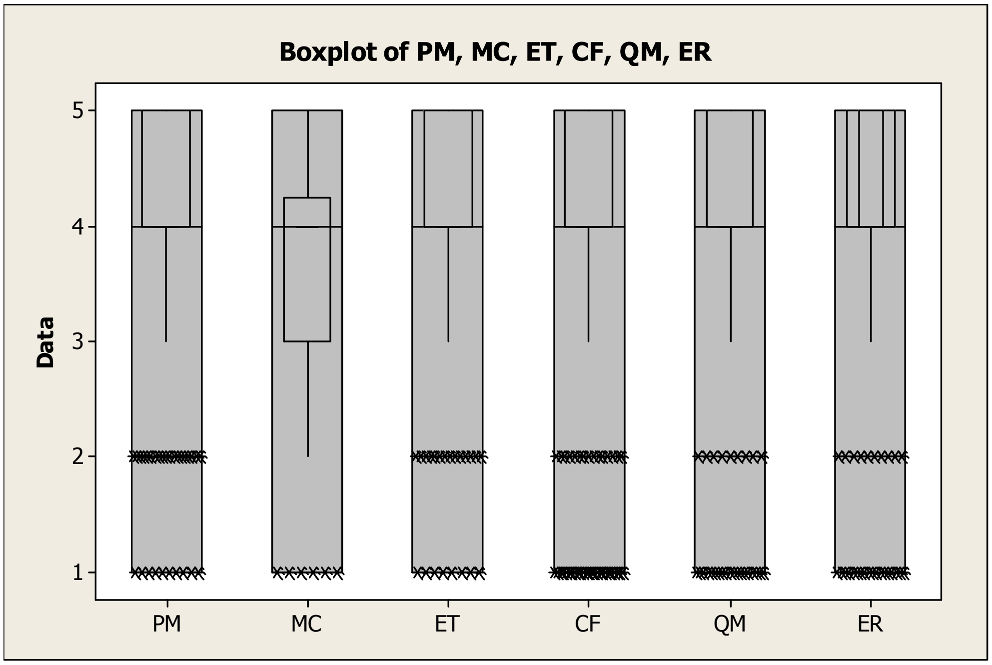


Figure 18. Boxplots of Six Hypothesized Critical Factors

Regression Results and Discussions

The residuals plots were reviewed to determine the validity of the regression model. The residuals, or estimated error values ε, are defined as the differences between the observed Y_i and the predicted Y_i ($Yhat_i$) values of the dependent variable, for given values of X_i (independent variable values): $\varepsilon = Y_i - Yhat_i$. The following observations of the residuals plots were made to validate the regression model and its underlying assumptions:

1. The normality probability plot provides graphical evidence to confirm the assumption of normality since the graph roughly depicts a straight line. Therefore a linear relationship appears to exist between the tested independent variables and dependent variable quality.

2. Homoscedasticity (also known as constant variance) and the independence assumptions appear to be valid since there do not appear to be major differences in the variability of the residuals for different values of X_i.
3. The histogram provides graphical evidence the data are normally distributed as it appears to roughly approximate the classic bell shaped curve; thus, normality is tenable.
4. The versus order plot provides graphical evidence that no steady rises or falls occur which supports that data randomness exists; this further supports the assumption of normality.
5. There versus fits plot provides graphical evidence of an apparent pattern. This may violate aptness of fit considerations. However, given the weight of most of the evidence it is somewhat likely that this may be attributed to the small sample size.

The boxplot of the hypothesized critical factors provides graphical evidence that there are no outliers. This makes intuitive sense because the measures were bounded by discrete numerical responses (1 to 5). Notably, the plot also revealed that the upper bound of possible responses proved prevalent.

An examination of the regression model's additional diagnostic output was also done to determine actions needed to refine the model. In particular, the *adjusted R-square value of 83.1% indicated a very good linear fit* even when taking into account the relative large number of independent variables (6). In addition, five of the factors had p-values < .05 which indicates that if model is validated, these factors will have predictive value at the 95% confidence level. The single exception was the education and training factor with a value of 0.590 which is > .05.

Significantly, the best subsets regression test was run and it was determined that the range adjusted R-square values was 28.7 to 83.1 whereby over 93% of the best subsets had adjusted R-square values > 62% and 75% had values > 80%. This indicates it may be wise to increase the sample size (vis à vis the planned full scale study) or reduce the significance level rather than reduce the number of factors in the model at this time.

On the other hand, two of the independent variables (quality metrics and employee responsibility) had variable inflation factor (VIF) values that were > 5 (6.297 and 6.939, respectively). This indicates these two factors may be somewhat correlated and therefore justifiably removed from the model to maintain the .05 significance level. Lastly, employee training is negative which indicates that as it lessens, the linear relationship is strengthens. This appears counterintuitive.

Regression Conclusions and Recommendations

Because this was a pilot test of only 15 samples, the results only provided sufficient evidence to support conducting the full-scale study. In particular, the pilot study results indicate the likelihood that a strong liner relationship exists between all of the six factors and the dependent variable.

Reliability

Minitab® was used to compute the Cronbach alpha coefficient for the pilot study's six constructs. The results are reported in the Table 15.

Table 15. *Cronbach's Alpha Results*

Construct	Process Management	Management Commitment	Education & Training	Customer Focus	Quality Metrics	Employee Responsibility
Cronbach's Alpha = α	0.8752	0.8454	0.9615	0.9711	0.9874	0.9879

Alpha coefficients range in value from 0 to 1 and may be used to describe the reliability of factors extracted from the Likert scale schema previously described. The higher the score, the more reliable the generated scale is. Nunnally (1978) has indicated 0.7 to be an acceptable reliability coefficient. This pilot study's results indicate excellent internal consistency with computed Cronbach's alpha values that range from a low of 0.8454 to a high of 0.9879.

Final Results and Conclusions

The regression analysis indicated that a statistically significant linear relationship exists between the six tested constructs and product quality measures. However, since this was a pilot study of a small population, it is difficult to generalize these findings to a larger population. The small sample increases the sampling error, so a larger sample size would yield more precise results due to a decrease in the measure of variability.

However, this pilot study was of value in assessing the internal consistency of the survey instrument used in the new technology venture environment. Based on the analysis, each construct resulted in a Cronbach's alpha > 0.7 so this instrument could be used to conduct a similar study on a larger population.

In addition *the baseline regression model adequately explains 83.1% of the data and thereby does a good job of predicting product quality*. It was decided that further model refinement was not justified at this time. Rather, these results strongly support moving forward to conduct the full-scale study and complete its data collection. Thus, the iterative steps using the prescribed investigative schema would be applied to the data collected from the full-scale study. In addition, should the model generated from the full-scale study's data yield similar results, principal component analysis will be then be performed to confirm whether a specified set of constructs influences responses in a predicted way. Specifically, if multiple linear regression analysis reveals a model that adequately explains greater than 60% of the full-scale study's data, then principal component analysis will be performed on the six constructs (process management, management commitment, education and training, customer focus, quality metrics, and employee responsibility) to determine more precisely their influence on product quality measures.

Thus, this pilot study concluded (1) the refined new technology venture product quality management instrument (NTV PQMI) may be useful for assessing new technology venture environments for the purpose of installing product quality improvement initiatives, and (2) additional research is justified using the NTV PQMI. A larger study will determine if this measurement instrument is a reliable measurement for product quality in the new technology venture sector.

Full-Scale Study One

Full-Scale Study Justifiably Commenced

The full-scale study ($n = 102$) commenced once the pilot study’s results justified its pursuit. 442 NTV managers were sent the survey electronically; 102 fully completed surveys were returned. This is a 23% response rate. The following tests were run using data from the full-scale study:

1. Cronbach’s Alpha to re-establish NTV PQMI's internal consistency.
2. Mean differences of Quality (dependent) variables compared.
3. Multiple linear regression.
    a. Stepwise regression.
    b. Minitab® output examined for multicollinearity, correlation, and outliers. VIF less than 5.
    c. Best Subsets

d. R-sq. adjusted values greater than .50

e. Residuals Analyzed to validate resultant model.

The coefficient of determination or the ***un***adjusted R^2 is the proportion of variability in a data set that is accounted for by the statistical model. It is a measure of how well the regression line approximates the real data points. An R^2 of 1.0 indicates the regression line perfectly fits the data.

The adjusted R^2 accounts for degrees of freedom and is an approximately unbiased estimator of how well the regression line approximates the actual data points. In contrast, the unadjusted R^2 is biased upward and overstates true explanatory power.

Generally, R^2 values of greater than .50 show that the correlation is strong. However, in social sciences, R^2 values of as low as .25 are sometimes accepted as indication that some correlation does exist (Brooks & Barcikowski 1999; Newman & Newman, 2000; Morgan & Wilson VanVoorhis, 2007).

The full scale study's data analyses uses adjusted R^2 values because this value is a more conservative statistical measure than unadjusted R^2 values. Additionally, adjusted R^2 values > .50 are used because this benchmark indicates a strong correlation exists for attitudinal survey research (Brooks & Barcikowski, 1999; Newman & Newman, 2000; Morgan & Wilson VanVoorhis, 2007).

Respondents' Knowledge and Experience

Participants in this study affirmed their understanding of the following definitions and experience prior to completing the survey instrument.

Definitions:

- A new technology venture (NTV) is defined as engaging in preparing a new technologically advanced product for release to its final consumer for the first time with a first to early generation production process.
- A new technologically advanced product may be software or hardware (e.g., device, machinery, vehicle, etc.) a formulation (e.g., chemical, pharmaceutical, etc.) or delivery mechanism (e.g., Bluetooth, Internet, cloud computing, etc.) and is one that offers wholly new benefits; (1) significant (5 to 10 times) improvement in known benefits; or (2) significant (30 to 50%) reduction in cost (Ansoff, 1957; Booz-Allen & Hamilton, Inc., 1982; Leifer et al., 2001; O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009).

Experience

1. A new technology venture (NTV) manager that managed the launch of a new technology venture for a minimum of three years within the last five years (O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009).

Table 16 depicts the results of respondents' affirmation understanding of definitions and experience required to complete the survey.

Table 16. *Respondents Affirm Understanding of Definitions and Experience*

Definitions, experience, contacts provided on first page; "Do you want to proceed with this survey?"

#	Answer		Response	%
1	Yes		102	100 %
2	No		0	0%
	Total		102	100 %

Cronbach's Alpha

The 57-item NTV PQMI survey instrument was once again analyzed to re-establish its internal consistency. The measure of internal consistency is Cronbach alpha; the closer this value is to 1, the greater the internal consistency. This full-scale (*n* = 102) study's results indicate excellent internal consistency with computed Cronbach alpha values that range from a low of 0.8379 to a high of 0.9172 as indicated in Table 17.

Table 17. *Cronbach's Alpha Results – Full-Scale Study (n = 102)*

Construct	Process Management	Management Commitment	Education & Training	Customer Focus	Quality Metrics	Employee Responsibility
Cronbach's Alpha = α	0.9172	0.8964	0.8379	0.8739	0.9045	0.8604

Descriptive Statistics for the Three Dependent Quality Variables

The three dependent quality measures are Q_1 = Product Performance, Q_2 = Organizational Performance, and Q_3 = Customer Satisfaction. Descriptive statistics on these three dependent variables are provided in Tables 18, 19, and 20.

Table 18. *Q1 = Dependent Quality Variable; Product Performance*

Q1 = Product Performance
"New technology product quality performance of the new technology venture department was measured during the past 3 years and compared to any existing industry standards."

#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Disagree		10	10%
3	Neither Agree nor Disagree		23	23%
4	Agree		37	36%
5	Strongly Agree		33	32%

Statistic	Value
Min Value	2
Max Value	5
Total Responses	102

Table 19. *Q3 = Quality (Dependent) Variable; Organizational Performance*

Q2 = Organizational Performance
“Overall organizational quality (NTV and non-NTV) performance was measured during the past 3 years and compared to any existing industry standards.”

#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Disagree		13	13%
3	Neither Agree nor Disagree		18	18%
4	Agree		54	53%
5	Strongly Agree		17	17%

Statistic	Value
Min Value	2
Max Value	5
Total Responses	102

Table 20. *Q3 = Quality (Dependent) Variable; Customer Satisfaction*

Q3= Customer Satisfaction
"Customer satisfaction with product quality was measured, evaluated, and acted upon during the past 3 years."

#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Disagree		8	8%
3	Neither Agree nor Disagree		18	18%
4	Agree		49	48%
5	Strongly Agree		27	26%

Statistic	Value
Min Value	2
Max Value	5
Total Responses	102

Stepwise Regression

The full study's data set was analyzed using stepwise regression. While few explicit guidelines exist for determining stepwise regression sample size (Baggaley, 1983), Guadagnoli and Velicer (1988) reviewed several studies that concluded that absolute minimum sample sizes, rather than subject to item ratios, are most relevant. These studies range in their recommendations from an *N* of 50 (Barrett & Kline, 1981) to 400 (Aleamoni, 1976). In addition, Brooks and Barcikowski (1999) used a cross-validation methodology to determine the strength of predictor coefficients when using stepwise regression. Given 15 to 16 predictors in the final stepwise model with an unadjusted $R^2 > .70$ (which is the case in the present study), a sample size of 96 to 102 would be appropriate to project a precision efficacy of .80. The sample size for the full scale study was chosen to be > 100 which is more than double Barrett and Kline's (1981) minimum sample size and satisfies Brooks and Barcikowski's criteria.

Stepwise regression finds the "best" regression model. It uses a partial F test criterion to examine a model with any number of explanatory variables; in this case 54. An important feature of this stepwise process is that an explanatory variable that has entered into the model at an early stage can subsequently be removed, once other explanatory variables are considered. Variables are either added to or deleted from the regression model at each step of the model-building process. The step-wise procedure terminates with the selection of a best-fitting model, when no variables can be added to or deleted from the last model fitted.

- Additionally, the model was tested for multicollinearity, correlation, and outliers: This was done in Minitab® A VIF of 5 or less was used to ensure low correlation.
- The output from the Best Subsets test was examined to eliminate those factors with minimal influence and retain those with strong influence on the quality response variables.
- The fit of the model was tested by examining the R-sq adjusted value after each iteration to see if it was > .50. Examining the residuals of the final model tested the resultant model's validity. The "iid" assumptions of linear regression were thereby validated.

Product Performance Regression Equation

The product performance regression equation is:

$$Q_1 = -0.657 + 0.312\ PM_3 - 0.270\ PM_4 - 0.273\ PM_{11} - 0.135\ MC_{15} + 0.130\ MC_{23} + 0.181\ ET_{24} + 0.220\ ET_{25} + 0.301\ CF_{30} + 0.192\ CF_{36} + 0.344\ QM_{38} + 0.29\ QM_{43} - .199\ ER_{46} - 0.145\ ER_{49} + 0.404\ ER_{50} - 0.220\ ER_{51}$$

Regression diagnostic output for Q_1 is provided in Table 21.

Table 21. *Regression Diagnostic Output for Q1*

Predictor	*Coef*	*SE Coef*	*T*	*P*	*VIF*
Constant	-0.6566	0.3174	-2.07	0.042	
43	0.28995	0.09036	3.21	0.002	2.584
38	0.34372	0.07814	4.40	0.000	2.248
30	0.30050	0.07356	4.08	0.000	1.977
3	0.31216	0.07117	4.39	0.000	2.027
50	0.40441	0.09747	4.15	0.000	2.827
11	-0.27251	0.07591	-3.59	0.001	1.955
25	0.22005	0.07446	2.96	0.004	2.479
46	-0.19904	0.06450	-3.09	0.003	2.045
51	-0.22014	0.08075	-2.73	0.008	2.796
4	-0.27037	0.07809	-3.46	0.001	2.218
36	0.19163	0.06802	2.82	0.006	2.061
49	-0.14547	0.07966	-1.83	0.071	2.240
24	0.18084	0.08250	2.19	0.031	2.448
15	-0.13563	0.07210	-1.88	0.063	2.113
23	0.13014	0.07086	1.84	0.070	2.043

S = 0.460189   R-Sq = 77.2%   R-Sq(adj) = 73.2%
PRESS = 27.3925   R-Sq(pred) = 65.70%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	15	61.6404	4.1094	19.40	0.000
Residual Error	86	18.2126	0.2118		
Total	101	79.8529			

Discussion

The p-values of the predictor variables are all < .05; likewise the p-value for the multiple linear regression as indicated in the ANOVA is 0.0001. These values indicate predictive capability within a 95% confidence level. In addition, each VIF value is < 5 which indicates a sufficiently low correlation amongst predictor variables. The R-sq (adj) value is 73.2%, which indicates this multiple linear regression model explains 73.2% of the data. This is considered an overall very good fit of this data set.

Model Validation

The model’s residuals plots depicted in Figure 19 were examined to determine the validity of the final model.

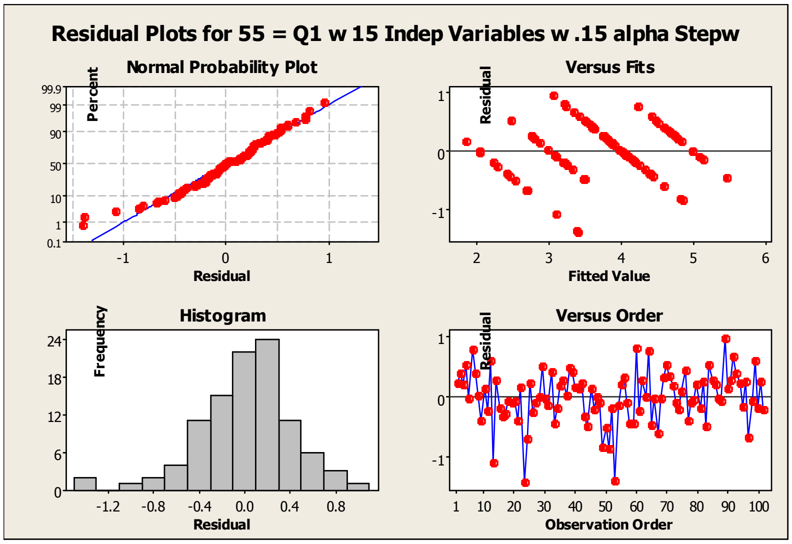


Figure 19. Residual Plots for Product Performance, Q1

Explanation and Interpretation of Graphs Used to Validate Model

Figure 19 depicts the four in one residuals' plots. These are used to validate the model. Recognize the residuals, or estimated error values of e_i are defined as the differences between the observed Y_1 and predicted Y_i values of the dependent variable, for given values of X_i. The evaluation of the aptness of the fitted regression model is done by plotting the residuals on the vertical axis against the corresponding X_i values of the independent variable on the horizontal axis. If the fitted plot model is appropriate for the data, there will be no apparent pattern in this plot of the residuals vs. X_i. If the model is not appropriate, there will a relationship between the X_i values and the residuals ei.

In this case, the Residuals vs. Fitted value graph is examined and there are no significant outliers. This graph reveals the anticipated pattern due to the 1-5 response boundary imposed by the survey instrument. Additionally, homoscedasticity and independence assumptions appear to be valid since there do not appear to be major differences in the variability of the residuals for different values of X_i. Thus, it can be concluded that for this fitted model, there is no violation of the assumption of equal variance at each level X_i. Also, the Normality Probability Plot appears to confirm the assumption of normality since the graph approximately depicts a straight line. Likewise the Histogram Plot is mostly characterized by a normal curve, which provides further graphical evidence of normality. Therefore, the Gaussian simple linear regression is adequate. Thus, there is aptness of fit and no assumptions of regression have been violated.

Quality Management Factors That Explain Greater Than 70% of Data's Variance

An analysis of the independent variables significantly contributing to multiple regression model for dependent variable, product performance, Q1 determined PM_3, PM_4, PM_{11}, MC_{15}, and ET_{23} account for 73.1% of the model. Statistical evidence summarized in Figure 20 and Table 22 supports the inclusion of these product quality management practices into the scorecard.

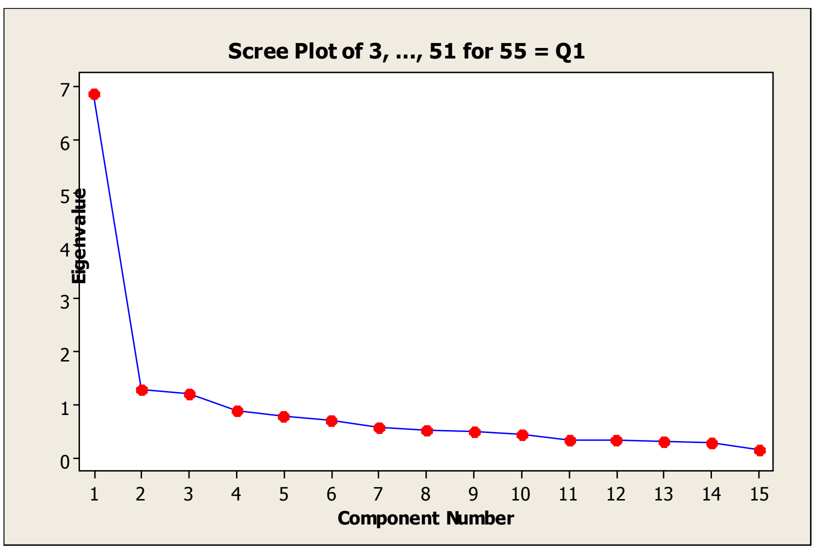


Figure 20. Scree Plot of Product Performance Q1

Table 22. *Eigenanalysis of the Correlation Matrix for Q1*

Eigenanalysis of the Correlation Matrix								
Eigenvalue	6.8582	1.2697	1.1864	0.8765	0.7672	0.6960	0.5742	0.5050
Proportion	0.457	0.085	0.079	0.058	0.051	0.046	0.038	0.034
Cumulative	0.457	0.542	0.621	0.679	0.731	0.777	0.815	0.849
Eigenvalue	0.4826	0.4328	0.3298	0.3195	0.2953	0.2627	0.1440	
Proportion	0.032	0.029	0.022	0.021	0.020	0.018	0.010	
Cumulative	0.881	0.910	0.932	0.953	0.973	0.990	1.000	
3, 4, 11, 15, and 23 account for 73.1% of model								

Organizational Performance Regression Equation

The organizational performance regression equation is:

$$Q_2 = -0.6159 + 0.249\ PM_3 - 0.146\ PM_{11} + 0.332\ PM_{12} + 0.201\ PM_{13} + 0.185\ MC_{22} - 0.22\ MC_{21} + 0.25\ ET_{27} + 0.191\ ET_{28} + 0.276\ CF_{34} + 0.248\ QM_{39} + 0.26\ QM_{40} - 0.23\ QM_{41} + 0.246\ ER_{52} + 0.148\ ER_{53} - 0.208\ ER_{47} - 0.128 ER_{51}$$

Regression diagnostic output for Q_2 is depicted in Table 23.

Discussion

The p-values of the predictor variables are all < .05; likewise the p-value for the multiple linear regression as indicated in the ANOVA is 0.001. These values indicate predictive capability within a 95% confidence level. In addition, each VIF value is < 5 which indicates a sufficiently low correlation amongst predictor variables. The R-sq (adj) value is 66.4%, which indicates this multiple linear regression model explains 66.4% of the data. This is considered an overall good fit of this data set.

Table 23. *Regression Diagnostic Output, Q2*

Predictor	*Coef*	*SE Coef*	*T*	*P*	*VIF*
Constant	-0.6159	0.4032	-1.53	0.130	
39	0.24809	0.09705	2.56	0.012	2.256
3	0.24855	0.06988	3.56	0.001	1.326
34	0.27645	0.06851	4.04	0.000	1.842
52	0.24608	0.08274	2.97	0.004	2.006
22	0.18514	0.07851	2.36	0.021	2.039
27	-0.24741	0.09964	-2.48	0.015	2.820
12	0.33212	0.09881	3.36	0.001	2.150
53	0.14801	0.07240	2.04	0.044	1.544
47	-0.20767	0.08003	-2.59	0.011	2.023
13	0.20086	0.07774	2.58	0.011	1.885
41	-0.2306	0.1215	-1.90	0.061	3.158
40	0.2601	0.1074	2.42	0.018	2.437
21	-0.2159	0.1051	-2.05	0.043	2.477
28	0.19116	0.09485	2.02	0.047	3.072
51	-0.12762	0.08193	-1.56	0.123	1.952
11	-0.14615	0.09477	-1.54	0.127	2.067

S = 0.558733   R-Sq = 71.7%   R-Sq(adj) = 66.4%
PRESS = 40.2651   R-Sq(pred) = 57.08%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	16	67.2782	4.2049	13.47	0.000
Residual Error	85	26.5355	0.3122		
Total	101	93.8137			

Model Validation

The model's residuals plots depicted in Figure 21 were examined to determine the validity of the final model.

Explanation and Interpretation of Graphs Used to Validate Model

In this case, the Residuals vs. Fitted value graph is examined and there are no significant outliers. This graph reveals the anticipated pattern due to the 1-5 response boundary imposed by the survey instrument. Additionally, homoscedasticity and independence assumptions appear to be valid since there do not appear to be major differences in the variability of the residuals for different values of X_i. Thus, it can be concluded that for this fitted model, there is no violation of the assumption of equal variance at each level X_i. Also, the Normality Probability Plot appears to confirm the assumption of normality since the graph approximately depicts a straight line. Likewise the Histogram Plot is mostly characterized by a normal curve, which provides further graphical evidence of normality. Therefore, the Gaussian simple linear regression is adequate. Thus, there is aptness of fit and no assumptions of regression have been violated.

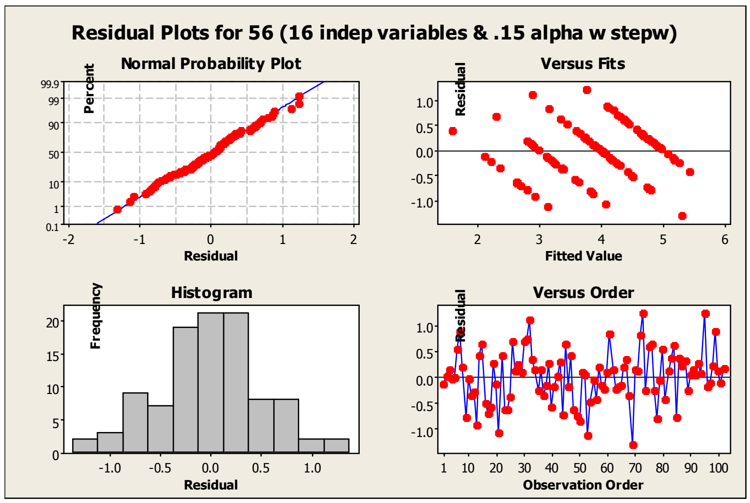


Figure 21. Residuals Plots for Organizational Performance, Q2

Product Quality Management Factors That Explain Greater Than 70% of Data's Variance

An analysis of the independent variables significantly contributing to multiple regression model for dependent variable, organizational performance, Q2 determined PM_3, PM_{11}, PM_{12}, PM_{13}, and MC_{21} account for 72.5% of the model. Statistical evidence summarized in Figure 22 and Table 24 supports the inclusion of these product quality management practices in the NTV scorecard design.

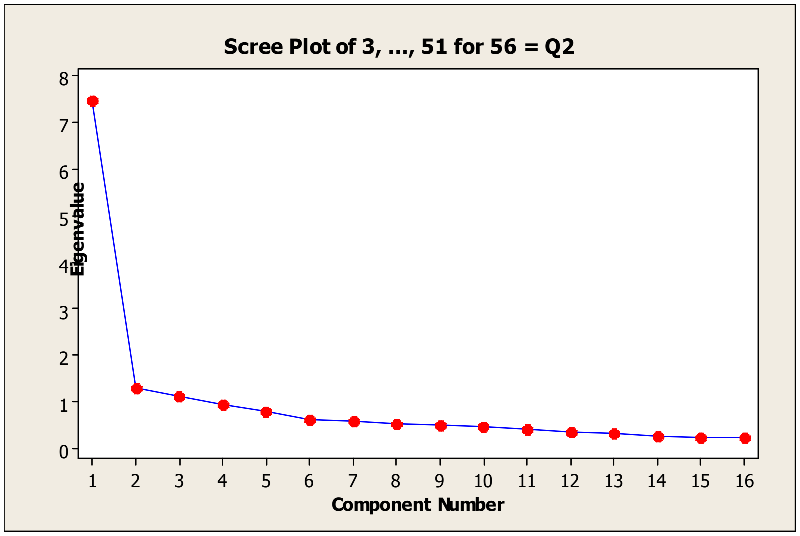


Figure 22. Scree Plot of Organizational Performance Q2

Table 24. *Eigenanalysis of the Correlation Matrix for Q2*

Eigenanalysis of the Correlation Matrix								
Eigenvalue	7.4707	1.3026	1.1108	0.9396	0.7764	0.6092	0.5751	0.5118
Proportion	0.467	0.081	0.069	0.059	0.049	0.038	0.036	0.032
Cumulative	0.467	0.548	0.618	0.676	0.725	0.763	0.799	0.831
Eigenvalue	0.4869	0.4508	0.4046	0.3339	0.3091	0.2613	0.2393	0.2180
Proportion	0.030	0.028	0.025	0.021	0.019	0.016	0.015	0.014
Cumulative	0.861	0.890	0.915	0.936	0.955	0.971	0.986	1.000
3, 11, 12, 13, and 21 account for 72.5% of Model								

Customer Satisfaction Regression Equation

The customer satisfaction regression equation is:

$$Q_3 = 0.437 + 0.308\ PM_3 - 0.352\ PM_4 + 0.252\ PM_9 - 0.407\ MC_{16} + 0.293\ MC_{17} + 0.359\ MC_{23} - 0.277\ ET_{29} + 0.355\ CF_{32} + 0.222\ CF_{35} + 0.172\ QM_{39} + 0.351\ QM_{40} - 0.326\ QM_{41} + 0.234\ QM_{42} - 0.300\ QM_{43} - 0.130\ ER_{46} + 0.149\ ER_{53}$$

Regression diagnostic output is provided in Table 25.

Table 25. *Regression Diagnostic Output for Q3*

Predictor	*Coef*	*SE Coef*	*T*	*P*	*VIF*
Constant	0.4366	0.3862	1.13	0.261	
32	0.35461	0.09389	3.78	0.000	2.699
9	0.25205	0.09055	2.78	0.007	2.144
17	0.29264	0.09176	3.19	0.002	2.156
3	0.30787	0.07811	3.94	0.000	1.855
4	-0.35206	0.09000	-3.91	0.000	2.238
29	-0.27667	0.07597	-3.64	0.000	1.878
23	0.35908	0.08505	4.22	0.000	2.236
39	0.17191	0.08545	2.01	0.047	1.959
41	-0.3260	0.1046	-3.12	0.002	2.619
46	-0.13044	0.06505	-2.01	0.048	1.580
16	-0.4067	0.1033	-3.94	0.000	3.095
53	0.14903	0.07018	2.12	0.037	1.625
40	0.3507	0.1085	3.23	0.002	2.787
43	-0.2997	0.1101	-2.72	0.008	2.915
42	0.23448	0.09898	2.37	0.020	3.005
35	0.22164	0.08489	2.61	0.011	2.162

S = 0.527977   R-Sq = 70.1%   R-Sq(adj) = 63.2%
PRESS = 36.5762   R-Sq(pred) = 52.20%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	16	52.8250	3.3016	11.84	0.000
Residual Error	85	23.6946	0.2788		
Total	101	76.5196			

Discussion

The p-values of the predictor variables are all < .05; likewise the p-value for the multiple linear regression as indicated in the ANOVA is 0.001. These values indicate predictive capability within a 95% confidence level. In addition, each VIF value is < 5 which indicates a sufficiently low correlation amongst predictor variables. The R-sq (adj) value is 63.2%, which indicates this multiple linear regression model explains 63.2% of the data. This is considered an overall good fit of this data set.

Model Validation

The model's residuals plots depicted in Figure 23 were examined to determine the validity of the final model.

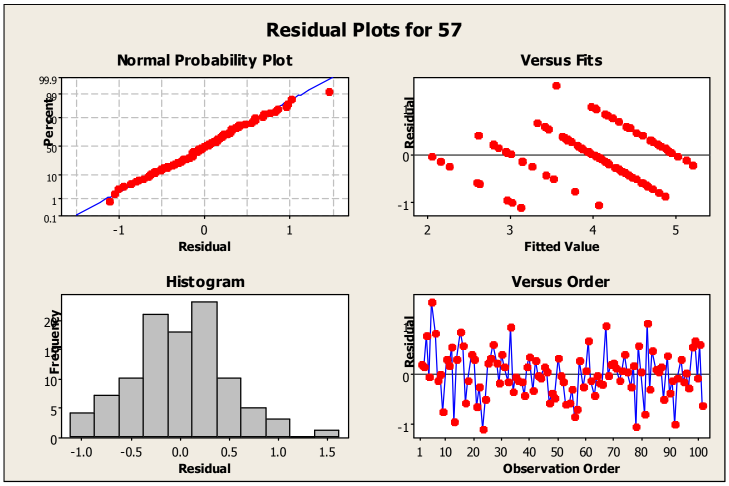


Figure 23. Residual Plots for Customer Satisfaction Performance, Q3

Explanation and Interpretation of Graphs Used to Validate Model

In this case, the Residuals vs. Fitted value graph is examined and there are no significant outliers. This graph reveals the anticipated pattern due to the 1-5 response boundary imposed by the survey instrument. Additionally, homoscedasticity and independence assumptions appear to be valid since there do not appear to be major differences in the variability of the residuals for different values of X_i. Thus, it can be concluded that for this fitted model, there is no violation of the assumption of equal variance at each level X_i. Also, the Normality Probability Plot appears to confirm the assumption of normality since the graph approximately depicts a straight line. Likewise the Histogram Plot is mostly characterized by a normal curve, which provides further graphical evidence of normality. Therefore, the Gaussian simple linear regression is adequate. Thus, there is aptness of fit and no assumptions of regression have been violated.

Factors That Explain Greater Than 70% of Data's Variance

An analysis of the independent variables that significantly contribute to the multiple regression model for dependent variable, customer satisfaction performance, Q3 determined PM_3, $PM_{4,}$ PM_9, MC_{17}, and CF_{32}, account for 71.8% of the model. Statistical evidence summarized in Figure 24 and Table 26 supports the inclusion of these product quality management practices in the NTV scorecard design.

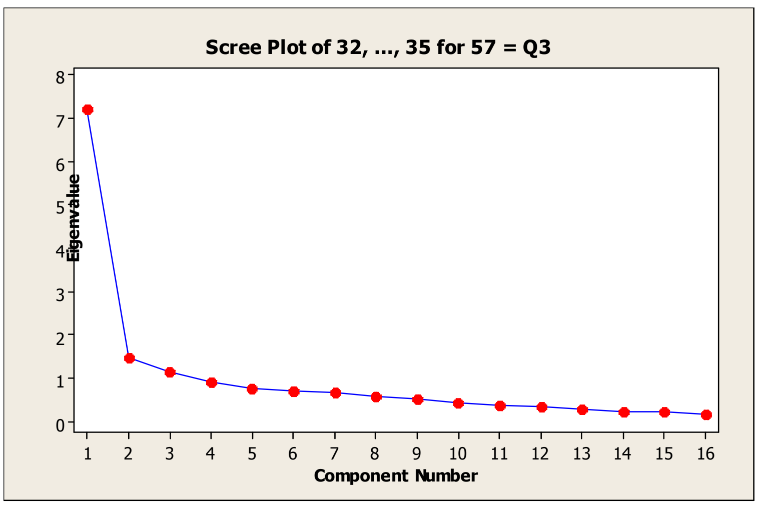


Figure 24. Residuals Plots for Product Performance, Q3

Table 26. *Eigenanalysis of the Correlation Matrix for Q3*

Eigenanalysis of the Correlation Matrix								
Eigenvalue	7.2132	1.4594	1.1352	0.9043	0.7709	0.7056	0.6668	0.5722
Proportion	0.451	0.091	0.071	0.057	0.048	0.044	0.042	0.036
Cumulative	0.451	0.542	0.613	0.670	0.718	0.762	0.803	0.839
Eigenvalue	0.5183	0.4266	0.3809	0.3508	0.2784	0.2314	0.2162	0.1697
Proportion	0.032	0.027	0.024	0.022	0.017	0.014	0.014	0.011
Cumulative	0.872	0.898	0.922	0.944	0.961	0.976	0.989	1.000
32, 9, 17, 3, and 4 account for 71.8% of the model.								

Interactions

The test for interactions was run to determine if any of the predictor variables influenced other variables in a statistically significant manner. The results are reported in Tables 27, 28, and 29. Interactions were only for extracted predictors that explained greater than 70% of the data's variance. This was done for each of the quality measures denoted as Q1, Q2, and Q3 in equations 3, 4, and 5, respectively.

Summary of Performance Management Practices Extracted

The determination of factors or performance management practices that would be incorporated into the scorecard was based on those that explained greater than 70% of the model with statistically insignificant interactions. The interactions were tested for these extracted predictors and results indicate interactions are statistically insignificant. In sum, the following factors were extracted and will be incorporated into the scorecard:

1. NTV processes of other organizations (e.g., competitors) are benchmarked.
2. Statistical methods (e.g., control charts, variation analysis, etc.) are used to control the NTV process.
3. NTV process defects are thoroughly analyzed.
4. NTV process reuse is emphasized.
5. Top management allocates necessary personnel resources for quality improvement.
6. Top NTV management provides the leadership to create an overall quality culture.
7. Specific quality related work skills training are provided for NTV personnel.
8. Quality-related training is provided for NTV personnel.
9. Statistical techniques (e.g., control charts, variation analysis, etc.) are emphasized in quality-related educational programs.

Table 27. *Interactions Insignificant for Extracted Predictors, Q1*

ANOVA: Two-Factor With Replication

SUMMARY	Value	Response Q1	Total
Predictor 3			
Count	102	102	204
Sum	403	381	784
Average	3.9510	3.7353	3.8431
Variance	0.8392	0.7906	0.8226
Predictor 4			
Count	102	102	204
Sum	398	381	779
Average	3.9020	3.7353	3.8186
Variance	0.7626	0.7906	0.7797
Predictor 11			
Count	102	102	204
Sum	404	381	785
Average	3.9608	3.7353	3.8480
Variance	0.7113	0.7906	0.7600
Predictor 15			
Count	102	102	204
Sum	394	381	775
Average	3.8627	3.7353	3.7990
Variance	0.8523	0.7906	0.8215
Predictor 23			
Count	102	102	204
Sum	391	381	772
Average	3.8333	3.7353	3.7843
Variance	0.8531	0.7906	0.8202
Total			
Count	510	510	
Sum	1990	1905	
Average	3.9020	3.7353	
Variance	0.7998	0.7844	

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Predictor	0.6176	4	0.1544	0.1937	0.9417	2.3807
Value	7.0833	1	7.0833	8.8858	0.0029	3.8507
Interaction	0.6176	4	0.1544	0.1937	0.9417	2.3807
Within	805.1275	1010	0.7972			
Total	813.4461	1019				

Since Calculated F = 0.1937 < F crit = 2.3807 Interactions *not* significant

Table 28. *Interactions Insignificant for Extracted Predictors, Q2*

ANOVA: Two-Factor With Replication

SUMMARY	Value	Response Q2	Total
Predictor 3			
Count	102	102	204
Sum	403	397	800
Average	3.9510	3.8922	3.9216
Variance	0.8392	0.9288	0.8805
Predictor 11			
Count	102	102	204
Sum	404	397	801
Average	3.9608	3.8922	3.9265
Variance	0.7113	0.9288	0.8172
Predictor 12			
Count	102	102	204
Sum	413	397	810
Average	4.0490	3.8922	3.9706
Variance	0.6807	0.9288	0.8070
Predictor 13			
Count	102	102	204
Sum	382	397	779
Average	3.7451	3.8922	3.8186
Variance	0.9641	0.9288	0.9472
Predictor 21			
Count	102	102	204
Sum	406	397	803
Average	3.9804	3.8922	3.9363
Variance	0.6927	0.9288	0.8087
Total			
Count	510	510	
Sum	2008	1985	
Average	3.9373	3.8922	
Variance	0.7819	0.9215	

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Sample	2.6529	4	0.6632	0.7773	0.5400	2.3807
Columns	0.5186	1	0.5186	0.6078	0.4358	3.8507
Interaction	2.6529	4	0.6632	0.7773	0.5400	2.3807
Within	861.7549	1010	0.8532			
Total	867.5794	1019				

Since Calculated F = 0.7773 < F crit = 2.3807 Interactions *not* significant

Table 29. *Interactions Insignificant for Extracted Predictors, Q3*

ANOVA: Two-Factor With Replication

SUMMARY	Value	Response Q 3	Total
Predictor 3			
Count	102	102	204
Sum	403	401	804
Average	3.9510	3.9314	3.9412
Variance	0.8392	0.7576	0.7946
Predictor 4			
Count	102	102	204
Sum	398	401	799
Average	3.9020	3.9314	3.9167
Variance	0.7626	0.7576	0.7566
Predictor 9			
Count	102	102	204
Sum	405	401	806
Average	3.9706	3.9314	3.9510
Variance	0.7219	0.7576	0.7365
Predictor 17			
Count	102	102	204
Sum	400	401	801
Average	3.9216	3.9314	3.9265
Variance	0.7067	0.7576	0.7286
Predictor 32			
Count	102	102	204
Sum	395	401	796
Average	3.8725	3.9314	3.9020
Variance	0.8450	0.7576	0.7982
Total			
Count	510	510	
Sum	2001	2005	
Average	3.9235	3.9314	
Variance	0.7702	0.7517	

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Sample	0.3078	4	0.0770	0.1004	0.9823	2.3807
Columns	0.0157	1	0.0157	0.0205	0.8863	3.8507
Interaction	0.3078	4	0.0770	0.1004	0.9823	2.3807
Within	774	1010	0.7663			
Total	774.6314	1019				

Since Calculated F = 0.1004 < F crit = 2.3807 Interactions *not* significant

10. Quality metrics are emphasized in quality-related educational programs.
11. Customer requirements are completely elicited in developing NTV process.
12. Surveys are employed to assess customer satisfaction with the new technology product.
13. Customer requirements are traced and referred back to throughout the NTV process development process.
14. Data regarding quality are collected.
15. Top management assumes responsibility for quality performance.

Mean Differences in Responses of Job Rank Variables Compared

It was of interest to know if the mean responses to the NTV PQMI varied by job rank. Descriptive statistics for job rank are depicted in Table 30.

Table 30. *Rank in the New Technology Development Department*

"My rank in the new technology development department is/was:"

#	Answer		Response	%
1	Top Manager		31	30%
2	Middle Manager		35	34%
3	Lead engineer		24	24%
4	Non-manager (e.g., engineer)		19	19%
5	Other		7	7%

The repeated measures or paired t-test was conducted on the demographic job rank measures. This test analyzes the difference between the means of two groups when the sample data are obtained from populations that are related; when results of the first group are not independent of the second group. This "dependence" characteristic of the two groups occurs either because the items or individuals are paired (or matched) according to some characteristic or because repeated measurements are obtained from the same set of items or individuals. It is this latter scenario that is indicative of the present study. Note that in either case, the variable of interest is the difference between the values of the observations. Recall the demographic measures that were compared using the paired t-test in the present study were Q_{58} = Job Rank at the time the respondent was engaged in the new technology venture under study. Four job rankings were identified plus an "other" category. These were top manager = 1; middle manager = 2; lead engineer = 3; non-manager = 4; and other = 5.

The t-test for the mean difference in related samples has the following hypothesis:

$H_0: \mu_D = 0$ where $\mu_D = \mu - \mu_1$

$\mu_D = \mu - \mu_2$

$\mu_D = \mu - \mu_3$

$\mu_D = \mu - \mu_4$

$\mu_D = \mu - \mu_5$

$H_a: \mu_D \neq 0$

For means comparisons by job rank measures 1, 2, 3, 4, and 5 with P-value > .05 indicate there is no statistically significant difference. Table 31 depicts the results of the paired t-tests mean responses compared to five job rank subsets:

The results for the means comparisons paired t-tests indicate significant differences in the mean responses by job rank.

Table 31. *Mean Responses Compared to Mean Responses of Job Rank*

t-Test: Paired Two Sample for Means By "Experienced As"		
	Mean Responses	Mean Responses of Top Mgr
Mean	3.89	4.04
Variance	0.019	0.02
Observations	57	57
Pearson Correlation	0.669	
Hypothesized Mean Difference	0	
df	56	
t Stat	-10.889	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two tail	0.00	
t Critical two-tail	2.00	
	Mean Responses	Mean Responses of Middle Mgt
Mean	3.89	4.04
Variance	0.019	0.02
Observations	57	57
Pearson Correlation	0.669	
Hypothesized Mean Difference	0	
df	56	
t Stat	-10.889	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two tail	0.00	
t Critical two-tail	2.00	
t-Test: Paired Two Sample for Means By "Experienced As"		
	Mean Responses	Mean Responses of Lead Egr
Mean	3.89	4.04
Variance	0.019	0.02
Observations	57	57
Pearson Correlation	0.669	
Hypothesized Mean Difference	0	
Df	56	
t Stat	-10.889	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two tail	0.00	
t Critical two-tail	2.00	

Table 31—Continued

t-Test: Paired Two Sample for Means By “Experienced As”		
	Mean Responses	Mean Responses of Non-Engineers
Mean	3.89	4.04
Variance	0.010	0.06
Observations	57	57
Pearson Correlation	0.60	
Hypothesized Mean Difference	0	
Df	56	
t Stat	-5.53	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two tail	0.00	
t Critical two-tail	2.00	
	Mean Responses	Mean Responses of Other
Mean	3.89	3.95
Variance	0.01	0.028
Observations	57	57
Pearson Correlation	0.74	
Hypothesized Mean Difference	0	
Df	56	
t Stat	-4.32	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two tail	0.00	
t Critical two-tail	2.00	

Mean of “Experienced As” Variables Compared

It was of interest to know if the mean responses to the NTV PQMI varied by the level of experience respondents had. Descriptive statistics for level of experience are depicted in Table 32.

Table 32. *Experience Levels of Respondents*

"I am experienced in the following positions during the time covered by this survey:"

#	Answer		Response	%
1	Upper Management		19	19%
2	Project Management		31	30%
3	Quality Management		18	18%
4	Quality Engineer		23	23%
5	Other		11	11%
	Total		102	100%

A second set of paired t-tests was conducted using the mean responses compared to the responses by "experienced as." The demographic measures that were compared using the paired t-test were "experienced as" at the time the respondent was engaged in the new technology venture under study. Four job rankings plus an "other" category were: upper manager = 1; project manager = 2; quality manager = 3; quality engineer = 4; and other = 5.

The t-test for the mean difference in related samples has the following hypothesis:

H_0: $\mu_D = 0$ where $\mu_D = \mu - \mu_1$

$\mu_D = \mu - \mu_2$

$\mu_D = \mu - \mu_3$

$\mu_D = \mu - \mu_4$

$\mu_D = \mu - \mu_5$

H_a: $\mu_D \neq 0$

For means compared to the experienced as job rank measures 1, 2, 3, 4, and 5; a P-value > .05 indicates there is no statistically significant difference. Table 33 depicts the results of the paired t-tests for mean responses compared to "experienced as."

Table 33. *Mean Responses Compared to Responses of "Experienced As"*

t-Test: Paired Two Sample for Means By "Experienced As"		
	Mean Responses	Experienced Upper Managers
Mean	3.89	3.46
Variance	0.01	0.045
Observations	57	57
Pearson Correlation	0.50	
Hypothesized Mean Difference	0	
Df	56	
t Stat	17.56	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Mean Responses	Experienced Project Mgrs
Mean	3.86	3.76
Variance	0.01	0.069
Observations	57	57
Pearson Correlation	0.37	
Hypothesized Mean Difference	0	
Df	56	
t Stat	3.87	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 33—Continued

t-Test: Paired Two Sample for Means By “Experienced As”	Mean Responses	Experienced Quality Mgrs
Mean	3.89	3.97
Variance	0.01	0.021
Observations	57	57
Pearson Correlation	0.747	
Hypothesized Mean Difference	0	
Df	56	
t Stat	-6.19	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Mean Responses	Experienced as Quality Engineer
Mean	3.89	4.07
Variance	0.01	0.018
Observations	57	57
Pearson Correlation	0.59	
Hypothesized Mean Difference	0	
Df	56	
t Stat	-12.34	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.672	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Mean Responses	Experienced as Other
Mean	3.89	4.00
Variance	0.01	0.05
Observations	57	57
Pearson Correlation	0.42	
Hypothesized Mean Difference	0	
Df	56	
t Stat	-4.31	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

The results for the means comparisons paired t-tests indicate significant differences in the mean responses by experience.

Mean Responses Compared to Mean Responses by Years of Experience

It was of interest to know if the mean responses to the NTV PQMI varied by years of experience. Descriptive statistics for years of experience are provided in Table 34.

Table 34. *Respondents' Number of Years of Experience*

"I have the following total number of years experience in new technology venture arenas."

#	Answer		Response	%
1	3 to 5 years		37	36%
2	5 to 10 years		42	41%
3	More than 10 years		23	23%
	Total		102	100%

The repeated measures or paired t-test was conducted on the demographic years of experience measures. The demographic measures that were compared using the paired t-test is the number of years of experience at the time the respondent was engaged in the new technology venture under study. Three years of experience categories were delineated. These were 3 to 5 years = 1; 5 to 10 years = 2; More than 10 years = 3.

The test was conducted using the mean responses compared to the years of experience subset under examination. The t-test for the mean difference in related samples has the following hypothesis:

$H_0: \mu_D = 0$ where $\mu_D = \mu - \mu_1$

$\mu_D = \mu - \mu_2$

$\mu_D = \mu - \mu_3$

$H_a: \mu_D \neq 0$

For means comparisons of years of experience measures 1, 2, and 3, with P-value >.05 indicate no statistically significant difference for the paired t-test. Table 35 depicts the results of the paired t-tests for mean responses compared by “years of experience.”

Results for the means comparisons paired t-tests indicate significant differences in the mean responses by “years of experience.”

Interpretation of Statistical Differences in Means

The paired t-tests indicate responses by job rank (e.g., top manager, middle manager, lead engineer, non-engineer, and "other"), and by “experienced as” (e.g., experienced as upper manager, project manager, quality manager, quality engineer and "other"), as well as by years of experience (e.g., 3 to 5 years, 5 to 10 years, and more than 10 years) indicated statistically significant differences in means. This is likely due to the criteria established by former research experts and followed in the present study. In particular, the extensive experience requirement. Only those NTV managers with at least three years of experience within the last five years were asked to complete the survey. Additionally, the types of industries included in this research were purposefully broad and diverse. These criteria were an integral part of the research objectives; to determine if this highly heterogeneous sector would nevertheless confirm a common core of product quality management practices (O’Connor & De Martino, 2006; O’Connor et al., 2008;

Kelley, 2009). If so, then these product quality management practices would be incorporated into a scorecard.

Table 35. *Mean Responses Compared to Mean Responses by Years of Experience*

t-Test: Paired Two Sample for Means By Years of Experience		
	Variable means	3-5 yrs
Mean	3.89	3.85
Variance	0.01	0.01
Observations	57.00	57.00
Pearson Correlation	0.62	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	3.32	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	5 to 10 yrs
Mean	3.89	4.00
Variance	0.01	0.02
Observations	57.00	57.00
Pearson Correlation	0.80	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-9.57	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	> 10 yrs
Mean	3.89	3.73
Variance	0.01	0.03
Observations	57.00	57.00
Pearson Correlation	0.76	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	9.88	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

In addition, evidence supports the nature of new technology venture organizations as managed by highly experienced, well-trained personnel charged with making rapid-fire decisions of weighty importance (Sathe, 1989; Peters, 1994; Tushman & O'Reilly, 1997; Antonicic & Hirsch, 2001, 2004; Morris & Kuratko, 2002). With an average number of years of NTV experience of nearly 8 years, such personnel tend to have high levels of education and specialized training. Therefore, it is anticipated that these NTV managers have broad levels of quality training and undergone CPI indoctrination for many years that was industry-specific.

The above schema used to examine the first three demographics—by job rank, “experienced by,” and “years of experience”—will be used to examine the remaining ones. These are by industry, size of entire firm, size of NTV department, start-up or spin-off; gross annual sales of entire firm, annual budget of NTV department.

Descriptive statistics for by industry, size of entire firm, size of NTV department, gross annual sales of entire firm, annual budget of NTV department, and start-up or spin-off are tabularized in Tables 36, 38, 40, 42, 44, and 46, respectively. The paired t-test results for these same categories are provided in Tables 37, 39, 41, 43, 45, and 47, respectively

By Industry

Table 36. *NTV Departments by Industry*

"The NTV department that I used to complete this survey is best described by the following industry:

#	Answer		Response	%
1	Automotive, Aviation and Aerospace		11	11%
2	Biotechnology, Medical Devices, Genomics		4	4%
3	Pharmaceuticals		7	7%
4	Chemicals and Materials		7	7%
5	Manufacturing		38	37%
6	Computer Hardware and Networking		10	10%
7	Computer Software		7	7%
8	E-Commerce and Information Technology		6	6%
9	Consumer Goods		2	2%
10	Other		10	10%
	Total		102	100%

Table 37. *Mean Responses Compared to Means of Industry Responses*

t-Test: Paired Two Sample for Means
By Industry

	Variable means	Automotive, Aviation, Aerospace
Mean	3.89	3.78
Variance	0.01	0.04
Observations	57.00	57.00
Pearson Correlation	0.61	
Hypothesized Mean Difference	0.00	
Df	56.00	
t Stat	4.65	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 37—Continued

t-Test: Paired Two Sample for Means By Industry		
	Variable means	Biotechnology, Med Devices, Genomics
Mean	3.89	3.76
Variance	0.01	0.15
Observations	57.00	57.00
Pearson Correlation	0.33	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	2.66	
P(T<=t) one-tail	0.01	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.01	
t Critical two-tail	2.00	
	Variable means	Pharmaceuticals
Mean	3.89	3.76
Variance	0.01	0.10
Observations	57.00	57.00
Pearson Correlation	0.43	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	3.39	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	Chemicals & Materials
Mean	3.89	3.76
Variance	0.01	0.04
Observations	57.00	57.00
Pearson Correlation	0.26	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	4.81	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 37—Continued

t-Test: Paired Two Sample for Means
By Industry

	Variable means	Manufacturing
Mean	3.89	3.89
Variance	0.01	0.02
Observations	57.00	57.00
Pearson Correlation	0.80	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	0.05	
P(T<=t) one-tail	0.48	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.96	
t Critical two-tail	2.00	

	Variable means	Computer Hardware & Networking
Mean	3.89	4.20
Variance	0.01	0.05
Observations	57.00	57.00
Pearson Correlation	0.51	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-12.96	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

	Variable means	Computer Software
Mean	3.89	3.78
Variance	0.01	0.08
Observations	57.00	57.00
Pearson Correlation	0.55	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	3.28	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 37—Continued

t-Test: Paired Two Sample for Means By Industry		
	Variable means	E-Commerce & IT
Mean	3.89	3.89
Variance	0.01	0.09
Observations	57.00	57.00
Pearson Correlation	0.30	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-0.24	
P(T<=t) one-tail	0.41	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.81	
t Critical two-tail	2.00	
	Variable means	Consumer Goods
Mean	3.89	4.38
Variance	0.01	0.20
Observations	57.00	57.00
Pearson Correlation	0.12	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-8.34	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	Other
Mean	3.89	3.88
Variance	0.01	0.03
Observations	57.00	57.00
Pearson Correlation	-0.02	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	0.11	
P(T<=t) one-tail	0.45	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.96	
t Critical two-tail	2.00	

Interpretation by Industry

The paired t-tests indicate responses by industry (e.g., Automotive, Aviation and Aerospace; Biotechnology, Medical Devices, and Genomics; Pharmaceuticals; Chemicals and Materials; Manufacturing; Computer Hardware and Networking; Computer Software; E-Commerce and Information Technology; Consumer Goods, and "other"), indicated statistically significant differences in mean responses when compared to mean responses. This is likely due to the criteria established by former research experts and followed in the present study whereby a broad and diverse group was invited to participate in the study (O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009). This was done for the expressed purpose of determining if a common core of product quality management practices could be delineated from such a diverse group—which is the primary purpose of this research.

In addition, only experienced NTV managers who are managing the launch of new venture that offers significant benefits and/or significant reductions in cost—were invited to complete the survey (O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009). Evidence supports the nature of new technology venture organizations as characterized by distributed controls, with personnel from global search and with multidisciplinary expertise; integrated decision-making with a flat organizational structure; staff with distributed responsibilities that are milestone driven and may have direct financial incentives. This is indicative of strong core communalities. However, with an average number of years of NTV experience of nearly 8 years, such personnel tend to have high levels of education and specialized training. Therefore, it is anticipated that these NTV managers have broad levels of quality training and have undergone CPI indoctrination for many years that was industry-specific (Sathe, 1989; Peters, 1994; Tushman & O'Reilly, 1997; Antonicic & Hirsch 2001, 2004; Morris

& Kuratko, 2002; Jackson & Lloyd, 2006). Thus, these paired t-test results provide statistical evidence that is consistent with the literature.

By Size of Entire Firm

Table 38. *Size of Entire Firm (Number of Employees Worldwide)*

The following questions are regarding the size and nature of your firm and NTV department: The size of the entire firm (number of employees worldwide) is:

#	Answer		Response	%
1	less than 100		14	14%
2	101 to 1,000		23	23%
3	1,001 to 5,000		21	21%
4	5,001 to 10,000		14	14%
5	10,001 to 25,000		16	16%
6	25,001 to 50,000		5	5%
7	Greater than 50,000		8	8%
8	Other		1	1%
	Total		102	100%

Table 39. *Mean Responses Compared to Mean Responses by Size of the Company (Number of Employees Worldwide)*

t-Test: Paired Two Sample for Means
By Size of Company (Employees Worldwide)

	Variable means	Less than 100
Mean	3.89	4.01
Variance	0.01	0.04
Observations	57.00	57.00
Pearson Correlation	0.52	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-5.29	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 39—Continued

t-Test: Paired Two Sample for Means By Size of Company (Employees Worldwide)		
	Variable means	101-1000
Mean	3.89	3.82
Variance	0.01	0.03
Observations	57.00	57.00
Pearson Correlation	0.73	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	3.62	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	1001-5000
Mean	3.88	3.89
Variance	0.01	0.02
Observations	57.00	57.00
Pearson Correlation	0.47	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-0.13	
P(T<=t) one-tail	0.45	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.96	
t Critical two-tail	2.00	
	Variable means	5000-10K
Mean	3.89	4.14
Variance	0.01	0.03
Observations	57.00	57.00
Pearson Correlation	0.56	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-13.08	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 39—Continued

t-Test: Paired Two Sample for Means By Size of Company (Employees Worldwide)		
	Variable means	10001-25K
Mean	3.89	3.71
Variance	0.01	0.05
Observations	57.00	57.00
Pearson Correlation	0.56	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	6.65	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	25001-50K
Mean	3.89	3.73
Variance	0.01	0.14
Observations	57.00	57.00
Pearson Correlation	0.41	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	3.38	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	>50K
Mean	3.89	3.91
Variance	0.01	0.06
Observations	57.00	57.00
Pearson Correlation	0.12	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-0.80	
P(T<=t) one-tail	0.21	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.42	
t Critical two-tail	2.00	

Table 39—Continued

t-Test: Paired Two Sample for Means
By Size of Company (Employees Worldwide)

	Variable means	Other
Mean	3.89	3.21
Variance	0.01	0.85
Observations	57.00	57.00
Pearson Correlation	-0.15	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	5.42	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Interpretation of Statistical Differences in Means by Company Size

The paired t-tests indicate responses by size of the company as measured by the number of employees worldwide (e.g., less than 100; 101 to 1,000; 1,001 to 5,000; 10,001 to 25,000; 25,001 to 50,000; and “other”), indicated statistically significant differences in mean responses when compared to mean responses. This is likely due to the criteria established by former research experts and followed in the present study whereby a broad and diverse group was invited to participate in the study. In fact, care was taken to include a wide range of company sizes as an integral part of the design of experiment (O’Connor & De Martino, 2006; O’Connor et al., 2008; Kelley, 2009). This was done for the expressed purpose of determining if a common core of product quality management practices could be delineated from such a diverse group—which is the primary purpose of this research.

In addition, only experienced NTV managers who are managing the launch of new venture that offers significant benefits and/or significant reductions in cost—were invited to complete the survey (O’Connor & De Martino, 2006; O’Connor et al., 2008; Kelley, 2009).

Evidence supports the nature of new technology venture organizations as characterized by distributed controls, with personnel from global search and with multidisciplinary expertise; integrated decision-making with a flat organizational structure; staff with distributed responsibilities that are milestone driven and may have direct financial incentives. This is indicative of strong core communalities. However, with an average number of years of NTV experience of nearly 8 years, such personnel tend to have high levels of education and specialized training. Therefore, it is anticipated that these NTV managers have broad levels of quality training and have undergone CPI indoctrination for many years that was industry-specific (Sathe, 1989; Peters, 1994; Tushman & O'Reilly, 1997; Antonicic & Hirsch 2001, 2004; Morris & Kuratko, 2002; Jackson & Lloyd, 2006). Thus, these paired t-test results provide statistical evidence that is consistent with the literature (Sathe, 1989; Peters, 1994; Tushman & O'Reilly, 1997; Antonicic & Hirsch 2001, 2004; Morris & Kuratko, 2002; Jackson & Lloyd, 2006).

These paired t-test results provide statistical evidence that is consistent with the literature; NTV's are managed distinctly as a sector that transcends the size of the firm. The two exceptions are those respondents in firms with 5,001 to 10,000 and those with over 50,000 people worldwide. No statistically significant difference was computed for this category of responses, which were two of the largest sized firm. It may be hypothesized that once a firm gets so large, its NTV departments evolve differently from those in smaller firms. In particular, standardized operating procedures may be more firmly in place in larger firms. This would be consistent with the literature.

Size of NTV Department

Table 40. *Size of Entire NTV Department (Number of Employees Worldwide)*

The size of the entire NTV department (number of NTV team members worldwide) is:

#	Answer		Response	%
1	01-10		18	18%
2	11-25		11	11%
3	26-100		36	35%
4	101-500		26	25%
5	501-1,000		11	11%
	Total		102	100%

Statistic	Value
Min Value	1
Max Value	1000
Mean	145.2
Variance	50398
Standard Deviation	224.5
Total Responses	102

Table 41. *Mean Responses Compared to Size of NTV Department (Number of NTV Team Members Worldwide)*

t-Test: Paired Two Sample for Means by Size of NTV Department (Number of Team Members Worldwide)

	Variable means	1-10
Mean	3.89	3.94
Variance	0.01	0.02
Observations	57.00	57.00
Pearson Correlation	0.22	
Hypothesized Mean Difference	0.00	
Df	56.00	
t Stat	-2.68	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.01	
t Critical two-tail	2.00	

Table 41—Continued

t-Test: Paired Two Sample for Means by Size of NTV Department (Number of Team Members Worldwide)		
	Variable means	11-25
Mean	3.89	4.09
Variance	0.01	0.03
Observations	57.00	57.00
Pearson Correlation	0.03	
Hypothesized Mean Difference	0.00	
Df	56.00	
t Stat	-8.00	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	26-100
Mean	3.89	3.71
Variance	0.01	0.02
Observations	57.00	57.00
Pearson Correlation	0.78	
Hypothesized Mean Difference	0.00	
Df	56.00	
t Stat	14.19	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	101-500
Mean	3.89	3.90
Variance	0.01	0.04
Observations	57.00	57.00
Pearson Correlation	0.78	
Hypothesized Mean Difference	0.00	
Df	56.00	
t Stat	-1.04	
P(T<=t) one-tail	0.15	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.30	
t Critical two-tail	2.00	

Table 41—Continued

t-Test: Paired Two Sample for Means by Size of NTV Department (Number of Team Members Worldwide)		
	Variable means	501-1000+
Mean	3.89	4.12
Variance	0.01	0.07
Observations	57.00	57.00
Pearson Correlation	0.63	
Hypothesized Mean Difference	0.00	
Df	56.00	
t Stat	-8.15	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Interpretation of Statistical Difference in Means Department Size

The paired t-tests indicate responses by size of the NTV department as measured by the number of employees worldwide (e.g., 1 to 10; 11 to 25; 26 to 100; 501 to 1,000 or more), indicated statistically significant differences in mean responses when compared to mean responses. This is likely due to the criteria whereby a broad and diverse group was invited to participate in the study. In fact, care was taken to include a wide range of NTV department sizes as an integral part of the design of experiment (O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009). This was done for the expressed purpose of determining if a common core of product quality management practices could be delineated from such a diverse group—which is the primary purpose of this research.

The one exception computed from this data set was those respondents with NTV departments with over 101 to 500 people worldwide. No statistically significant difference was computed for this category of responses, which was the second to largest sized department category. It may be hypothesized that once an NTV department gets so large, its management practices evolve differently from smaller departments. In particular, these practices become more standardized. This would be consistent with the literature. However, note that the largest sized department category, 501 to 1,000 had statistically significant differences between mean responses as compared by NTV department size. Therefore, prudence would dictate that more evidence is needed to make any additional generalizations from these results.

Gross Annual Sales of Entire Firm

Table 42. *Gross Annual Sales of Entire Firm Worldwide*

Gross annual sales of the entire firm worldwide is:

#	Answer		Response	%
1	less than $1 million		13	13%
2	$1 million - $5 million		10	10%
3	$6 million - $50 million		26	25%
4	$51 million - $100 million		16	16%
5	$101 million - $500 million		14	14%
6	$501 million - $1 billion		9	9%
7	Over $1 billion		14	14%
	Total		102	100%

Table 43. *Mean Responses Compared by Gross Annual Sales of Entire Firm*

t-Test: Paired Two Sample for Means
by Gross Annual Sales of Entire Firm Worldwide

	Variable means	Less than $1Million
Mean	3.89	4.00
Variance	0.01	0.04
Observations	57.00	57.00
Pearson Correlation	0.51	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-5.15	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 43—Continued

t-Test: Paired Two Sample for Means
by Gross Annual Sales of Entire Firm Worldwide

	Variable means	$1M-$5M
Mean	3.89	3.74
Variance	0.01	0.04
Observations	57.00	57.00
Pearson Correlation	0.60	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	6.89	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

	Variable means	$6M-$50M
Mean	3.89	3.89
Variance	0.01	0.02
Observations	57.00	57.00
Pearson Correlation	0.64	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-0.45	
P(T<=t) one-tail	0.33	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.66	
t Critical two-tail	2.00	

	Variable means	$51M-$100M
Mean	3.89	3.80
Variance	0.01	0.05
Observations	57.00	57.00
Pearson Correlation	0.51	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	3.27	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 43—Continued

t-Test: Paired Two Sample for Means by Gross Annual Sales of Entire Firm Worldwide		
	Variable means	$101M-$500M
Mean	3.89	4.07
Variance	0.01	0.03
Observations	57.00	57.00
Pearson Correlation	0.48	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-9.18	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	$501M-$1B
Mean	3.89	3.80
Variance	0.01	0.07
Observations	57.00	57.00
Pearson Correlation	0.65	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	3.04	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	Variable means	Greater than $1Billion
Mean	3.89	3.84
Variance	0.01	0.03
Observations	57.00	57.00
Pearson Correlation	0.40	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	1.94	
P(T<=t) one-tail	0.03	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.06	
t Critical two-tail	2.00	

Interpretation of Statistical Differences in Means by Gross Annual Sales

The paired t-tests indicate responses by size of gross annual sales of entire firm worldwide (e.g., less than $1 million; $1 million to $5 million; $6 million to $50 million; $51 million to $100 million; $101 million to $500 million; $501 million to $1billion; and over $1 billion), indicated all but two categories had statistically significant differences when compared to mean responses. These data were captured purely as descriptive statistics so, generalizations prove difficult due to the fact that no data were captured to sufficiently characterize each firm through proper segmentation. For example, how much was spent on R&D compared to the firm's core revenue generating business; and when are NTV departments expected to provide a ROI; what is the net profit from sales by department, and so on? These and many more questions would have to be answered to adequately explain these data. And, the time required by survey respondents would disallow the opportunity to test systematic assessment of the NTV environment due to survey time-out concerns—which is the primary purpose of this research. A maximum of thirty minutes duration was the guideline used for this electronic survey. After that time, respondents tend to drop out (De Leeuw, 2005; Dillman, Smyth, & Christian, 2009). Therefore, it was decided that the bulk of the time spent by respondents would be devoted to responding to the first 57 questions. It was these responses that captured data to achieve the primary objectives of this study.

Questions relating to ROI, and business segmentation, and the like were not included as they were outside the scope of the study. It thereby makes interpretation of this demographic data difficult. In point of fact, the size of gross annual sales of entire firm worldwide was captured and provided purely as a descriptive statistic. This is consistent with the literature (Sousa et al., 2006; Cooper et al., 2007; Vitharana & Mone 2008; Fotopoulos & Psomas, 2009). Sousa, Fotopoulos, Vitharana, and Cooper along with their co-researchers conducted performance management practice research with sample sizes of 52, 107, 125, and 161, respectively. Study one of this research had a sample size of 100; study two, 151—which is consistent with the literature. In each case, this type of data was captured for purely descriptive statistics purposes.

Annual Budget of NTV Department

Table 44. *Annual Budget of NTV Department*

Annual Budget of NTV Department:

#	Answer		Response	%
1	less than $500,000		25	25%
2	$500,001 - $1 million		33	32%
3	$1 million - $5 million		32	31%
4	Greater than $5 million		12	12%
	Total		102	100%

Statistic	Value
Min Value	<.5
Max Value	>5
Mean	1.933
Variance	4.649
Standard Deviation	2.196
Total Responses	102

Table 45. *Mean Responses Compared by Annual Budget of NTV Department*

t-Test: Paired Two Sample for Means by Annual Budget of NTV Department		
	Variable means	Less than <$500K
Mean	3.89	3.88
Variance	0.01	0.02
Observations	57.00	57.00
Pearson Correlation	0.57	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	0.32	
P(T<=t) one-tail	0.38	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.75	
t Critical two-tail	2.00	
	Variable means	$500K-$1Million
Mean	3.89	3.92
Variance	0.01	0.03
Observations	57.00	57.00
Pearson Correlation	0.70	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-2.25	
P(T<=t) one-tail	0.01	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.03	
t Critical two-tail	2.00	
	Variable means	$1M-$5M
Mean	3.86	3.85
Variance	0.01	0.02
Observations	57	57
Pearson Correlation	0.81	
Hypothesized Mean Difference	0	
df	56	
t Stat	2.62	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.01	
t Critical two-tail	2.00	

Table 45—Continued

t-Test: Paired Two Sample for Means By Annual Budget of NTV Department		
	Variable means	More than >$5M
Mean	3.89	3.88
Variance	0.01	0.02
Observations	57	57
Pearson Correlation	0.23	
Hypothesized Mean Difference	0	
df	56	
t Stat	0.39	
P(T<=t) one-tail	0.35	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.69	
t Critical two-tail	2.00	

Interpretation of Statistical Differences in Means by Department Annual Budget

The paired t-tests indicate responses by size of annual budget of NTV department (e.g., less than $500,000; $500,001 to $1 million; $1 million to $5 million; greater than $5 million), indicated statistically significant differences when compared to mean responses. These data were captured purely as descriptive statistics so, generalizations prove difficult due to the fact that no data were captured to sufficiently characterize each firm through proper segmentation. For example, how much was spent on R&D compared to the firm's core revenue generating business; and when are NTV departments expected to provide a ROI; what is the net profit from sales by department, and so on? These and many more questions would have to be answered to adequately explain these data. And, the time required by survey respondents would disallow the opportunity to test systematic assessment of the NTV environment due to survey time-out concerns—which is the primary purpose of this research. A maximum of thirty minutes duration was the guideline used for this electronic survey. After that time, respondents tend to drop out (De Leeuw, 2005; Dillman et al., 2009). Therefore, it was decided that the bulk of the time spent by respondents would be devoted to responding to the first 57 questions. It was these responses that captured data to achieve the primary objectives of this study.

Questions relating to ROI, and business segmentation, and the like were not included as they were outside the scope of the study. It thereby makes interpretation of this demographic data difficult. In point of fact, the size of gross annual sales of entire firm worldwide was captured and provided purely as a descriptive statistic. This is consistent with the literature (Sousa et al., 2006; Cooper et al., 2007; Vitharana & Mone 2008; Fotopoulos & Psomas, 2009). Sousa, Fotopoulos, Vitharana, and Cooper along with their co-researchers conducted performance management practice research with sample sizes of 52, 107, 125, and 161, respectively. Study one of this research had a sample size of 100; study two, 151—which is consistent with the literature. In each case, this type of data was captured for purely descriptive statistics purposes.

By Start-Up or Spin-Off

Table 46. *Number of NTV Departments that Are/Were Start-Ups or Spin-Offs*

Your NTV is best characterized as a start-up (brand new firm) or a spin-off (part of a an existing firm)?

#	Answer		Response	%
1	Start-up		25	25%
2	Spin-off		77	75%
	Total		102	100%

Table 47. *Mean Responses Compared by Type of NTV; Start-Up vs. Spin-Off*

t-Test: Paired Two Sample for Means
By Start-up and Spin-Off

	Variable means	Start-up
Mean	3.89	3.99
Variance	0.01	0.02
Observations	57.00	57.00
Pearson Correlation	0.52	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-5.97	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

	Variable means	Spin-off
Mean	3.89	3.85
Variance	0.01	0.01
Observations	57.00	57.00
Pearson Correlation	0.93	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	5.97	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Interpretation of No Statistical Difference in Means by Type of NTV

The paired t-tests indicate responses by start-up vs. spin-off, indicated statistically significant differences when compared to mean responses. It may be hypothesized that start-ups and spin-offs evolve to different types of organizations; organizations with different perspectives on how best to manage product quality decisions. However, as mentioned in earlier sections, determining such fine distinctions is beyond the scope of this study. Importantly, it this study purposefully incorporated both start-ups and spin-offs in an attempt to verify that given any similarities or differences that exist between these two categories, could a common core of product quality management practices be delineated.

Significantly, these data were captured purely as descriptive statistics so, generalizations prove difficult due to the fact that no data were captured to sufficiently characterize each firm through proper segmentation. For example, how much was spent on R&D compared to the firm's core revenue generating business; and when are NTV departments expected to provide a ROI; what is the net profit from sales by department, and so on? These and many more questions would have to be answered to adequately explain these data. And, the time required by survey respondents would disallow the opportunity to test systematic assessment of the NTV environment due to survey time-out concerns—which is the primary purpose of this research. A maximum of thirty minutes duration was the guideline used for this electronic survey. After that time, respondents tend to drop out (De Leeuw, 2005; Dillman et al., 2009). Therefore, it was decided that the bulk of the time spent by respondents would be devoted to responding to the first 57 questions. It was these responses that captured data to achieve the primary objectives of this study.

Questions relating to ROI, and business segmentation, and the like were not included as they were outside the scope of the study. It thereby makes interpretation of this demographic data difficult. In point of fact, the size of gross annual sales of entire firm worldwide was captured and provided purely as a descriptive statistic. This is consistent with the literature (Sousa et al., 2006; Cooper et al., 2007; Vitharana & Mone 2008; Fotopoulos & Psomas, 2009). Sousa, Fotopoulos, Vitharana, and Cooper along with their co-researchers conducted performance management practice research with sample sizes of 52, 107, 125, and 161, respectively. Study one of this research had a sample size of 100; study two, 151—which is consistent with the literature. In each case, this type of data was captured for purely descriptive statistics purposes.

Future research may be employed to obtain evidence to further characterize the NTV sector and its actors.

Scorecard Development

How and Why Study One's Results Will Be Used

As discussed in the methods and procedures section, the balanced scorecard (BSC) originators acknowledged that the precise format of the scorecard was a business sector and/or company specific issue (Letza, 1996). Since that time, performance measurement researchers began devising both business sector as well as company specific balanced scorecards. The process to develop a business sector BSC mirrors the process that had been devised and refined by its originators and subsequent specialists (Kaplan & Norton 2001a, 2001b; Ahn, 2001; Akkermans & van Oorschot, 2005; Papalexandris et al., 2005; Burney & Swanson, 2010). A major task facing the performance measurement researcher is to determine the critical factors that impact the industry sectors' standard business unit (SBU).

As previously discussed, a study was conducted to identify the critical factors that drive product quality critical in the new technology venture environment. This study employed electronic survey methodology using a previously validated product quality management instrument that had been shown capable of determining the critical factors that drive quality. A model was built by measuring experienced new technology venture managers' perceptions of potential drivers of product quality using this instrument. It was these resultant critical factors that will be incorporated into the NTV *Product Quality Management* Balanced Scorecard. These factors, once in scorecard form, articulate the archetypal NTV measures for indigenous modification.

Scorecards developed for a specific business sector have been introduced as a way for individual firms to quickly adopt the effective balanced scorecard system. As early as 1993, Kaplan and Norton offered a balanced scorecard (BSC) template that was adopted by several collaborating firms as a way for them to quickly incorporate this tool after indigenous modification (Kaplan & Norton, 1993).

The BSC scorecard development process is depicted in Figure 25. This figure depicts the electronic survey's role as part of the NTV sector's scorecard development process. The survey accomplished steps 1, 2, and 3. Steps 4, 5, and 6 would be done indigenously.

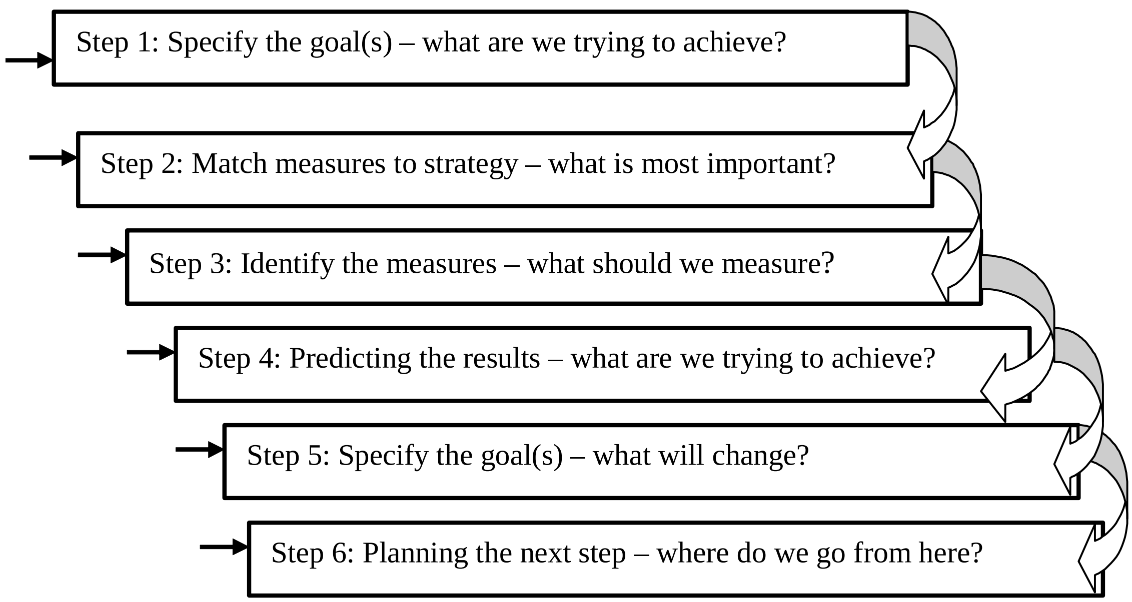


Figure 25. Scorecard Development: Six-Step Methodology (Vitale et al., 1994)

The Development of the NTV Product Quality Management Scorecard

The original perspective framework investigated by study one resulted in a reduction of the original six-prong model down to four. The resultant four quadrants are depicted in Figure

26. These quadrants will be populated by the performance management practices that explain more than 70% of the data's variance.

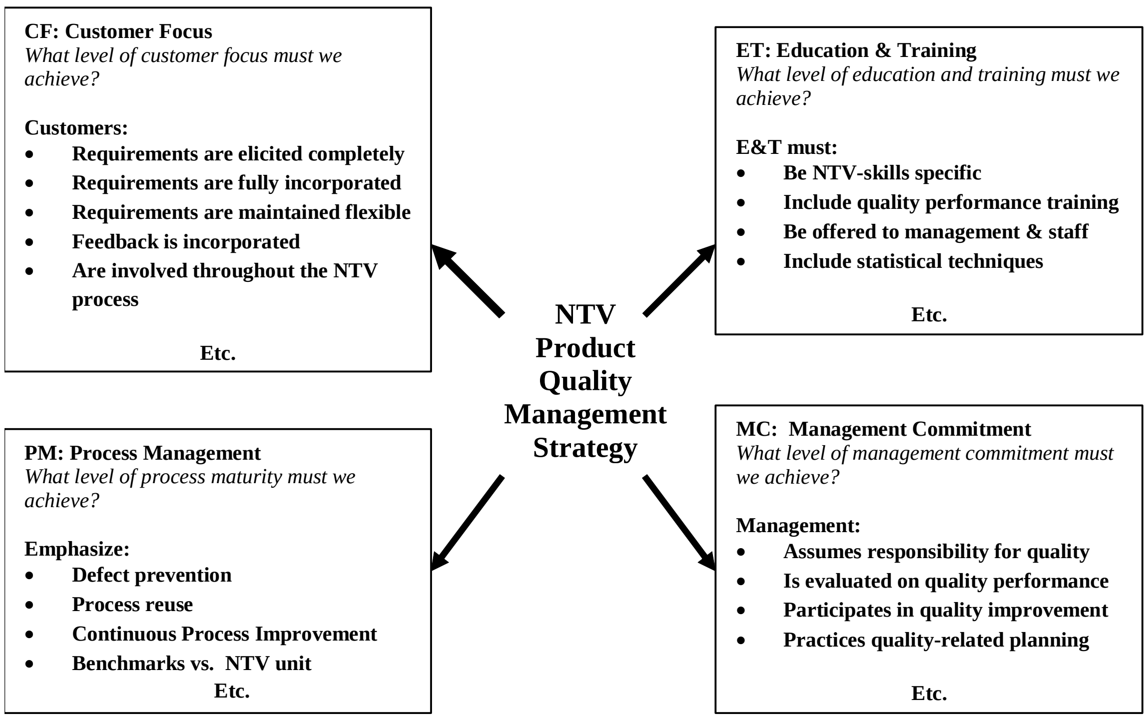


Figure 26. NTV Balanced Scorecard PQM Balanced Scorecard Perspective Framework

The Development of the Scorecard Using Statistically Significant Factors

Statistical analyses delineated in study one's results section determined which product quality management practices that accounted for most of the data's variation. Only those performance management practices that explained greater than 70% of the model will be incorporated into the scorecard. The following performance management practices will be converted into performance measures and incorporated into the scorecard:

1. NTV processes of other organizations (e.g., competitors) are benchmarked.
2. Statistical methods (e.g., control charts, variation analysis, etc.) are used to control the NTV process.
3. NTV process defects are thoroughly analyzed.
4. NTV process reuse is emphasized.
5. Top management allocates necessary personnel resources for quality improvement.
6. Top NTV management provides the leadership to create an overall quality culture.
7. Specific quality related work skills training are provided for NTV personnel.
8. Quality-related training is provided for NTV personnel.
9. Statistical techniques (e.g., control charts, variation analysis, etc.) are emphasized in quality-related educational programs.
10. Quality metrics are emphasized in quality-related educational programs.
11. Customer requirements are completely elicited in developing NTV process.
12. Surveys are employed to assess customer satisfaction with the new technology product.
13. Customer requirements are traced and referred back to throughout the NTV process development process.
14. Data regarding quality are collected.
15. Top management assumes responsibility for quality performance.

The derived fifteen items are depicted in Table 48. These were previously grouped in the following pre-defined domains: (1) customer focus, (2) employee training, (3) NTV process management, and (4) management commitment. These four domains were retained for the scorecard, which determined its **Perspective Framework**, the first of five key scorecard elements. Then, these domains were converted to project-level objectives using established procedures that were devised by recognized scorecard development experts (Kaplan & Norton, 2000, 2004, 2005; Niven, 2006; Keyes, 2011). These Objectives formed the second key element of the scorecard. Both the scorecard's Perspective Framework and Project-level Objectives are depicted in Table 49.

Product Quality Performance Practices Summarized by Category

Table 48. *Critical PQM Practices and Pre-Defined Constructs from Study One*

Critical *Factors* of Product Quality Management Practices	**Pre-Defined *Constructs***
1. Customer requirements are completely elicited in developing NTV process. 2. Customer requirements are traced and referred back to throughout the NTV process development. 3. Surveys are employed to assess customer satisfaction with the new technology product.	**Customer Focus**
4. Quality-related education is provided for NTV personnel. 5. Quality metrics are emphasized in quality-related educational programs. 6. Specific quality-related work-skills education is provided for NTV personnel. 7. Statistical methods (e.g., control charts, variation analysis, etc.) are emphasized in quality-related educational programs.	**Employee Training**
8. NTV process reuse is emphasized. 9. NTV process defects are thoroughly analyzed. 10. Statistical methods (e.g., control charts, variation analysis, etc.) are used to control the NTV process. 11. Data regarding quality are collected. 12. NTV processes of other organizations (e.g., competitors) are benchmarked.	**NTV Process Management**
13. Top management provides the leadership to create an overall quality culture. 14. Top management allocates necessary personnel resources for product quality improvement. 15. Top management assumes responsibility for quality performance.	**Management Commitment**

First and Second Key Scorecard Elements: Perspective Framework and Objectives

Table 49. *Scorecard with Perspective Framework and Objectives*

Perspective Framework	**Objectives**
Customer Focus	1. Institutionalize Customer Requirements Traceability (CRT) Program
Employee Training	2. Provide NTV Project Personnel that are Quality Trained
NTV Process Management	3. Institutionalize Quality Management Initiatives
Management Commitment	4.1 Top management provides leadership for overall quality culture
	4.2 Top management allocates necessary personnel resources

The original derived items were stated as product quality management practices and had to be converted to key performance measures or indicators. For example, “Surveys are employed to assess customer satisfaction with the new technology product” was converted to a measurable indicator—“Surveys Planned and Implemented.” A measurable indicator can be counted and tracked. Notably, a measurable indicator can be graphed (Kaplan & Norton, 2001b; Chenhall & Langfield-Smith, 2007); Agostino & Arnaboldi, 2012). In some instances, the item was revised after feedback from the panel of experts that was convened to establish face validity. For example, “Customer requirements are traced and referred back to throughout the NTV process development” was first used verbatim but after expert feedback was converted to, “Customer requirements are traced and used as basis for product development.” Here again, recognized procedures were followed (Letza 1996; Hitt et al., 1998; Otley, 1999; Kaplan & Norton, 2001a, 2001b; Davis & Albright, 2004; Papalexandris et al., 2005; Chenhall & Langfield-Smith, 2007; Agostino & Arnaboldi, 2012). Each of the original items was mapped into a Key Performance Indicators, which is the third key element of the scorecard.

Industry Experts Provide Input

The development of a business sector scorecard requires that industry experts be iteratively involved to establish the face and content validity of the scorecard elements and displays. This research accomplished the iterative process of the scorecard’s development by convening a panel of NTV sector experts to assess the initial scorecard. This panel was charged with evaluating the scorecard’s face and content validity to accomplish the iterative process depicted in Figure 27.

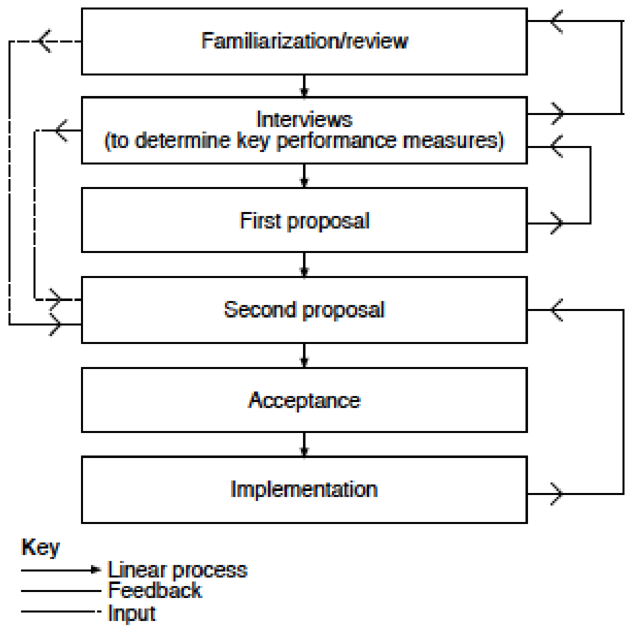


Figure 27. Iterations in Identifying Key Performance Measures for BSC (Letza, 1996)

The review process with the panel of experts was iterative; the first proposed scorecard, strategic views, and displays were e-mailed. Follow-up phone interviews were conducted and/or e-mailed feedback was provided. Then a second proposed scorecard, strategic views, and displays were e-mailed which garnered a mean of 5.2 (on a 6-point Likert scale) for face validity; a mean of 5.4 on content validity. Face validity was ranked for ease of use, clarity, and readability. Content validity was ranked on the representativeness and relevance of the scorecard elements and displays. To capture this information, the panel of experts scored an assessment, saved the document as a pdf file and e-mailed it back to the researcher. The assessment is depicted in Figure 28.

NTV *Product Quality Management*
Balanced Scorecard Usability Survey Assessment

Appearance							**Score**
» *The survey's appearance is*	*Completely Disagree*					*Completely Agree*	
1. Clearly laid out	1	2	3	4	5	6	
2. Readable	1	2	3	4	5	6	
3. Interpretable	1	2	3	4	5	6	
Perspective Framework							
» *How relevant is the Perspective Framework to Effectively Manage NTV Product Quality?*	*Completely Irrelevant*					*Completely Relevant*	
1. Customer Focus, Employee Training, NTV Process Management, Management Commitment	1	2	3	4	5	6	
» *How representative is the Perspective Framework to Effectively Manage NTV Product Quality?*	*Completely Unrepresentative*					*Completely Representative*	
2. Customer Focus, Employee Training, NTV Process Management, Management Commitment	1	2	3	4	5	6	
Objectives							
»*How relevant are the Objectives to Effectively Manage NTV Product Quality?*	*Completely Irrelevant*					*Completely Relevant*	
1. Refer to scorecard	1	2	3	4	5	6	
»*How representative are the Objectives to Effectively Manage NTV Product Quality?*	*Completely Unrepresentative*					*Completely Representative*	
2. Refer to scorecard	1	2	3	4	5	6	
Key Performance Indicators (KPI's)							
»*How relevant are the KPI's to Effectively Manage NTV Product Quality?*	*Completely Irrelevant*					*Completely Relevant*	
1. Refer to scorecard	1	2	3	4	5	6	
Key Performance Indicators (KPI's)							
»*How representative are the KPI's to Effectively Manage NTV Product Quality?*	*Completely Unrepresentative*					*Completely Representative*	
2. Refer to scorecard	1	2	3	4	5	6	
Strategy Map with Links							
»*How relevant is the Strategy Map with Links to Effectively Manage NTV Product Quality?*	*Completely Irrelevant*					*Completely Relevant*	
1. Refer to strategy map with links	1	2	3	4	5	6	
Strategy Map with Links							
»*How representative is the Strategy Map with Links to Effectively Manage NTV Product Quality?*	*Completely Unrepresentative*					*Completely Representative*	
2. Refer to strategy map with links	1	2	3	4	5	6	
Data Display							
»*How representative is the Data Display to Effectively Manage NTV Product Quality?*	*Completely Unrepresentative*					*Completely Representative*	
1. See Data Display – Aggregate View	1	2	3	4	5	6	
2. See Data Display – KPI View	1	2	3	4	5	6	

Figure 28. NTV Product Quality Management Balanced Scorecard Assessment

The panel convened to assess the survey, scorecard elements, and displays was comprised of two vice presidents (i.e., VP Global Innovation and VP Engineering and Technology), a Honeywell in Global Technology Management, the Executive Officer for the North American Advanced Manufacturing Research and Education Initiative (NAAMREI), an Engineering Manager of Honda Automotive's Bluetooth Technology, a Senior Design Engineer who specialized in rapid prototyping, among other qualified experts. Five industry and four academic experts were involved in this iterative process. The resultant scorecard narrative is depicted in Table 50, replete with NTV industry sector derived narratives of perspective framework, objectives, and key performance indicators (KPI's).

Third Key Scorecard Element: Key Performance Indicators

Table 50. *Scorecard with Perspective Framework, Objectives, and Key Performance Indicators*

Perspective Framework	**Objectives**	**Key Performance Indicators (KPI's)**
Customer Focus	1. Institutionalize Customer Requirements Traceability (CRT) Program	1.1 Surveys Planned and Surveys Administered 1.2 Customer Requirements Traced and used as basis for product development. 1.3 Cost of CRT Program as a % of Cost of Returns
Employee Training	2. Provide NTV Project Personnel that are Quality Trained	2.1 Quality Training Planned and Implemented 2.2 Cost of Quality Training as a % of Savings Due to Quality Training 2.3 Cost of Quality Training as a % of Planned Training Costs
NTV Process Management	3. Institutionalize Quality Management Initiatives	3.1 NTV Process Reuse Planned and Actual 3.2 Savings Due To Quality Initiatives as a % of Budgeted Engineering Design Rework 3.3 Competitors' Processes Benchmarked as a % of Planned
	4.1 Top management provides leadership for overall quality culture	4.1 Quality Initiatives Approved and Implemented
Management Commitment	4.2 Top management allocates necessary personnel resources	4.2.a Approved NTV Staffing Requisitions and Staff Hired 4.2.b NTV Staffing Requisitions Approved by Top Management as % of Requested by NTV Project Manager

Once the perspective framework, objectives, and key performance indicators were delineated and iteratively assessed by the NTV expert panel, the result was the final scorecard depicted in Table 51. It was this final scorecard that was subsequently assessed by NTV managers using the Scorecard Design and Evaluation Survey Instrument. Thus, it was anticipated study two's results will provide an archetypal narrative template for the NTV managers so they may devise appropriate targets and engage their personnel in actions that influence product quality.

Table 51. *Final NTV Product Quality Management Balanced Scorecard*

NTV *Product Quality Management*
Balanced Scorecard

Perspective Framework	Objectives	Key Performance Measures (KPI's)
Customer Focus	1. Institutionalize Customer Requirements Traceability (CRT) Program	1.1 Surveys Planned and Surveys Administered 1.2 Cost of Customer Requirements Traced and Used as Basis for Product Development 1.3 Cost of CRT Program as a % of Cost of Returns
Employee Training	2. Provide NTV Project Personnel that are Quality Trained	2.1 Quality Training Planned and Implemented 2.2 Cost of Quality Training as a % of Savings Due to Quality Training 2.3 Cost of Quality Training as a % of Planned Training Costs
NTV Process Management	3. Institutionalize Quality Management Initiatives	3.1 NTV Process Reuse Planned and Actual 3.2 Savings Due To Quality Initiatives as a % of Budgeted Engineering Design Rework 3.3 Competitors' Processes Benchmarked as a % of Planned
Management Commitment	4.1 Top management provides leadership for overall quality culture 4.2 Top management allocates necessary personnel resources	4.1 Quality Initiatives Approved and Implemented 4.2.a Approved Staffing Requisitions and Staff Hired 4.2.b Staffing Requisitions Approved by Top Management as % of Requested by NTV Project Manager

Developing the Fourth Key Element – Strategic View 1

Establish Relationship Between Measures and Strategic Views

The relationship between critical factors and quality performance measures must now be established using recognize procedures (Letza, 1996; Hitt et al., 1998; Otley, 1999; Kaplan & Norton, 2001a, 2001b; Davis & Albright, 2004; Papalexandris et al., 2005; Chenhall & Langfield-Smith, 2007; Agostino & Arnaboldi, 2012). This is accomplished in a strategic view known as a scorecard strategy map with links. The following are the four required steps to design a scorecard management system; step three is the strategic view known as strategy map with links (Kaplan & Norton, 2001b; Davis & Albright, 2004; Chenhall & Langfield-Smith, 2007):

1. Translate the vision into operational goals;
2. Communicate the vision and link it to individual or specific process performance;
3. Transform cause and effect into criteria based targets;
4. Have feedback, learn, and adjust the strategy accordingly.

The first two steps delineated above have been accomplished with the development of the narrative for perspective framework, objectives, and key performance indicators. The fourth element, strategy map with links is accomplished here using prescribed procedures designed by BSC experts (Kaplan & Norton, 2001b; Davis & Albright, 2004; Chenhall & Langfield-Smith, 2007).

Fourth Key Element – Strategic View 1; Strategy Map with Links

Once an effective perspective framework is established, a strategy map is devised. A strategy map can be constructed by integrating the six perspectives' results and collapsing appropriate constructs for reporting efficiency. Recognize too many measures tend to dilute the overall impact of a balanced scorecard and may cause implementation problems (Kaplan & Norton, 2001b; Davis & Albright, 2004; Chenhall & Langfield-Smith, 2007). Kaplan and Norton define strategy maps as: A visual representation of the cause-and-effect relationships among the components of an organization's strategy. Moreover, they stipulate that it is as big an insight to executives as the Balanced Scorecard itself. Strategy maps transform the constructs from intangible assets to tangible assets (Kaplan & Norton, 2001b). The NTV environment's mission, vision, strategies, and objectives are cascaded to the strategy map. The pre-study strategy map with links is depicted in Figure 29.

Vision: Construct a distinguished NTV department imbued with TQM/CMMI tenets to prepare a new technology venture product for the marketplace for the first time.

Mission: Cultivate a superior innovation culture
Provide a superb total quality management-learning environment
Highlight humanity as well as technology
Set a basis for the innovationÕs family future development
Achieve outstanding research and development gate criteria
Translate commercialization goals into effective department-level operational goal
Become a model among the firmÕs NTV commercialization departments

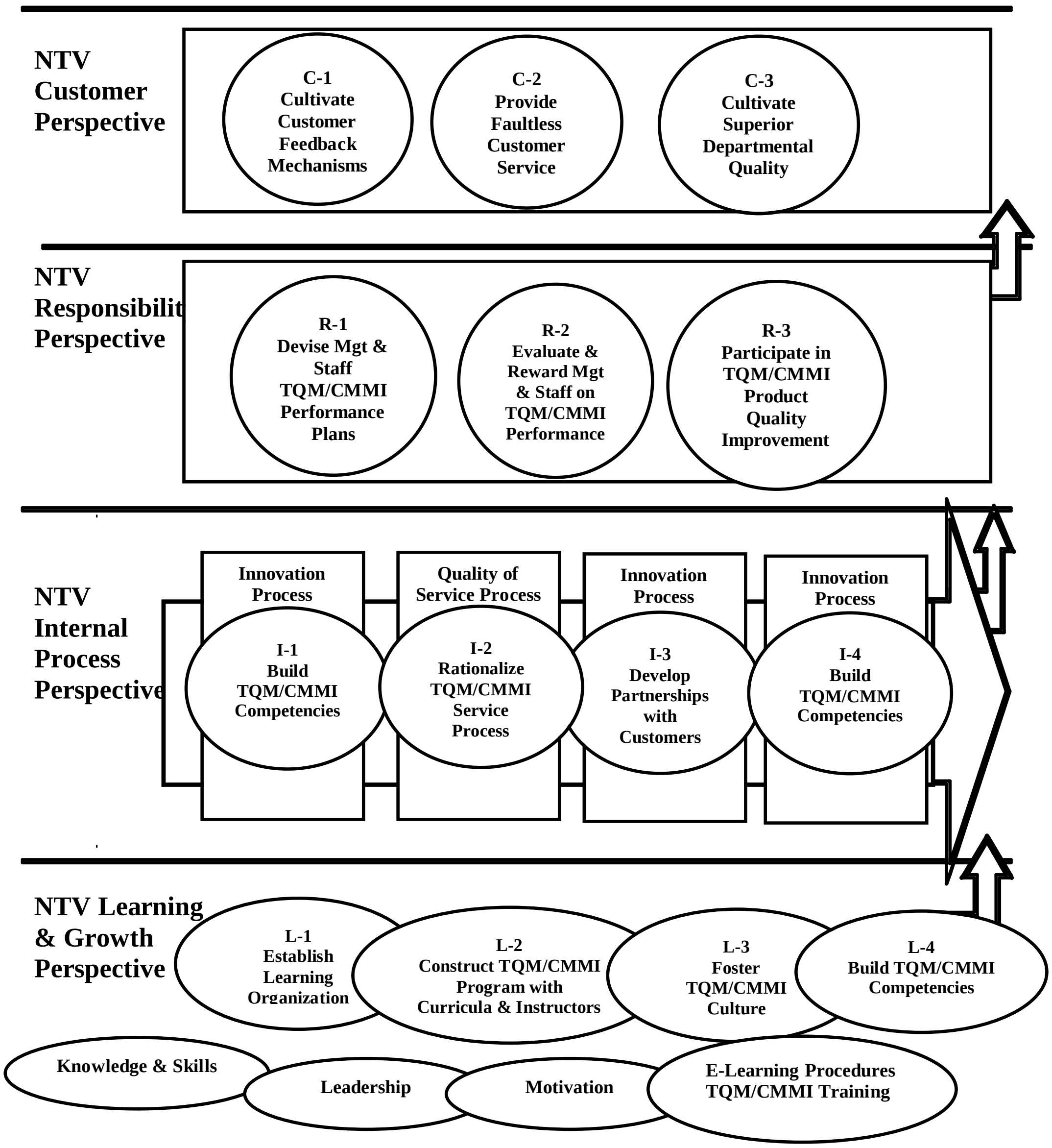


Figure 29. Pre-Study Two Strategy Map with Links for NTV Environment

Using results from study one along with input from the iterative review completed by the panel of NTV experts, the derived strategy map with links is depicted in Figure 30 (Kaplan & Norton, 2001b; Davis & Albright, 2004; Chenhall & Langfield-Smith, 2007).

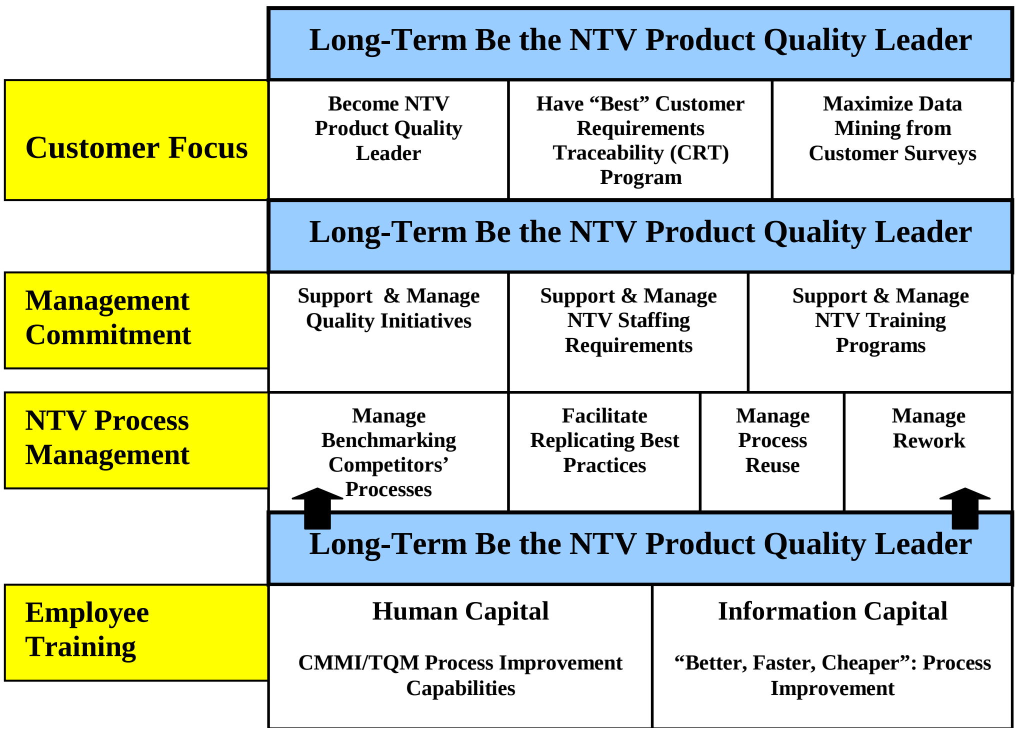


Figure 30. Final Strategic View 1: Strategy Map with Links

Development of the Fifth Key Element of Scorecard: KPI Displays

Because practicing, experienced NTV managers would evaluate the scorecard, care was taken to use a professional application to make the scorecard operational. The NTV Product Quality Management Scorecard was made operational using the recognized web-based application Quickscore™. The decision to use Quickscore™ was based on its (1) ease of use, (2) relative affordability, (3) professional appearance, (4) association with the Balanced

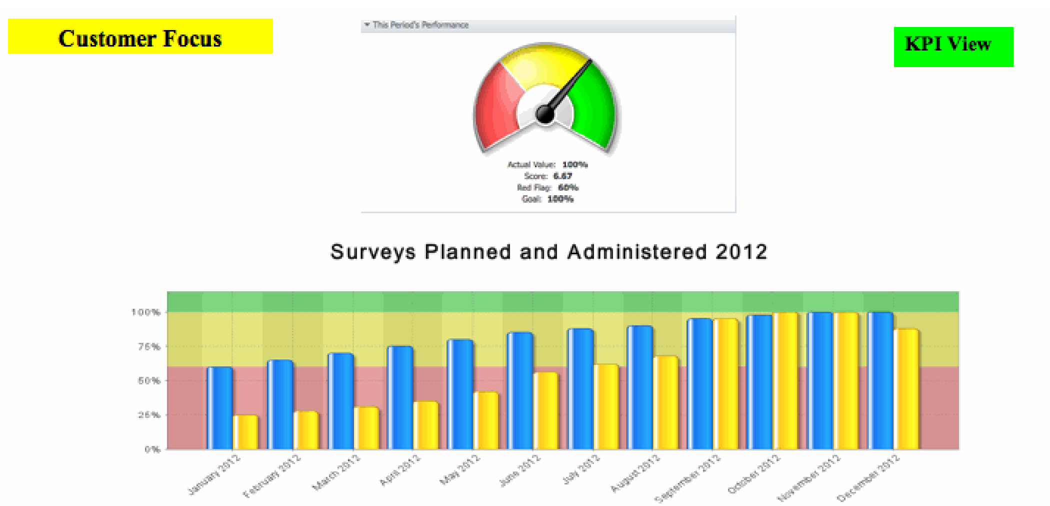
Scorecard Institute, and its (5) growing global clientele. (http://www.balancedscorecard.org/; http://www.spiderstrategies.com). Quickscore™ has web-based training videos available 24/7 plus extensive phone and downloadable document support. It is relatively affordable and can be purchased for as little as $99 per month, which makes it accessible, by small new-tech ventures. Its expert appearance was considered important for this study since all survey respondents worked in professional business environments. In addition, numerous large firms and government agencies such as IBM, Bank of America, Walmart, the Food and Drug Administration, Pitney Bowes, the United States Army, Starbucks Coffee, the United Nations, and Google, among others—as well as thousands of small to medium-sized firms, use Quickscore™.

All scorecard displays were designed within Quickscore™ and incorporated cognitive fit guidelines. Cognitive fit researchers stipulate the most effective multi-variate data displays in descending order are graphs, tables, and schematics (e.g., gauges) as evidenced by decision speed and accuracy (Moriarity, 1979; Stock & Watson, 1984; Kotovsky et al., 1985; MacKay & Villarreal, 1987; Nibblelin, Bailey, & Zmud, 1992; Narayan & Vessey, 1994; Khatri et al., 2006). The scorecard's KPI displays incorporated cognitive fit theory by using bar graphs and stacked bar graphs as principal components in its design. Each KPI had a bar graph, raw data table, and gauge for consistency; muted colors were chosen for simplicity. Both consistency and simplicity aid cognition (Tuffte, 2006; Few, 2006). Twelve KPI displays were designed. In total, these twelve KPI displays provide a ***graphical scorecard template*** for use by project-level NTV managers. The twelve KPI displays were based entirely on the performance management practices that had been converted into perspective framework, objectives, and key performance indicators. The panel of experts reviewed these twelve displays iteratively. The twelve KPI views comprise the fifth key element of the scorecard. A final view, entitled, aggregate view—depicts each KPI bar graph with a composite gauge in its appropriate quadrant. This aggregate view, after analysis, was grouped with strategic views of the NTV *Product Quality Management* Balanced Scorecard.

The scorecard's narrative inclusive of the (1) perspective framework, (2) objectives, (3) key performance indicators (KPI's) and (4) strategic views, and (5) KPI views and aggregate view—were developed for subsequent evaluation by experienced NTV managers in study two.

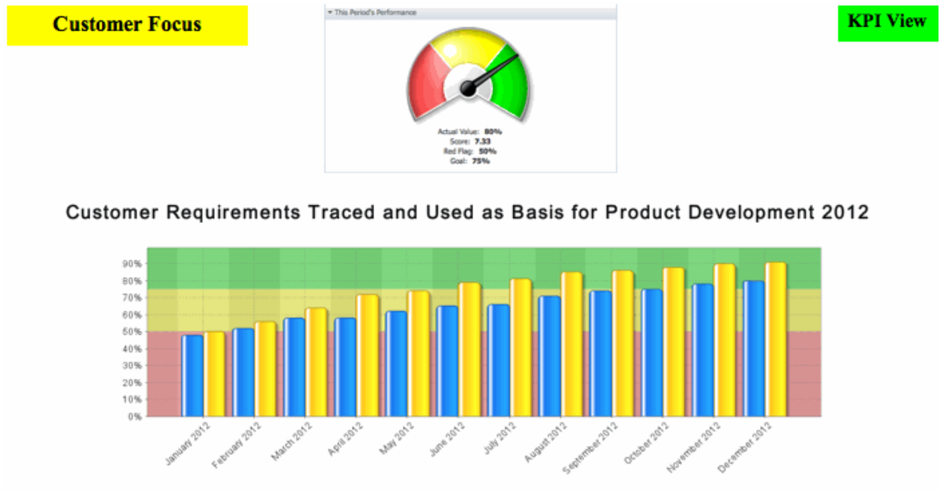
What follows are the twelve KPI views (Figures 31 through 42) and the aggregate view (Figures 43 and 44).

Fifth Key Element of Scorecard: Displays of KPI's



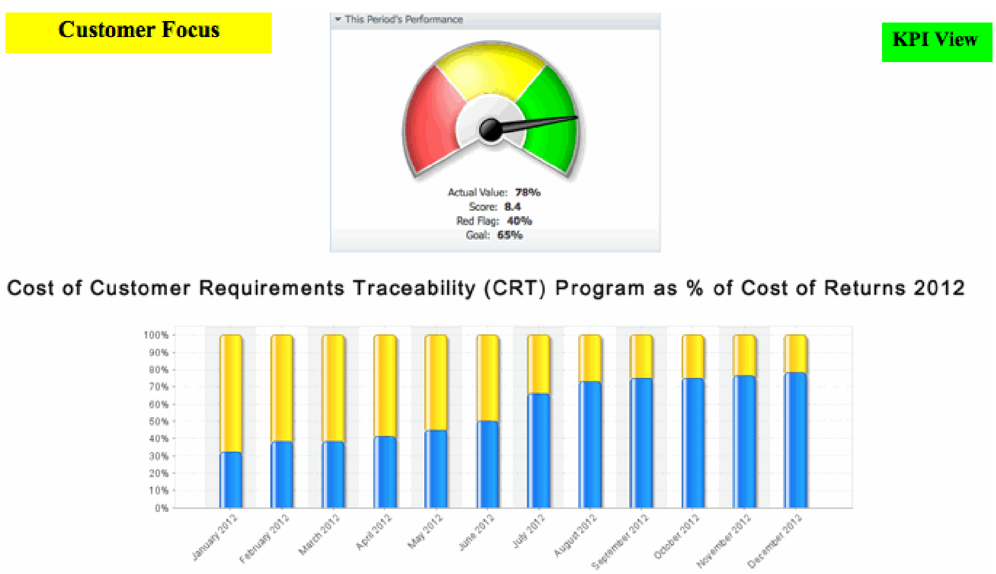
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	1.1.b. % Surveys Planned	Project	60%	65%	70%	75%	80%	85%	88%	90%	95%	98%	100%	100%
	1.1.a. % Surveys Administered	Project	25%	28%	31%	35%	42%	56%	62%	68%	95%	100%	100%	88%

Figure 31. Customer Focus KPI 1: Surveys Planned and Administered



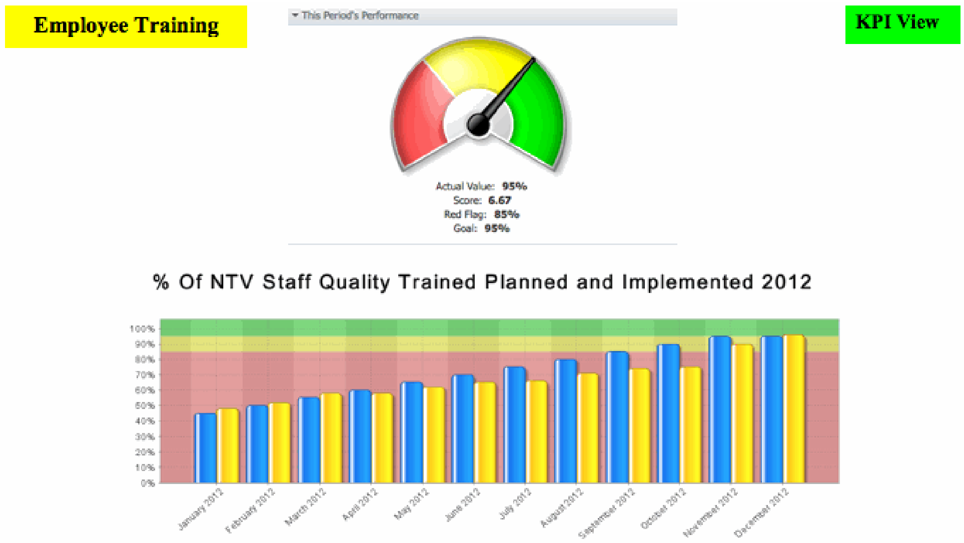
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	1.3.a. % Customer Requirements Traced	Project	48%	52%	58%	58%	62%	65%	66%	71%	74%	75%	78%	80%
	1.3.b. % Customer Requirements Used as Basis for Product Development	Project	50%	56%	64%	72%	74%	79%	81%	85%	86%	88%	90%	91%

Figure 32. Customer Focus KPI 2: Customer Requirements Traced and Used



Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	1.2.a. Cost of Customer Requirements Traceability Program as a % of	Project	32% (32%)	38% (38%)	38% (38%)	41% (41%)	45% (45%)	50% (50%)	66% (66%)	73% (73%)	75% (75%)	75% (75%)	76% (76%)	78% (78%)
	1.2.b. Projected Cost of Returns	Project	68% (68%)	62% (62%)	62% (62%)	59% (59%)	55% (55%)	50% (50%)	34% (34%)	27% (27%)	25% (25%)	25% (25%)	24% (24%)	22% (22%)

Figure 33. Customer Focus KPI 3: Cost of Customer Requirements Traceability (CRT)



Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	2.1.b % NTV Staff Quality Planned to be Trained	Project	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	95%
	2.1.a % NTV Staff Quality Trained	Project	48%	52%	58%	58%	62%	65%	66%	71%	74%	75%	90%	96%

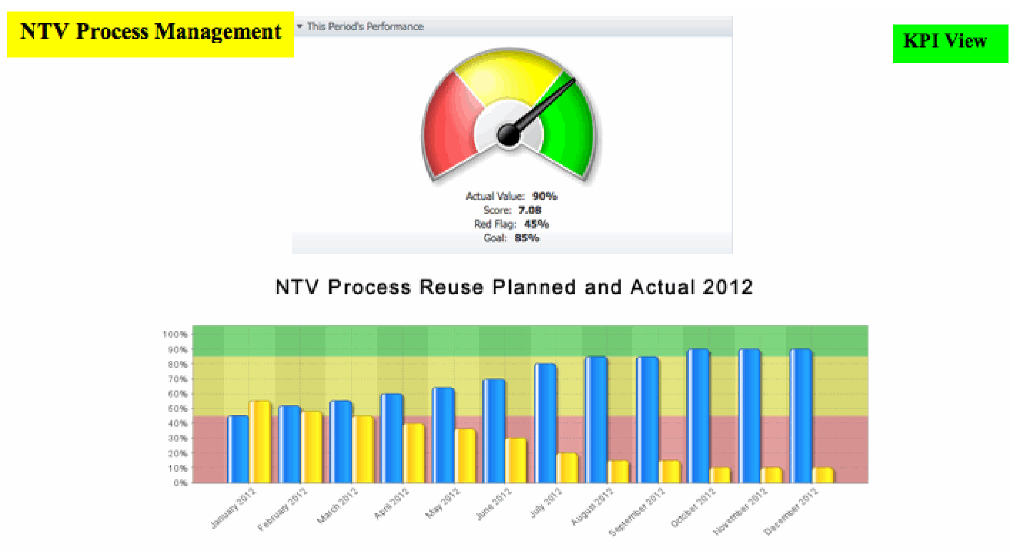
Figure 34. Employee Training KPI 4: % of NTV Staff Quality Trained

Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	2.2.a. Cost of Quality Training as a % of	Project	68% (68%)	62% (62%)	62% (62%)	59% (59%)	50% (50%)	50% (50%)	34% (34%)	27% (27%)	25% (25%)	25% (25%)	24% (24%)	22% (22%)
	2.2.b. Planned Training Costs	Project	32% (32%)	38% (38%)	38% (38%)	41% (41%)	50% (50%)	50% (50%)	66% (66%)	73% (73%)	75% (75%)	75% (75%)	76% (76%)	78% (78%)

Figure 35. Employee Training KPI 5: Cost of Quality Training as Percent of Planned Training Costs

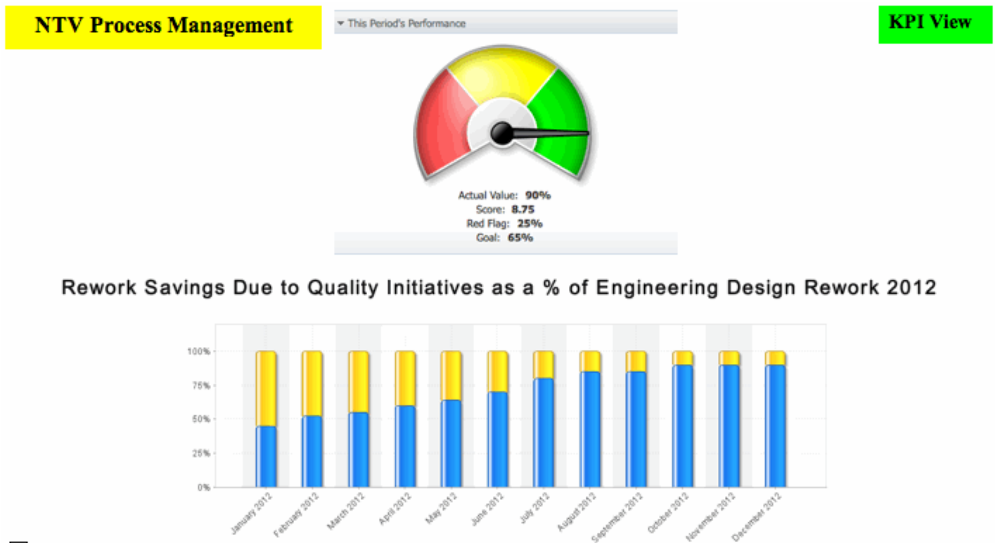
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	2.2.a Cost of Quality Training as a % of	Project	32% (41.56%)	38% (42.22%)	38% (40.86%)	41% (40.59%)	50% (43.86%)	50% (41.67%)	66% (45.21%)	73% (46.2%)	75% (46.88%)	75% (45.45%)	76% (45.78%)	78% (46.43%)
	3.3.a. Reduction in Design Rework Costs	Project	45% (58.44%)	52% (57.78%)	55% (59.14%)	60% (59.41%)	64% (56.14%)	70% (58.33%)	80% (54.79%)	85% (53.8%)	85% (53.12%)	90% (54.55%)	90% (54.22%)	90% (53.57%)

Figure 36. Employee Training KPI 6: Cost of Quality Training



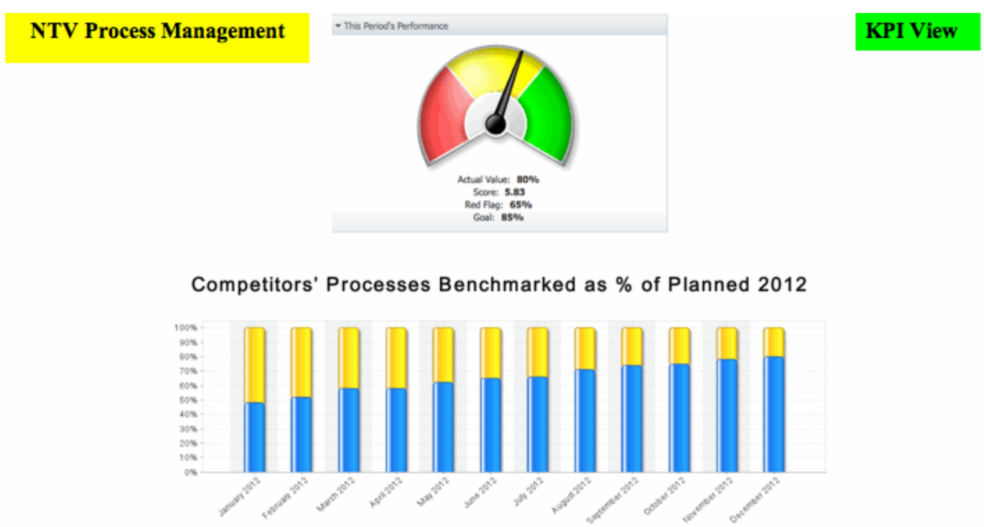
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	3.2.a. NTV Process Reuse as a % of	Project	45%	52%	55%	60%	64%	70%	80%	85%	85%	90%	90%	90%
	3.2.b.Actual NTV Process Reuse	Project	55%	48%	45%	40%	36%	30%	20%	15%	15%	10%	10%	10%

Figure 37. NTV Process Management KPI 7: NTV Process Reuse Planned and Actual



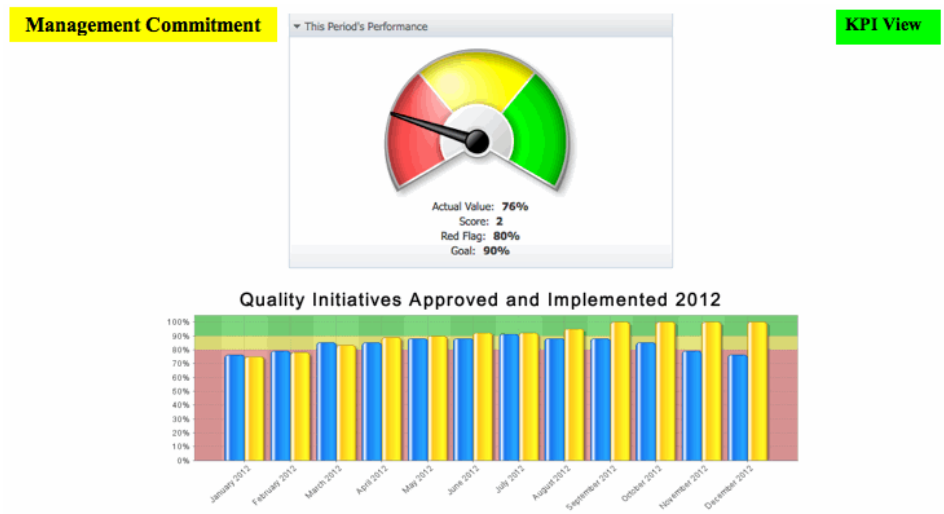
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	3.3.a. Rework Savings Attributed to Quality Initiatives as a % of	Project	45%	52%	55%	60%	64%	70%	80%	85%	85%	90%	90%	90%
	3.3.b. Engineering Design Rework	Project	55%	48%	45%	40%	36%	30%	20%	15%	15%	10%	10%	10%

Figure 38. NTV Process Management KPI 8: Rework Savings Due to Quality Initiatives



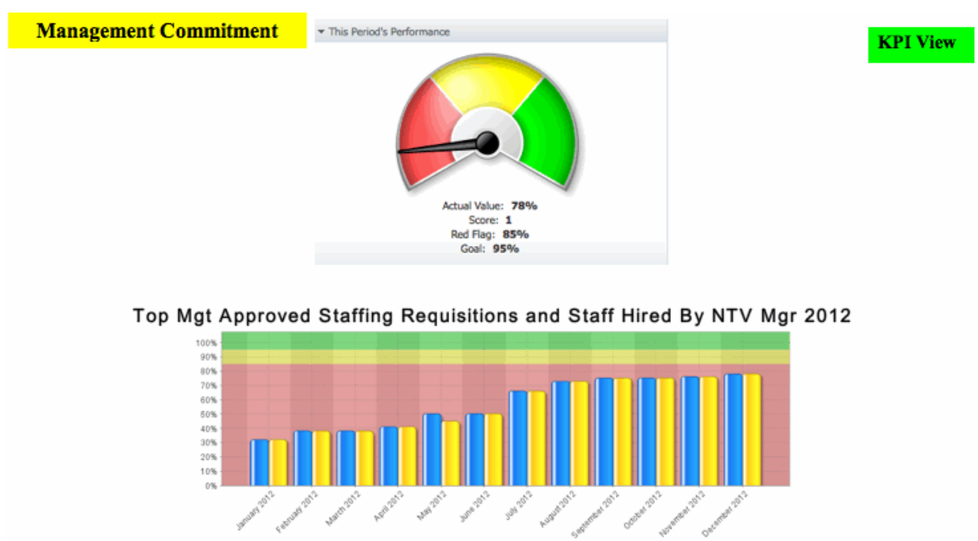
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	3.1.a. Competitors' Processes Benchmarked as % of	Project	48% (48%)	52% (52%)	58% (58%)	58% (58%)	62% (62%)	65% (65%)	66% (66%)	71% (71%)	74% (74%)	75% (75%)	78% (78%)	80% (80%)
	3.1.b. Planned Competitors' Processes Benchmarked	Project	52% (52%)	48% (48%)	42% (42%)	42% (42%)	38% (38%)	35% (35%)	34% (34%)	29% (29%)	26% (26%)	25% (25%)	22% (22%)	20% (20%)

Figure 39. NTV Process Management KPI 9: Competitors’ Processes Benchmarked



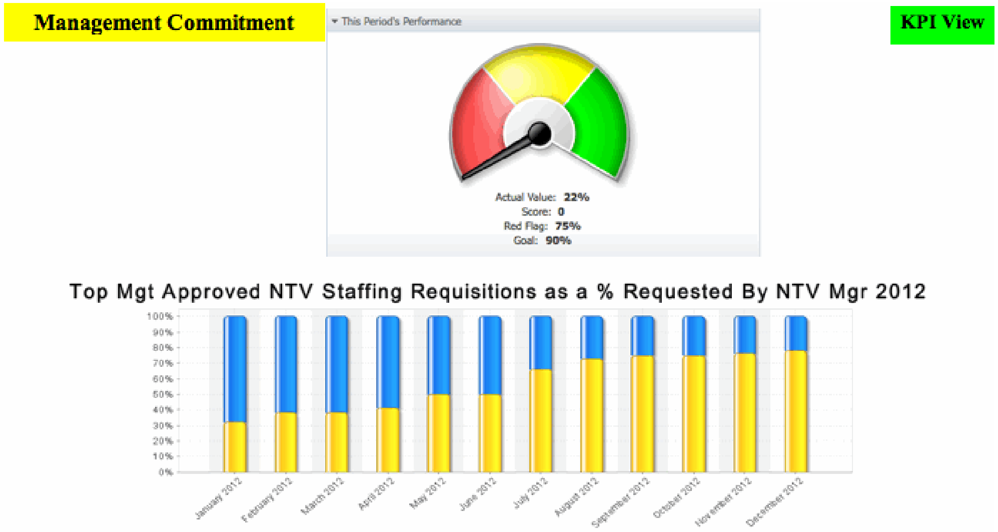
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	4.2.a. Quality Initiatives Approved by Top Mgt as a % of	Project	76%	79%	85%	85%	88%	88%	91%	88%	88%	85%	79%	76%
	4.2.c. Quality Initiatives Implemented by NTV Project Manager	Project	75%	78%	83%	89%	90%	92%	92%	95%	100%	100%	100%	100%

Figure 40. Management Commitment KPI 10: Quality Initiatives Approved and Implemented



Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	4.1.a. NTV Staffing Requisitions Approved by Top Mgt	Project	32%	38%	38%	41%	50%	50%	66%	73%	75%	75%	76%	78%
	4.1.c. % Hired by NTV Project manager	Project	32%	38%	38%	41%	45%	50%	66%	73%	75%	75%	76%	78%

Figure 41. Management Commitment KPI 11: Staffing Requisitions and Hired by NTV Manager



Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	4.1.a. Top Mgt Approved NTV Staffing Requisitions as a % of	Project	32% (32%)	38% (38%)	38% (38%)	41% (41%)	50% (50%)	50% (50%)	66% (66%)	73% (73%)	75% (75%)	75% (75%)	76% (76%)	78% (78%)
	4.1.b. Requisitions Requested by NTV Manager	Project	68% (68%)	62% (62%)	62% (62%)	59% (59%)	50% (50%)	50% (50%)	34% (34%)	27% (27%)	25% (25%)	25% (25%)	24% (24%)	22% (22%)

Figure 42. Management Commitment KPI 12: Approved NTV Requisitions as a Percent Requested

The aggregate view is comprised of the four resultant quadrants known as the perspective framework that is populated with the appropriate miniature bar graph and composite gauge that measures performance against set targets. The aggregate is depicted with quadrants featured.

Figure 43. Strategic View 2 with Quadrants Featured: Aggregate View of KPI's

The final aggregate view is strategic view 2 and is depicted in Figure 44.

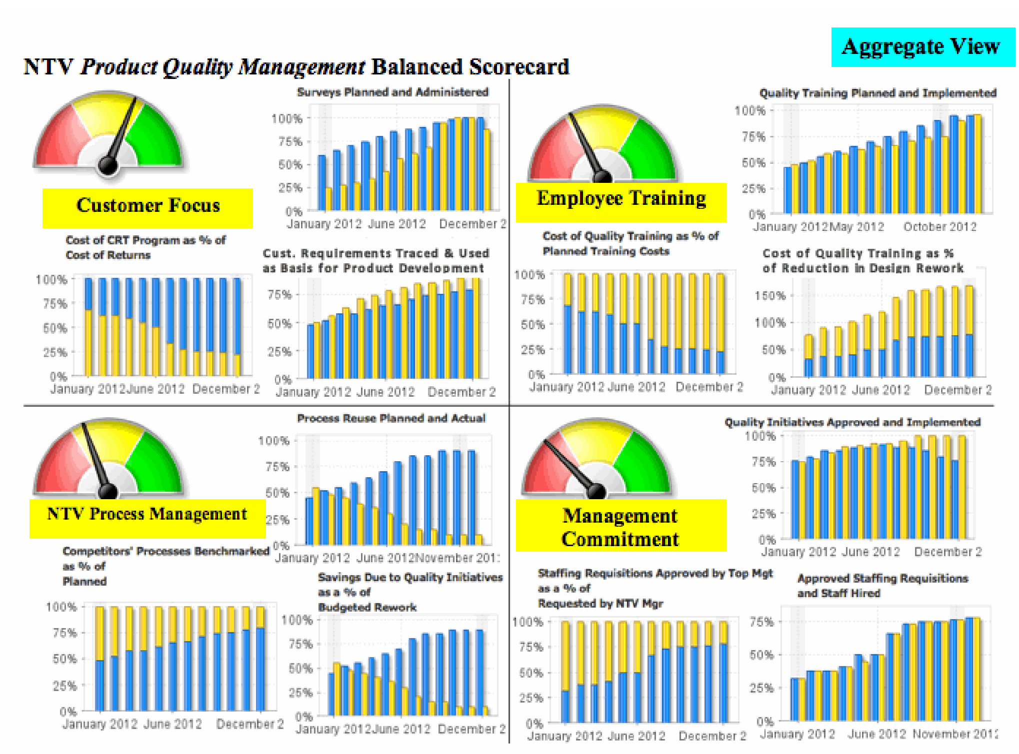
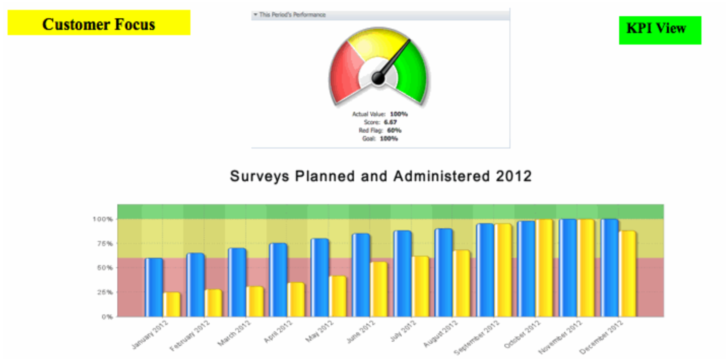


Figure 44. Strategic View 2: Aggregate View

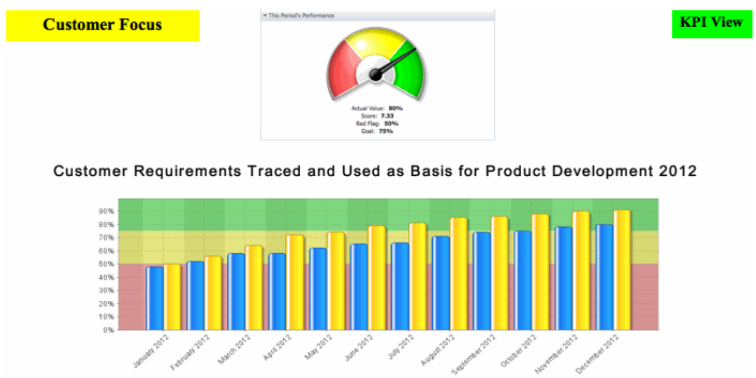
KPI and Aggregate Views – Display Design Discussion

The displays were designed as visual indicators of performance for the archetypal NTV department. Therefore, once modified for indigenous use, a manager can quickly and systematically assess NTV product quality initiatives. Each of the visual displays gives a snapshot of performance that corresponds to an identified critical factor that drives product quality in an NTV department. For example, the customer focused metric (see Figure 45, KPI 1), "surveys planned and administered," depicts raw data and graphs how many customer surveys were planned and how many were actually administered. The gauge indicates how well the NTV team is doing with administering surveys compared to their goal. The NTV manager can see at a glance that in January, 25% of the surveys planned were actually administered. Armed with this measure, the manager could lead the team by placing emphasis on getting the surveys done in a timely fashion. In turn, the information obtained from the surveys will be used as the basis for product design (see Figure 45, KPI 1). When timely and comprehensive customer input is incorporated into product development; the better the product quality tends to be (O'Connor & De Martino, 2006; O'Connor et al., 2008; Vitharana & Mone, 2008; Kelly, 2009).

Importantly, much can be discerned quickly. Bars moving in the upward direction indicate a positive trend; bars moving in the downward direction indicate a negative trend. September's raw data is colored green and provides further quick visual evidence the department is making positive progress. Note the manager can see at a glance that by September, 100% of the planned surveys were administered; the department thereby achieved this goal and can project an incremental positive impact on product quality.



Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	1.1.b. % Surveys Planned	Project	60%	65%	70%	75%	80%	85%	88%	90%	95%	98%	100%	100%
	1.1.a. % Surveys Administered	Project	25%	28%	31%	35%	42%	56%	62%	68%	95%	100%	100%	88%



Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	1.3.a. % Customer Requirements Traced	Project	48%	52%	58%	58%	62%	65%	66%	71%	74%	75%	78%	80%
	1.3.b. % Customer Requirements Used as Basis for Product Development	Project	50%	56%	64%	72%	74%	79%	81%	85%	86%	88%	90%	91%

Figure 45. KPI 1 and KPI 2: How This Display Can Prove Useful to NTV Management

Figure 45, KPI 2 depicts the customer focus metric, “customer requirements traced and used as the basis for product development.” Recognize the customer requirements were derived from the aforementioned surveys. Here the NTV manager can see at a glance that an upward trend indicates the NTV team is progressing toward its pre-established goal. As mentioned earlier, the more customer requirements that are traced and used as the basis for product development, the better the product quality will be. Bars moving in the upward direction indicate a positive trend; bars moving in the downward direction indicate a negative trend. Note that by October, 75% of the customer requirements were traced; 88% of those were used as the basis for product development. The green shading in the raw data table further confirms positive outcomes relative to goals. It is evident at a glance that the department achieved its goal of more than 75% by October, and can project an incremental positive impact on product quality.

The aggregate view is a composite of all of the KPI's within their respective product quality management categories. For example, the customer focus metric, "surveys planned and administered" has a miniature bar graph from this KPI display in the upper right of the **Customer Focus** quadrant. Also note that each of the three customer focus metrics is displayed in miniature in this quadrant. In addition, a composite gauge for this quadrant is displayed. The remaining three quadrants have a miniature bar graph and composite gauge indicative of the raw data for each measure. This is for consistency and simplicity to aid cognition. In practice, the NTV project manager may examine the aggregate view daily, while the KPI view is typically examined as needed. As needed may occur when the composite-level gauge and/or individual miniature bar graphs indicate a negative trend that requires intervention.

Summary of Scorecard Development Results

The development of a balanced scorecard for project-level new technology managers required the identification of critical factors that impact product quality, the incorporation of these factors into a balanced scorecard, the design of the scorecard elements into visual displays. These steps have been accomplished and summarized in this results section. The final step in the process of developing a scorecard that is deemed usable and effective is to have experienced NTV managers evaluate this newly devised tool. This final step comprises study two.

Study Two

Scorecard Evaluation Challenges

The NTV *Product Quality Management* Balanced Scorecard was designed to help improve the quality of management decisions. The scorecard was evaluated in order to determine how effective and useable the tool is for making decisions that improve product quality. Experienced NTV managers that came from a broad array of industries made this evaluation. Care was taken to include (1) start-ups and spin-offs; (2) firms with small (less than 10) to sizable (over 500 to 1,000) NTV teams; (3) firms with gross annual sales from a low of less than $1million to over a billion. In addition, the managers themselves, came from a broad array of engineering management experience; from (lead engineer to upper management; 3 to 5 years of experience to over 10 years; from and had acted as non-manager (e.g., engineer) up to top manager while gaining experience in the NTV environment. A primary goal and challenge of this research was to establish if such a heterogeneous group could, in fact, benefit from an NTV sector scorecard. Was there a sufficient common core of product quality management practices that could be incorporated into a useful scorecard that would prove meaningful to a large number of NTV's in that sector?

In addition, a new survey instrument had to be developed because no such instrument existed in the literature. The recognized procedures (Desselle, 2005) to develop this instrument are detailed in the methods section. First, a synopsis of procedures is provided followed by (1) pilot study results, then (2) full-scale study's results.

Scorecard Evaluation Survey Instrument Development

The new survey instrument was developed to measure the scorecard's product quality management practices from the viewpoint of project-level new technology managers because no such instrument existed in the literature. A four-part procedure was developed and followed to devise this new survey instrument entitled, NTV product quality management scorecard design and evaluation & usability instrument (SE & UI).

1. Items (e.g., critical factors that impact product quality) were identified from the first study's statistical analyses results.
2. A six-point Likert scale was devised to have equal intervals for a balanced summated attitudinal scale (Desselle, 2005).
3. Content was composed using recognized procedures (Desselle, 2005; Vithrana & Mone, 2008).
4. Survey instrument's validity and reliability were established.

The following steps were taken to verify the Scorecard Design and Evaluation Survey Instrument's validity and reliability.

Validity

Four types of validity are generally considered to validate a survey instrument:

1. Face
2. Content
3. Construct, and
4. Criterion.

- Face validity establishes an instrument's ease of use, clarity, and readability. A team of new technology venture management industry and academic experts—evaluated the scorecard design and evaluation survey instrument.
- Content validity is the extent to which scale items represent the arena from which they are drawn (Cronbach, 1951). The instrument in the present study had its content validity established from (1) the results of phase-one's study, which determined the

critical factors that drive product quality, and by (2) an evaluation of the initial instrument by a team of experts and researchers.

- Construct validity establishes the survey instrument's ability to actually measure the constructs it was developed to measure. It is an evaluation of an instrument's ability to relate to other variables or the degree to which it follows a pattern predicted by a theory (Desselle, 2005). The present survey's construct validity was established using factor analysis to establish the factors' convergence, and unidimensionality. This test utilizes the covariance existing between responses to the items in order to group them together into "factors" or domains. These can then be evaluated to determine whether items load onto the domains previously hypothesized when constructing the scale. In addition, items may load onto other domains. However, factor analysis may also reveal that certain items do ***not*** load onto any of the domains, thus providing justification for their deletion from the model (Desselle, 2005).
- Criterion validity determines the extent to which an instrument estimates present performance or predicts future performance (Nunnally, 1978). Criterion validity of the instrument was assessed by examining the coefficients of determination for the five factors and the dependent variable, usability. Usability was determined by the decision of respondents to actually use the scorecard under examination. For example, it was hypothesized that if an experienced NTV manager respondent strongly agreed to use the scorecard, then this would indicate a strong degree of scorecard usability. Multiple regression results revealed on the 151 respondents ($n = 151$) that the critical factors of the NTV Product Quality Management Scorecard significantly impacted the dependent variable ($F = 44.06$, p-value $<.0001$). The corresponding coefficient of determination or unadjusted R^2 was 62.3%; and 60.8%

for the more conservative measure, adjusted R^2. These results indicate that the instrument has a high degree of criterion validity.

Readability

Microsoft Word was used to verify word and line count; an Excel spreadsheet was used to tally and confirm syllable count as well as compute the grade level. Using equation 1, it was determined the NTV PQMI is written at 12.56 or somewhat above a 12^{th} grade reading level which is for around ages 18-19 in the United States of America. It was confirmed that all 15 pilot study respondents had education levels that exceeded the 12^{th} grade. Pools of participants were previously identified and are summarized in the participants' section. Because the full-study participants were engineers and scientists with at least three years of management experience in the new technology venture environment, the reading level was deemed appropriate.

Pilot Study

Data Collection

An electronic survey methodology was employed for both the pilot and full-scale studies. Qualtrics was used to host the survey. The pilot study (n=15) was a sample of convenience and yielded positive results. Notably, Cronbach alpha values for each construct were greater than .70 and an adjusted R2 greater than 75% was computed for the regression analysis. The full-scale study (n = 151) commenced once the pilot study's results justified its pursuit. 478 NTV managers were sent the survey electronically; 151 returned a fully completed survey. This is a 31.58% response rate.

Definitions, Experience, and Color-Discernment

Participants in this study affirmed their understanding of the following definitions and experience prior to completing the survey instrument; these results are depicted in Table 52.

Table 52. *Respondents Affirm Understanding of Definitions and Experience*

Definitions, experience, provided on first page; "Do you want to proceed with this survey?"

#	Answer		Response	%
1	Yes		151	100%
2	No		0	0%
	Total		151	100%

Definitions

- A new technology venture (NTV) is defined as engaging in preparing a new technologically advanced product for release to its final consumer for the first time with a first to early generation production process.
- A new technologically advanced product may be software or hardware (e.g., device, machinery, vehicle, etc.) a formulation (e.g., chemical, pharmaceutical, etc.) or delivery mechanism (e.g., Bluetooth, Internet, cloud computing, etc.) and is one that offers wholly new benefits; (1) significant (5 to 10 times) improvement in known benefits; or (2) significant (30 to 50%) reduction in cost (Ansoff, 1957; Booz-Allen & Hamilton, Inc., 1982; Leifer et al., 2001; O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009).

Experience Required

A new technology venture (NTV) manager that managed the launch of a new technology venture for a minimum of three years within the last five years (O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009).

It was important that respondents be able to discern color differences due to the colors used in the KPI displays. In particular, red, yellow, and green required proper interpretation in order for an evaluation of the KPI displays to be effective. It was explained that respondents must be able to discern differences between the colors red, yellow, and green prior to completing the survey instrument. Participants in this study affirmed that they were could discern color differences by responding to the question, “Are you color blind?” These results are depicted in Table 53. In addition, skip logic was used so that those responding “yes,” would skip to the end of the survey.

Table 53. *Respondents Affirm that They Are Not Color Blind*

Color is used in the displays and respondents must be able to discern differences between the colors red, yellow, and green. Are you color blind?

#	Answer		Response	%
1	Yes		0	0%
2	No		151	100%
	Total		151	100%

NTV Managers’ Decision to Use New Scorecard and Hypotheses

The five scorecard elements (perspective framework, objectives, key performance indicators, displays of key performance indicators, and strategic views) each had ten to thirteen items (independent variables) that were ranked from 1 = strongly disagree to 6 = strongly agree for importance, effectiveness, usefulness, or usability. As detailed in section 1, these elements were derived from the first study’s results.

It was hypothesized that the NTV managers’ decision to use the newly devised scorecard would have a strong relationship with their ratings of the scorecard’s elements. If the managers ranked the scorecard’s elements as important, effective, and useful for effective decision-making of an NTV department and that the displays of these elements were usable for said purpose, then the NTV manager would choose to use the scorecard (Kaplan and Norton, 1992; Otley, 1999; Chenhall, 2005). For example, if a manager ranked the perspective framework as important to effectively manage an NTV department (independent variable), then it was hypothesized the manager would choose to use the scorecard (dependent variable).

Cronbach's Alpha – Pilot Study

Minitab® was used to compute the Cronbach alpha coefficients for the pilot study's five constructs. These five constructs are (1) perspective framework, (2) objectives, (3) key performance indicators (KPI's), (4) strategy map with links, and (5) data displays.

Alpha coefficients range in value from 0 to 1 and are used to describe the reliability of factors extracted from the Likert scale schema described fully in the long version of this proposal. The higher the Cronbach alpha score, the more reliable the generated scale is. Nunnally (1978) has indicated 0.7 to be an acceptable reliability coefficient. This pilot study's results indicate acceptable to excellent internal consistency with computed Cronbach alpha values that range from a low of 0.7322 to a high of 0.9777 as indicated in Table 54.

Table 54. *Cronbach Alpha Results (n = 15)*

Construct	Perspective Framework	Objectives	Key Performance Indicators (KPI's)	Strategy Map with Links	Display
Cronbach's Alpha = α	0.7322	0.9557	0.9137	0.8963	0.9777

Regression Analysis – Pilot Study

The pilot study's results indicated the likelihood that a linear relationship exists between the five constructs (independent variables) and the dependent variable. The means of the constructs were used to compute this regression. The baseline regression model for the construct means adequately explains 75.7% of the data and thereby does a reasonable job of predicting scorecard usage. The analysis of variance computed a p-value of .002 which is <.05 and indicates the five independent variables will have predictive value within the 95% confidence interval. Minitab® was used to compute the regression equation and analysis of variance depicted in Table 55.

The regression equation is:

$$USE = -1.33 + 1.18\ PF_M + 0.286\ OBJ_M + 0.577\ KPI_M + 0.446\ DIS\text{-}KPI_M + 0.564\ DIS\text{-}MAP_M$$

Table 55. *Analysis of Variance Phase Two Pilot Study*

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	5	14.962	2.992	9.72	0.002
Residual Error	9	2.771	0.3079		
Total	14	17.7333			
S = 0.554896 R-Sq = 84.4% R-Sq (adj) = 75.7%					

The coefficient of determination is also known as the ***un***adjusted $R^{2.}$ It is the proportion of variability in a data set that is accounted for by the statistical model. It is a measure of how well the regression line approximates the real data points. An R^2 value of 1.0 indicates the regression line perfectly fits the data. The ***adjusted*** R^2 accounts for degrees of freedom and is an approximately unbiased estimator of how well the regression line approximates the actual data points. In contrast, the ***un***adjusted R^2 is biased upward and overstates true explanatory power. This pilot study's analyses uses adjusted R^2 values because this value is a more conservative statistical measure than unadjusted R^2 values. Adjusted R^2 values > .50 are used because this benchmark indicates a strong correlation exists for this type of research (Brooks & Barcikowski, 1999; Newman & Newman, 2000; Morgan & Wilson VanVoorhis, 2007).

Generally, ***un***adjusted R^2 values of greater than .50 show that the correlation is strong. However, in social sciences, R^2 values of as low as .25 are sometimes accepted as indication that some correlation does exist. Moreover, this study uses the ***adjusted*** R^2 value because it is a more conservative statistical measure than unadjusted R^2 values. Adjusted R^2 values greater than .50 indicate a strong correlation exist for this type of research (Brooks & Barcikowski, 1999; Newman & Newman, 2000; Morgan & Wilson VanVoorhis, 2007). In this case, the adjusted R^2 value for the pilot study's regression model was 75.7% and indicates a strong correlation exists.

The four-in-one residuals plots depicted in Figure 46 were reviewed to determine the validity of the regression model. The normality probability plot provides graphical evidence to confirm the assumption of normality since the graph roughly approximates a straight line. Therefore a linear relationship appears to exist between the five independent variables (perspective framework, objectives, KPI's, strategy map with links, and displays)—and the dependent variable (use). Homoscedasticity and the independence assumptions appear to be valid since there do not appear to be major differences in the variability of the residuals for different values of the independent variables. The histogram provides graphical evidence the data are normally distributed as it appears to roughly approximate the classic bell curve; thus normality is tenable. The versus order plot provides graphical evidence that no steady rises or falls occur which supports that data randomness exists. This further supports the assumption of normality. Lastly, the versus fits plot indicates an apparent pattern. This may violate aptness of fit considerations. However, given the weight of most of the evidence, it is likely that this may be attributed to the small size.

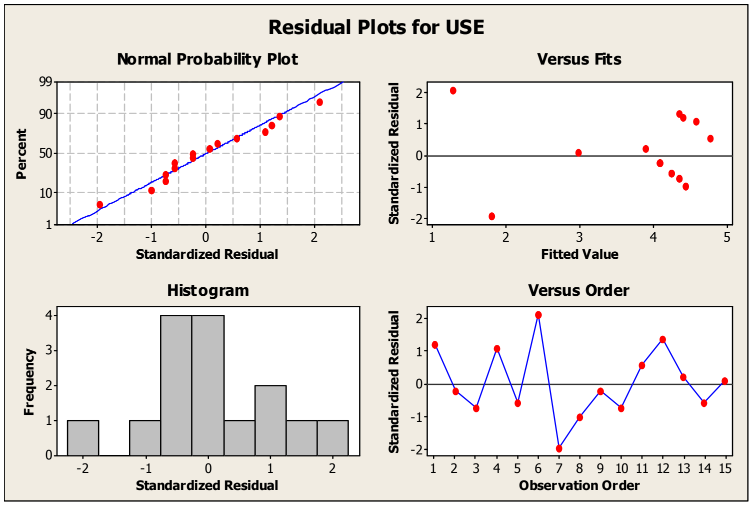


Figure 46. Four in One Residuals Plots for Scorecard Elements and Use

In sum, pilot study results strongly supported moving forward to conduct the full-scale study, which commenced.

Full-Scale Study

Data Collection

The full-scale study (n = 151) commenced once the pilot study's results justified its pursuit. 478 NTV managers were sent the survey electronically; 151 returned a fully completed survey. This is a 31.58% response rate. Dependent variable descriptive statistics are reported. In addition, the following tests were run using data from the full-scale study:

1. Cronbach Alpha to establish NTV SD & EI's internal consistency.
2. Factor Analysis
3. Maximum Likelihood with Varimax Rotation
4. Select Factors with Loadings > .50
5. Reduce Data Set with Significant Loadings for linear regression model.
6. Multiple linear regression.

7. Minitab® output examined for multicollinearity, correlation, and outliers. VIF < 10
8. Best Subsets
9. R-sq. adjusted values > .50
10. Residuals Analyzed to validate resultant model.

The full scale study like the pilot, uses adjusted R^2 values because this value is a more conservative statistical measure than unadjusted R^2 values—as described in the previous section regarding the pilot study. Also as previously justified, adjusted R^2 values > .50 are used because this benchmark indicates a strong correlation exists for this type of research (Brooks & Barcikowski, 1999; Newman & Newman, 2000; Morgan & Wilson VanVoorhis, 2007).

Dependent Variable Descriptive Statistics

The dependent variable was “Respondents’ who would use the NTV *Product Quality Management* Balanced Scorecard as an NTV project-level manager.” The scorecard comprised the elements included in this study: perspective framework, objectives, key performance indicators (KPI’s), displays of KPI’s and aggregate scorecard, as well as the display of the strategy map with links. Figure 47 depicts the respondents’ responses on a 6-point Likert scale.

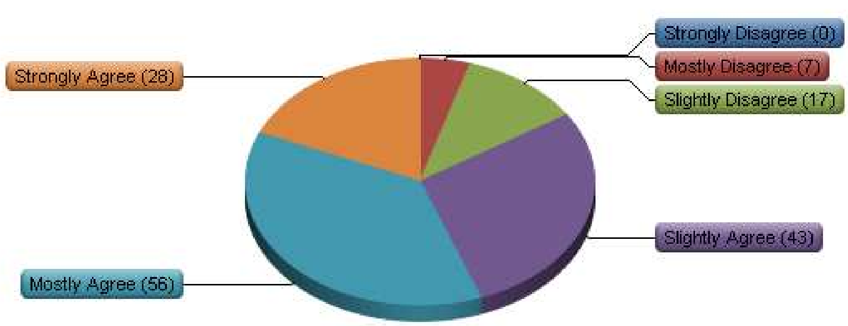


Figure 47. NTV Managers Who Would Use Scorecard

Table 56 depicts the descriptive statistics for the dependent variable.

Table 56. *(Dependent Variable) NTV Managers Who Would Use Scorecard*

#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Mostly Disagree		7	5%
3	Slightly Disagree		17	11%
4	Slightly Agree		43	28%
5	Mostly Agree		56	37%
6	Strongly Agree		28	19%
	Total		151	100%

Statistic	Value
Min Value	2
Max Value	6
Mean	4.54
Variance	1.13
Standard Deviation	1.06
Total Responses	151

Cronbach's Alpha – Full-Scale Study

The 54-item scorecard evaluation and usability (SE&UI) survey instrument was once again analyzed to re-establish its internal consistency. The measure of internal consistency is Cronbach alpha; the closer this value is to 1, the greater the internal consistency. This full-scale (n=151) study's results indicate excellent internal consistency with Cronbach alpha values that range from 0.9280 to 0.9465 as indicated in Table 57.

Table 57. *Cronbach Alpha Results – Full-Scale Study (n = 151)*

Construct	Perspective Framework	Objectives	Key Performance Indicators (KPI's)	Display – KPI's and Aggregate	Display - Strategy Map with Links
Cronbach's Alpha = α	0.9465	0.9411	0.9280	0.9451	0.9327

Factor Analysis

Factor analysis can be performed to summarize the data covariance structure into a smaller number of dimensions. This test determined which of the 53 variables in the present study that could be reduced based on factor loadings to explain a significant percentage (e.g., ≥ 60%) of the data's variability.

The theoretical factors in this study were estimated using summed-item scales also known as Likert scales. As with the dependent variable described in the previous section, the Likert scale comprised 1 = Strong Disagree; 2 = Mostly Disagree; 3 = Slightly Disagree; 4 = Slightly Agree; 5 = Mostly Agree; and 6 = Strongly Agree. Unidimensionality is demonstrated by a single factor solution identified during factor analysis. The guideline for an item to be included in this final factor solution is a loading of 0.50 or greater (Nunnally, 1978). In addition, Cronbach's alpha was used to assess reliability (Pedhazur & Schmelkin, 1991); each factor (or construct) had a Cronbach's alpha of greater than .70. The scales used in this study met these criteria of unidimensionality and reliability. The factor analyses are summarized herein.

Factor Analysis Using Minitab®

Convergence, sometimes denoted as *convergent validity*, is accepted when factorial loads are higher than 0.50 in the final iteration of factor analysis (Nunnally, 1978). Factor analysis was done iteratively using the 0.5 guideline. One factor was eliminated since no items loaded onto it. A total of fourteen items were deleted until the entire factor loading exceeded 0.50. This process established that the remaining 38 items have the ability to strongly relate to other variables. Therefore, the final four factors are all measuring some aspect of the same construct. The second and last iteration provided a final unique solution set of items that explain 65.4% of data variation.

Unidimensionality, sometimes denoted as *discriminant validity*, is demonstrated by a single factor solution identified during factor analysis. This was established and is demonstrated by the final unique solution's sorted rotated factor loadings and communalities table. Therefore, each of the final factors is measuring is measuring a unique aspect of that construct.

An additional condition of *construct validity* is statistical significance. P-values < 0.05 indicate statistical significance. P-values were derived from multivariate statistical analyses. Multiple linear regression was used to compute p-values of the original five constructs that comprised the model's independent variables. The P-values were computed for: (1) perspective framework; (2) strategic views, (3) key performance indicators (KPI's), and (4) displays of KPI's were 0.044, 0.027, 0.035, and 0.0001, respectively. These values were all < 0.05; these findings along with the factor analysis results established construct validity (Netemeyer et al., 2003; Desselle, 2005)

Criterion Validity

Criterion validity determines the extent to which an instrument estimates present performance or predicts future performance (Nunnally, 1978). Examining the coefficients of determination for the five factors and the dependent variable, usability assessed criterion validity of the instrument. Usability was determined by the decision of respondents to actually use the scorecard under examination. For example, it was hypothesized that if an experienced NTV manager respondent strongly agreed to use the scorecard, then this would indicate a strong degree of scorecard usability. Multiple regression results on the 151 respondents (n=151) revealed that the critical factors of the NTV *Product Quality Management* Scorecard significantly impacted the dependent variable (F = 44.06, p-value <.0001). The corresponding coefficient of determination or unadjusted R^2 was 62.3%; and 60.8% for the more conservative measure, adjusted R^2. These results indicate that the instrument has a high degree of criterion validity.

Reliability

Each construct's Cronbach alpha coefficient was used to assess reliability since it is the most frequently used tool for this purpose (Pedhazur & Schmelkin, 1991). The guideline for this test is the coefficient must be above 0.7 to establish the instrument's reliability (Nunnally, 1978). In this case, the Cronbach alpha values for: (1) perspective framework, (2) objectives, (3) key performance indicators (KPI's), display of KPI's, and strategy map with links—were computed to be 0.9465, 0.9411, 0.9280, 0.9451, and 0.9327, respectively.

PCA Factor Analysis Results

The goals of factor analysis are to first determine which factors are not so highly correlated as to prevent items uniquely loading onto one factor. Second, establish which items do have a common core strongly associated with only one of the remaining factors. Lastly, identify each common core by iteratively examining the rotated factor analysis matrices (Netemeyer et al., 2003; Desselle, 2005).

To determine which factors were not so highly correlated as to prevent items uniquely loading onto one factor, the initial factor analysis matrix, Table 58 was examined. This table was computed using PCA factor analysis with Varimax rotation. It was examined for factors and items that could be deleted using guidelines to establish construct validity. Justified deletions were made when (1) factors did not have items load onto it; (2) items did not have loadings > 0.50 on a single factor (>.50); and (3) items that loaded with >0.50 on more than one factor. Items with loadings >0.50 on more than one factor are referred to as too complex (Netemeyer et al., 2003; Desselle, 2005).

The examination of the initial factor analysis matrix (Table 58) revealed no items loaded onto factor 5 (objectives)—so it is justifiably eliminated; in so doing only 0.027 or 2.7% of the variance was lost. The second iteration of factor analysis was then run with only four factors. This revealed unique and strong (>0.50) factor loadings on the remaining four factors. Additionally, items with weak loadings (<0.50) and items deemed too complex were deleted. The final factor analysis matrix (Table 59) depicts a matrix strongly evidenced to establish construct validity with item convergence and items that are unique measures. In sum, the four factors are all measuring some aspect of the same construct (convergence), but are also measuring a unique aspect of that construct (discriminant validity).

The remaining items are depicted categorically with their factor loadings that correspond to the final factor matrix results depicted in Table 59. Tables 60, 61, 62, and 63 depict the resultant thirty-eight items. These items together comprise the valid and reliable survey entitled, NTV product quality management scorecard evaluation and usability instrument (SE & UI).

Table 58. *Initial Factor Analysis Matrix*

Initial Factor Analysis Matrix

Components

Sorted Rotated Factor Loadings and Communalities

	Item	Factor1	Factor2	Factor3	Factor4	Factor5	Communality
Factor 1: Perspective Framework	C3	**0.809**	0.196	0.151	0.087	0.053	0.726
	C6	**0.792**	0.222	0.196	0.093	0.081	0.730
	C15	**0.774**	0.088	0.295	0.189	0.075	0.736
	C5	**0.770**	0.162	0.152	0.163	0.050	0.671
	C2	**0.769**	0.202	0.263	0.141	-0.087	0.728
	C4	**0.763**	0.183	0.147	0.086	-0.173	0.675
	C10	**0.757**	0.183	0.166	0.128	-0.049	0.652
	C8	**0.755**	0.165	0.279	0.124	0.111	0.703
	C9	**0.748**	0.172	0.142	0.096	-0.327	0.726
	C13	**0.743**	0.105	0.260	0.116	-0.052	0.647
	C7	**0.733**	0.170	0.216	0.127	-0.278	0.707
	C12	**0.719**	0.099	0.291	0.159	0.053	0.639
	C11	**0.704**	0.117	0.296	0.195	0.062	0.638
	C1	**0.698**	0.168	0.075	0.264	0.144	0.612
	C14	**0.627**	0.100	0.397	0.260	-0.292	0.713
	C24	**0.568**	0.320	0.378	0.015	-0.242	0.627
Factor 2: Strategy Map with Links	C50	0.163	**0.786**	0.178	0.166	-0.124	0.719
	C48	0.220	**0.775**	0.134	0.187	-0.172	0.731
	C45	0.225	**0.772**	0.215	0.265	0.002	0.764
	C47	0.095	**0.761**	0.139	0.339	-0.132	0.741
	C51	0.187	**0.747**	0.209	0.293	-0.202	0.763
	C46	0.133	**0.739**	0.151	0.272	0.050	0.664
	C52	0.263	**0.736**	0.200	0.202	-0.230	0.744
	C49	0.172	**0.732**	0.166	0.305	-0.168	0.713
	C53	0.124	**0.727**	0.344	0.200	0.054	0.706
	C44	0.192	**0.685**	0.045	0.167	0.200	0.576
	C43	0.199	**0.611**	0.214	0.178	0.086	0.498
	C32	0.211	**0.542**	0.257	0.284	0.134	0.503
Factor 3: Key Performance Indicators (KPI's)	C26	0.334	0.158	**0.709**	0.208	0.128	0.699
	C21	0.384	0.247	**0.705**	0.195	0.067	0.748
	C27	0.340	0.197	**0.701**	0.083	-0.063	0.656
	C29	0.362	0.232	**0.646**	0.204	-0.080	0.651
	C22	0.434	0.373	**0.598**	0.083	0.188	0.727
	C28	0.180	0.287	**0.595**	0.288	-0.403	0.714
	C30	0.245	0.191	**0.590**	0.331	-0.309	0.650
	C20	0.541	0.243	**0.573**	0.006	-0.048	0.682
	C16	0.518	0.265	**0.562**	0.194	0.058	0.695
	C25	0.449	0.248	**0.554**	0.148	-0.076	0.598
	C17	0.515	0.235	**0.548**	0.140	0.011	0.640
	C18	0.486	0.189	**0.545**	0.164	-0.166	0.624
	C23	0.417	0.316	0.382	0.233	-0.328	0.582
	C19	0.498	0.304	0.366	0.157	-0.244	0.559
Factor 4: Display of KPI's	C41	0.102	0.234	0.081	**0.780**	-0.013	0.680
	C35	0.234	0.235	0.078	**0.758**	-0.147	0.711
	C42	0.176	0.190	0.113	**0.755**	-0.018	0.651
	C39	0.061	0.436	0.049	**0.688**	-0.312	0.767
	C36	0.103	0.368	0.216	**0.684**	0.096	0.670
	C37	0.116	0.282	0.348	**0.670**	0.091	0.671
	C33	0.140	0.343	0.250	**0.610**	-0.211	0.616
	C40	0.278	0.442	0.200	**0.581**	0.035	0.651
	C34	0.326	0.452	0.029	**0.513**	0.134	0.594
	C31	0.336	0.447	0.197	**0.511**	-0.039	0.615
Factor 5: Objectives	C38	0.293	0.353	0.311	0.429	0.186	0.526
	Variance	12.074	9.036	6.693	6.176	1.450	35.430
	% Var	0.228	0.170	0.126	0.117	0.027	0.668

Table 59. *Final Factor Analysis Matrix*

	Components				
	Item	**Perspective Framework**	**Strategic Views**	**Key Performance Indicators (KPI's)**	**Display of KPI's**
Perspective Framework	3	**0.811**	0.196	0.137	0.079
	6	**0.796**	0.222	0.188	0.081
	5	**0.771**	0.161	0.147	0.668
	2	**0.768**	0.206	0.270	0.133
	4	**0.761**	0.190	0.163	0.087
	8	**0.759**	0.164	0.257	0.110
	10	**0.757**	0.185	0.169	0.128
	9	**0.742**	0.182	0.180	0.111
	7	**0.730**	0.181	0.252	0.127
	1	**0.703**	0.168	0.058	0.586
Strategic Views	50	0.160	**0.789**	0.192	0.166
	48	0.217	**0.780**	0.151	0.187
	45	0.227	**0.774**	0.214	0.254
	47	0.093	**0.765**	0.155	0.343
	51	0.183	**0.752**	0.235	0.296
	52	0.258	**0.742**	0.233	0.296
	46	0.136	**0.737**	0.137	0.269
	53	0.128	**0.726**	0.336	0.191
	44	0.197	**0.680**	0.025	0.153
	43*****	0.202	**0.609**	0.199	0.168
Key Performance Indicators (KPI's)	27	0.342	0.200	**0.708**	0.074
	26	0.341	0.155	**0.695**	0.189
	21	0.391	0.248	**0.692**	0.176
	29	0.365	0.236	**0.661**	0.193
	28	0.176	0.300	**0.641**	0.292
	30	0.243	0.200	**0.635**	0.337
	22	0.442	0.368	**0.562**	0.068
	25	0.450	0.252	**0.557**	0.140
Display of KPI's	41	0.104	0.233	0.085	**0.788**
	35	0.232	0.238	0.103	**0.771**
	42	0.178	0.192	0.129	**0.754**
	39	0.057	0.445	0.096	**0.701**
	36	0.108	0.366	0.197	**0.678**
	37	0.123	0.283	0.337	**0.651**
	33	0.142	0.354	0.273	**0.601**
	40	0.282	0.443	0.199	**0.574**
	31	0.338	0.450	0.194	**0.509**
	34	0.331	0.451	0.014	**0.500**

No items loaded onto the Objectives' Construct. Examination of the Objectives' Construct Pearson Correlation Coefficient (0.841) and VIF (7.456) further substantiated its elimination from the model due to concerns of multicollinearity.
*****The Aggregate View of KPI's was originally hypothesized as part of Display of KPI's; analysis revealed this item loaded with strategic views.

Table 60. *Perspective Framework Items Listed by Factor Loadings*

Perspective Framework Item	Factor Loading
3. NTV Process Management is important	0.811
6. Customer Focus is useful	0.796
5. The Perspective Framework in its entirety is important	0.771
2. Employee Training is important	0.768
4. Management Commitment is important	0.761
8. NTV Process Management is useful	0.759
10. The Perspective Framework in its entirety is useful	0.757
9. Management Commitment is useful	0.742
7. Employee Training is useful	0.730
1. Customer Focus is important	0.703
…to effectively manage NTV Product Quality	

Table 61. *Key Performance Indicators' Items Listed by Factor Loadings*

Key Performance Indicators Item	Factor Loading
27. Savings Due to Quality Initiatives as a % of Budgeted Engineering Design Rework	0.708
26. NTV Process Reuse Planned and Actual	0.695
21. Surveys Planned and Administered is	0.692
29. Quality Initiatives Approved and Implemented	0.661
28. Competitors' Processes benchmarked as a % of Planned	0.641
30. Approved NTV Staffing Requisitions and Staff Hired	0.635
22. Customer Requirements Traced and Used as Basis for Product Development	0.562
25. Cost of Quality Training as a % of Reduction in Design Rework Costs	0.557
…is useful to effectively manage NTV Product Quality	

Table 62. *Strategic Views' Items Listed by Factor Loadings*

Strategic Views that Item	Factor Loading
50. Show how project-level objectives impact product quality is useful	0.789
48. Specify the relationships among key measures is important	0.780
45. Show cause-and-effect relationships between the NTV project manager's actions and the project's performance measurement outcomes is important	0.774
47. Specify the NTV project management's role in achieving the larger objective is important	0.765
51. Show cause-and-effect relationships between the NTV project manager's actions and the project's performance measurement outcomes is useful	0.762
52. Specify the NTV project management's role in achieving the larger objective is useful	0.742
46. Show cause-and-effect relationships between the NTV project manager's actions and the project's performance measurement outcomes is important	0.737
53. Specify the relationships among key measures is useful	0.726
44. Provide measures that relate to project-level organizational strategy is important	0.680
43. and the BSC's Aggregate View of Data Displays is usable	0.609
…to effectively manage NTV Product Quality	

Table 63. *Display of KPI Items Listed by Factor Loadings*

Display of KPI's *Item*	*Factor Loading*
41. Top Management Approved Staffing Requisitions and Staff Hired	0.788
35. Cost of Quality Training as a % of Planned Training Costs	0.771
42. Approved NTV Staffing Requisitions as a % Requested by NTV Manager	0.754
39. Competitors' Processes Benchmarked as a % of Planned	0.701
36. Cost of Quality Training as a % of Reduction in Design Rework Costs	0.678
37. NTV Process Reuse Planned and Actual	0.651
33. Cost of Customer Traceability Program as a % of Cost of Returns	0.601
40 Quality Initiatives Approved and Implemented	0.574
31. Surveys Planned and Administered	0.509
34. Quality Training Planned and Implemented	0.500
… is a usable display to effectively manage NTV Product Quality	

Interactions

The test for interactions was run to determine if any of the predictor variables influenced other variables in a statistically significant manner. The results are reported in Table 64.

Interaction Results

The interaction results indicate there are no statistically significant interactions among the five independent variables: (1) perspective framework, (2) objectives, (3) key performance indicators (KPI's), (4) displays of KPI's, and (5) strategic Views. No statistically significant interactions exist as evidenced by a calculated F-value for interactions of 1.256 that is less than the critical F-value for interactions of 2.378.

Examination of Regression Diagnostic Output

Table 65 provides the regression diagnostic output. The variance inflation factors (VIF's) were examined for each of the original five constructs or factors to further evaluate the appropriateness of eliminating factor 5 (objectives) from the model. The VIF was computed when determining the regression relationship and is depicted in Table 65. The VIF values for (1) perspective framework, (2) objectives, (3) key performance indicators (KPI's), (4) display of KPI's, and (5) strategy map with links were 3.505; 7.456; 3.215; 3.201; and 4.914, respectively. The construct, objectives, with a VIF of 7.456 is highly correlated with other factors and was justifiably removed from the model.

Table 64. *ANOVA: Two-Factor with Replication to Check for Interactions*

SUMMARY	Value	Response	Total
Perspective Framework 1			
Count	151	151	302
Sum	714.5	687.52	1402.02
Average	4.73	4.55	4.64
Variance	0.70	0.57	0.64
Objectives 2			
Count	151	151	302
Sum	710.1	687.52	1397.62
Average	4.70	4.56	4.63
Variance	0.62	0.56	0.59
KPI's 3			
Count	151	151	302
Sum	689	687.52	1376.52
Average	4.56	4.55	4.56
Variance	0.81	0.57	0.69
Displays-KPI 4			
Count	151	151	302
Sum	679.91	687.52	1367.43
Average	4.50	4.55	4.53
Variance	0.54	0.57	0.56
Strategic Views 5			
Count	151	151	302
Sum	687.52	687.52	1375.04
Average	4.55	4.55	4.55
Variance	0.56	0.57	0.56
Total			
Count	755	755	
Sum	3481.03	3437.6	
Average	4.61	4.55	
Variance	0.65	0.56	

ANOVA

Source of Variation	SS	df	MS	F calculated	P-value	F critical
Sample	3.049	4	0.762	1.256	0.285	2.378
Columns	1.25	1	1.25	2.058	0.152	3.848
Interaction	3.05	4	0.76	1.256	0.285	2.378
Within	910.07	1500	0.60			
Total	917.41	1509				

Table 65. *Analysis of Variance with T, P, and VIF Values – Using All Five Key Elements*

Analysis of Variance for Multiple Linear Regression					
Source	DF	SS	MS	F	P
Regression	5	102.251	20.450	44.06	0.000
Residual Error	145	67.299	0.464		
Total	150	169.550			

		Coef	SE Coef	T	P	VIF
	Predictor Constant	0.5800	0.3781	1.53	0.127	
Perspective Framework	PF	-0.1967	0.1248	-1.58	0.017	3.505
Objectives	OBJ	-0.3658	0.1936	-1.89	0.061	7.456
Key Performance Indicators (KPI's)	KPI	0.12945	0.09993	1.30	0.04	3.215
Display of KPI's	DIS	-0.3762	0.1346	-2.80	0.006	3.201
Strategic Views	SViEWS	1.6904	0.1639	10.32	0.000	4.914
	S = 0.681272 R-Sq = 62.3% R-Sq(adj) = 60.8%					

Examination of Pearson Correlation Coefficients

The Pearson correlation coefficients and p-values were run on the five original constructs using the basic descriptive statistics feature in Minitab®. The results appear in the first table below. A second set of Pearson coefficients and p-values were run without the construct, objectives. Both sets of results (with and without objectives) are depicted in Tables 66 and 67.

Table 66. *Pearson Correlation Coefficients and P-Values with Objectives Prior to Deletion*

	Perspective Framework	Objectives	Key Performance Indicators (KPI's)	Display of KPI's	Strategic Views
Perspective Framework	1.0000				
Objectives	0.841 0.001	1.0000			
Key Performance Indicators	0.658 0.001	0.826 0.001	1.0000		
Display of KPI's	0.580 0.001	0.667 0.001	0.576 0.001	1.000	
Strategic Views	0.708 0.001	0.798 0.001	0.657 0.001	0.828 0.001	1.00

Table 67. *Pearson Correlation Coefficients and P-Values without Objectives (after Deletion)*

	Perspective Framework	Strategic Views	Key Performance Indicators (KPI's)	Display of KPI's
Perspective Framework	1.0000			
Strategic Views	0.708 0.0001	1.0000		
Key Performance Indicators	0.658 0.0001	0.657 0.0001	1.000	
Display of KPI's	0.580 0.0001	0.828 0.0001	0.576 0.0001	1.00

The Pearson correlation test revealed that all of the constructs had a relatively high level of correlation. In other words, all of the constructs are somewhat inter-related. This was to be expected due to the holistic nature of product quality management. The construct, objectives, however, had the highest Pearson correlation coefficient of 0.841 and failed to have items load onto it. Construct, key performance indicators, had a Pearson correlation of 0.828—while high, was sufficiently low enough for the factor analysis test to identify items that strongly and uniquely loaded onto this construct. The model without objectives constitutes the final model.

All Pearson correlations were found to be statistically significant at a level of 0.05. All of the correlations are positive. This high correlation among factors indicates a high degree of interdependence among the factors, which supports the prevailing view that a holistic approach to quality management is appropriate in many business sectors (Saraph et al., 1989; Joseph et al., 1999; Sureschandar et al., 2001; Issac et al., 2003). This holistic quality management approach was reflected in the NTV *Product Quality Management* Balanced Scorecard examined in this study. Nevertheless, once the construct "objectives" was removed from the model, the remaining constructs were successful in establishing strong construct validity that exhibited item convergence, as well as, unique loadings that exhibited discriminant validity.

Final Model Discussion

Factor analysis, regression analysis, and Pearson correlation examination indicate the elimination of "objectives" from the model. No items strongly and uniquely loaded onto this construct (factor analysis); p-value of 0.061 indicates there is no statistically significance (regression analysis); and the Pearson correlation value of 0.841 are each values that justify the elimination of "objectives." The final model's regression results are reported in Table 68.

Table 68. *Final Model's Regression Results*

Independent Variables	Independent Variables		Beta Coefficients, t-statistics and p-values
PF	Perspective Framework	H1	ß = 0.210 t = 2.03 p = .044
SVIEWS	Strategic Views	H3	ß = .195 t = 1.58 p = .027
KPI	Key Performance Indicators (KPI's)	H4	ß = 0.279 t = 2.13 p = 0.035
DIS-KPI	Displays of KPI's	H5	ß = 1.69 t = 10.61 p = .0001

Mean Differences in Responses of Job Rank Variables Compared

It was of interest to know if the mean responses to the NTV PQMI varied by job rank. Descriptive statistics for job rank are provided in Table 69.

Table 69. *Job Rank in the New Technology Development Department*

The following questions are regarding your experience with new technology development: "My rank in the new technology development department is/was:"

#	Answer		Response	%
1	Top Manager		14	9%
2	Middle Manager		54	36%
3	Lead Engineer		31	21%
4	Non-manager (e.g., engineer)		38	25%
5	Other		14	9%
	Total		151	100%

Paired t-Tests

The repeated measures or paired t-test was conducted on the demographic job rank measures. This test analyzes the difference between the means of two groups when the sample data are obtained from populations that are related; when results of the first group are not independent of the second group. This “dependence” characteristic of the two groups occurs either because the items or individuals are paired (or matched) according to some characteristic or because repeated measurements are obtained from the same set of items or individuals. It is this latter scenario that is indicative of the present study. Note that in either case, the variable of interest is the difference between the values of the observations. Recall the demographic measures that were compared using the paired t-test in the present study were Q_{58} = Job Rank at the time the respondent was engaged in the new technology venture under study. Four job rankings were identified plus an "other" category. These were top manager = 1; middle manager = 2; lead engineer = 3; non-manager = 4; and other = 5.

The t-test for the mean difference in related samples has the following hypothesis:

H_0: $\mu_D = 0$ where $\mu_D = \mu - \mu_1$

$\mu_D = \mu - \mu_2$

$\mu_D = \mu - \mu_3$

$\mu_D = \mu - \mu_4$

$\mu_D = \mu - \mu_5$

H_a: $\mu_D \neq 0$

For means comparisons by job rank measures 1, 2, 3, 4, and 5 with P-value > .05 indicate there is no statistically significant difference. Table 70 depicts the results of the paired t-tests mean responses compared to five job rank subsets:

Table 70. *Mean Responses Compared to Mean Responses of Job Rank*

t-Test: Paired Two Sample for Means by Job Rank		
	variable means	Top Manager
Mean	5.33	4.88
Variance	0.62	0.50
Observations	57.00	57.00
Pearson Correlation	0.62	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	5.25	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 70—Continued

t-Test: Paired Two Sample for Means by Job Rank		
	variable means	Middle Mgr
Mean	5.33	4.18
Variance	0.62	2.15
Observations	57.00	57.00
Pearson Correlation	0.09	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	5.46	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	variable means	Lead Eng
Mean	5.33	3.81
Variance	0.62	1.87
Observations	57.00	57.00
Pearson Correlation	0.24	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	8.21	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	variable means	non-Mgr
Mean	5.33	4.23
Variance	0.62	1.14
Observations	57.00	57.00
Pearson Correlation	0.35	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	7.72	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 70—Continued

t-Test: Paired Two Sample for Means by Job Rank		
	variable means	other
Mean	5.33	4.28
Variance	0.62	0.88
Observations	57.00	57.00
Pearson Correlation	0.50	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	9.09	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

The results for the means comparisons paired t-tests indicate significant differences in the mean responses by job rank.

Mean of "Experienced As" Variables Compared

It was of interest to know if the mean responses to the NTV PQMI varied by the level of experience respondents had. Descriptive statistics for level of experience are depicted in Table 71.

Table 71. *Experience Levels of Respondents*

"I am experienced in the following positions during the time covered by this survey:"

#	Answer		Response	%
1	Upper Management		17	11%
2	Project Management		53	35%
3	Quality Management		24	16%
4	Quality Engineer		26	17%
5	Other		31	21%
	Total		151	100%

A second set of paired t-tests was conducted using the mean responses compared to the responses by “experienced as.” The demographic measures that were compared using the paired t-test were “experienced as” at the time the respondent was engaged in the new technology venture under study. Four job rankings plus an “other” category were: upper manager = 1; project manager = 2; quality manager = 3; quality engineer = 4; and other = 5.

The t-test for the mean difference in related samples has the following hypothesis:

$H_0: \mu_D = 0$ where $\mu_D = \mu - \mu_1$

$\mu_D = \mu - \mu_2$

$\mu_D = \mu - \mu_3$

$\mu_D = \mu - \mu_4$

$\mu_D = \mu - \mu_5$

$H_a: \mu_D \neq 0$

For means compared to the experienced as job rank measures 1, 2, 3, 4, and 5; a P-value > .05 indicates there is no statistically significant difference. Table 72 depicts the results of the paired t-tests for mean responses compared to “experienced as.”

Table 72. *Mean Responses Compared to Responses of “Experienced As”*

t-Test: Paired Two Sample for Means by “Experienced As”		
	variable means	Upper Mgt
Mean	4.30	4.58
Variance	1.14	0.82
Observations	57.00	57.00
Pearson Correlation	0.04	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-1.54	
P(T<=t) one-tail	0.06	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.13	
t Critical two-tail	2.00	

Table 72—Continued

t-Test: Paired Two Sample for Means by "Experienced As"		
	variable means	Project Mgt
Mean	4.30	5.18
Variance	1.14	0.61
Observations	57.00	57.00
Pearson Correlation	0.17	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-5.47	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	variable means	Quality Mgt
Mean	4.30	2.25
Variance	1.14	0.47
Observations	57.00	57.00
Pearson Correlation	-0.20	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	11.22	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	variable means	Quality Engr
Mean	4.30	4.88
Variance	1.14	0.50
Observations	57.00	57.00
Pearson Correlation	0.26	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-3.91	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	

Table 72—Continued

t-Test: Paired Two Sample for Means by “Experienced As”		
	variable means	other
Mean	4.30	4.28
Variance	1.14	0.88
Observations	57.00	57.00
Pearson Correlation	0.11	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	0.10	
P(T<=t) one-tail	0.46	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.92	
t Critical two-tail	2.00	

The results for the means comparisons paired t-tests indicate significant differences in the mean responses by experience.

Mean Responses Compared to Mean Responses by Years of Experience

It was of interest to know if the mean responses to the NTV PQMI varied by years of experience. Descriptive statistics for job rank are depicted in Table 73.

Table 73. *Respondents’ Number of Years of Experience*

"I have the following total number of years of experience in new technology venture arenas."

#	Answer		Response	%
1	3 to 5 years		58	38%
2	5 to 10 years		43	28%
3	More than 10 years		50	33%
	Total		151	100%

The repeated measures or paired t-test was conducted on the demographic years of experience measures. The demographic measures that were compared using the paired t-test is the number of years of experience at the time the respondent was engaged in the new technology venture under study. Three years of experience categories were delineated. These were 3 to 5 years = 1; 5 to 10 years = 2; More than 10 years = 3.

The test was conducted using the mean responses compared to the years of experience subset under examination. The t-test for the mean difference in related samples has the following hypothesis:

H_0: $\mu_D = 0$ where $\mu_D = \mu - \mu_1$

$\mu_D = \mu - \mu_2$

$\mu_D = \mu - \mu_3$

H_a: $\mu_D \neq 0$

For means comparisons of years of experience measures 1, 2, and 3, a P-value >.05 indicates no statistically significant difference for the paired t-test.

Table 74 provides the results for the means comparisons paired t-tests. These tests indicate there are no significant differences in the mean responses by years of experience for the 3 to 5 year category, and there is a statistically significant difference for both of the remaining categories, 5 to 10 years and more than 10 years.

Table 74. *Mean Responses Compared to Mean Responses by Years of Experience*

t-Test: Paired Two Sample for Means by Years of Experience	variable means	3-5 years
Mean	4.88	4.68
Variance	1.00	1.43
Observations	57.00	57.00
Pearson Correlation	0.58	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	1.42	
P(T<=t) one-tail	0.08	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.00	

Table 74—Continued

t-Test: Paired Two Sample for Means by Years of Experience		
	variable means	5-10 years
Mean	4.88	5.30
Variance	1.00	1.03
Observations	57.00	57.00
Pearson Correlation	0.70	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	-4.09	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.00	
	variable means	More Than 10 yrs
Mean	4.88	4.54
Variance	1.00	1.36
Observations	57.00	57.00
Pearson Correlation	0.53	
Hypothesized Mean Difference	0.00	
df	56.00	
t Stat	2.38	
P(T<=t) one-tail	0.01	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.02	
t Critical two-tail	2.00	

Interpretation of Statistical Differences in Means

The paired t-tests indicate responses by job rank (e.g., top manager, middle manager, lead engineer, non-engineer, and “other”), and by “experienced as” (e.g., experienced as upper manager, project manager, quality manager, quality engineer and “other”), as well as by years of experience (e.g., 3 to 5 years, 5 to 10 years, and more than 10 years) indicated statistically significant differences in means. This is likely due to the criteria established by former research experts and followed in the present study. In particular, the extensive experience requirement.

Only those NTV managers with at least three years of experience within the last five years were asked to complete the survey. Additionally, the types of industries included in this research were purposefully broad and diverse. These criteria were an integral part of the research objectives; to determine if this highly heterogeneous sector would nevertheless confirm a common core of product quality management practices (O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009). If so, then these product quality management practices would be incorporated into a scorecard.

In addition, evidence supports the nature of new technology venture organizations as managed by highly experienced, well-trained personnel charged with making rapid-fire decisions of weighty importance (Sathe, 1989; Peters, 1994; Tushman & O'Reilly, 1997; Antonicic & Hirsch 2001, 2004; Morris & Kuratko, 2002). With an average number of years of NTV experience of nearly 8 years, such personnel tend to have high levels of education and specialized training. Therefore, it is anticipated that these NTV managers have broad levels of quality training and undergone CPI indoctrination for many years that was industry-specific.

The above schema used to examine the first three demographics—by job rank, "experienced by," and years of experience—will be used to examine the remaining ones. These are by industry, size of entire firm, size of NTV department, start-up or spin-off; gross annual sales of entire firm, annual budget of NTV department.

Descriptive statistics for by industry, size of entire firm, size of NTV department, gross annual sales of entire firm, annual budget of NTV department, and start-up or spin-off are tabularized in Tables 75, 77, 79, 81, 83, and 85, respectively. The paired t-test results for these same categories are provided in Tables 76, 78, 80, 82, 84, and 86, respectively

By Industry

Table 75. *NTV Departments by Industry*

"The NTV department that I used to complete this survey is best described by the following industry (check all that apply):

#	Answer		Response	%
1	Automotive, Aviation and Aerospace		16	11%
2	Biotechnology, Medical Devices, Genomics		4	3%
3	Pharmaceuticals		4	3%
4	Chemicals and Materials		7	5%
5	Manufacturing		36	24%
6	Computer Hardware and Networking		19	13%
7	Computer Software		21	14%
8	E-Commerce and Information Technology		15	10%
9	Consumer Goods		1	1%
10	Other		28	19%
	Total		151	100%

Table 76. *Mean Responses Compared to Means of Industry Responses*

t-Test: Paired Two Sample for Means by Industry		
	variable means	Automotive, Aviation, Aerospace
Mean	4.60	4.69
Variance	0.03	0.21
Observations	54.00	54.00
Pearson Correlation	0.91	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-2.13	
P(T<=t) one-tail	0.02	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.04	
t Critical two-tail	2.01	

Table 76—Continued

t-Test: Paired Two Sample for Means by Industry		
	variable means	Biotech, Medical Devices, Genomics
Mean	4.60	4.86
Variance	0.03	0.18
Observations	54.00	54.00
Pearson Correlation	0.42	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-5.01	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	
	variable means	Pharmaceuticals
Mean	4.60	4.15
Variance	0.03	0.07
Observations	54.00	54.00
Pearson Correlation	-0.08	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	10.21	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	
	variable means	Chemicals & Materials
Mean	4.60	4.56
Variance	0.03	0.09
Observations	54.00	54.00
Pearson Correlation	0.56	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	1.19	
P(T<=t) one-tail	0.12	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.24	
t Critical two-tail	2.01	

Table 76—Continued

t-Test: Paired Two Sample for Means by Industry		
	variable means	Manufacturing
Mean	4.60	4.54
Variance	0.03	0.03
Observations	54.00	54.00
Pearson Correlation	0.86	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	5.14	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	
	variable means	Computer Hardware
Mean	4.60	4.55
Variance	0.03	0.03
Observations	54.00	54.00
Pearson Correlation	0.31	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	1.76	
P(T<=t) one-tail	0.04	
t Critical one-tail	1.67	
	variable means	Other
Mean	4.60	4.55
Variance	0.03	0.03
Observations	54.00	54.00
Pearson Correlation	0.85	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	3.88	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	

Interpretation by Industry

The paired t-tests indicate responses by industry (e.g., Automotive, Aviation and Aerospace; Biotechnology, Medical Devices, and Genomics; Pharmaceuticals; Chemicals and Materials; Manufacturing; Computer Hardware and Networking; Computer Software; E-Commerce and Information Technology; Consumer Goods, and “other”), all but the Chemicals and Materials category indicated statistically significant differences in mean responses when compared to mean responses. This is likely due to the criteria established by former research experts and followed in the present study whereby a broad and diverse group was invited to participate in the study (O’Connor & De Martino, 2006; O’Connor et al., 2008; Kelley, 2009). This was done for the expressed purpose of determining if a common core of product quality management practices could be delineated from such a diverse group—which is the primary purpose of this research.

In addition, only experienced NTV managers who are managing the launch of new venture that offers significant benefits and/or significant reductions in cost—were invited to complete the survey (O’Connor & De Martino, 2006; O’Connor et al., 2008; Kelley, 2009). Evidence supports the nature of new technology venture organizations as characterized by distributed controls, with personnel from global search and with multidisciplinary expertise; integrated decision-making with a flat organizational structure; staff with distributed responsibilities that are milestone driven and may have direct financial incentives. This is indicative of strong core communalities. However, with an average number of years of NTV experience of nearly 8 years, such personnel tend to have high levels of education and specialized training. Therefore, it is anticipated that these NTV managers have broad levels of quality training and have undergone CPI indoctrination for many years that was industry-specific (Sathe, 1989; Peters, 1994; Tushman & O’Reilly, 1997; Antonicic & Hirsch 2001, 2004; Morris

& Kuratko, 2002; Jackson & Lloyd, 2006). Thus, these paired t-test results provide statistical evidence that is consistent with the literature.

By Size of Entire Firm

Table 77. *Size of Entire Firm (Number of Employees Worldwide)*

The following questions are regarding the size and nature of your firm and NTV department: The size of the entire firm (number of employees worldwide) is:

#	Answer		Response	%
1	Less than 100		31	21%
2	101 to 1,000		25	17%
3	1,001 to 5,000		33	22%
4	5,001 to 10,000		18	12%
5	10,001 to 25,000		9	6%
6	25,001 to 50,000		12	8%
7	Greater than 50,000		19	13%
8	Other		4	3%
	Total		151	100%

Table 78. *Mean Responses Compared to Mean Responses by Size of the Company (Number of Employees Worldwide)*

t-Test: Paired Two Sample for Means by Size of Company (Employees Worldwide)		
	Variable means	Less than 100
Mean	4.60	4.50
Variance	0.03	0.04
Observations	54.00	54.00
Pearson Correlation	0.64	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	5.09	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	

Table 78—Continued

t-Test: Paired Two Sample for Means by Size of Company (Employees Worldwide)		
	Variable means	101-1000
Mean	4.60	4.50
Variance	0.03	0.04
Observations	54.00	54.00
Pearson Correlation	0.64	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	5.09	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	
	Variable means	1001-5000
Mean	4.60	4.65
Variance	0.03	0.04
Observations	54.00	54.00
Pearson Correlation	0.83	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-3.06	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	
	Variable means	5000-10K
Mean	4.60	4.58
Variance	0.03	0.03
Observations	54.00	54.00
Pearson Correlation	0.46	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	0.93	
P(T<=t) one-tail	0.18	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.35	

Table 78—Continued

t-Test: Paired Two Sample for Means
by Size of Company (Employees Worldwide)

	Variable means	10001-25K
Mean	4.60	4.56
Variance	0.03	0.08
Observations	54.00	54.00
Pearson Correlation	0.63	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	1.28	
P(T<=t) one-tail	0.10	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.21	
t Critical two-tail	2.01	

	Variable means	25001-50K
Mean	4.60	4.56
Variance	0.03	0.08
Observations	54.00	54.00
Pearson Correlation	0.63	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	1.28	
P(T<=t) one-tail	0.10	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.21	
t Critical two-tail	2.01	

	Variable means	>50K
Mean	4.60	4.56
Variance	0.03	0.08
Observations	54.00	54.00
Pearson Correlation	0.63	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	1.28	
P(T<=t) one-tail	0.10	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.21	
t Critical two-tail	2.01	

Table 78—Continued

t-Test: Paired Two Sample for Means by Size of Company (Employees Worldwide)		
	Variable means	Other
Mean	4.60	4.44
Variance	0.03	0.21
Observations	54.00	54.00
Pearson Correlation	0.57	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	3.13	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	

Interpretation of Statistical Differences in Means by Company Size

The paired t-tests indicate responses by size of the company as measured by the number of employees worldwide (e.g., less than 100; 101 to 1,000; 1,001 to 5,000; 10,001 to 25,000; 25,001 to 50,000; and "other"), indicated that all but the "other" category had no statistically significant differences in mean responses when compared to mean responses. This is likely due to the criteria established by former research experts and followed in the present study whereby a broad and diverse group was invited to participate in the study. In fact, care was taken to include a wide range of company sizes as an integral part of the design of experiment (O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009). This was done for the expressed purpose of determining if a common core of product quality management practices could be delineated from such a diverse group—which is the primary purpose of this research.

In addition, only experienced NTV managers who are managing the launch of new venture that offers significant benefits and/or significant reductions in cost—were invited to complete the survey (O'Connor & De Martino, 2006; O'Connor et al., 2008; Kelley, 2009).

Evidence supports the nature of new technology venture organizations as characterized by distributed controls, with personnel from global search and with multidisciplinary expertise; integrated decision-making with a flat organizational structure; staff with distributed responsibilities that are milestone driven and may have direct financial incentives. This is indicative of strong core communalities. However, with an average number of years of NTV experience of nearly 8 years, such personnel tend to have high levels of education and specialized training. Therefore, it is anticipated that these NTV managers have broad levels of quality training and have undergone CPI indoctrination for many years that is industry-specific (Sathe, 1989; Peters, 1994; Tushman & O'Reilly, 1997; Antonicic & Hirsch 2001, 2004; Morris & Kuratko, 2002; Jackson & Lloyd, 2006). Thus, these paired t-test results provide statistical evidence that is consistent with the literature.

These paired t-test results provide statistical evidence that is consistent with the literature; NTV's are managed distinctly as a sector that transcends the size of the firm. The one exception is respondents in firms with well over 50,000 people worldwide; a statistically significant difference was computed for this category of responses, which were was the largest sized firm. It may be hypothesized that once a firm gets so large, its NTV departments evolve differently from those in smaller firms. In particular, standardized operating procedures may be more firmly in place in larger firms. This would be consistent with the literature.

Size of NTV Department

Table 79. *Size of Entire NTV Department (Number of Employees Worldwide)*

The size of the entire NTV department (number of employees worldwide) is:

#	Answer		Response	%
1	01 - 10		30	20%
2	11 - 25		22	15%
3	26 - 100		34	23%
4	101 - 500		40	26%
5	501 - 1,000		25	17%
	Total		151	100%

Table 80. *Mean Responses Compared by Number of NTV Members Worldwide*

t-Test: Paired Two Sample for Means
by Size of NTV Department (Number of Team Members Worldwide)

	Variable means	1-10
Mean	4.60	4.46
Variance	0.03	0.03
Observations	54.00	54.00
Pearson Correlation	0.82	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	9.89	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	

	Variable means	11-25
Mean	4.60	4.67
Variance	0.03	0.14
Observations	54.00	54.00
Pearson Correlation	0.82	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-2.02	
P(T<=t) one-tail	0.02	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.05	
t Critical two-tail	2.01	

Table 80—Continued

t-Test: Paired Two Sample for Means by Size of NTV Department (Number of Team Members Worldwide)		
	Variable means	26-100
Mean	4.60	4.62
Variance	0.03	0.04
Observations	54.00	54.00
Pearson Correlation	0.75	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-1.20	
P(T<=t) one-tail	0.12	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.23	
t Critical two-tail	2.01	
	Variable means	101-500
Mean	4.60	4.65
Variance	0.03	0.03
Observations	54.00	54.00
Pearson Correlation	0.48	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-2.06	
P(T<=t) one-tail	0.02	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.04	
t Critical two-tail	2.01	
	Variable means	501-1000+
Mean	4.60	4.60
Variance	0.03	0.06
Observations	54.00	54.00
Pearson Correlation	0.85	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	0.22	
P(T<=t) one-tail	0.41	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.83	
t Critical two-tail	2.01	

Interpretation of Statistical Difference in Means by Department Size

The paired t-tests indicate responses by size of the NTV department as measured by the number of employees worldwide (e.g., 1 to 10; 11 to 25; 26 to 100; 101 to 500; and 501 to 1,000 or more), indicated statistically significant differences in mean responses when compared to mean responses for the smallest (1 to 10) and next to the largest (101 to 500) size NTV department. This is likely due to the criteria whereby a broad and diverse group was invited to participate in the study. In fact, care was taken to include a wide range of NTV department sizes as an integral part of the design of experiment (O’Connor & De Martino, 2006; O’Connor et al., 2008; Kelley, 2009). This was done for the expressed purpose of determining if a common core of product quality management practices could be delineated from such a diverse group—which is the primary purpose of this research.

The two exceptions computed from this data set were those respondents with NTV departments with 10 or less and those with over 101 to 500 people worldwide. No statistically significant differences were computed for these categories of responses, which was the second to largest sized department category. It may be hypothesized that once an NTV department gets so large, its management practices evolve differently from smaller departments. In particular, these practices become more standardized. And conversely, the tiniest of NTV departments may run more on an ad hoc basis. There is evidence in the literature to support each of these suppositions. However, prudence would dictate that more evidence is needed to make any additional generalizations from these results.

Gross Annual Sales of Entire Firm

Table 81. *Gross Annual Sales of Entire Firm Worldwide*

Gross annual sales of the entire firm worldwide is:

#	Answer		Response	%
1	Less than $1 million		15	10%
2	$1 million - $5 million		21	14%
3	$6 million - $50 million		24	16%
4	$51 million - $100 million		8	5%
5	$101 million - $500 million		16	11%
6	$501 million - $1 billion		13	9%
7	Over $1 billion		21	14%
8	Other/Don't Know		33	22%
	Total		151	100%

Table 82. *Mean Responses Compared by Size of Gross Annual Sales of Entire Firm*

t-Test: Paired Two Sample for Means
by Gross Annual Sales of Entire Firm Worldwide

	Variable means	Less than $1Million
Mean	4.60	4.51
Variance	0.03	0.03
Observations	54.00	54.00
Pearson Correlation	0.65	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	4.96	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	

Table 82—Continued

t-Test: Paired Two Sample for Means by Gross Annual Sales of Entire Firm Worldwide		
	Variable means	$1M-$5M
Mean	4.60	4.84
Variance	0.03	0.04
Observations	54.00	54.00
Pearson Correlation	0.71	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-12.32	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	
	Variable means	$6M-$50M
Mean	4.60	4.57
Variance	0.03	0.04
Observations	54.00	54.00
Pearson Correlation	0.73	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	1.65	
P(T<=t) one-tail	0.05	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.11	
t Critical two-tail	2.01	
	Variable means	$51M-$100M
Mean	4.60	4.50
Variance	0.03	0.05
Observations	54.00	54.00
Pearson Correlation	0.63	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	4.18	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	

Table 82—Continued

t-Test: Paired Two Sample for Means
by Gross Annual Sales of Entire Firm Worldwide

	Variable means	$101M-$500M
Mean	4.60	4.66
Variance	0.03	0.19
Observations	54.00	54.00
Pearson Correlation	0.81	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-1.32	
P(T<=t) one-tail	0.10	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.19	
t Critical two-tail	2.01	
	Variable means	$501M-$1B
Mean	4.60	4.61
Variance	0.03	0.06
Observations	54.00	54.00
Pearson Correlation	0.69	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-0.52	
P(T<=t) one-tail	0.30	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.60	
t Critical two-tail	2.01	
	Variable means	Greater than $1Billion
Mean	4.60	4.61
Variance	0.03	0.06
Observations	54.00	54.00
Pearson Correlation	0.69	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-0.52	
P(T<=t) one-tail	0.30	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.60	
t Critical two-tail	2.01	

Table 82—Continued

t-Test: Paired Two Sample for Means by Gross Annual Sales of Entire Firm Worldwide		
	variable means	don't know
Mean	4.60	4.43
Variance	0.03	0.20
Observations	54.00	54.00
Pearson Correlation	0.56	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	3.34	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	

Interpretation of Statistical Differences in Means by Gross Annual Sales

The paired t-tests indicate responses by size of gross annual sales of entire firm worldwide (e.g., less than $1 million; $1 million to $5 million; $6 million to $50 million; $51 million to $100 million; $101 million to $500 million; $501 million to $1billion; and over $1 billion), indicated four of the categories had statistically significant differences when compared to mean responses; and half did not. These data were captured purely as descriptive statistics so, generalizations prove difficult due to the fact that no data were captured to sufficiently characterize each firm through proper segmentation. For example, how much was spent on R&D compared to the firm’s core revenue generating business; and when are NTV departments expected to provide a ROI; what is the net profit from sales by department, and so on? These and many more questions would have to be answered to adequately explain these data. And, the time required by survey respondents would disallow the opportunity to test systematic assessment of the NTV environment due to survey time-out concerns—which is the primary purpose of this research. A maximum of thirty minutes duration was the guideline used for this electronic survey. After that time, respondents tend to drop out (De Leeuw, 2005; Dillman et al., 2009). Therefore, it was decided that the bulk of the time spent by respondents would be devoted to responding to the first 57 questions. It was these responses that captured data to achieve the primary objectives of this study.

Questions relating to ROI, and business segmentation, and the like were not included as they were outside the scope of the study. It thereby makes interpretation of this demographic data difficult. In point of fact, the size of gross annual sales of entire firm worldwide was captured and provided purely as a descriptive statistic. This is consistent with the literature (Sousa et al., 2006; Cooper et al., 2007; Vitharana & Mone 2008; Fotopoulos & Psomas, 2009). Sousa, Fotopoulos, Vitharana, and Cooper along with their co-researchers conducted performance management practice research with sample sizes of 52, 107, 125, and 161, respectively. Study one of this research had a sample size of 100; study two, 151—which is consistent with the literature. In each case, this type of data was captured for purely descriptive statistics purposes.

Annual Budget of NTV Department

Table 83. *Annual Budget of NTV Department*

Annual Budget of NTV Department:

#	Answer		Response	%
1	Less than $500,000		52	34%
2	$500,000 - $1 million		42	28%
3	$1 million - $5 million		40	26%
4	Greater than $5 million		17	11%
	Total		151	100%

Table 84. *Mean Responses Compared by Annual Budget of NTV Department*

t-Test: Paired Two Sample for Means by Annual Budget of NTV Department		
	Variable means	Less than <$500K
Mean	4.60	4.56
Variance	0.03	0.03
Observations	54.00	54.00
Pearson Correlation	0.91	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	4.60	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	
	Variable means	$500K-$1Million
Mean	4.60	4.71
Variance	0.03	0.04
Observations	54.00	54.00
Pearson Correlation	0.88	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-7.72	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	
	Variable means	$1M-$5M
Mean	4.60	4.58
Variance	0.03	0.05
Observations	54.00	54.00
Pearson Correlation	0.90	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	1.30	
P(T<=t) one-tail	0.10	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.20	
t Critical two-tail	2.01	

Table 84—Continued

t-Test: Paired Two Sample for Means by Annual Budget of NTV Department		
	Variable means	More than >$5M
Mean	4.60	4.51
Variance	0.03	0.03
Observations	54.00	54.00
Pearson Correlation	0.51	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	3.74	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.01	

Interpretation of Statistical Differences in Means by Department Budget

The paired t-tests indicate responses by size of annual budget of NTV department (e.g., less than $500,000; $500,001 to $1 million; $1 million to $5 million; greater than $5million), indicated statistically significant differences when compared to mean responses with the exception of the $1 million to $5 million category. These data were captured purely as descriptive statistics so, generalizations prove difficult due to the fact that no data were captured to sufficiently characterize each firm through proper segmentation. For example, how much was spent on R&D compared to the firm’s core revenue generating business; and when are NTV departments expected to provide a ROI; what is the net profit from sales by department, and so on? These and many more questions would have to be answered to adequately explain these data. And, the time required by survey respondents would disallow the opportunity to test systematic assessment of the NTV environment due to survey time-out concerns—which is the primary purpose of this research. A maximum of thirty minutes duration was the guideline used for this electronic survey. After that time, respondents tend to drop out (De Leeuw, 2005; Dillman et al., 2009). Therefore, it was decided that the bulk of the time spent by respondents would be devoted to responding to the first 57 questions. It was these responses that captured data to achieve the primary objectives of this study.

Questions relating to ROI, and business segmentation, and the like were not included as they were outside the scope of the study. It thereby makes interpretation of this demographic data difficult. In point of fact, the size of annual budget of the NTV department was captured and provided purely as a descriptive statistic. This is consistent with the literature (Sousa et al., 2006; Cooper et al., 2007; Vitharana & Mone 2008; Fotopoulos & Psomas., 2009). Sousa, Fotopoulos, Vitharana, and Cooper along with their co-researchers conducted performance management practice research with sample sizes of 52, 107, 125, and 161, respectively. Study one of this research had a sample size of 100; study two, 151—which is consistent with the literature. In each case, this type of data was captured for purely descriptive statistics purposes.

By Start-Up or Spin-Off

Table 85. *Number of NTV Departments that Are/Were Start-Ups or Spin-Offs*

Your NTV is best characterized as a start-up (brand new firm) or a spin-off (part of a an existing firm)?

#	Answer		Response	%
1	Start-up		26	25%
2	Spin-off		99	75%
	Total		151	100%

Table 86. *Response Means Compared to Type of NTV; Start-Up vs. Spin-Off*

t-Test: Paired Two Sample for Means by Start-up and Spin-Off		
	Variable means	Start-up
Mean	4.60	4.62
Variance	0.03	0.04
Observations	54.00	54.00
Pearson Correlation	0.94	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-2.04	
P(T<=t) one-tail	0.02	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.05	
t Critical two-tail	2.01	
	Variable means	Spin-off
Mean	4.60	4.62
Variance	0.03	0.04
Observations	54.00	54.00
Pearson Correlation	0.94	
Hypothesized Mean Difference	0.00	
df	53.00	
t Stat	-2.04	
P(T<=t) one-tail	0.02	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.05	
t Critical two-tail	2.01	

Interpretation of No Statistical Difference in Means by Type of NTV

The paired t-tests indicate responses by start-up vs. spin-off, indicated both categories had p-values of 0.05 which is less than the 0.05 break point to distinguish statistically significant differences. This indicates weak statistical evidence that there is a difference in response means compared to the type of NTV. It may be hypothesized that start-ups and spin-offs evolve to different types of organizations; organizations with different perspectives on how best to manage product quality decisions. However, as mentioned in earlier sections, determining such fine distinctions is beyond the scope of this study. Importantly, this study purposefully incorporated both start-ups and spin-offs in an attempt to determine if a common core of product quality management practices could be delineated—given any similarities or differences that exist between these two categories. Significantly, these data were captured purely as descriptive statistics so, generalizations prove difficult due to the fact that no data were captured to sufficiently characterize each firm through proper segmentation. For example, how much was spent on R&D compared to the firm's core revenue generating business; and when are NTV departments expected to provide a ROI; what is the net profit from sales by department, and so on? These and many more questions would have to be answered to adequately explain these data. And, the time required by survey respondents would disallow the opportunity to test systematic assessment of the NTV environment due to survey time-out concerns—which is the primary purpose of this research. A maximum of thirty minutes duration was the guideline used for this electronic survey. After that time, respondents tend to drop out (De Leeuw, 2005; Dillman et al., 2009). Therefore, it was decided that the bulk of the time spent by respondents would be devoted to responding to the first 53 questions. It was these responses that captured data to achieve the primary objectives of this study.

Questions relating to ROI, and business segmentation, and the like were not included as they were outside the scope of the study. It thereby makes interpretation of this demographic data difficult. In point of fact, the size of gross annual sales of entire firm worldwide was captured and provided purely as a descriptive statistic. This is consistent with the literature (Sousa et al., 2006; Cooper et al., 2007; Vitharana & Mone 2008; Fotopoulos & Psomas, 2009). Sousa, Fotopoulos, Vitharana, and Cooper along with their co-researchers conducted performance management practice research with sample sizes of 52, 107, 125, and 161, respectively. Study one of this research had a sample size of 100; study two, 151—which is consistent with the literature. In each case, this type of data was captured for purely descriptive statistics purposes. Future research may be employed to obtain evidence to further characterize the NTV sector and its actors.

Conclusions

This study's hypothesized relationships were tested using multiple linear regression. Since the construct, objectives—independent variable with corresponding hypothesis H2—was justifiably eliminated from the model, the results for the remaining hypotheses are reported. The final model resulted in a strong linear relationship (F = 53.25; p = .0001) with a coefficient of determination R^2 value of 59.3% and the more conservative measure, adjusted R^2 value of 58.2%. A positive, significant relationship (p = 0.044) exists between perspective framework and usability. Managers who perceived a stronger link between the firm's strategy and the measures within the scorecard also reported higher levels of usability (p = 0.027). The relationship between managers' perceived importance/ usefulness of key performance indicators and usability had a significant positive relationship with usability (p = 0.035). Lastly, the relationship between managers' perceived usefulness of the key performance indicators' displays was positive and significant (p = 0.0001).

The scorecard evaluation results indicate a strong positive correlation exists between the importance and usefulness of the scorecard elements and a manager's decision to use the scorecard. Experienced NTV managers have found the scorecard a useable tool to aid in making effective decisions that impact product quality.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Summary

The goal of this research project was to design a balanced scorecard that could be used by project-level new technology venture (NTV) managers to make better product quality management decisions. The survey instrument used to make the assessment of this new scorecard was analyzed. This research determined the survey is a reliable and valid instrument to evaluate such a scorecard. This instrument was used to invite experienced NTV managers to evaluate the NTV *Product Quality Management* Balanced Scorecard. The scorecard was deemed an effective and usable scorecard—capable of enabling NTV managers to attain project-level product quality goals.

This scorecard was designed as a template for indigenous modification and can be rapidly incorporated into a variety of face-paced NTV environments. Now, engineering managers charged with launching technologically advanced products to the market for the first time can take guidance from the NTV *Product Quality Management* Balanced Scorecard. This measurement system designed to aid engineering managers with making more effective process improvement decisions that impact product quality is a significant advancement. Once adopted, NTV departments may project:

An increased likelihood that engineering design changes would be made when

1. Ease of change is highest;
2. Cost of change is lowest; and
3. The likelihood of confounding design errors due to complexity is lowest.

In addition,

4. Strong product quality goal congruency would result between the NTV department level manager and top management that would result in
5. Enhanced product quality, and
6. Increased successful launch rates.

The scorecard was designed for quick incorporation into a variety of new technology product development environments so NTV managers could begin to guide their teams toward higher quality products. As indicated in the list above, these leadership endeavors guided by the scorecard may have a positive influence on launch rates of technologically advanced products since superior product quality has been positively correlated with launch success.

Research Significance

An effective balanced scorecard that new technology entrepreneurs and managers can confidently use to enhance product quality is an innovation. It is an innovation because conventional wisdom dictates new technology venture environments rely on ad hoc manufacturing design processes and heroic management efforts to push a new technology into the market place even if it sacrifices product quality. Now, statistically evidence support the notion that new technology managers can invest sufficient up-front time to improve product quality while the cost to make design changes are lowest and least compounded. Significantly, the newly devised NTV scorecard provides managers a reliable tool that they can be easily incorporated as a day-today management tool that will aid in justifying making better process improvement decisions that they need to keep their new technology venture thriving in any competitive environment. The NTV scorecard provides an accessible, easy to use, and interpretable data display that makes straightforward for the NTV manager to improve their process management decisions; particularly in the areas that support product quality.

Recognize the isomorphic connection between the aerospace industry and the many fundamental shared characteristics it has with the new technology venture sector. This connection provided this researcher with the intuitive insight to test the NTV PQMI instrument in the NTV sector. The NTV PQMI survey instrument represents a step forward for those seeking to better understand the NTV environment. It will be an advancement because it provides a fast, inexpensive, and easy to administer survey instrument method of evaluation as compared to the slow, expensive, and arduous case study method of evaluation, which is now the dominate research tool in this sector. The ability to study and characterize the NTV environment will be enabled with this tool. Consequently, more expansive research may be conducted that may better characterize this arena. In turn, this will better equip practitioners with the capability to systematically launch newly commercialized technological products of higher quality.

In sum, this study is significant because (1) its results provide researchers and practitioners a new technology development product quality management model and success conformance imperatives that lead to replicable results, and thereby (2) may assist practitioners with improving the quality of first- or early- generation new technology products. This, in turn, may lead to the systematic increase of successful launch rates for new technologies. In addition, since this research does *not* rely on the time-consuming case study method and instead uses an efficient instrument to measure responses—(3) its proven efficacy makes expansive research of the NTV sector possible.

The importance of such research was underscored in a report titled *Innovation Measurement; Tracking the State of Innovation in the American Economy*, issued by the United States Secretary of Commerce, January 2008 and prepared by The Advisory Committee on Measuring Innovation in the 21st Century Economy (Schramm, 2008). This report articulated how critical it is for America's business leaders and legislators to obtain a better understanding of the factors that influence America's successful innovation including the critical factors that drive radically innovative product quality as defined in this research project. Authored by America's leading industrialists, they issued a call to action for researchers to examine the critical factors that drive radically innovative product quality so as to assist in the identification and assessment of radical innovation outcomes at the project level, as well as, develop effective and efficient innovation management measures. This research provides evidence in response to these imperatives.

Limitations and Further Research

Survey methodology has advantages such as systematic assessment of large samples. However, it also has limitations: (1) samples may not represent the entire population making generalizations difficult, and (2) the potential for non-response bias may influence results. In addition, future research is needed that studies NTV's "before and after" scorecard usage to actually affirm the new scorecard's actual effectiveness.

Another limitation is the use of a cross-sectional sample that may not represent the entire population. As such, survey results may not be generalizable across populations.

As noted earlier, while consistent with the literature, subjective measures were chosen due to the diversity in size and type of the firms surveyed. The use of these subjective measures as surrogates for product quality performance, however, can prove problematic.

Finally, as with any other research, findings should be replicated b considering time sensitive items; product quality management practices that may change over time. More research is required to verify and further support the findings, and the quantitative findings may be complimented with qualitative research.

Notwithstanding the limitations, this research has developed a methodology that enables researchers to conduct additional systematic assessment at numerous levels.

Because this research demonstrated the feasibility of using the systematic assessment method to evaluate the diverse NTV sector in the United States, this may enable future research to explore NTV's outside of this country. The importance of gaining an understanding the global industrial stage is becoming ever more significant to all players in the economy; consumers, industrialists, new tech entrepreneurs, amongst others, particularly as it relates to the development of technologically advanced products. The weapons race and the development of new energy sources are two arenas that are front row center stage. This type of research has the capability to provide a better understanding of how best to innovate successfully.

In addition, future researchers may wish to explore the use of the schema devised in this research to assess a business sector, corporation, division, or department. In addition, organizations such as non-profits, colleges, and universities where CMMI/TQM initiatives are applicable may be assessed. Once the assessment is done, researchers in their respective environments can then devise a balanced scorecard, and finally assess the scorecard's usability. These steps make contributions. However, it would be a significant contribution to take the next steps; to implement the newly devised scorecard and after a period of time, evaluate the scorecard's actual impact on product quality.

Researchers could also extend this research with the exploration of other BSC operational environments including the general purpose software, Microsoft Excel as well as specialized applications designed for the expressed purpose of making BSC's operational.

Rapid BSC Ramp-Up in NTV's

The newly devised NTV Product Quality Management Balanced Scorecard was evaluated by 151 experienced managers and deemed usable tool. Given the importance of innovation, and the fact that managing the quality of new technologically advanced products is essential to the success of each new venture—this newly devised business sector scorecard may have many applications. Because this scorecard is designed as a template for indigenous modification, it may be quickly incorporated into the fast-paced new technology product development arena. NTV managers grounded in continuous process improvement practices can now confidently incorporate this tool to guide their teams toward higher quality products. This, in turn, may have a positive influence on the successful launch rates of technologically advanced products since superior product quality has been positively correlated with launch success. And significantly, this scorecard may be used with confidence since its potential value has been established in this study.

Potential for Broad Use

This research project builds on process or capability maturity theory and is comprised of two studies. The first study determined critical factors that drive product quality in the NTV environment. In fact, this instrument may be revised and used in a number of environments where CMMI/TQM continuous process improvement initiatives can be applied. Study one indicates that even diverse business sectors may benefit from using this systematic assessment tool.

In addition to business sectors, individual firms that wish to devise their own indigenous BSC may start the process using the systematic assessment tool used in study one—to derive their own company-specific product quality performance management practices. These practices can then be readily converted to key performance indicators, as well as, the other key scorecard elements—using the precise (or a modified) scorecard development schema investigated, utilized, and proven in this research.

Conclusions

This research has demonstrated the efficacy of a five-step process to improve product quality in the NTV environment. It has shown that product quality management practices was systematically

1. Identified, and
2. Incorporated into a balanced scorecard.

This scorecard was

3. Developed for speedy and accurate interpretation.

In addition, the scorecard was

4. Made operational for immediate use,
5. Evaluated and deemed a usable tool.

Importantly, this five-step process may be tested in other environments. In addition, further research may be done to extend this methodology for a business unit or an entire business sector. In particular, this extension could include an evaluation of a business sector's product quality performance before and after the balanced scorecard's implementation to substantiate the anticipated product quality improvements.

This research expanded the applicability of the reliable and valid CMMI/TQM based instrument devised by Vitharana and Mone (2008). In addition, a new valid and reliable survey instrument to measure the effectiveness of NTV BSC elements was developed. And lastly, this research culminated in the development of a usable business sector NTV *Product Quality Management* Balanced Scorecard. This scorecard was deemed an effective tool for managers to improve the product quality management decisions in new technology venture departments.

Appendix A

Study One—New Technology Venture Product Quality Management Survey Instrument (NTV PQMI) Sequentially Numbered Survey

NTV Product Quality Management Instrument (NTV PQMI)

An Instrument for Measuring the Critical Factors of NTV Product Quality Management

The initial 54 items used for measuring critical factors of NTV Process quality management. The items noted with an asterisk (*) were subsequently deleted from the instrument. For each item, a response on a 5-point Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree) was solicited.

Process Management
»*Managing the process in developing NTV Process*

1. NTV processes are documented.
2. NTV processes utilized in practice are compared against ideal processes.
3. NTV processes of other organizations (e.g., competitors) are benchmarked.
4. NTV processes are continuously improved.
5. Top management emphasizes process quality in relation to product quality.
6. Configuration management techniques are utilized throughout the NTV development process.
7. Inspections and reviews are utilized in verifying various NTV Process documents (e.g., requirements specification, design specification, code, etc.).
8. A comprehensive testing program is utilized to validate the NTV Process.
9. Statistical methods (e.g., control charts, variation analysis, etc.) are used to control the NTV Process.
10. Computer-aided NTV Process engineering (CASE) tools are utilized in the NTV development process.
11. Defect prevention is emphasized over defect detection.
12. NTV Process defects are thoroughly analyzed.
13. NTV Process reuse is emphasized.
14. NTV process is emphasized over expediency.

Top NTV Management Commitment
»*Top New Technology Venture (NTV) management commitment to developing NTV Process*

15. Top NTV management assumes responsibility for quality performance.
16. Top NTV management is evaluated on quality performance.
17. Top NTV management links quality to the success of the NTV function.
18. Top NTV management participates in quality improvement efforts.
19. Quality issues are discussed during top NTV management meetings.
20. Top NTV management participates in quality-related planning (e.g., quality goals, guidelines, metrics, etc.).
21. Top NTV management emphasizes quality in relation to cost and schedule objectives.
22. Top NTV management allocates necessary personnel resources for quality improvement.
23. Top NTV management provides the leadership to create an overall quality culture.

Education and Training
» *Quality-related education and training for NTV personnel and NTV management*

24. Specific work-skills training are provided for NTV personnel.
25. Quality-related training is provided for NTV personnel.
26. Quality-related training is provided for NTV management.
27. Statistical techniques (e.g., control charts, variation analysis, etc.) are emphasized in quality-related educational programs.
28. Quality metrics are emphasized in quality-related educational programs.
29. Necessary non-personnel resources (e.g., financial capital) are provided for quality-related education and training.

Customer Focus
» *Focusing on customers who are any internal or external constituents for whom the NTV Process is developed*

30. Customer requirements are strongly elicited in developing NTV Process.
31. Customer requirements are fully incorporated into the NTV development process.
32. Customer requirements are traced and referred back to throughout the NTV Process development process.
33. Customer requirements are maintained flexible during NTV development in order to handle possible changes in customer needs.
34. Surveys are employed to assess customer satisfaction with the new technology product.
35. Customer feedback is incorporated into the new technology development process.
36. Customers are involved throughout the new technology development process.

Quality Metrics
»*Using quality-related metrics in developing NTV Process*

37. NTV Process quality metrics are available.
38. NTV Process quality metrics are utilized.
39. Data regarding quality are collected.
40. Data regarding quality are analyzed.
41. Statistical techniques (e.g., control charts, variation analysis, etc.) are used in analyzing data regarding quality.
42. Quality metrics are tightly coupled with the NTV development process.
43. NTV management value quality metrics for improving NTV Process quality.
44. NTV personnel value quality metrics in improving NTV Process quality.
45. Collecting data regarding quality is emphasized over expediency.

Employee Responsibility
»*Employee responsibility is defined for developing NTV Process.*

46. NTV personnel are held responsible for quality performance.
47. NTV personnel are evaluated on quality performance.
48. NTV personnel are rewarded for quality performance.
49. NTV personnel link quality to the success of the NTV function.
50. NTV personnel are involved in NTV Process quality improvement efforts.
51. NTV personnel participate in quality-related planning (e.g., quality goals, guidelines, metrics, etc.).
52. Quality teams are implemented in the NTV department.

53. NTV personnel emphasize quality in relation to schedule objectives.
54. NTV personnel provide feedback on quality to NTV management.

	PM Process Mgt	**MC** Mgt Commitment	**ET** Employee Training	**CF** Customer Focus	**QM** Quality Metrics	**ER** Employee Responsibility
Question #	1 - 14	15 - 23	24 - 29	30 - 36	37 - 45	46 - 54

Appendix B

Study One—Minitab Detailed Results:
Stepwise Regression Output and
Cronbach's Alpha Output

Stepwise Regression: 55 = Q1 versus 1, 2, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is 55 on 54 predictors, with N = 102

Step	1	2	3	4	5	6
Constant	0.9201	0.1240	-0.1825	-0.4542	-0.7478	-0.6405
43	0.721	0.533	0.429	0.382	0.326	0.361
T-Value	8.81	6.47	5.14	4.58	3.86	4.27
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
38		0.385	0.282	0.259	0.227	0.281
T-Value		5.03	3.63	3.38	2.99	3.59
P-Value		0.000	0.000	0.001	0.004	0.001
30			0.286	0.258	0.206	0.234
T-Value			3.54	3.26	2.57	2.93
P-Value			0.001	0.002	0.012	0.004
3				0.166	0.178	0.183
T-Value				2.46	2.70	2.82
P-Value				0.016	0.008	0.006
50					0.203	0.239
T-Value					2.43	2.86
P-Value					0.017	0.005
11						-0.182
T-Value						-2.18
P-Value						0.032
S	0.671	0.601	0.569	0.555	0.541	0.531
R-Sq	43.69	55.15	60.24	62.58	64.76	66.43
R-Sq(adj)	43.12	54.24	59.03	61.04	62.92	64.31
Mallows Cp	60.9	30.6	18.2	13.6	9.5	6.7
PRESS	46.8819	37.7328	34.5154	34.4491	32.9558	32.1781
R-Sq(pred)	41.29	52.75	56.78	56.86	58.73	59.70

Step	7	8	9	10	11	12
Constant	-0.7910	-0.7904	-0.8783	-0.8385	-0.8189	-0.7533
43	0.282	0.257	0.243	0.246	0.237	0.290
T-Value	3.09	2.84	2.74	2.83	2.79	3.23
P-Value	0.003	0.006	0.007	0.006	0.006	0.002
38	0.303	0.342	0.373	0.402	0.340	0.356
T-Value	3.89	4.33	4.75	5.15	4.22	4.43
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
30	0.222	0.261	0.289	0.295	0.288	0.287
T-Value	2.83	3.28	3.66	3.81	3.81	3.83
P-Value	0.006	0.001	0.000	0.000	0.000	0.000
3	0.192	0.197	0.216	0.307	0.338	0.348
T-Value	3.02	3.14	3.48	4.18	4.64	4.81
P-Value	0.003	0.002	0.001	0.000	0.000	0.000
50	0.224	0.271	0.395	0.463	0.431	0.424
T-Value	2.71	3.21	3.95	4.52	4.27	4.24
P-Value	0.008	0.002	0.000	0.000	0.000	0.000
11	-0.203	-0.220	-0.218	-0.217	-0.228	-0.234
T-Value	-2.45	-2.68	-2.72	-2.75	-2.97	-3.07
P-Value	0.016	0.009	0.008	0.007	0.004	0.003
25	0.136	0.181	0.233	0.280	0.268	0.296
T-Value	2.09	2.67	3.31	3.87	3.80	4.12
P-Value	0.040	0.009	0.001	0.000	0.000	0.000

46		-0.135	-0.176	-0.204	-0.227	-0.215
T-Value		-2.03	-2.60	-3.03	-3.42	-3.26
P-Value		0.045	0.011	0.003	0.001	0.002
51			-0.181	-0.234	-0.228	-0.234
T-Value			-2.21	-2.79	-2.79	-2.89
P-Value			0.030	0.006	0.006	0.005
4				-0.176	-0.218	-0.219
T-Value				-2.22	-2.74	-2.78
P-Value				0.029	0.007	0.007
36					0.163	0.190
T-Value					2.37	2.71
P-Value					0.020	0.008
49						-0.136
T-Value						-1.70
P-Value						0.093
S	0.522	0.514	0.503	0.493	0.481	0.476
R-Sq	67.92	69.28	70.83	72.33	73.95	74.76
R-Sq(adj)	65.53	66.64	67.98	69.29	70.76	71.36
Mallows Cp	4.5	2.7	0.3	-1.9	-4.5	-4.8
PRESS	31.3667	30.9739	30.4248	29.3439	28.1741	28.1239
R-Sq(pred)	60.72	61.21	61.90	63.25	64.72	64.78

Step	13	14	15
Constant	-0.7644	-0.6794	-0.6566
43	0.278	0.311	0.290
T-Value	3.12	3.42	3.21
P-Value	0.002	0.001	0.002
38	0.358	0.344	0.344
T-Value	4.51	4.34	4.40
P-Value	0.000	0.000	0.000
30	0.278	0.277	0.301
T-Value	3.75	3.78	4.08
P-Value	0.000	0.000	0.000
3	0.326	0.321	0.312
T-Value	4.49	4.45	4.39
P-Value	0.000	0.000	0.000
50	0.432	0.420	0.404
T-Value	4.37	4.27	4.15
P-Value	0.000	0.000	0.000
11	-0.242	-0.240	-0.273
T-Value	-3.21	-3.21	-3.59
P-Value	0.002	0.002	0.001
25	0.253	0.236	0.220
T-Value	3.39	3.15	2.96
P-Value	0.001	0.002	0.004
46	-0.218	-0.208	-0.199
T-Value	-3.34	-3.19	-3.09
P-Value	0.001	0.002	0.003
51	-0.250	-0.223	-0.220
T-Value	-3.11	-2.73	-2.73
P-Value	0.003	0.008	0.008
4	-0.232	-0.248	-0.270
T-Value	-2.97	-3.17	-3.46
P-Value	0.004	0.002	0.001

36	0.185	0.195	0.192
T-Value	2.68	2.82	2.82
P-Value	0.009	0.006	0.006
49	-0.151	-0.129	-0.145
T-Value	-1.90	-1.61	-1.83
P-Value	0.061	0.111	0.071
24	0.140	0.188	0.181
T-Value	1.79	2.26	2.19
P-Value	0.076	0.027	0.031
15		-0.110	-0.136
T-Value		-1.54	-1.88
P-Value		0.128	0.063
23			0.130
T-Value			1.84
P-Value			0.070
S	0.470	0.466	0.460
R-Sq	75.65	76.30	77.19
R-Sq(adj)	72.06	72.48	73.21
Mallows Cp	-5.3	-5.1	-5.6
PRESS	27.8441	27.3328	27.3925
R-Sq(pred)	65.13	65.77	65.70

Regression Analysis: 55 = Q1 versus 43, 38, ...

```
The regression equation is
55 = - 0.657 + 0.290 43 + 0.344 38 + 0.301 30 + 0.312 3 + 0.404 50 - 0.273 11
     + 0.220 25 - 0.199 46 - 0.220 51 - 0.270 4 + 0.192 36 - 0.145 49 + 0.181 24
     - 0.136 15 + 0.130 23
```

Predictor	Coef	SE Coef	T	P	VIF
Constant	-0.6566	0.3174	-2.07	0.042	
43	0.28995	0.09036	3.21	0.002	2.584
38	0.34372	0.07814	4.40	0.000	2.248
30	0.30050	0.07356	4.08	0.000	1.977
3	0.31216	0.07117	4.39	0.000	2.027
50	0.40441	0.09747	4.15	0.000	2.827
11	-0.27251	0.07591	-3.59	0.001	1.955
25	0.22005	0.07446	2.96	0.004	2.479
46	-0.19904	0.06450	-3.09	0.003	2.045
51	-0.22014	0.08075	-2.73	0.008	2.796
4	-0.27037	0.07809	-3.46	0.001	2.218
36	0.19163	0.06802	2.82	0.006	2.061
49	-0.14547	0.07966	-1.83	0.071	2.240
24	0.18084	0.08250	2.19	0.031	2.448
15	-0.13563	0.07210	-1.88	0.063	2.113
23	0.13014	0.07086	1.84	0.070	2.043

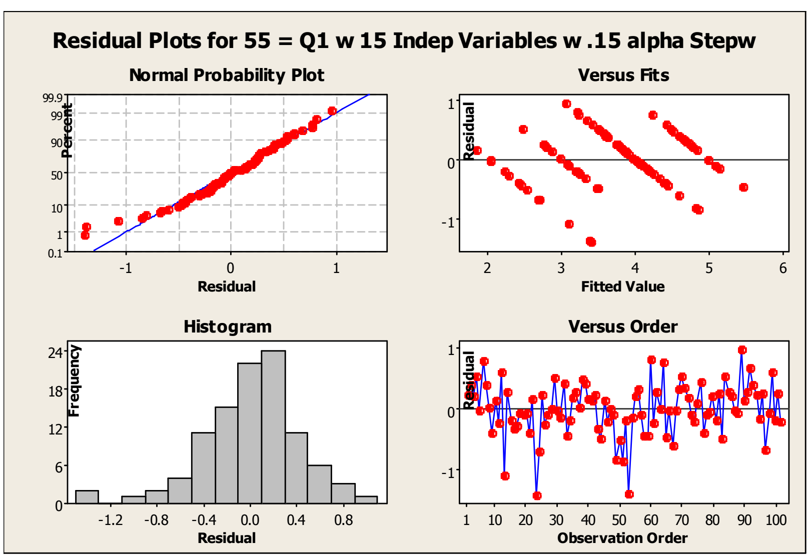
S = 0.460189   R-Sq = 77.2%   R-Sq(adj) = 73.2%

PRESS = 27.3925   R-Sq(pred) = 65.70%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	15	61.6404	4.1094	19.40	0.000
Residual Error	86	18.2126	0.2118		
Total	101	79.8529			

Residual Plots for 55 = Q1



```
The product performance regression equation is

55 = - 0.657 + 0.290 43 + 0.344 38 + 0.301 30 + 0.312 3 + 0.404 50 - 0.273 11
     + 0.220 25 - 0.199 46 - 0.220 51 - 0.270 4 + 0.192 36 - 0.145 49 + 0.181 24
     - 0.136 15 + 0.130 23
```

	PM Process Mgt	**MC** Mgt Commitment	**ET** Employee Training	**CF** Customer Focus	**QM** Quality Metrics	**ER** Employee Responsibility
Question #	1 - 14	15 - 23	24 - 29	30 - 36	37 - 45	46 - 54

Product Performance

$Q_1 =$ $-0.657 + 0.29\ QM_{43} + 0.344\ QM_{38} + 0.301\ CF_{30} + 0.312\ PM_3 + 0.404\ ER_{50} - 0.273\ PM_{11} + 0.220\ ET_{25} - .199\ ER_{46} - 0.220\ ER_{51} - 0.270\ PM_4 + 0.192\ CF_{36} - 0.145\ ER_{49} + 0.181\ ET_{24} - 0.135\ MC_{15} + 0.130\ MC_{23}$

<u>Grouping Constructs the product performance regression equation is:</u>

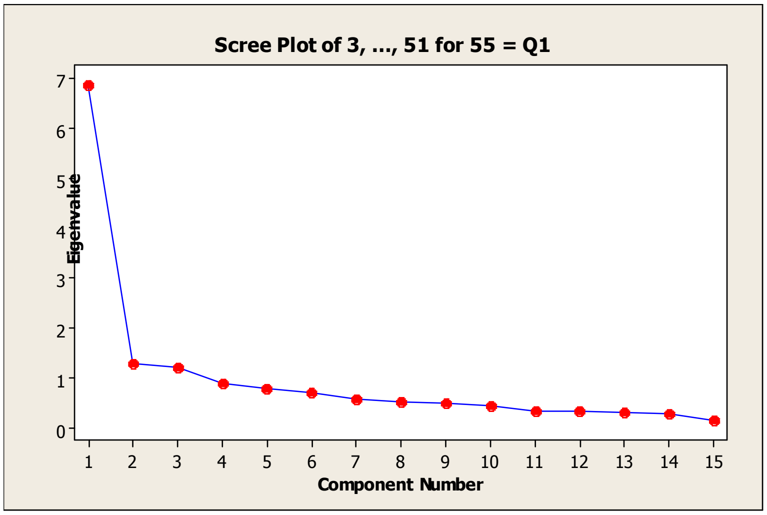
$Q_1 =$ $-0.657 + 0.312\ PM_3 - 0.270\ PM_4 - 0.273\ PM_{11} - 0.135\ MC_{15} + 0.130\ MC_{23} + 0.181\ ET_{24} + 0.220\ ET_{25} + 0.301\ CF_{30} + 0.192\ CF_{36} + 0.344\ QM_{38} + 0.29\ QM_{43} - .199\ ER_{46} - 0.145\ ER_{49} + 0.404\ ER_{50} - 0.220\ ER_{51}$

Best Subsets Regression: 55 versus 43, 38, ...

Response is 55

Vars	R-Sq	R-Sq(adj)	Mallows Cp	S	43	38	30	3	50	11	25	46	51	4	36	49	24	15	23
1	43.7	43.1	114.3	0.67058	X														
1	38.7	38.1	133.2	0.69979			X												
2	55.1	54.2	73.1	0.60147	X	X													
2	54.9	54.0	74.0	0.60311	X		X												
3	60.2	59.0	55.9	0.56915	X	X	X												
3	59.1	57.8	60.4	0.57758	X		X								X				
4	62.6	61.1	49.0	0.55477	X		X	X							X				
4	62.6	61.0	49.1	0.55503	X	X	X	X											
5	64.8	62.9	42.9	0.54145	X	X	X	X	X										
5	64.4	62.5	44.2	0.54415	X	X	X	X							X				
6	66.4	64.3	38.6	0.53119	X	X	X	X	X	X									
6	65.9	63.7	40.7	0.53558	X	X	X	X	X		X								
7	67.9	65.5	35.0	0.52207	X	X	X	X	X	X	X								
7	67.8	65.4	35.6	0.52339	X	X	X	X	X	X							X		
8	69.3	66.6	31.8	0.51357	X	X	X	X	X	X	X	X							
8	68.9	66.3	33.1	0.51647	X	X	X	X	X	X							X	X	
9	70.8	68.0	28.0	0.50317	X	X	X	X	X	X	X	X	X						
9	70.5	67.6	29.4	0.50637	X	X	X	X	X	X	X	X			X				
10	72.3	69.3	24.3	0.49278	X	X	X	X	X	X	X	X	X	X					
10	71.8	68.7	26.4	0.49765	X	X	X	X	X	X	X	X	X		X				
11	73.9	70.8	20.2	0.48080	X	X	X	X	X	X	X	X	X	X	X				
11	73.2	69.9	23.2	0.48791	X	X	X	X	X	X	X	X	X	X			X		
12	74.8	71.4	19.2	0.47584	X	X	X	X	X	X	X	X	X	X	X	X			
12	74.7	71.2	19.6	0.47683	X	X	X	X	X	X	X	X	X	X	X		X		
13	75.7	72.1	17.8	0.47002	X	X	X	X	X	X	X	X	X	X	X	X	X		
13	75.6	72.0	18.0	0.47064	X	X	X	X	X	X	X	X	X	X	X		X	X	
14	76.3	72.5	17.3	0.46632	X	X	X	X	X	X	X	X	X	X	X		X	X	X
14	76.3	72.5	17.4	0.46642	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
15	77.2	73.2	16.0	0.46019	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Scree Plot of 3, ..., 51 IV's of 55 = Q1



Eigenanalysis of the Correlation Matrix

Eigenvalue	6.8582	1.2697	1.1864	0.8765	0.7672	0.6960	0.5742	0.5050
Proportion	0.457	0.085	0.079	0.058	0.051	0.046	0.038	0.034
Cumulative	0.457	0.542	0.621	0.679	0.731	0.777	0.815	0.849

Eigenvalue	0.4826	0.4328	0.3298	0.3195	0.2953	0.2627	0.1440
Proportion	0.032	0.029	0.022	0.021	0.020	0.018	0.010
Cumulative	0.881	0.910	0.932	0.953	0.973	0.990	1.000

3, 4, 11, 15, and 23 account for 73.1% of model

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
3	0.193	0.491	-0.409	0.126	-0.300	0.208	-0.091	0.001	-0.150
4	0.225	0.441	-0.354	-0.066	-0.088	-0.394	-0.118	-0.020	0.142
11	0.265	-0.127	-0.176	0.169	0.386	0.020	0.560	-0.284	-0.102
15	0.254	0.029	0.375	0.088	0.067	0.491	-0.396	-0.245	-0.061
23	0.267	0.253	0.139	0.075	0.404	-0.191	-0.017	-0.194	-0.486
24	0.284	0.233	0.232	0.029	-0.177	0.119	0.029	-0.425	0.358
25	0.247	0.083	0.448	-0.106	-0.213	-0.373	0.400	0.039	0.240
30	0.265	-0.204	-0.207	0.052	-0.300	0.328	0.305	0.165	0.096
36	0.261	-0.229	-0.144	-0.365	0.244	-0.211	-0.346	-0.115	0.360
38	0.256	-0.216	-0.379	-0.156	0.259	0.223	0.022	-0.026	0.186
43	0.299	0.138	0.127	0.019	0.128	0.120	0.126	0.545	-0.113
46	0.233	-0.316	-0.007	-0.405	-0.490	-0.047	0.021	-0.247	-0.474
49	0.280	0.084	0.174	-0.391	0.121	0.109	-0.102	0.457	-0.039
50	0.265	-0.332	-0.064	0.335	-0.106	-0.369	-0.286	0.119	-0.239
51	0.262	-0.214	0.068	0.580	-0.103	-0.072	-0.155	0.125	0.228

Variable	PC10	PC11	PC12	PC13	PC14	PC15
3	0.279	0.028	-0.292	-0.300	-0.225	-0.264
4	-0.267	0.101	0.158	0.134	0.503	0.224
11	-0.047	0.400	-0.349	-0.024	0.099	0.076
15	-0.194	0.137	0.007	-0.197	0.443	-0.170
23	-0.024	-0.578	0.091	0.049	-0.139	0.032
24	0.003	0.148	0.162	0.431	-0.457	0.113
25	0.181	-0.106	0.003	-0.276	0.187	-0.402
30	-0.534	-0.458	-0.056	0.107	0.011	-0.081
36	-0.213	-0.061	-0.228	-0.404	-0.308	0.027
38	0.479	-0.114	0.481	0.113	0.160	-0.236
43	-0.143	0.313	0.436	-0.303	-0.259	0.225
46	0.154	0.077	0.085	-0.093	0.041	0.326
49	0.191	0.026	-0.474	0.462	0.087	0.041
50	-0.130	0.266	0.051	0.279	-0.136	-0.466
51	0.347	-0.204	-0.151	-0.098	0.108	0.481

Stepwise Regression: 56 versus 1, 2, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is 56 on 54 predictors, with N = 102

Step	1	2	3	4	5	6
Constant	1.45229	0.84459	0.21883	-0.08907	-0.12412	-0.10804
42	0.635	0.437	0.341	0.260	0.153	
T-Value	7.62	4.42	3.43	2.56	1.35	
P-Value	0.000	0.000	0.001	0.012	0.180	
39		0.355	0.346	0.342	0.298	0.345
T-Value		3.36	3.42	3.48	3.00	3.68
P-Value		0.001	0.001	0.001	0.003	0.000
3			0.261	0.244	0.215	0.231
T-Value			3.15	3.02	2.65	2.87
P-Value			0.002	0.003	0.009	0.005
34				0.178	0.162	0.182
T-Value				2.61	2.41	2.75
P-Value				0.011	0.018	0.007
52					0.208	0.274
T-Value					2.00	2.98
P-Value					0.048	0.004
S	0.770	0.734	0.703	0.683	0.672	0.675
R-Sq	36.73	43.22	48.44	51.81	53.74	52.87
R-Sq(adj)	36.10	42.07	46.86	49.82	51.34	50.92
Mallows Cp	50.9	37.6	27.3	21.4	18.8	18.9
PRESS	61.6346	56.3712	53.0349	50.6295	49.7845	49.7056
R-Sq(pred)	34.30	39.91	43.47	46.03	46.93	47.02

Step	7	8	9	10	11	12
Constant	-0.3326	-0.2870	-0.5858	-0.8760	-0.8050	-0.8376
42						
T-Value						
P-Value						
39	0.289	0.341	0.290	0.264	0.261	0.246
T-Value	3.05	3.57	3.09	2.83	2.83	2.70
P-Value	0.003	0.001	0.003	0.006	0.006	0.008
3	0.218	0.235	0.212	0.219	0.220	0.231
T-Value	2.76	3.03	2.82	2.95	3.00	3.18
P-Value	0.007	0.003	0.006	0.004	0.003	0.002
34	0.190	0.255	0.208	0.214	0.224	0.233
T-Value	2.93	3.67	3.01	3.14	3.33	3.49
P-Value	0.004	0.000	0.003	0.002	0.001	0.001
52	0.225	0.232	0.237	0.221	0.224	0.203
T-Value	2.43	2.56	2.71	2.55	2.62	2.38
P-Value	0.017	0.012	0.008	0.012	0.010	0.019
22	0.170	0.227	0.207	0.193	0.197	0.197
T-Value	2.27	2.93	2.76	2.60	2.70	2.73
P-Value	0.025	0.004	0.007	0.011	0.008	0.008
27		-0.213	-0.302	-0.306	-0.240	-0.264
T-Value		-2.30	-3.19	-3.27	-2.44	-2.69
P-Value		0.024	0.002	0.002	0.017	0.008
12			0.287	0.284	0.310	0.297
T-Value			2.84	2.84	3.13	3.02
P-Value			0.006	0.006	0.002	0.003

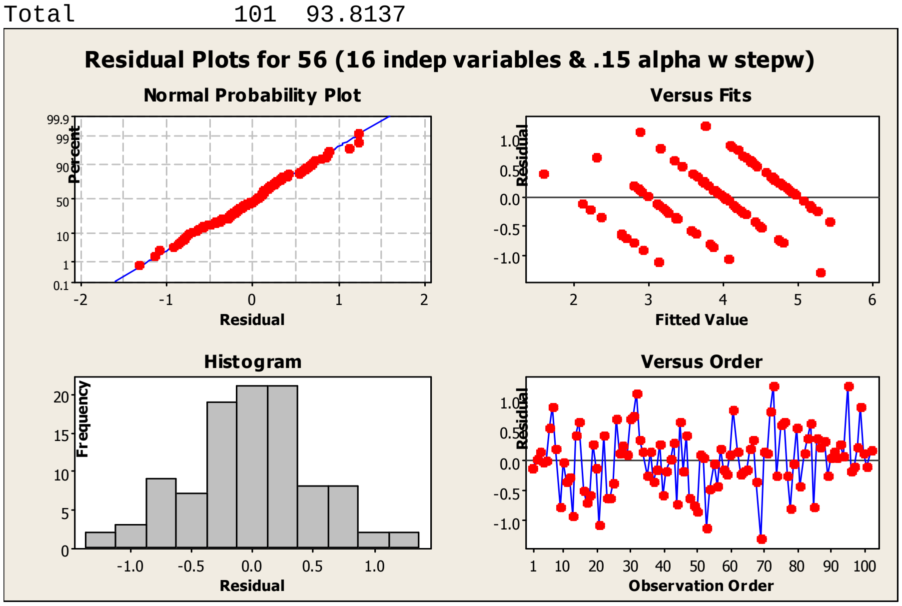
53				0.130	0.159	0.112
T-Value				1.91	2.31	1.55
P-Value				0.059	0.023	0.124
47					-0.153	-0.191
T-Value					-1.94	-2.38
P-Value					0.055	0.020
13						0.149
T-Value						1.84
P-Value						0.069
S	0.661	0.647	0.624	0.615	0.606	0.599
R-Sq	55.27	57.63	60.97	62.45	63.93	65.22
R-Sq(adj)	52.94	54.95	58.06	59.22	60.40	61.40
Mallows Cp	15.3	11.7	5.8	4.4	2.9	1.8
PRESS	47.7106	46.7190	43.9544	43.4155	42.8123	42.1107
R-Sq(pred)	49.14	50.20	53.15	53.72	54.36	55.11

Step	13	14	15	16	17	18
Constant	-0.7929	-0.8957	-0.8315	-0.6974	-0.7176	-0.6159
42						
T-Value						
P-Value						
39	0.301	0.297	0.266	0.216	0.243	0.248
T-Value	3.19	3.19	2.85	2.22	2.48	2.56
P-Value	0.002	0.002	0.006	0.029	0.015	0.012
3	0.243	0.221	0.220	0.233	0.248	0.249
T-Value	3.38	3.08	3.11	3.30	3.53	3.56
P-Value	0.001	0.003	0.003	0.001	0.001	0.001
34	0.281	0.294	0.295	0.273	0.282	0.276
T-Value	4.00	4.21	4.28	3.92	4.08	4.04
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
52	0.234	0.223	0.252	0.249	0.244	0.246
T-Value	2.75	2.63	2.97	2.95	2.92	2.97
P-Value	0.007	0.010	0.004	0.004	0.004	0.004
22	0.171	0.119	0.153	0.143	0.171	0.185
T-Value	2.37	1.54	1.95	1.84	2.17	2.36
P-Value	0.020	0.127	0.054	0.069	0.033	0.021
27	-0.21	-0.24	-0.21	-0.23	-0.25	-0.25
T-Value	-2.07	-2.39	-2.06	-2.25	-2.44	-2.48
P-Value	0.041	0.019	0.042	0.027	0.017	0.015
12	0.322	0.284	0.332	0.315	0.322	0.332
T-Value	3.29	2.88	3.29	3.14	3.24	3.36
P-Value	0.001	0.005	0.001	0.002	0.002	0.001
53	0.126	0.119	0.147	0.141	0.167	0.148
T-Value	1.75	1.68	2.06	1.98	2.32	2.04
P-Value	0.083	0.096	0.043	0.051	0.023	0.044
47	-0.181	-0.184	-0.168	-0.211	-0.209	-0.208
T-Value	-2.28	-2.35	-2.16	-2.58	-2.59	-2.59
P-Value	0.025	0.021	0.033	0.011	0.011	0.011
13	0.161	0.163	0.162	0.179	0.202	0.201
T-Value	2.01	2.05	2.07	2.29	2.57	2.58
P-Value	0.048	0.043	0.041	0.024	0.012	0.011
41	-0.24	-0.27	-0.26	-0.28	-0.25	-0.23
T-Value	-1.94	-2.13	-2.11	-2.26	-2.09	-1.90
P-Value	0.056	0.036	0.038	0.026	0.039	0.061

40		0.20	0.22	0.21	0.22	0.26
T-Value		1.83	2.02	1.97	2.11	2.42
P-Value		0.070	0.046	0.052	0.038	0.018
21			-0.19	-0.22	-0.24	-0.22
T-Value			-1.83	-2.05	-2.25	-2.05
P-Value			0.071	0.043	0.027	0.043
28				0.154	0.174	0.191
T-Value				1.61	1.84	2.02
P-Value				0.110	0.070	0.047
51					-0.142	-0.128
T-Value					-1.74	-1.56
P-Value					0.086	0.123
11						-0.146
T-Value						-1.54
P-Value						0.127
S	0.590	0.582	0.575	0.570	0.563	0.559
R-Sq	66.62	67.83	69.01	69.91	70.92	71.71
R-Sq(adj)	62.54	63.49	64.43	65.06	65.85	66.39
Mallows Cp	0.6	-0.3	-1.1	-1.2	-1.6	-1.4
PRESS	41.8874	42.2403	41.3388	40.9447	40.1008	40.2651
R-Sq(pred)	55.35	54.97	55.94	56.36	57.25	57.08

Regression Analysis: Question 56 = Q2 versus 39, 3, ...

```
The regression equation is
56 = - 0.616 + 0.248 39 + 0.249 3 + 0.276 34 + 0.246 52 + 0.185 22 - 0.247 27
     + 0.332 12 + 0.148 53 - 0.208 47 + 0.201 13 - 0.231 41 + 0.260 40
     - 0.216 21 + 0.191 28 - 0.128 51 - 0.146 11


Predictor       Coef   SE Coef      T      P    VIF
Constant     -0.6159    0.4032  -1.53  0.130
39           0.24809   0.09705   2.56  0.012  2.256
3            0.24855   0.06988   3.56  0.001  1.326
34           0.27645   0.06851   4.04  0.000  1.842
52           0.24608   0.08274   2.97  0.004  2.006
22           0.18514   0.07851   2.36  0.021  2.039
27          -0.24741   0.09964  -2.48  0.015  2.820
12           0.33212   0.09881   3.36  0.001  2.150
53           0.14801   0.07240   2.04  0.044  1.544
47          -0.20767   0.08003  -2.59  0.011  2.023
13           0.20086   0.07774   2.58  0.011  1.885
41           -0.2306    0.1215  -1.90  0.061  3.158
40            0.2601    0.1074   2.42  0.018  2.437
21           -0.2159    0.1051  -2.05  0.043  2.477
28           0.19116   0.09485   2.02  0.047  3.072
51          -0.12762   0.08193  -1.56  0.123  1.952
11          -0.14615   0.09477  -1.54  0.127  2.067

S = 0.558733   R-Sq = 71.7%   R-Sq(adj) = 66.4%

PRESS = 40.2651   R-Sq(pred) = 57.08%

Analysis of Variance

Source           DF       SS      MS      F      P
Regression       16  67.2782  4.2049  13.47  0.000
Residual Error   85  26.5355  0.3122
Total           101  93.8137
```



```
The organizational performance regression equation is
56 = - 0.616 + 0.248 39 + 0.249 3 + 0.276 34 + 0.246 52 + 0.185 22 - 0.247 27
     + 0.332 12 + 0.148 53 - 0.208 47 + 0.201 13 - 0.231 41 + 0.260 40
     - 0.216 21 + 0.191 28 - 0.128 51 - 0.146 11
```

	PM Process Mgt	**MC** Mgt Commitment	**ET** Employee Training	**CF** Customer Focus	**QM** Quality Metrics	**ER** Employee Responsibility
Question #	1 - 14	15 - 23	24 - 29	30 - 36	37 - 45	46 - 54

Organizational Performance

Q_2 = $-0.6159 + 0.248x_{39} + 0.249x_3 + 0.276x_{34} + 0.246x_{52} + 0.185x_{22} + 0.25x_{27}$
$+ 0.332x_{12} + .148x_{53} – 0.208x_{47} + 0.201x_{13} – 0.23x_{41} + 0.26x_{40}$
$– 0.22x_{21} + .191x_{28} –.128x_{51} – .146x_{11}$

Grouping Constructs:

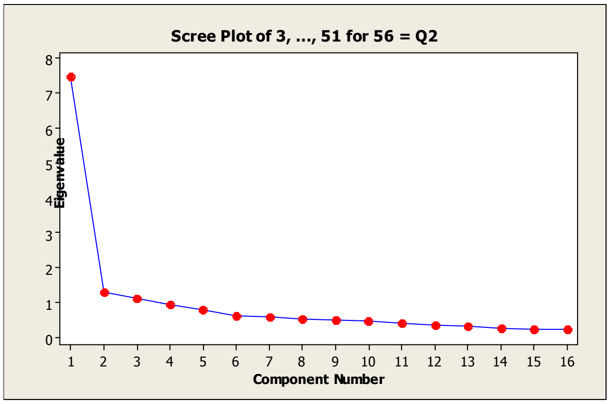
Q_2 = $-0.6159 + 0.249\ PM_3 – 0.146\ PM_{11} + 0.332\ PM_{12} + 0.201\ PM_{13} + 0.185\ MC_{22} – 0.22\ MC_{21}$
$+ 0.25\ ET_{27} + 0.191\ ET_{28} + 0.276\ CF_{34} + 0.248\ QM_{39} + 0.26\ QM_{40} – 0.23\ QM_{41}$
$+ 0.246\ ER_{52} + 0.148\ ER_{53} – 0.208\ ER_{47} – 0.128ER_{51}$

Best Subsets Regression: 56 versus 39, 3, ...

Response is 56

Vars	R-Sq	R-Sq(adj)	Mallows Cp	S	39	3	34	52	22	27	12	53	47	13	41	40	21	28	51	11
1	36.5	35.8	92.9	0.77192				X												
1	32.0	31.3	106.4	0.79873	X															
2	46.7	45.6	64.2	0.71080				X			X									
2	44.4	43.3	71.1	0.72590	X			X												
3	50.3	48.8	55.3	0.68975	X			X			X									
3	49.9	48.3	56.6	0.69266		X		X			X									
4	53.6	51.6	47.6	0.67022	X	X		X			X									
4	52.9	50.9	49.6	0.67517	X	X	X	X												
5	55.3	52.9	44.4	0.66115	X	X	X	X	X											
5	55.2	52.9	44.6	0.66157	X		X	X		X						X				
6	58.1	55.4	38.0	0.64355	X	X	X	X			X				X					
6	58.0	55.4	38.2	0.64386	X	X	X	X		X						X				
7	61.0	58.1	31.3	0.62411	X	X	X	X	X	X	X									
7	60.5	57.6	32.7	0.62780	X	X	X	X			X	X			X					
8	62.4	59.2	28.8	0.61546	X	X	X	X	X	X	X	X								
8	62.4	59.2	29.0	0.61578	X	X	X	X	X	X	X			X						
9	64.3	60.8	25.3	0.60331	X	X	X	X	X	X	X		X	X						
9	64.2	60.7	25.6	0.60434	X	X	X	X		X	X	X			X	X				
10	65.8	62.0	22.8	0.59375	X	X	X	X		X	X		X	X	X	X				
10	65.5	61.7	23.7	0.59658	X	X	X	X	X	X	X		X	X	X					
11	67.0	63.0	21.2	0.58648	X	X	X	X	X	X	X		X	X		X				X
11	67.0	62.9	21.2	0.58673	X	X	X	X		X	X	X	X	X	X	X				
12	68.1	63.7	20.0	0.58031	X	X	X	X	X	X	X		X	X	X	X				X
12	67.9	63.6	20.4	0.58135	X	X	X	X		X	X		X	X	X	X		X		X
13	69.1	64.5	18.8	0.57383	X	X	X	X	X	X	X		X	X	X	X		X		X
13	69.0	64.4	19.1	0.57482	X	X	X	X	X	X	X	X	X	X	X	X	X			
14	69.9	65.1	18.4	0.56966	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
14	69.9	65.1	18.5	0.56973	X	X	X	X	X	X	X		X	X	X	X	X	X		X
15	70.9	65.9	17.4	0.56319	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
15	70.9	65.8	17.4	0.56335	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
16	71.7	66.4	17.0	0.55873	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Scree Plot of 3, ..., 51 for 56 = Q2



Principal Component Analysis: 3, 11, 12, 13, 21, 22, 27, 28, 34, 39, 40, 41, 52 ... For 56 = Q2

Eigenanalysis of the Correlation Matrix

Eigenvalue	7.4707	1.3026	1.1108	0.9396	0.7764	0.6092	0.5751	0.5118
Proportion	0.467	0.081	0.069	0.059	0.049	0.038	0.036	0.032
Cumulative	0.467	0.548	0.618	0.676	0.725	0.763	0.799	0.831

Eigenvalue	0.4869	0.4508	0.4046	0.3339	0.3091	0.2613	0.2393	0.2180
Proportion	0.030	0.028	0.025	0.021	0.019	0.016	0.015	0.014
Cumulative	0.861	0.890	0.915	0.936	0.955	0.971	0.986	1.000

3, 11, 12, 13, and 21 account for 72.5% of Model

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
3	0.160	-0.228	-0.366	-0.479	-0.613	0.285	0.009	-0.022	-0.156
11	0.264	-0.100	-0.248	0.185	0.188	0.151	0.092	0.076	0.218
12	0.269	-0.205	0.074	0.161	-0.039	0.117	0.167	0.595	-0.015
13	0.226	0.394	0.261	-0.029	-0.158	0.143	-0.390	0.129	0.573
21	0.276	0.030	-0.054	0.291	-0.275	-0.412	0.088	0.122	-0.098
22	0.231	0.189	-0.457	0.280	0.084	-0.170	0.065	-0.377	0.091
27	0.292	-0.162	0.109	0.212	-0.063	0.041	-0.173	0.002	0.001
28	0.299	-0.079	0.149	0.097	0.210	0.024	0.040	-0.181	-0.430
34	0.201	-0.434	0.387	-0.164	0.012	-0.274	0.354	-0.266	0.268
39	0.255	0.102	-0.085	-0.290	0.508	0.096	-0.266	0.201	-0.334
40	0.277	-0.001	-0.328	0.174	-0.062	0.048	0.077	0.152	0.096
41	0.293	-0.173	0.220	-0.226	0.104	-0.032	-0.039	0.138	0.050
52	0.252	-0.023	-0.165	-0.375	0.030	-0.507	-0.388	-0.146	0.085
53	0.151	0.617	0.202	-0.171	-0.216	-0.250	0.368	0.155	-0.273
47	0.247	0.049	0.320	0.256	-0.261	0.326	-0.271	-0.409	-0.272
51	0.249	0.243	-0.033	-0.256	0.205	0.385	0.453	-0.260	0.215

Variable	PC10	PC11	PC12	PC13	PC14	PC15	PC16
3	-0.035	-0.001	0.189	0.170	-0.094	0.021	0.048
11	0.745	-0.010	0.188	0.260	0.117	0.133	-0.122
12	-0.281	-0.449	-0.225	0.111	0.289	0.162	0.062
13	-0.087	-0.074	0.102	0.206	-0.313	0.025	0.136
21	0.083	-0.282	0.337	-0.318	-0.280	-0.389	-0.165
22	-0.396	-0.009	0.131	0.330	0.280	-0.095	0.248
27	-0.257	0.443	0.353	-0.276	0.157	0.470	-0.297
28	0.057	-0.103	0.016	0.052	-0.493	0.359	0.468
34	-0.113	0.067	-0.081	0.370	-0.138	-0.094	-0.252
39	-0.173	0.029	0.114	0.228	-0.106	-0.293	-0.387
40	-0.021	0.461	-0.628	-0.129	-0.315	-0.129	-0.035
41	0.116	0.310	0.130	-0.216	0.330	-0.405	0.551
52	0.138	-0.251	-0.308	-0.202	0.171	0.288	-0.048
53	0.138	0.239	-0.037	0.197	0.183	0.173	-0.058
47	0.147	-0.128	-0.292	0.042	0.264	-0.237	-0.169
51	-0.090	-0.235	0.018	-0.475	0.003	0.023	-0.111

Stepwise Regression: 57 versus 1, 2, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is 57 on 54 predictors, with N = 102

Step	1	2	3	4	5	6
Constant	1.8845	1.1352	0.7575	0.4401	0.5048	0.6940
32	0.529	0.419	0.308	0.266	0.261	0.294
T-Value	6.73	5.13	3.27	2.81	2.83	3.17
P-Value	0.000	0.000	0.001	0.006	0.006	0.002
9		0.295	0.281	0.232	0.321	0.331
T-Value		3.34	3.23	2.62	3.46	3.61
P-Value		0.001	0.002	0.010	0.001	0.000
17			0.221	0.228	0.277	0.313
T-Value			2.24	2.35	2.88	3.23
P-Value			0.027	0.021	0.005	0.002
3				0.163	0.280	0.287
T-Value				2.03	3.11	3.22
P-Value				0.045	0.002	0.002
4					-0.27	-0.26
T-Value					-2.59	-2.58
P-Value					0.011	0.012
29						-0.143
T-Value						-1.90
P-Value						0.061
S	0.726	0.691	0.678	0.667	0.648	0.640
R-Sq	31.16	38.14	41.16	43.56	47.26	49.18
R-Sq(adj)	30.47	36.89	39.36	41.23	44.51	45.97
Mallows Cp	53.8	40.4	35.7	32.4	26.3	24.1
PRESS	54.9871	50.3030	49.6506	49.5651	46.6010	45.8107
R-Sq(pred)	28.14	34.26	35.11	35.23	39.10	40.13

Step	7	8	9	10	11	12
Constant	0.6466	0.4185	0.5260	0.5389	0.5549	0.6575
32	0.316	0.295	0.357	0.329	0.351	0.386
T-Value	3.49	3.32	3.95	3.63	3.91	4.23
P-Value	0.001	0.001	0.000	0.000	0.000	0.000
9	0.305	0.261	0.339	0.327	0.348	0.358
T-Value	3.39	2.91	3.63	3.55	3.80	3.95
P-Value	0.001	0.004	0.000	0.001	0.000	0.000
17	0.251	0.232	0.227	0.227	0.286	0.266
T-Value	2.58	2.44	2.44	2.47	3.00	2.79
P-Value	0.012	0.017	0.017	0.015	0.004	0.006
3	0.262	0.237	0.264	0.304	0.313	0.318
T-Value	3.00	2.77	3.13	3.55	3.70	3.79
P-Value	0.003	0.007	0.002	0.001	0.000	0.000
4	-0.310	-0.284	-0.319	-0.367	-0.383	-0.393
T-Value	-3.05	-2.84	-3.24	-3.66	-3.87	-4.00
P-Value	0.003	0.006	0.002	0.000	0.000	0.000
29	-0.204	-0.262	-0.231	-0.238	-0.239	-0.217
T-Value	-2.63	-3.31	-2.95	-3.08	-3.13	-2.83
P-Value	0.010	0.001	0.004	0.003	0.002	0.006

23	0.212	0.208	0.208	0.188	0.261	0.266
T-Value	2.46	2.47	2.53	2.30	2.94	3.02
P-Value	0.016	0.015	0.013	0.024	0.004	0.003
39		0.205	0.284	0.241	0.261	0.253
T-Value		2.46	3.22	2.70	2.94	2.87
P-Value		0.016	0.002	0.008	0.004	0.005
41			-0.26	-0.30	-0.30	-0.27
T-Value			-2.38	-2.72	-2.75	-2.54
P-Value			0.019	0.008	0.007	0.013
36				0.158	0.160	0.192
T-Value				1.92	1.98	2.33
P-Value				0.058	0.051	0.022
16					-0.188	-0.191
T-Value					-1.94	-1.99
P-Value					0.056	0.050
46						-0.118
T-Value						-1.70
P-Value						0.093
S	0.624	0.607	0.593	0.584	0.576	0.570
R-Sq	52.24	55.15	57.76	59.40	61.03	62.25
R-Sq(adj)	48.69	51.29	53.63	54.94	56.26	57.16
Mallows Cp	19.3	14.9	11.1	9.5	7.9	7.2
PRESS	43.4196	42.2477	40.2096	39.9372	39.4855	39.3318
R-Sq(pred)	43.26	44.79	47.45	47.81	48.40	48.60

Step	13	14	15	16	17	18
Constant	0.5895	0.4683	0.4234	0.4589	0.5944	0.4543
32	0.360	0.375	0.362	0.408	0.392	0.346
T-Value	3.98	4.17	4.06	4.39	4.28	3.70
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
9	0.371	0.356	0.301	0.307	0.295	0.271
T-Value	4.17	4.01	3.23	3.32	3.24	2.98
P-Value	0.000	0.000	0.002	0.001	0.002	0.004
17	0.247	0.222	0.209	0.230	0.242	0.272
T-Value	2.63	2.36	2.24	2.46	2.62	2.95
P-Value	0.010	0.020	0.028	0.016	0.010	0.004
3	0.339	0.333	0.319	0.328	0.312	0.335
T-Value	4.10	4.07	3.92	4.06	3.89	4.20
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
4	-0.406	-0.379	-0.377	-0.377	-0.380	-0.383
T-Value	-4.21	-3.91	-3.94	-3.97	-4.06	-4.16
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
29	-0.212	-0.246	-0.269	-0.250	-0.248	-0.265
T-Value	-2.82	-3.18	-3.47	-3.21	-3.24	-3.49
P-Value	0.006	0.002	0.001	0.002	0.002	0.001
23	0.262	0.282	0.292	0.327	0.347	0.343
T-Value	3.04	3.27	3.42	3.74	4.00	4.02
P-Value	0.003	0.002	0.001	0.000	0.000	0.000
39	0.226	0.223	0.207	0.210	0.165	0.151
T-Value	2.59	2.59	2.42	2.48	1.90	1.76
P-Value	0.011	0.011	0.018	0.015	0.061	0.083
41	-0.33	-0.31	-0.30	-0.29	-0.31	-0.36
T-Value	-3.03	-2.88	-2.83	-2.75	-2.97	-3.36
P-Value	0.003	0.005	0.006	0.007	0.004	0.001

36	0.187	0.189	0.165	0.158	0.128	0.091
T-Value	2.31	2.35	2.06	1.98	1.60	1.12
P-Value	0.023	0.021	0.043	0.051	0.113	0.267
16	-0.197	-0.234	-0.293	-0.280	-0.335	-0.381
T-Value	-2.09	-2.44	-2.91	-2.80	-3.26	-3.66
P-Value	0.039	0.017	0.005	0.006	0.002	0.000
46	-0.154	-0.177	-0.183	-0.183	-0.181	-0.166
T-Value	-2.19	-2.50	-2.61	-2.63	-2.64	-2.44
P-Value	0.031	0.014	0.011	0.010	0.010	0.017
19	0.169	0.152	0.151	0.149	0.138	0.102
T-Value	2.18	1.97	1.98	1.97	1.84	1.35
P-Value	0.032	0.053	0.051	0.052	0.069	0.181
53		0.117	0.136	0.120	0.115	0.133
T-Value		1.62	1.89	1.67	1.62	1.88
P-Value		0.109	0.062	0.099	0.108	0.064
40			0.19	0.22	0.24	0.31
T-Value			1.75	1.98	2.22	2.74
P-Value			0.083	0.051	0.029	0.007
43				-0.17	-0.25	-0.27
T-Value				-1.62	-2.21	-2.46
P-Value				0.109	0.030	0.016
42					0.19	0.20
T-Value					1.90	2.00
P-Value					0.060	0.049
35						0.170
T-Value						1.90
P-Value						0.061
S	0.558	0.553	0.546	0.541	0.533	0.525
R-Sq	64.19	65.23	66.44	67.44	68.79	70.09
R-Sq(adj)	58.90	59.64	60.58	61.32	62.47	63.61
Mallows Cp	5.0	4.7	4.0	3.8	2.8	1.9
PRESS	38.0869	38.2317	38.3648	38.6413	37.5625	37.3287
R-Sq(pred)	50.23	50.04	49.86	49.50	50.91	51.22

Step	19	20	21
Constant	0.4266	0.4366	0.3582
32	0.347	0.355	0.338
T-Value	3.70	3.78	3.62
P-Value	0.000	0.000	0.001
9	0.265	0.252	0.238
T-Value	2.92	2.78	2.65
P-Value	0.004	0.007	0.010
17	0.279	0.293	0.303
T-Value	3.04	3.19	3.33
P-Value	0.003	0.002	0.001
3	0.316	0.308	0.305
T-Value	4.05	3.94	3.95
P-Value	0.000	0.000	0.000
4	-0.360	-0.352	-0.350
T-Value	-4.00	-3.91	-3.93
P-Value	0.000	0.000	0.000
29	-0.268	-0.277	-0.305
T-Value	-3.53	-3.64	-3.97
P-Value	0.001	0.000	0.000

23	0.355	0.359	0.364
T-Value	4.19	4.22	4.32
P-Value	0.000	0.000	0.000
39	0.163	0.172	0.199
T-Value	1.91	2.01	2.31
P-Value	0.059	0.047	0.023
41	-0.35	-0.33	-0.39
T-Value	-3.30	-3.12	-3.56
P-Value	0.001	0.002	0.001
36			
T-Value			
P-Value			
16	-0.40	-0.41	-0.43
T-Value	-3.84	-3.94	-4.17
P-Value	0.000	0.000	0.000
46	-0.149	-0.130	-0.133
T-Value	-2.25	-2.01	-2.06
P-Value	0.027	0.048	0.042
19	0.099		
T-Value	1.30		
P-Value	0.198		
53	0.135	0.149	0.175
T-Value	1.91	2.12	2.47
P-Value	0.060	0.037	0.016
40	0.34	0.35	0.38
T-Value	3.12	3.23	3.50
P-Value	0.002	0.002	0.001
43	-0.29	-0.30	-0.31
T-Value	-2.64	-2.72	-2.81
P-Value	0.010	0.008	0.006
42	0.224	0.234	0.233
T-Value	2.27	2.37	2.38
P-Value	0.026	0.020	0.020
35	0.195	0.222	0.192
T-Value	2.23	2.61	2.24
P-Value	0.028	0.011	0.028
34			0.114
T-Value			1.72
P-Value			0.089
S	0.526	0.528	0.522
R-Sq	69.64	69.03	70.09
R-Sq(adj)	63.50	63.21	64.03
Mallows Cp	0.9	0.3	-0.0
PRESS	36.3573	36.5762	36.2564
R-Sq(pred)	52.49	52.20	52.62

Regression Analysis: 57 versus 32, 9, ...

```
The regression equation is
57 = 0.437 + 0.355 32 + 0.252 9 + 0.293 17 + 0.308 3 - 0.352 4 - 0.277 29
     + 0.359 23 + 0.172 39 - 0.326 41 - 0.130 46 - 0.407 16 + 0.149 53
     + 0.351 40 - 0.300 43 + 0.234 42 + 0.222 35
```

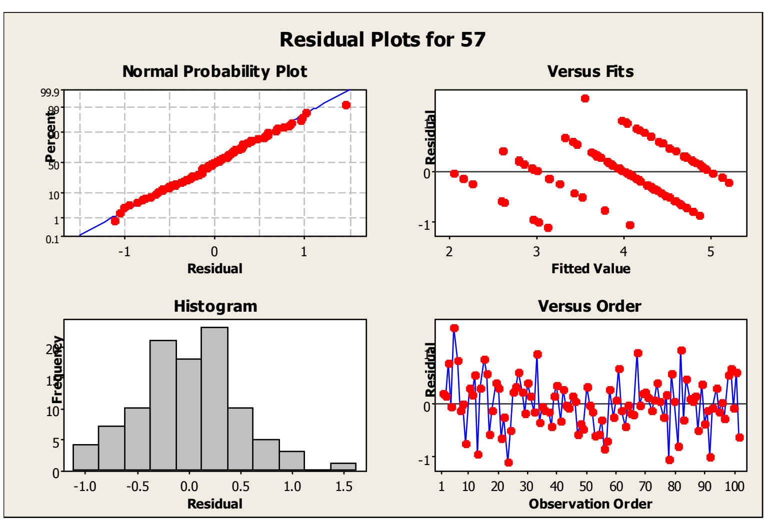
Predictor	Coef	SE Coef	T	P	VIF
Constant	0.4366	0.3862	1.13	0.261	
32	0.35461	0.09389	3.78	0.000	2.699
9	0.25205	0.09055	2.78	0.007	2.144
17	0.29264	0.09176	3.19	0.002	2.156
3	0.30787	0.07811	3.94	0.000	1.855
4	-0.35206	0.09000	-3.91	0.000	2.238
29	-0.27667	0.07597	-3.64	0.000	1.878
23	0.35908	0.08505	4.22	0.000	2.236
39	0.17191	0.08545	2.01	0.047	1.959
41	-0.3260	0.1046	-3.12	0.002	2.619
46	-0.13044	0.06505	-2.01	0.048	1.580
16	-0.4067	0.1033	-3.94	0.000	3.095
53	0.14903	0.07018	2.12	0.037	1.625
40	0.3507	0.1085	3.23	0.002	2.787
43	-0.2997	0.1101	-2.72	0.008	2.915
42	0.23448	0.09898	2.37	0.020	3.005
35	0.22164	0.08489	2.61	0.011	2.162

```
S = 0.527977   R-Sq = 70.1%   R-Sq(adj) = 63.2%

PRESS = 36.5762   R-Sq(pred) = 52.20%
```

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	16	52.8250	3.3016	11.84	0.000
Residual Error	85	23.6946	0.2788		
Total	101	76.5196			

Residual Plots for 57



```
The customer satisfaction regression equation is
57 = 0.437 + 0.355 32 + 0.252 9 + 0.293 17 + 0.308 3 - 0.352 4 - 0.277 29
     + 0.359 23 + 0.172 39 - 0.326 41 - 0.130 46 - 0.407 16 + 0.149 53
     + 0.351 40 - 0.300 43 + 0.234 42 + 0.222 35
```

	PM Process Mgt	**MC** Mgt Commitment	**ET** Employee Training	**CF** Customer Focus	**QM** Quality Metrics	**ER** Employee Responsibility
Question #	1 - 14	15 - 23	24 - 29	30 - 36	37 - 45	46 - 54

Customer Satisfaction Performance

$$Q_3 = 0.437 + 0.355\, x_{32} + 0.252\, x_9 + 0.293\, x_{17} + 0.308\, x_3 - 0.352\, x_4 - 0.277\, x_{29} + 0.359\, x_{23} + 0.172\, x_{39} - 0.326\, x_{41} - 0.130\, x_{46} - 0.407\, x_{16} + 0.149\, x_{53} + 0.351\, x_{40} - 0.300\, x_{43} + 0.234\, x_{42} + 0.222\, x_{35}$$

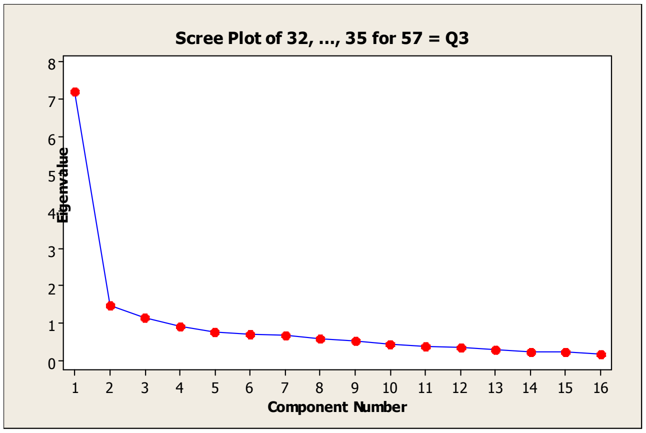
<u>Grouping Constructs:</u>

$$Q_3 = 0.437 + 0.308\, PM_3 - 0.352\, PM_4 + 0.252\, PM_9 - 0.407\, MC_{16} + 0.293\, MC_{17} + 0.359\, MC_{23} - 0.277\, ET_{29} + 0.355\, CF_{32} + 0.222\, CF_{35} + 0.172\, QM_{39} + 0.351\, QM_{40} - 0.326\, QM_{41} + 0.234\, QM_{42} - 0.300\, QM_{43} - 0.130\, ER_{46} + 0.149\, ER_{53}$$

Best Subsets Regression: 57 versus 32, 9, ...

```
Response is 57

                       Mallows           3   1     2 2 3 4 4 1 5 4 4 4 3
Vars  R-Sq  R-Sq(adj)       Cp        S  2 9 7 3 4 9 3 9 1 6 6 3 0 3 2 5
   1  31.2       30.5     91.0  0.72580  X
   1  25.9       25.1    105.5  0.75314                          X
   2  38.1       36.9     73.8  0.69147  X X
   2  37.3       36.0     76.1  0.69614  X                       X
   3  41.2       39.4     67.5  0.67781  X X X
   3  41.1       39.3     67.6  0.67794  X X           X
   4  45.6       43.4     57.3  0.65495  X         X X X
   4  43.9       41.6     62.1  0.66538  X         X X           X
   5  48.3       45.6     52.0  0.64211  X X       X X X
   5  47.8       45.1     53.2  0.64482  X         X X X         X
   6  50.0       46.8     49.3  0.63462  X X X     X X X
   6  49.9       46.8     49.4  0.63507  X X       X X X X
   7  52.4       48.8     44.7  0.62267  X X X X X     X X
   7  52.3       48.7     45.0  0.62320  X X   X X X X X
   8  55.2       51.3     39.1  0.60747  X X X X X X X X
   8  55.0       51.2     39.4  0.60829  X X   X X X X X X
   9  57.8       53.6     34.0  0.59273  X X X X X X X X X
   9  56.8       52.5     36.7  0.59970  X X X X X X X X     X
  10  59.3       54.9     31.6  0.58475  X X X X X X X X X   X
  10  59.1       54.6     32.2  0.58630  X X X X X X X X X         X
  11  60.5       55.7     30.3  0.57916  X X X X X X X X X   X   X
  11  60.5       55.7     30.4  0.57945  X X X X X X X X X   X         X
  12  62.5       57.4     26.9  0.56782  X X X X X X X X X   X   X     X
  12  62.3       57.2     27.4  0.56914  X X X X X X X X X   X     X X
  13  64.8       59.6     22.5  0.55292  X X X X X X X   X   X   X X X X
  13  64.4       59.2     23.6  0.55606  X X X X X X X X X   X   X X   X
  14  66.5       61.1     19.9  0.54255  X X X X X X X X X   X   X X X X
  14  66.0       60.5     21.3  0.54677  X X X X X X X   X   X X X X X X
  15  67.6       61.9     19.0  0.53717  X X X X X X X X X   X X X X X X
  15  67.6       61.9     19.0  0.53725  X X X X X X X   X X X X X X X X
  16  69.0       63.2     17.0  0.52798  X X X X X X X X X X X X X X X X
```

Scree Plot of 32, ..., 35 for 57 = Q3



Principal Component Analysis: 32, 9, 17, 3, 4, 29, 23, 39, 41, 46, 16, 53, 40, ... for 57 = Q3

Eigenanalysis of the Correlation Matrix

Eigenvalue	7.2132	1.4594	1.1352	0.9043	0.7709	0.7056	0.6668	0.5722
Proportion	0.451	0.091	0.071	0.057	0.048	0.044	0.042	0.036
Cumulative	0.451	0.542	0.613	0.670	0.718	0.762	0.803	0.839

Eigenvalue	0.5183	0.4266	0.3809	0.3508	0.2784	0.2314	0.2162	0.1697
Proportion	0.032	0.027	0.024	0.022	0.017	0.014	0.014	0.011
Cumulative	0.872	0.898	0.922	0.944	0.961	0.976	0.989	1.000

32, 9, 17, 3, and 4 account for 71.8% of the model.

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
32	0.279	-0.060	-0.061	0.189	-0.529	-0.152	-0.203	-0.006	-0.084
9	0.242	0.238	-0.247	-0.136	-0.065	0.512	0.398	0.066	-0.216
17	0.244	-0.079	0.433	0.193	-0.305	0.119	-0.218	0.027	-0.291
3	0.189	0.484	-0.112	-0.291	0.073	-0.226	-0.465	0.192	0.178
4	0.214	0.525	0.009	-0.169	-0.037	-0.083	0.037	0.229	-0.317
29	0.238	-0.254	0.116	-0.215	0.320	-0.402	0.040	-0.214	-0.555
23	0.246	0.157	0.365	-0.013	0.329	-0.246	0.417	0.021	0.241
39	0.239	-0.199	-0.264	0.075	0.500	0.177	-0.350	-0.105	0.003
41	0.275	-0.126	-0.407	0.072	0.060	0.050	-0.012	0.044	-0.039
46	0.206	-0.207	-0.269	-0.458	-0.364	-0.280	0.241	-0.269	0.325
16	0.284	-0.029	0.361	0.091	0.072	0.209	0.088	0.099	0.394
53	0.165	-0.428	0.238	-0.536	-0.047	0.233	-0.121	0.443	-0.002
40	0.287	0.112	0.046	-0.041	-0.007	0.360	0.043	-0.528	-0.048
43	0.297	0.077	0.130	0.234	-0.080	-0.200	-0.028	-0.229	0.077
42	0.304	-0.042	-0.089	0.145	0.078	0.047	-0.224	0.029	0.299
35	0.243	-0.175	-0.259	0.394	0.013	-0.198	0.320	0.486	-0.060

Variable	PC10	PC11	PC12	PC13	PC14	PC15	PC16
32	-0.078	-0.077	-0.214	-0.310	0.531	-0.271	0.134
9	-0.164	0.094	0.237	-0.180	0.252	0.356	0.122
17	0.428	-0.153	0.314	0.110	-0.111	0.323	-0.188
3	-0.172	-0.335	-0.036	-0.124	-0.050	0.340	-0.123
4	0.322	0.333	-0.166	0.235	-0.152	-0.377	0.156
29	-0.243	-0.002	-0.121	0.202	0.183	0.211	0.090
23	0.173	-0.160	0.257	-0.266	0.279	-0.235	-0.233
39	0.463	0.139	-0.060	-0.371	0.016	0.018	0.196
41	-0.062	-0.513	0.398	0.363	-0.104	-0.380	0.125
46	0.356	0.085	0.005	0.065	-0.107	0.187	0.029
16	-0.025	-0.163	-0.356	0.305	0.039	0.160	0.532
53	-0.198	0.089	0.030	-0.192	-0.155	-0.246	-0.095
40	-0.112	-0.173	-0.414	-0.029	-0.231	-0.187	-0.431
43	-0.371	0.297	0.312	-0.281	-0.492	-0.030	0.287
42	-0.162	0.520	0.136	0.428	0.292	0.027	-0.379
35	-0.000	-0.027	-0.336	-0.101	-0.276	0.191	-0.266

Cronbach Alpha

Item and Total Statistics

Variable	Total Count	Mean	StDev
1	102	4.049	0.958
2	102	3.990	0.990
3	102	3.951	0.916
4	102	3.902	0.873
5	102	4.108	0.964
6	102	3.843	0.793
7	102	4.020	0.832
8	102	3.892	0.900
9	102	3.971	0.850
10	102	3.951	1.028
11	102	3.961	0.843
12	102	4.049	0.825
13	102	3.745	0.982
14	102	3.588	1.066
Total	102	55.020	8.931

Cronbach's Alpha = 0.9172 for PM

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
1	50.971	8.285	0.6424	0.6618	0.9111
2	51.029	8.201	0.7098	0.6767	0.9086
3	51.069	8.372	0.5763	0.6007	0.9134
4	51.118	8.298	0.6998	0.6448	0.9092
5	50.912	8.190	0.7451	0.6435	0.9072
6	51.176	8.293	0.7872	0.7201	0.9069
7	51.000	8.368	0.6497	0.5512	0.9110
8	51.127	8.301	0.6724	0.5381	0.9101
9	51.049	8.375	0.6249	0.5487	0.9118
10	51.069	8.167	0.7150	0.6263	0.9083
11	51.059	8.397	0.6029	0.5092	0.9125
12	50.971	8.408	0.6039	0.4346	0.9125
13	51.275	8.437	0.4591	0.4131	0.9180
14	51.431	8.373	0.4773	0.4651	0.9181

Item Analysis of 15, 16, 17, 18, 19, 20, 21, 22, 23

Correlation Matrix

	15	16	17	18	19	20	21	22
16	0.676							
17	0.624	0.595						
18	0.607	0.593	0.644					
19	0.365	0.384	0.395	0.467				
20	0.422	0.527	0.483	0.521	0.526			
21	0.589	0.652	0.479	0.520	0.407	0.481		
22	0.488	0.576	0.399	0.550	0.233	0.401	0.536	
23	0.495	0.629	0.442	0.376	0.294	0.371	0.537	0.523

Cell Contents: Pearson correlation

Item and Total Statistics

Variable	Total Count	Mean	StDev
15	102	3.863	0.923
16	102	4.029	0.895
17	102	3.922	0.841
18	102	3.824	0.999
19	102	3.902	0.960
20	102	3.922	0.886
21	102	3.980	0.832
22	102	3.784	1.011
23	102	3.833	0.924
Total	102	35.059	6.129

Cronbach's Alpha = 0.8964 for MC

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
15	31.196	5.432	0.7182	0.5767	0.8802
16	31.029	5.398	0.7888	0.6604	0.8749
17	31.137	5.524	0.6825	0.5385	0.8834
18	31.235	5.368	0.7222	0.5963	0.8797
19	31.157	5.593	0.4991	0.3570	0.8976
20	31.137	5.538	0.6213	0.4431	0.8877
21	31.078	5.511	0.7084	0.5276	0.8817
22	31.275	5.454	0.6159	0.4753	0.8889
23	31.225	5.524	0.6071	0.4685	0.8889

Item Analysis of 24, 25, 26, 27, 28, 29

Correlation Matrix

	24	25	26	27	28
25	0.595				
26	0.729	0.563			
27	0.481	0.269	0.454		
28	0.388	0.264	0.414	0.653	
29	0.343	0.504	0.336	0.498	0.534

Cell Contents: Pearson correlation

Item and Total Statistics

Variable	Total Count	Mean	StDev
24	102	3.833	0.868
25	102	3.794	0.968
26	102	3.892	0.831
27	102	3.794	0.937
28	102	3.882	1.027
29	102	3.794	0.948
Total	102	22.990	4.157

Cronbach's Alpha = 0.8379 for ET

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
24	19.157	3.526	0.6683	0.6124	0.8015
25	19.196	3.535	0.5616	0.5163	0.8222
26	19.098	3.561	0.6590	0.5814	0.8043
27	19.196	3.504	0.6276	0.5233	0.8086
28	19.108	3.464	0.5935	0.5008	0.8168
29	19.196	3.527	0.5900	0.4683	0.8162

Item Analysis of 30, 31, 32, 33, 34, 35, 36

Correlation Matrix

	30	31	32	33	34	35
31	0.688					
32	0.615	0.618				
33	0.584	0.482	0.526			
34	0.292	0.258	0.451	0.515		
35	0.529	0.462	0.547	0.564	0.549	
36	0.443	0.531	0.473	0.506	0.466	0.533

Cell Contents: Pearson correlation

Item and Total Statistics

Variable	Total Count	Mean	StDev
30	102	3.922	0.875
31	102	4.010	0.873
32	102	3.873	0.919
33	102	3.902	0.896
34	102	3.931	1.101
35	102	3.941	0.910
36	102	3.725	0.966
Total	102	27.304	4.951

Cronbach's Alpha = 0.8739 for CF

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
30	23.382	4.317	0.6762	0.5967	0.8533
31	23.294	4.339	0.6501	0.5806	0.8565
32	23.431	4.260	0.7044	0.5333	0.8492
33	23.402	4.285	0.6966	0.5067	0.8505
34	23.373	4.268	0.5405	0.4298	0.8747
35	23.363	4.270	0.7011	0.5077	0.8497
36	23.578	4.276	0.6402	0.4409	0.8577

Item Analysis of 37, 38, 39, 40, 41, 42, 43, 44, 45

Correlation Matrix

	37	38	39	40	41	42	43	44
38	0.710							
39	0.647	0.533						
40	0.721	0.530	0.474					
41	0.627	0.553	0.584	0.514				
42	0.604	0.511	0.596	0.563	0.612			
43	0.483	0.454	0.403	0.605	0.501	0.679		
44	0.531	0.448	0.500	0.513	0.474	0.556	0.546	
45	0.365	0.318	0.456	0.416	0.382	0.435	0.368	0.539

Cell Contents: Pearson correlation

Item and Total Statistics

Variable	Total Count	Mean	StDev
37	102	3.922	0.886
38	102	3.980	0.879
39	102	3.853	0.861
40	102	4.020	0.808
41	102	3.951	0.813
42	102	3.843	0.920
43	102	3.902	0.815
44	102	3.735	0.943
45	102	3.765	1.045
Total	102	34.971	6.021

Cronbach's Alpha = 0.9045 for QM

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
37	31.049	5.309	0.7729	0.7371	0.8867
38	30.990	5.405	0.6588	0.5353	0.8952
39	31.118	5.394	0.6906	0.5432	0.8929
40	30.951	5.418	0.7125	0.6196	0.8917
41	31.020	5.426	0.6960	0.5162	0.8928
42	31.127	5.298	0.7516	0.6271	0.8881
43	31.069	5.452	0.6592	0.5739	0.8952
44	31.235	5.342	0.6766	0.4923	0.8940
45	31.206	5.403	0.5276	0.3634	0.9075

Item Analysis of 46, 47, 48, 49, 50, 51, 52, 53, 54

Correlation Matrix

	46	47	48	49	50	51	52	53
47	0.609							
48	0.408	0.594						
49	0.442	0.343	0.530					
50	0.494	0.429	0.408	0.372				
51	0.309	0.394	0.494	0.355	0.681			

52	0.372	0.335	0.280	0.327	0.423	0.419		
53	0.365	0.297	0.366	0.307	0.327	0.408	0.251	
54	0.333	0.483	0.476	0.515	0.496	0.476	0.356	0.337

Cell Contents: Pearson correlation

Item and Total Statistics

Variable	Total Count	Mean	StDev
46	102	3.804	1.015
47	102	3.882	0.988
48	102	3.716	0.989
49	102	3.951	0.860
50	102	3.902	0.790
51	102	3.853	0.948
52	102	3.814	0.952
53	102	3.686	0.954
54	102	3.971	0.802
Total	102	34.578	5.724

Cronbach's Alpha = 0.8604 for ER

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
46	30.775	5.056	0.6009	0.5343	0.8444
47	30.696	5.046	0.6342	0.5651	0.8408
48	30.863	5.037	0.6442	0.5268	0.8397
49	30.627	5.189	0.5703	0.4430	0.8472
50	30.676	5.173	0.6585	0.5776	0.8403
51	30.725	5.078	0.6311	0.5728	0.8411
52	30.765	5.201	0.4852	0.2691	0.8556
53	30.892	5.214	0.4688	0.2574	0.8572
54	30.608	5.190	0.6231	0.4601	0.8431

Appendix C

Study One—New Technology Venture Product Quality Management Survey Instrument: Raw Data

Study One: Raw Data

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
3	4	4	3	4	2	2	3	4	3	3	3	4	4	3
4	4	4	4	4	3	3	4	4	3	4	3	2	3	4
4	5	4	5	4	4	4	5	5	5	4	5	4	4	4
4	4	4	4	5	4	4	4	4	4	4	4	4	4	4
4	5	4	4	5	4	4	4	5	4	4	5	3	3	3
3	4	4	3	3	3	4	4	4	4	4	3	3	3	4
4	4	4	3	4	4	3	3	3	4	4	5	5	4	5
3	4	3	3	3	3	3	3	3	3	3	4	2	2	3
5	4	3	5	4	4	4	4	4	5	2	4	5	3	3
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	3	3	1	1	5
5	5	4	4	5	5	5	5	5	5	5	5	5	5	4
4	5	4	4	4	4	5	3	4	4	5	4	2	3	4
4	5	4	3	4	4	5	3	4	4	3	2	5	2	5
4	4	4	5	5	5	4	4	5	4	4	5	4	3	3
4	4	5	4	4	4	3	2	4	4	4	3	3	2	4
3	4	3	4	4	3	2	2	4	2	4	3	4	3	4
4	2	2	3	4	3	4	4	4	4	5	4	5	4	4
5	5	5	5	5	4	4	5	5	5	4	5	4	4	4
4	4	4	4	2	4	4	4	3	5	4	4	2	4	5
5	5	5	5	5	4	4	5	5	4	5	4	3	4	4
4	2	2	3	2	2	2	2	2	2	1	2	3	1	1
5	5	4	4	5	5	5	5	5	5	5	4	4	4	4
2	4	3	3	2	3	4	4	3	1	4	4	2	3	2
3	3	3	4	4	4	4	4	4	4	4	4	4	3	3
5	4	4	5	5	4	4	4	5	5	4	5	4	3	3
2	3	4	2	1	2	3	3	4	1	2	5	4	2	4
5	5	5	5	5	5	4	5	5	5	5	5	5	5	5
4	4	4	4	4	4	4	4	4	4	4	4	3	3	4
2	2	2	2	3	2	4	3	4	2	4	3	2	2	2
4	5	5	4	5	5	5	5	4	5	5	5	4	4	5
4	4	5	5	4	4	3	4	4	3	5	4	2	2	2
4	4	4	4	4	4	4	4	3	4	3	4	4	5	4
5	5	5	4	4	4	5	4	4	4	4	4	2	4	4
5	4	5	5	4	4	4	3	4	5	4	5	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	3	4	2	4	4	5	4	3	5	4	4	4	5
5	5	4	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	4	5	5	5	5	3	3	2
4	4	4	5	4	4	4	4	4	4	4	3	3	4	4

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
4	4	4	4	4	4	4	4	3	3	4	3	4	3	4
2	2	2	2	2	2	2	1	4	4	4	4	4	4	4
4	4	4	3	3	3	3	4	3	3	3	3	4	4	3
4	5	4	4	5	4	4	5	3	4	4	5	3	4	5
2	1	3	2	3	3	2	1	2	2	3	4	2	2	4
4	4	4	4	4	4	3	5	3	5	2	4	4	2	5
5	5	5	5	5	5	4	5	5	5	5	4	5	5	5
4	4	4	3	3	3	3	3	3	3	4	4	4	3	4
4	4	5	4	4	4	4	4	4	4	4	5	4	4	4
4	4	5	3	4	4	3	3	4	4	3	3	4	3	3
5	4	5	5	5	4	5	5	5	5	5	5	5	5	5
4	5	5	5	4	4	4	5	5	4	4	4	5	4	4
1	1	1	4	4	3	4	4	4	5	4	4	4	4	4
5	5	5	4	5	4	4	3	5	5	4	5	4	4	4
4	4	4	4	4	4	4	4	3	2	4	3	3	4	2
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	4	4	5	5	4	5	5	5	5
4	4	4	4	4	4	5	4	4	4	4	4	5	4	5
3	4	4	3	4	4	4	3	2	2	4	3	3	2	4
4	4	4	4	4	4	4	4	4	5	4	4	4	5	4
1	1	3	3	4	3	4	4	2	3	3	2	3	4	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	4	4	4	4	3	4	3	3	4	3	4	4	5	3
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5	4	5	4	5	4	4	5	5	4	4	5	4	2	4
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5	4	4	5	5	5	5	4	5	5	5	4	4	3	2
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3	3	3	2	3	3	4	2	2	3	4	4	4	3	4
5	5	5	4	5	4	5	5	5	5	5	5	5	5	5
5	4	4	4	5	4	5	4	4	5	5	4	5	4	4
4	4	5	3	4	4	5	4	3	4	4	3	5	4	4
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4	5	5	4	5	5	5	4	4	3	5	5	5	5	5
5	4	4	4	5	4	5	4	4	4	5	4	4	5	4
4	5	4	4	4	4	4	4	4	4	4	4	4	5	4

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
5	4	5	5	5	4	5	4	5	5	5	5	4	1	5
5	4	4	4	5	4	5	4	4	5	4	5	4	5	4
5	5	4	5	5	5	4	5	4	5	5	5	5	4	5
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3	4	4	4	4	3	4	2	5	3	2	4	2	2	4
5	5	5	5	5	5	5	5	4	5	5	5	5	5	5
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4	4	2	3	2	3	3	4	4	3	4	4	3	4	4
2	5	2	4	5	4	4	4	4	4	3	4	5	3	5
5	5	4	4	5	4	5	5	5	4	4	5	4	2	5

Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
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4	4	4	3	4	3	4	4	4	3	3	4	4	4	4
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3	3	4	4	4	3	4	3	3	3	3	3	3	3	3
3	4	3	2	3	3	4	3	2	2	2	3	3	2	4
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	1	1	5	5	5	5	5	5	1	1	1	3
4	4	4	2	4	5	4	4	4	3	3	4	4	4	4
5	4	5	5	5	4	4	4	4	4	4	5	5	3	3
4	5	4	4	4	5	4	3	4	4	4	3	4	4	5
4	4	4	4	4	4	3	4	4	3	4	5	5	4	3
3	2	2	3	4	3	3	4	4	4	4	2	3	4	4
4	4	4	3	2	4	3	4	5	5	5	4	3	4	2
5	4	4	4	4	4	4	5	4	4	4	4	4	4	3
4	4	5	4	4	4	3	5	3	4	3	4	5	4	3
5	5	5	5	4	4	4	4	4	3	3	4	5	5	5
4	5	4	4	5	4	4	5	3	4	3	4	5	5	5
2	3	1	4	2	2	1	1	2	2	2	2	2	2	2
4	3	2	4	4	5	4	3	4	4	4	5	5	5	5
2	3	3	4	3	3	2	3	2	2	2	2	2	2	3
4	3	4	4	4	4	4	3	3	3	3	4	4	3	4
4	4	3	4	4	4	3	4	4	3	4	4	4	3	4
4	3	1	5	2	4	1	4	4	4	4	3	4	2	4
5	5	5	5	5	5	4	5	5	5	5	5	5	5	5
4	4	4	4	4	4	4	4	4	3	4	4	4	4	3
2	1	2	2	1	2	3	2	2	3	2	3	2	3	2
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Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
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Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
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Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45
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Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45
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5	4	5	4	5	5	5	5	5	5	5	5	5	5	5
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4	4	4	5	5	4	4	4	4	4	4	5	5	4	4
3	4	4	5	3	3	3	4	3	4	4	2	3	4	4
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5	4	4	5	4	4	4	5	4	5	4	5	4	4	5
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Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45
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Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57	Q58	Q59	Q60
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4	4	4	4	4	4	4	4	4	4	4	4	3	4	1
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4	3	3	4	5	4	2	3	4	3	3	3	4	5	1
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5	4	4	5	2	2	4	5	4	4	4	5	5	5	1
3	4	4	3	5	3	4	3	4	4	5	5	1	1	2
3	3	3	4	3	4	5	4	4	4	4	4	4	4	1
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3	3	3	3	3	3	3	3	3	3	3	3	3	3	1
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5	5	4	4	5	5	5	5	4	5	5	4	1	1	1
4	4	3	4	4	4	4	3	4	4	4	4	4	2	2
3	4	4	4	4	5	4	4	4	4	3	4	1	2	2

Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57	Q58	Q59	Q60
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4	4	4	4	4	4	4	4	4	4	4	4	2	4	1
3	3	4	4	3	4	4	2	3	3	4	4	1	2	2
2	3	3	4	3	4	4	2	4	3	4	4	1	1	1
2	3	3	3	3	2	2	4	3	3	4	3	2	1	2
5	5	5	5	2	2	2	3	4	3	3	3	1	1	3
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4	4	4	4	4	4	4	3	4	3	3	4	4	4	2
4	4	4	5	5	5	4	4	5	4	4	4	3	2	3
5	4	1	4	3	3	4	4	3	2	3	4	5	3	1
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4	4	5	4	4	4	5	4	5	4	5	4	1	1	2
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4	5	4	4	4	4	5	4	5	5	4	5	1	1	2
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4	5	4	4	4	5	5	3	4	4	3	3	1	1	3
5	5	4	5	5	4	4	5	4	4	5	5	1	4	1
4	5	4	5	4	5	4	4	5	4	5	4	2	2	2
2	2	4	4	4	5	4	5	4	4	4	4	1	3	3

Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57	Q58	Q59	Q60
4	5	4	4	5	4	5	1	4	5	4	5	1	2	2
4	2	2	5	4	3	5	4	4	3	5	4	2	2	2
5	5	4	5	5	4	5	4	5	5	5	5	1	3	1
5	4	5	4	5	4	5	5	4	5	4	5	2	2	2
5	2	2	4	4	2	5	4	3	4	4	3	4	4	2
4	4	3	4	4	4	4	4	4	4	4	4	1	1	3
4	4	4	5	4	4	5	4	5	4	5	4	1	1	2
4	5	4	4	4	4	4	3	4	4	3	4	1	1	2
3	4	3	4	4	4	4	3	4	4	4	4	5	5	1
3	3	3	3	3	3	3	3	3	3	3	3	4	4	1
2	2	4	4	3	4	2	4	2	4	4	2	2	3	2
4	4	4	4	4	4	3	4	4	4	4	4	5	5	1
5	5	5	5	5	5	4	5	5	5	5	5	1	1	2
4	5	5	4	4	4	3	4	4	4	5	4	2	3	2
5	4	3	4	4	4	4	4	4	4	4	4	2	2	1
4	4	2	2	4	4	2	4	4	2	2	4	2	2	3
3	4	4	4	4	4	3	2	4	3	3	4	3	4	3
3	3	2	4	4	4	5	4	5	5	5	5	4	4	2
4	4	5	5	4	4	2	4	3	3	3	4	4	2	1
4	3	4	5	5	3	1	4	5	3	3	4	3	4	3
5	3	4	4	5	4	5	1	5	4	5	4	1	2	2

Note: Q55, Q56, and Q67 are the Dependent Variables
Q58 to Q63 are Demographic Q's

Q61	Q62	Q63	Q64	Q65	Q66
5	1	3	1	1	1
4	3	3	5	3	2
1	5	3	3	2	1
7	5	4	2	2	1
3	5	3	5	4	2
5	6	2	7	2	2
5	2	3	3	2	2
10	1	1	1	1	1
6	5	3	6	2	2
8	2	3	3	3	2
1	1	1	2	1	1
1	7	5	7	4	2
10	2	2	4	2	2
10	2	1	1	1	1
4	6	4	5	4	2
1	1	1	1	1	1
10	2	1	3	1	1
10	2	3	3	1	1
1	5	4	5	4	2
5	2	1	2	2	2
5	6	5	7	2	2
10	2	1	3	1	1
4	1	1	1	1	1
5	2	2	3	2	2
10	1	1	1	1	1
7	4	3	3	3	2
6	7	5	7	4	1
5	3	4	4	2	2
9	2	3	2	1	1
5	5	4	3	1	1
2	3	4	6	4	2
6	5	4	3	2	2
3	5	4	4	2	2
5	4	5	6	2	2
5	4	3	3	2	2
5	2	3	1	1	1
3	3	1	2	3	2
6	2	3	3	2	2
3	7	5	7	4	2
4	5	4	6	3	2

Q61	Q62	Q63	Q64	Q65	Q66
6	4	4	5	2	2
5	5	4	5	3	2
5	4	4	4	3	2
7	1	2	1	1	1
10	1	1	2	1	1
1	7	5	7	4	2
5	3	3	3	2	1
1	7	3	7	3	2
8	2	2	3	3	2
10	2	3	3	1	1
5	3	4	5	3	2
8	6	3	7	4	2
1	2	3	4	1	1
5	4	3	3	2	2
7	4	5	7	4	2
6	3	4	4	2	2
5	4	5	5	3	2
4	2	5	2	2	2
8	2	2	3	1	1
6	4	4	5	3	2
3	3	3	2	2	2
8	1	1	1	1	1
5	4	3	7	2	2
5	3	4	3	3	2
5	3	3	4	3	2
6	4	3	3	2	2
8	2	3	3	2	2
10	1	1	1	1	1
5	7	4	6	3	2
1	1	1	1	1	1
5	4	5	4	3	2
5	3	2	3	2	2
5	3	3	4	3	2
5	2	2	4	2	2
4	2	3	3	2	2
5	5	4	6	3	2
5	5	5	6	4	2
5	3	3	5	2	2
5	3	4	3	3	2
5	3	3	4	3	2
5	1	1	1	1	2

Q61	Q62	Q63	Q64	Q65	Q66
3	5	4	6	3	2
5	3	3	4	3	2
5	2	4	3	3	2
6	2	3	4	3	2
5	3	2	5	2	2
3	5	4	4	3	2
2	6	3	6	3	2
1	5	3	7	3	2
7	7	4	4	1	2
5	3	1	7	4	2
5	3	4	7	3	2
5	8	3	4	2	2
2	4	2	3	2	2
4	5	3	5	3	2
7	3	4	3	2	2
6	1	3	2	3	2
9	1	1	1	1	2
5	3	1	5	1	2
7	2	2	2	3	2
1	7	4	7	2	2
2	4	3	5	3	2

Note: Q55, Q56, and Q67 are the Dependent Variables
Q58 to Q63 are Demographic Q's

Appendix D

Study Two—Scorecard Design and User Evaluation Survey
(SD&UE) Instrument Development Documentation—
E-mail Sent to Panel of Experts Pre-Launch
and SD & UE Survey Assessment

E-Mail Sent to
Scorecard Design & Evaluation Survey Panel of Experts

Dear Sir/Madam,

Thank you for agreeing to assess my survey! I realize your time is very valuable. I think this may take only twenty to twenty-five minutes.

The survey you are about to assess is designed for project level managers of new technology ventures. It measures these managers' perceptions of five aspects of the newly devised NTV Product Quality Management Scorecard. These five aspects are: (1) perspective framework, (2) objectives, (3) key performance indicators (KPI's), (4) displays of KPI's and aggregate view, and (5) display of strategy map with links – and their relation to scorecard usability.

Attached you will find 4 items:

1) Assessment – this is what you will use to perform your assessment.

2) Survey – these are the 50 survey questions you will assess.

3) Scorecard & Strategy Map with Links – the first 40 survey questions refer to these.

4) Data Display – the last 10 survey questions refer to this.

Assessment Instructions:

1. Type your score in the far right column of the assessment.

2. When you are finished, *save your responses as a PDF file*, and

3. E-mail it back to me as an attachment.

Your score will provide a response for each item on a 6-point Likert scale as depicted below:

Score

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Completely Agree
Completely Irrelevant	Mostly Irrelevant	Slightly Irrelevant	Slightly Relevant	Mostly Relevant	Completely Relevant
Completely Unrepresentative	Mostly Unrepresentative	Slightly Unrepresentative	Slightly Representative	Mostly Representative	Completely Representative

Again, thank you, for your assessment of the survey, scorecard, strategy map with links, and data displays.

Zella Jackson Hannum, BSME, MBA, MSME, PhD Candidate
Industrial and Manufacturing Engineering
Western Michigan University

Background Synopsis:

An effective balanced scorecard has been developed for use by new technology entrepreneurs and managers in order to enhance product quality with confidence. Conventional wisdom assumes that new technology venture***** environments rely on ad hoc manufacturing design processes and heroic management efforts in order to push a new technology into the market place even if product quality is sacrificed. Now, using statistical analysis, a balanced scorecard has been developed and its usability will be evaluated. This newly developed NTV scorecard is a tool designed for project-level managers to improve process management decisions that impact product quality.

***New Technology Venture (NTV) Definition**

(Booz-Allen & Hamilton, Inc., 1982; Leifer et al., 2001; O'Connor & De Martino, 2006; O'Connor, G. et al., 2008)

A new technology venture (NTV) may be a start-up or spin-off that generates *first of its kind* products and technologies that have *high* impact on the market in terms of offering:

(1) Wholly new benefits; or

(2) Significant improvement (5 to 10 times) in known benefits; or

(3) Significant reduction (i.e., 30 to 50%) in cost.

Booz-Allen and Hamilton, Inc. (1982). *New Product Management for the 1980's*. New York: Booz-Allen and Hamilton.

Leifer, Richard, O'Connor, Gina Colarelli and Rice, Mark (2001). Implementing Radical Innovation in Mature Firms: The Role of Hubs. *Academy of Management Executive*. 15(3); 102–113.

O'Connor, G., and De Martino, R. (2006). Organizing for Radical Innovation: An Exploratory Study of the Structural Aspects of Radical Innovation Management Systems in Large Established Firms. *Journal of Product Innovation Management,* 23; 475-497.

O'Connor, G., Paulson, A., and De Martino, R. (2008). Organizational Approach to Building a Radical Innovation Dynamic Capability, *International Journal of Dynamic Technology Management*, 44 (1/2), 179-204.

NTV *Product Quality Management*
Balanced Scorecard Usability Survey Assessment

Appearance							**Score**
» *The survey's appearance is* *Completely Disagree* *Completely Agree*							
1. Clearly laid out	1	2	3	4	5	6	
2. Readable	1	2	3	4	5	6	
3. Interpretable	1	2	3	4	5	6	
Perspective Framework							
» *How <u>relevant</u> is the Perspective Framework to Effectively Manage NTV Product Quality?* *Completely Irrelevant* *Completely Relevant*							
1. Customer Focus, Employee Training,							
NTV Process Management, Management Commitment	1	2	3	4	5	6	
» *How <u>representative</u> is the Perspective Framework to Effectively Manage NTV Product Quality?* *Completely Unrepresentative* *Completely Representative*							
2. Customer Focus, Employee Training,							
NTV Process Management, Management Commitment	1	2	3	4	5	6	
Objectives							
»*How <u>relevant</u> are the Objectives to Effectively Manage NTV Product Quality?* *Completely Irrelevant* *Completely Relevant*							
1. Refer to scorecard	1	2	3	4	5	6	
»*How <u>representative</u> are the Objectives to Effectively Manage NTV Product Quality?* *Completely Unrepresentative* *Completely Representative*							
2. Refer to scorecard	1	2	3	4	5	6	
Key Performance Indicators (KPI's)							
»*How <u>relevant</u> are the KPI's to Effectively Manage NTV Product Quality?* *Completely Irrelevant* *Completely Relevant*							
1. Refer to scorecard	1	2	3	4	5	6	
Key Performance Indicators (KPI's)							
»*How <u>representative</u> are the KPI's to Effectively Manage NTV Product Quality?* *Completely Unrepresentative* *Completely Representative*							
2. Refer to scorecard	1	2	3	4	5	6	
Strategy Map with Links							
»*How <u>relevant</u> is the Strategy Map with Links to Effectively Manage NTV Product Quality?* *Completely Irrelevant* *Completely Relevant*							
1. Refer to strategy map with links	1	2	3	4	5	6	
Strategy Map with Links							
»*How <u>representative</u> is the Strategy Map with Links to Effectively Manage NTV Product Quality?* *Completely Unrepresentative* *Completely Representative*							
2. Refer to strategy map with links	1	2	3	4	5	6	

Data Display							
»*How <u>representative</u> is the Data Display to Effectively Manage NTV Product Quality?* *Completely Unrepresentative Completely Representative*							
1. See Data Display – Aggregate View	1	2	3	4	5	6	
2. See Data Display – KPI View	1	2	3	4	5	6	

Appendix E

Study Two—Scorecard Design and User Evaluation Survey Instrument
Condensed Version

Scorecard Design and User Evaluation Survey Instrument

This survey measures NTV managers' perception of five aspects of the newly devised NTV Product Quality scorecard designed for project level managers. These five aspects are: (1) perspective framework, (2) strategy map with links, (3) objectives, (4) key performance indicators, and (5) data display – and their relation to scorecard usability. A response on a 6-point Likert scale was solicited for each item.
1= Strongly Disagree, 2= Mostly Disagree, 3= Slightly Disagree, 4= Slightly Agree, 5= Mostly Agree, 6= Strongly Agree.

Perspective Framework

» *How important is the Category to Effectively Manage NTV Product Quality*

1. Customer Focus (CF)
2. Employee Training (ET)
3. NTV Process Management (PM)
4. Management Commitment (MC)
5. How important is the perspective framework in its entirety (CF, ET, PM, MC)

» *How Useful is the Category to Effectively Manage NTV Product Quality*

1. Customer Focus (CF)
2. Employee Training (ET)
3. NTV Process Management (PM)
4. Management Commitment (MC)
5. How useful is the perspective framework in its entirety (CF, ET, PM, MC)

Objectives

»*How Important is the Objective to Effectively Manage NTV Product Quality*

1. CF: Institutionalize customer requirements traceability procedures
2. ET: Provide NTV project personnel that are quality trained
3. PM: Institutionalize quality management initiatives
4. MC: Top management provides leadership for overall quality culture
5. MC: Top management allocates necessary personnel resources.

»*How Useful is the Objective to Effectively Manage NTV Product Quality*

1. CF: Institutionalize customer requirements traceability procedures
2. ET: Provide NTV project personnel that are quality trained
3. PM: Institutionalize quality management initiatives
4. MC: Top management provides leadership for overall quality culture
5. MC: Top management allocates necessary personnel resources.

Key Performance Indicators (KPI's)

»*How Useful is the KPI to Effectively Manage NTV Product Quality*

1. CF: Surveys Planned and Administered
2. CF: Customer Requirements Traced and Used as Basis for Product Development
3. CF: Cost of Customer Traceability Program as a % of Cost of Returns
4. ET: Quality Training Planned and Implemented
5. ET: Cost of Quality Training as a % of Reduction in Design Rework Costs
6. ET: Cost of Quality Training as a % Planned
7. PM: NTV Process Reuse Planned and Actual
8. PM: Savings Due to Quality Initiatives as a % of Budgeted Engineering Design Rework
9. PM: Competitors' Processes Benchmarked as a % of Planned
10. MC: Quality Initiatives Approved and Implemented
11. MC: Approved NTV Staffing Requisitions and Staff Hired
12. MC: Approved NTV Staffing Requisitions as a % Requested

Strategy Map with Links

»How important is the Strategy Map with Links to Effectively Manage NTV Product Quality

1. Provides measures that relate to project-level organizational strategy
2. Shows how project-level objectives impact product quality
3. Shows cause-and-effect relationships between the NTV project manager's actions and the project's performance measurement outcomes
4. Specifies the NTV project management's role in achieving the larger objective
5. Specifies the relationships among key measures

»How useful is the Strategy Map with Links to Effectively Manage NTV Product Quality

1. Provides measures that relate to project-level organizational strategy
2. Shows how project-level objectives impact product quality
3. Shows cause-and-effect relationships between the NTV project manager's actions and the project's performance measurement outcomes
4. Specifies the NTV project management's role in achieving the larger objective
5. Specifies the relationships among key measures

Data Display

»How Usable is the Data Display to Effectively Manage NTV Product Quality

1. CF: Surveys Planned and Administered
2. CF: Customer Requirements Traced and Used as Basis for Product Development
3. CF: Cost of Customer Traceability Program as a % of Cost of Returns
4. ET: Quality Training Planned and Implemented
5. ET: Cost of Quality Training as a % of Reduction in Design Rework Costs
6. ET: Cost of Quality Training as a % Planned
7. PM: NTV Process Reuse Planned and Actual
8. PM: Savings Due to Quality Initiatives as a % of Budgeted Engineering Design Rework
9. PM: Competitors' Processes Benchmarked as a % of Planned
10. MC: Quality Initiatives Approved and Implemented
11. MC: Approved NTV Staffing Requisitions and Staff Hired
12. MC: Approved NTV Staffing Requisitions as a % Requested

Appendix F

Study Two—Scorecard Design and User Evaluation Survey Instrument
Qualtrics Version

Scorecard for Product Quality Management in New Technology Ventures

Default Question Block

Scorecard for Product Quality Management in New Technology Ventures

Consent: You are invited to participate in a research project titled "The Development of a New Technology Venture Balanced Scorecard Derived From Critical Factors that Impact Product Quality". This study is designed to analyze managers' and engineers' perceptions of how usable the scorecard is to assist them in managing their firm's product quality practices in new technology venture departments.

A previous study determined specific factors that significantly impact product quality in new technology venture departments. These factors were incorporated into the scorecard you will assess.

Survey Purpose: To measure and determine the usability of the scorecard. The data will be used to assess the effectiveness of the scorecard as a tool to aid managers and engineers in managing product quality practices in new technology venture departments.

Definitions

- New technology venture departments are defined as those engaging in preparing a technologically advanced product for release to its final consumer for the first time with a first-to-early generation production process.

- A new technological product may be software or hardware (e.g. device, machinery, vehicle, etc.), a formulation (e.g. chemical, pharmaceutical, etc.) or delivery mechanism (e.g. Bluetooth, internet, cloud computing, etc.) and is one that offers wholly new benefits:

1. Significant improvement (5 to 10 times) in known benefits; or
2. Significant reduction (30 to 50%) in cost.

This survey instrument is comprised of 63 multiple-choice questions. The survey should take approximately **30 minutes** to complete. Your replies will be completely anonymous; so do not put your name anywhere on the form. You may choose to not answer any question and simply leave it blank. Participation is voluntary. Completing the survey indicates your consent for use of the answers you supply.

Dr. David Lyth and Graduate Student, Zella Jackson Hannum from Western Michigan University, Department of Industrial & Manufacturing Engineering, are conducting the study. This research is being conducted as part of the dissertation requirements for Zella Jackson Hannum.

Respondents: Have three or more years experience in managing product quality practices in new technology venture departments within the last five years. **Note:** Color is used in the displays and respondents **must be able to discern** differences between the colors **red**, **yellow**, and **green**.

This research project was submitted to **Western Michigan University's Human Subject's Institutional Review Board** for administrative review and it was determined that a review was not needed since no personal data is being compiled and all responses remain anonymous. If you have any questions, you may contact Dr. David Lyth at 269-276-3353, Zella Jackson Hannum at 616-225-1402, the Human Subjects Institutional Review Board (269-387-8293) or the vice president for research (269-387-8298).

Instructions: Please indicate your response selection by filling the appropriate circle.

Do you want to proceed with this survey?

◯ Yes

◯ No

Color is used in the displays and respondents **must be able to discern** differences between the colors **red**, **yellow**, and **green**.

Are you color blind?

◯ Yes

◯ No

Do you have three or more years experience in managing new technology ventures in the past five years?

◯ Yes

◯ No

The following questions refer to the NTV *Product Quality Management* Balanced Scorecard depicted below:

NTV *Product Quality Management*
Balanced Scorecard

Perspective Framework	Objectives	Key Performance Measures (KPI's)
Customer Focus	1. Institutionalize Customer Requirements Traceability (CRT) Program	1.1 Surveys Planned and Surveys Administered 1.2 Cost of Customer Requirements Traced and Used as Basis for Product Development 1.3 Cost of CRT Program as a % of Cost of Returns
Employee Training	2. Provide NTV Project Personnel that are Quality Trained	2.1 Quality Training Planned and Implemented 2.2 Cost of Quality Training as a % of Savings Due to Quality Training 2.3 Cost of Quality Training as a % of Planned Training Costs
NTV Process Management	3. Institutionalize Quality Management Initiatives	3.1 NTV Process Reuse Planned and Actual 3.2 Savings Due To Quality Initiatives as a % of Budgeted Engineering Design Rework 3.3 Competitors' Processes Benchmarked as a % of Planned
Management Commitment	4.1 Top management provides leadership for overall quality culture 4.2 Top management allocates necessary personnel resources	4.1 Quality Initiatives Approved and Implemented 4.2.a Approved Staffing Requisitions and Staff Hired 4.2.b Staffing Requisitions Approved by Top Management as % of Requested by NTV Project Manager

The following five questions are regarding how important the scorecard's perspective framework categories are.

Perspective Framework

Customer Focus

Employee Training

NTV Process Management

Management Commitment

Q1 Customer Focus (CF) is an **important** category in the perspective framework to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q2 Employee Training (ET) is an **important** category in the perspective framework to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q3 NTV Process Management (PM) is an **important** category in the perspective framework to effectively manage NTV product quality.

STrongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q4 Management Commitment MC) is an **important** category in the perspective framework to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q5 The entire perspective framework (CF, ET, PM, MC) is **important** to effectively manage NTV product quality practices.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

The following five questions are regarding how useful the scorecard's perspective framework categories are.

Perspective Framework

Customer Focus

Employee Training

NTV Process Management

Management Commitment.

Q6 Customer Focus (CF) is a **useful** category in the perspective framework to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q7 Employee Training (ET) is a **useful** category in the perspective framework to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q8 NTV Process Management (PM) is a **useful** category in the perspective framework to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q9 Management Commitment (MC) is a **useful** category in the perspective framework to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q10 The entire perspective framework (CF, ET, PM, MC) is **useful** to effectively manage NTV product quality practices.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

The following five questions are regarding how important the scorecard's objectives are.

NTV Product Quality Management
Balanced Scorecard

Perspective Framework	Objectives
Customer Focus	1. Institutionalize Customer Requirements Traceability (CRT) Program
Employee Training	2. Provide NTV Project Personnel that are Quality Trained
NTV Process Management	3. Institutionalize Quality Management Initiatives
Management Commitment	4.1 Top management provides leadership for overall quality culture 4.2 Top management allocates necessary personnel resources

Q11 Customer Focus: Institutionalize customer requirements traceability procedures is an **important** objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q12 Employee Training: Provide NTV project personnel that are quality trained is an **important** objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q13 NTV Process Management: Institutionalize quality management initiatives is an **important** objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q14 Management Commitment: Top management provides leadership for overall quality culture is an **important** objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q15 Management Commitment: Top management allocates necessary personnel resources is an **important** objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

The following five questions are regarding how useful the scorecard's objectives are.

NTV Product Quality Management
Balanced Scorecard

Perspective Framework	Objectives
Customer Focus	1. Institutionalize Customer Requirements Traceability (CRT) Program
Employee Training	2. Provide NTV Project Personnel that are Quality Trained
NTV Process Management	3. Institutionalize Quality Management Initiatives
Management Commitment	4.1 Top management provides leadership for overall quality culture
	4.2 Top management allocates necessary personnel resources

Q16 Customer Focus: Institutionalize customer requirements traceability procedures is a *useful* objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q17 Employee Training: Provide NTV project personnel that are quality trained is a **useful** objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q18 NTV Process Management: Institutionalize quality management initiatives is a **useful** objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q19 Management Commitment: Top management provides leadership for overall quality culture is a **useful** objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q20 Management Commitment: Top management allocates necessary personnel resources is a **useful** objective to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

The following ten questions are regarding how *useful* the scorecard's *Key Performance Indicators (KPI's)* are.

NTV *Product Quality Management*
Balanced Scorecard

Perspective Framework	Objectives	Key Performance Indicators (KPI's)
Customer Focus	1. Institutionalize Customer Requirements Traceability (CRT) Program	1.1 Surveys Planned and Surveys Administered 1.2 Customer Requirements Traced and Used as Basis for Product Development 1.3 Cost of CRT Program as a % of Cost of Returns
Employee Training	2. Provide NTV Project Personnel that are Quality Trained	2.1 Quality Training Planned and Implemented 2.2 Cost of Quality Training as a % of Reduction in Design Rework Costs 2.3 Cost of Quality Training as a % of Planned Training Costs
NTV Process Management	3. Institutionalize Quality Management Initiatives	3.1 NTV Process Reuse Planned and Actual 3.2 Savings Due To Quality Initiatives as a % of Budgeted Engineering Design Rework 3.3 Competitors' Processes Benchmarked as a % of Planned
Management Commitment	4.1 Top management provides leadership for overall quality culture 4.2 Top management allocates necessary personnel resources	4.1 Quality Initiatives Approved and Implemented 4.2.a Approved NTV Staffing Requisitions and Staff Hired 4.2.b NTV Staffing Requisitions Approved by Top Management as % of Requested by NTV Project Manager

Q21 Customer Focus KPI: <u>Surveys Planned and Administered</u> is a useful key performance indicator when managing NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q22 Customer Focus KPI: <u>Customer Requirements Traced and Used as a basis for Product Development</u> is a useful key performance indicator when managing NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q23 Customer Focus KPI: <u>Cost of Customer Traceability Program as a % of Cost of Returns</u> is a useful key performance indicator when managing NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q24 Employee Training KPI: <u>Quality Training Planned and Implemented</u> is a useful key performance indicator when managing NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q25 Employee Training KPI: <u>Cost of Quality Training as a % of Reduction in Design Rework Costs; % Planned</u> are useful key performance indicators when managing NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q26 NTV Process Management KPI: <u>NTV Process Reuse Planned and Actual</u> is a useful key performance indicator when managing NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Mostly Agre	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q27 NTV Process Management KPI: <u>Savings Due to Quality Initiatives as a % of Budgeted Engineering Design Rework</u> is a useful key performance indicator when managing NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q28 NTV Process Management KPI: <u>Competitors' Processes Benchmarked as a % of Planned</u> is a useful key performance indicator when managing NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q29 Management Commitment KPI: <u>Quality Initiatives Approved and Implemented</u> is a useful key performance indicator when managing NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q30 Management Commitment KPI: <u>Approved NTV Staffing Requisitions and Staff Hired; % Requested</u> are useful key performance indicators when managing NTV Product Quality.

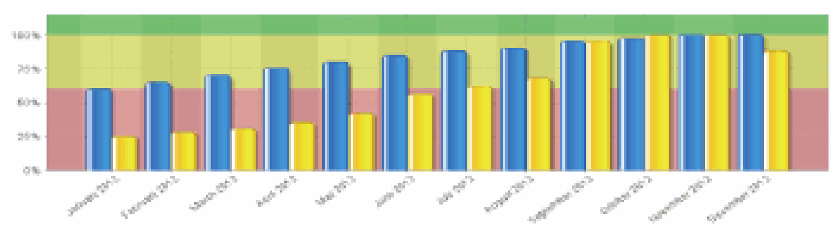
Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

The following twelve questions are regarding how usable the scorecard's twelve KPI displays are.

Customer Focus

KPI View

Surveys Planned and Administered 2012



Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	1.1.b. % Surveys Planned	Project	60%	65%	70%	75%	80%	85%	88%	90%	95%	98%	100%	100%
	1.1.a. % Surveys Administered	Project	25%	28%	31%	35%	42%	56%	62%	68%	95%	100%	100%	88%

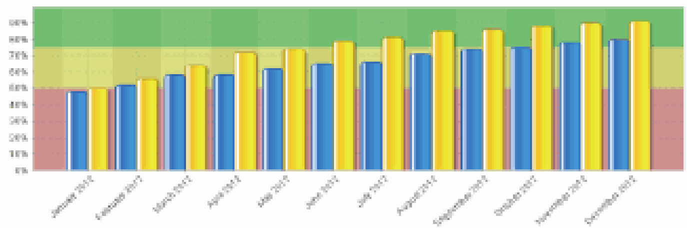
Q31 Customer Focus KPI Display: <u>Surveys Planned and Administered</u> is a usable display of the KPI to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Customer Focus

KPI View

Customer Requirements Traced and Used as Basis for Product Development 2012

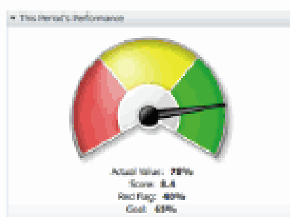


Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	1.3.a. % Customer Requirements Traced	Project	48%	52%	58%	58%	62%	65%	66%	71%	74%	75%	78%	80%
	1.3.b. % Customer Requirements Used as Basis for Product Development	Project	50%	56%	64%	72%	74%	79%	81%	85%	86%	88%	90%	91%

Q32 Customer Focus KPI Display: <u>Customer Requirements Traced and Used as Basis for Product Development</u> **is a usable display of the KPI to effectively manage NTV product quality.**

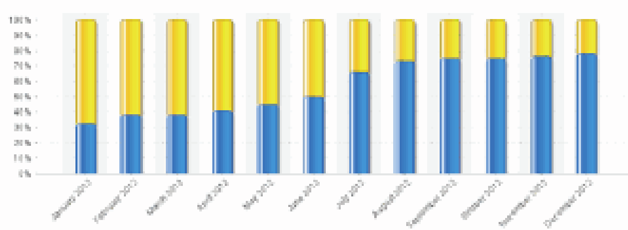
Strongly Disagree ○ | Mostly Disagree ○ | Slightly Disagree ○ | Slightly Agree ○ | Mostly Agree ○ | Strongly Agree ○

Customer Focus



KPI View

Cost of Customer Requirements Traceability (CRT) Program as % of Cost of Returns 2012



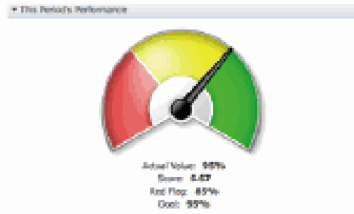
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	1.2.a. Cost of Customer Requirements Traceability Program as a % of	Project	32% (32%)	38% (38%)	38% (38%)	41% (41%)	45% (45%)	50% (50%)	66% (66%)	73% (73%)	75% (75%)	75% (75%)	76% (76%)	78% (78%)
	1.2.b. Projected Cost of Returns	Project	68% (68%)	62% (62%)	62% (62%)	59% (59%)	55% (55%)	50% (50%)	34% (34%)	27% (27%)	25% (25%)	25% (25%)	24% (24%)	22% (22%)

Q33 Customer Focus KPI Display: <u>Cost of Customer Traceability Program as a % of Cost of Returns</u> **is a usable display of the KPI to effectively manage NTV product quality.**

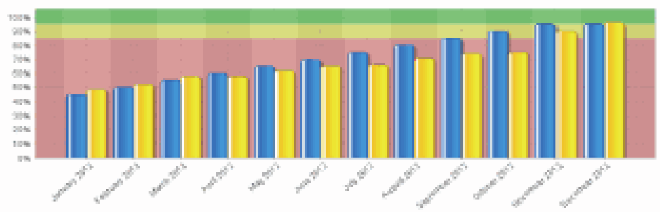
Strongly Disagree ○ | Mostly Disagree ○ | Slightly Disagree ○ | Slightly Agree ○ | Mostly Agree ○ | Strongly Agree ○

Employee Training

KPI View



% Of NTV Staff Quality Trained Planned and Implemented 2012



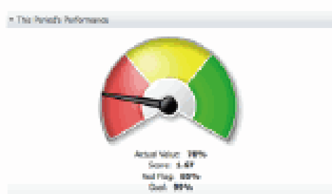
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	2.1.b % NTV Staff Quality Planned to be Trained	Project	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	95%
	2.1.a % NTV Staff Quality Trained	Project	48%	52%	56%	58%	62%	65%	66%	71%	74%	75%	90%	90%

Q34 Employee Training KPI Display: Quality Training Planned and Implemented is a usable display of the KPI to effectively manage NTV product quality.

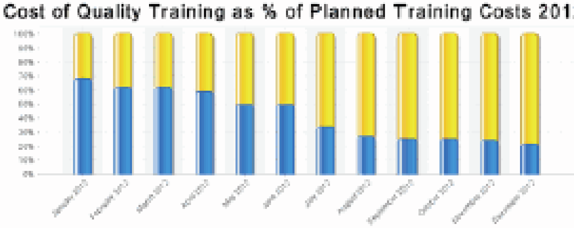
Strongly Disagree ◯ | Mostly Disagree ◯ | Slightly Disagree ◯ | Slightly Agree ◯ | Mostly Agree ◯ | Strongly Agree ◯

Employee Training

KPI View



Cost of Quality Training as % of Planned Training Costs 2012



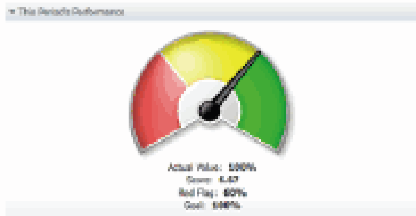
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	2.2.a. Cost of Quality Training as a % of	Project	68% (68%)	62% (62%)	62% (62%)	58% (58%)	50% (50%)	50% (50%)	34% (34%)	27% (27%)	25% (25%)	25% (25%)	24% (24%)	22% (22%)
	2.2.b. Planned Training Costs	Project	32% (32%)	38% (38%)	38% (38%)	41% (41%)	50% (50%)	50% (50%)	66% (66%)	73% (73%)	75% (75%)	75% (75%)	76% (76%)	78% (78%)

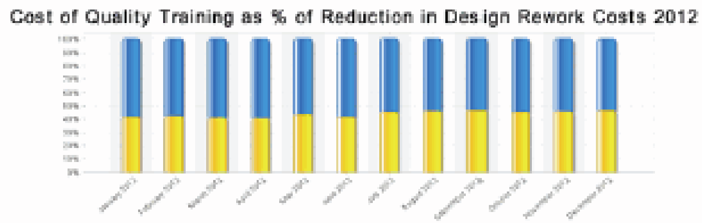
Q35 Employee Training KPI Display: Cost of Quality Training as a % of Planned Training Costs is a usable display of the KPI to effectively manage NTV product quality.

Strongly Disagree ◯ | Mostly Disagree ◯ | Slightly Disagree ◯ | Slightly Agree ◯ | Mostly Agree ◯ | Strongly Agree ◯

Employee Training

KPI View





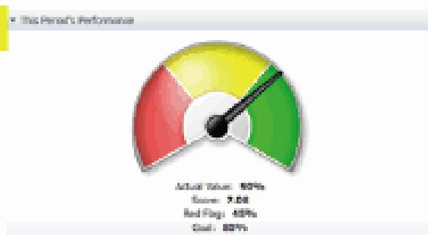
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	2.2.a Cost of Quality Training as a % of	Project	32% (41.58%)	38% (42.22%)	38% (40.88%)	41% (40.59%)	50% (43.88%)	50% (41.67%)	68% (45.21%)	73% (48.2%)	75% (48.88%)	75% (45.45%)	78% (45.78%)	78% (48.43%)
	3.3.a. Reduction in Design Rework Costs	Project	45% (58.44%)	52% (57.78%)	55% (56.14%)	60% (58.41%)	64% (56.14%)	70% (58.33%)	80% (54.79%)	85% (53.8%)	85% (53.12%)	90% (54.06%)	90% (54.22%)	90% (53.67%)

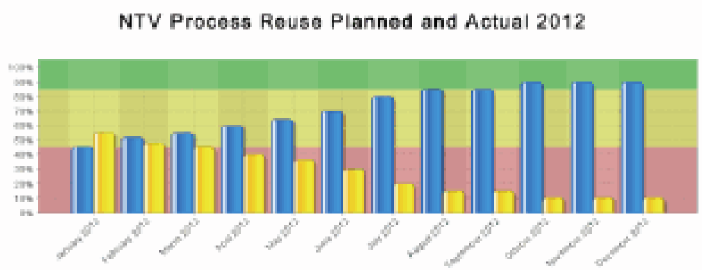
Q36 Employee Training KPI Display: Cost of Quality Training as a % of Reduction in Design Rework Costs is a usable display of the KPI to effectively manage NTV product quality.

Strongly Disagree ○ MostlyDisagree ○ Slightly Disagree ○ Slightly Agree ○ Mostly Agree ○ Strongly Agree ○

NTV Process Management

KPI View





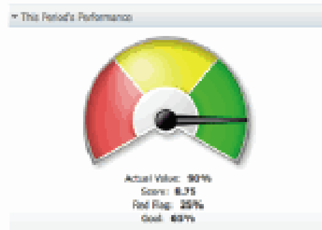
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	3.2.a. NTV Process Reuse as a % of	Project	45%	52%	55%	60%	64%	70%	80%	85%	85%	90%	90%	90%
	3.2.b.Actual NTV Process Reuse	Project	55%	48%	45%	40%	36%	30%	20%	15%	15%	10%	10%	10%

Q37 NTV Process Management KPI Display: NTV Process Reuse Planned and Actual is a usable display of the KPI to effectively manage NTV product quality.

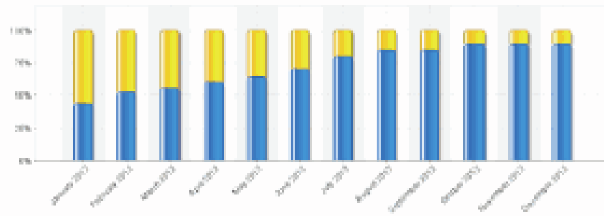
Strongly Disagree ○ Mostly Disagree ○ Slightly Disagree ○ Slightly Agree ○ Mostly Agree ○ Strongly Agree ○

NTV Process Management

KPI View



Rework Savings Due to Quality Initiatives as a % of Engineering Design Rework 2012



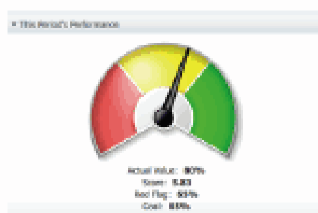
Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	3.3.a. Rework Savings Attributed to Quality Initiatives as a % of	Project	45%	52%	55%	60%	64%	70%	80%	85%	85%	90%	90%	90%
	3.3.b. Engineering Design Rework	Project	55%	48%	45%	40%	36%	30%	20%	15%	15%	10%	10%	10%

Q38 NTV Process Management KPI Display: <u>Savings Due to Quality Initiatives as a % of Engineering Design Rework</u> is a usable display of the KPI to effectively manage NTV product quality.

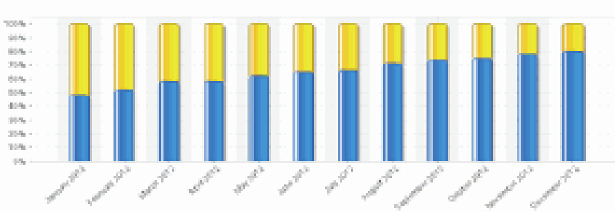
Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

NTV Process Management

KPI View



Competitors' Processes Benchmarked as % of Planned 2012

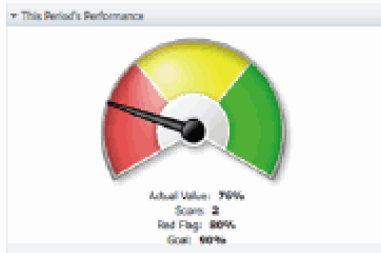


Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	3.1.a. Competitors' Processes Benchmarked as % of	Project	48% (48%)	52% (52%)	58% (58%)	58% (58%)	62% (62%)	65% (65%)	66% (66%)	71% (71%)	74% (74%)	75% (75%)	78% (78%)	80% (80%)
	3.1.b. Planned Competitors' Processes Benchmarked	Project	52% (52%)	48% (48%)	42% (42%)	42% (42%)	38% (38%)	35% (35%)	34% (34%)	29% (29%)	26% (26%)	25% (25%)	22% (22%)	20% (20%)

Q39 NTV Process Management KPI Display: <u>Competitors' Processes Benchmarked as a % of Planned</u> is a usable display of the KPI to effectively manage NTV product quality.

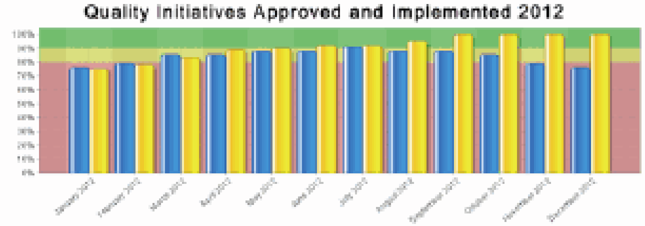
Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Disagree
○	○	○	○	○	○

Management Commitment



KPI View

Quality Initiatives Approved and Implemented 2012

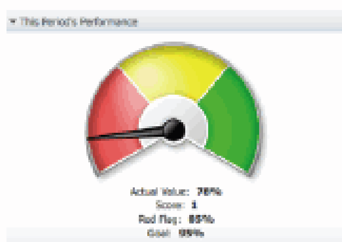


Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	4.2.a. Quality Initiatives Approved by Top Mgt as a % of	Project	76%	79%	85%	85%	88%	88%	91%	88%	88%	85%	79%	76%
	4.2.c. Quality Initiatives Implemented by NTV Project Manager	Project	76%	78%	83%	89%	90%	92%	92%	95%	100%	100%	100%	100%

Q40 NTV Process Management KPI Display: Quality Initiatives Approved and Implemented is a usable display of the KPI to effectively manage NTV product quality.

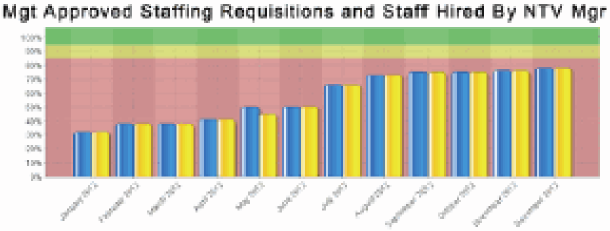
Strongly Disagree ○ Mostly Disagree ○ Slightly Disagree ○ Slightly Agree ○ Mostly Agree ○ Strongly Agree ○

Management Commitment



KPI View

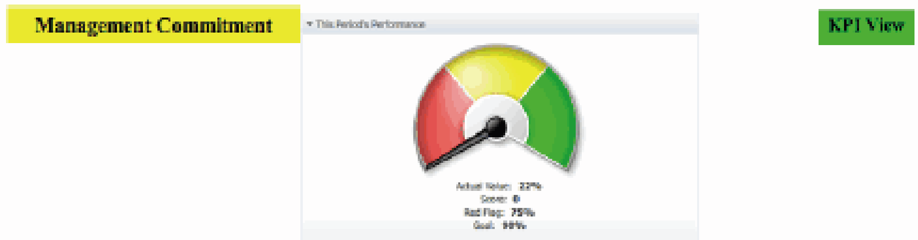
Top Mgt Approved Staffing Requisitions and Staff Hired By NTV Mgr 2012

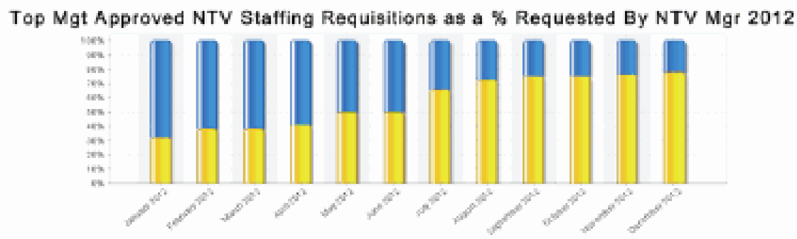


Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	4.1.a. NTV Staffing Requisitions Approved by Top Mgt	Project	32%	38%	38%	41%	50%	56%	66%	73%	75%	75%	76%	78%
	4.1.c. % Hired by NTV Project manager	Project	32%	38%	38%	41%	45%	56%	66%	73%	75%	75%	76%	78%

Q41 NTV Process Management KPI Display: Top Management Approved NTV Staffing Requisitions and Staff Hired is a usable display of the KPI to effectively manage NTV product quality.

Strongly Disagree ○ Mostly Disagree ○ Slightly Disagree ○ Slightly Agree ○ Mostly Agree ○ Strongly Agree ○



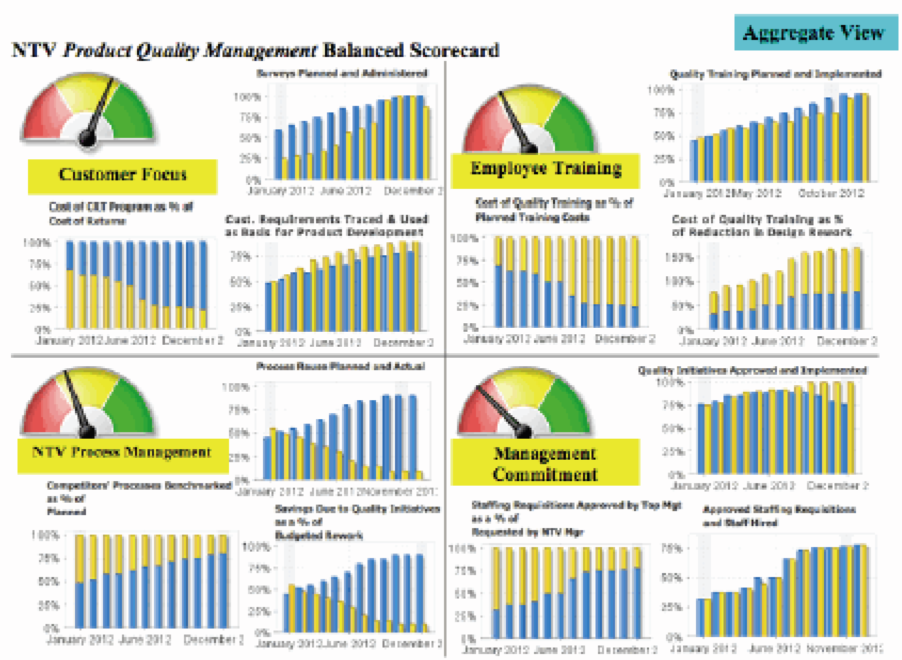


Color	KPI	NTV	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
	4.1.a. Top Mgt Approved NTV Staffing Requisitions as a % of	Project	32% (32%)	38% (38%)	38% (38%)	41% (41%)	50% (50%)	50% (50%)	66% (66%)	73% (73%)	75% (75%)	75% (75%)	76% (76%)	78% (78%)
	4.1.b. Requisitions Requested by NTV Manager	Project	68% (68%)	62% (62%)	62% (62%)	59% (59%)	50% (50%)	50% (50%)	34% (34%)	27% (27%)	25% (25%)	25% (25%)	24% (24%)	22% (22%)

Q42 NTV Process Management KPI Display: <u>Top Management Approved NTV Staffing Requisitions as a % Requested By NTV Manager</u> is a usable display of the KPI to effectively manage NTV product quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
◯	◯	◯	◯	◯	◯

The following question is regarding the scorecard's dashboard or aggregate view, which is depicted below:

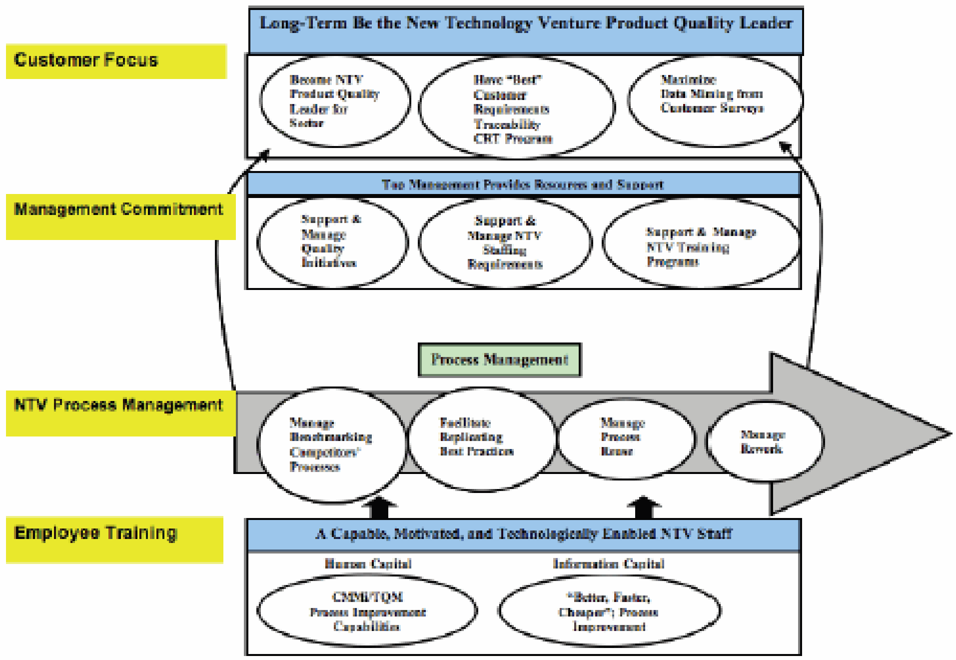


Q43 The scorecard's dashboard or <u>aggregate view</u> is a usable display.

Strongly Disagree ◯ Mostly Disagree ◯ Slightly Disagree ◯ Slightly Agree ◯ Mostly Agree ◯ Strongly Agree ◯

The following questions refer to the Scorecard's **Strategy Map with Links**. Five questions ask how **important** they are; five ask how **useful**.

NTV *Product Quality Management* Strategy Map with Links: To Become The Leader in Product Quality



Q44 The Strategy Map with Links:

Provides measures that relate to project-level organizational strategy, which **is important** to effectively manage NTV Product Quality.

Strongly Disagree ◯ Mostly Disagree ◯ Slightly Disagree ◯ Slightly Agree ◯ Mostly Agree ◯ Strongly Agree ◯

Q45 The Strategy Map with Links:

Shows how project-level objectives impact product quality, which **is important** to effectively manage NTV Product Quality.

Strongly Disagree ◯ Mostly Disagree ◯ Slightly Disagree ◯ Slightly Agree ◯ Mostly Agree ◯ Strongly Agree ◯

Q46 The Strategy Map with Links:

Shows cause-and-effect relationships between the NTV project manager's actions and the project's performance measurement outcomes, which **is important** to effectively manage NTV Product Quality.

Strongly Disagree ◯ Mostly Disagree ◯ Slightly Disagree ◯ Slightly Agree ◯ Mostly Agree ◯ Strongly Agree ◯

Q47 The Strategy Map with Links:

Specifies the NTV project management's role in achieving the larger objective, which **is important** to effectively manage NTV Product Quality.

Strongly Disagree ◯ Mostly Disagree ◯ Slightly Disagree ◯ Slightly Agree ◯ Mostly Agree ◯ Strongly Agree ◯

Q48 The Strategy Map with Links:

Specifies the relationships among key measures, which is **important** to effectively manage NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q49 The Strategy Map with Links:

Provides measures that relate to project-level organizational strategy, which is **useful** to effectively manage NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q50 The Strategy Map with Links:

Shows how project-level objectives impact product quality, which is **useful** to effectively manage NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q51 The Strategy Map with Links:

Shows cause-and-effect relationships between the NTV project manager's actions and the project's performance measurement outcomes, which is **useful** to effectively manage NTV Product Quality.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q52 The Strategy Map with Links:

Specifies the NTV project management's role in achieving the larger objective, which is **useful** to effectively manage NTV Product Quality

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q53 The Strategy Map with Links:

Specifies the relationships among key measures, which is **useful** to effectively manage NTV Product Quality

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

The following questions are regarding your experience with new technology development:

Q 54 "My rank in the new technology development department is/was:"

- ○ Top Manager
- ○ Middle Manager
- ○ Lead Engineer
- ○ Non-manager (e.g. engineer
- ○ Other

Q55 "I am experienced in the following positions during the time covered by this survey:"

- ○ Upper Management
- ○ Project Management
- ○ Quality Management
- ○ Quality Engineer
- ○

Other

Q 56 "I have the following total number of years experience in new technology venture arenas."

- 3 to 5 years
- 5 to 10 years
- More than 10 years

Q57 "The NTV department that I used to complete this survey is best described by the following industry (check all that apply):

- Automotive, Aviation and Aerospace
- Biotechnology, Medical Devices, Genomics
- Pharmaceuticals
- Chemicals and Materials
- Manufacturing
- Computer Hardware and Networking
- Computer Software
- E-Commerce and Information Technology
- Consumer Goods
- Other

The following questions are regarding the size and nature of your firm and NTV department:

Q58 The size of the entire firm (number of employees worldwide) is:

- Less than 100
- 101 to 1,000
- 1,001 to 5,000
- 5,001 to 10,000
- 10,001 to 25,000
- 25,001 to 50,000
- Greater than 50,000
- Other

Q59 Gross annual sales of the entire firm worldwide is:

- Less than $1 million
- $1 million - $5 million
- $6 million - $50 million
- $51 million - $100 million
- $101 million - $500 million
- $501 million - $1 billion
- Over $1 billion
- Other/Don't Know

Q60 The size of the entire NTV department (number of employees worldwide) is:

- 01 - 10
- 11 - 25
- 26 - 100
- 101 - 500

501 - 1,000

Q61 Annual Budget of NTV Department:

- Less than $500,000
- $500,000 - $1 million
- $1 million - $5 million
- Greater than $5 million

Q62 Your NTV department is/was best characterized as a start-up (brand new firm) or as a spin-off (part of an existing firm?

- Start-up (brand new firm)
- Spin-off (part of an existing firm)

In sum, the scorecard you have just assessed is comprised of 1) Perspective Framework, 2) Objectives, 3) Key Performance Indicators (KPI's), 4) Displays of the KPI's and an Aggregate View, as well as the 5) Display of a Strategy Map with Links.

Please respond to the following question regarding the NTV Product Quality Management Balanced Scorecard in its entirety.

Q63 I would use this scorecard as an NTV manager at the project-level.

Strongly Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Strongly Agree
○	○	○	○	○	○

Q64 Is there any feedback you wish to provide that may help clarify questions for the revision of this survey for future respondents?

- Yes
- Maybe
- Add your comments here:

Appendix G

Study Two—Scorecard Design and User Evaluation
Survey Instrument: Raw Data

Study Two: Raw Data

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
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Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
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Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
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Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
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Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
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Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
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Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
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Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
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Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45
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Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45
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Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45
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Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45
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Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57	Q58	Q59	Q60
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Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57	Q58	Q59	Q60
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6	6	6	5	5	6	5	6	2	2	3	2	2	3	3
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4	4	4	4	3	4	3	4	4	5	1	6	7	8	2
5	5	5	5	5	5	5	5	4	2	1	7	3	8	1
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4	6	5	5	5	5	5	6	2	2	3	5	7	7	4
2	2	2	2	2	2	2	2	4	4	3	10	5	8	3
5	5	5	5	5	5	5	5	2	2	3	1	7	7	5
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Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57	Q58	Q59	Q60
6	5	5	5	5	5	6	5	5	5	1	7	1	1	1
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5	5	5	5	5	4	5	5	3	2	2	4	7	8	5
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6	6	6	6	6	6	6	6	4	2	1	7	2	2	4
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5	5	5	5	5	5	5	5	2	2	1	7	1	1	1
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2	4	4	5	5	4	5	3	4	2	1	1	6	7	4
5	5	4	5	5	5	5	5	2	5	3	10	1	2	1
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4	4	4	4	4	4	4	4	3	3	3	6	1	2	3
5	4	5	4	5	4	5	5	1	1	2	8	1	2	2
4	4	3	4	4	4	3	3	2	2	1	8	4	4	3
4	4	4	4	4	4	4	4	3	5	2	5	4	7	2
4	5	4	4	4	4	4	5	2	3	1	8	1	1	1
5	5	4	4	4	5	4	5	2	2	2	10	1	2	1
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3	4	4	4	3	4	4	3	4	2	1	1	2	3	1

Note: Q63 is the Dependent Variable
Q53 to Q62 are Demographic Q's

Q61	Q62	Q63
3	2	3
3	2	4
2	2	5
1	2	3
2	2	2
1	2	4
1	1	4
1	2	4
2	2	2
1	2	4
1	2	6
2	2	5
3	2	6
1	2	6
2	2	5
2	2	5
1	2	3
2	1	4
1	2	3
4	2	3
4	2	6
4	2	4
2	1	3
2	1	2
2	2	5
1	1	6
1	2	5
2	2	3
1	2	5
1	1	5
1	2	5
2	2	5
3	2	5
3	2	6
2	2	6
2	1	2
1	2	5
3	2	5
1	2	2
1	2	5

Q61	Q62	Q63
2	2	3
3	2	5
2	2	6
3	2	4
4	2	5
4	2	5
4	2	3
2	1	3
1	2	2
3	2	4
3	2	5
2	2	5
3	2	6
2	1	5
4	2	4
1	2	5
2	2	5
2	2	4
3	2	6
3	2	5
1	1	6
1	2	4
2	2	5
2	2	5
2	2	6
3	1	5
3	2	4
2	2	5
4	2	4
2	2	4
4	1	4
3	2	3
3	2	5
1	2	4
4	2	4
3	2	3
2	2	4
2	2	4
3	2	4
3	1	5
1	2	4

Q61	Q62	Q63
3	2	5
1	2	4
3	2	5
2	2	5
3	1	4
3	2	4
2	2	6
1	2	6
1	2	4
3	1	4
1	2	4
4	2	3
4	2	4
3	2	6
1	2	4
1	2	4
4	2	5
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4	2	5
1	2	6
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2	2	5
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1	2	6
3	1	6
1	2	6
2	2	4
1	2	5
2	2	5
3	2	5
3	2	3
3	2	5
2	2	4
1	1	5
1	1	5

Q61	Q62	Q63
1	2	2
4	1	5
1	2	5
2	2	5
3	2	3
3	2	4
1	2	6
1	1	3
1	2	5
1	2	5
3	2	5
3	1	4
1	2	6
2	2	6
3	2	4
3	2	5
4	2	4
2	2	4
2	1	6
1	1	4
1	2	4
3	2	5
3	2	6
3	2	6
4	2	5
1	2	5
1	2	3
2	1	5
1	2	6

Note: Q63 is the Dependent Variable
Q53 to Q62 are Demographic Q's

Appendix H

Human Subjects Institutional Review Board
Letters of Approval

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: March 24, 2010

To: Zella Nora Daisy Jackson Hannum, Student Investigator

From: Amy Naugle, Ph.D., Chair

Re: Approval not needed

This letter will serve as confirmation that your project "The Impact of Process Maturity in New Technology Product Quality for the Development of a Resource Allocation Decision-Making Tool" has been reviewed by the Human Subjects Institutional Review Board (HSIRB). Based on that review, the HSIRB has determined that approval is not required for you to conduct this project because you are studying process quality management systems and you are not collecting private information about individuals. Thank you for your concerns about protecting the rights and welfare of human subjects.

A copy of your protocol and a copy of this letter will be maintained in the HSIRB files.

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: February 23, 2011

To: David Lyth, Principal Investigator
Zella Jackson Hannum, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: Approval not needed

This letter will serve as confirmation that your project "A Study to Determine the Critical Factors of New Technology Venture Product Quality Management and Develop a Resource Allocation Decision-Making Tool." has been reviewed by the Human Subjects Institutional Review Board (HSIRB). Based on that review, the HSIRB has determined that approval is not required for you to conduct this project because it does not meet the definition of human subject research ((45 CFR 46.102(f)) 2010). You are studying process quality management systems and not collecting identifiable information about an individual. Thank you for your concerns about protecting the rights and welfare of human subjects.

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

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