An Empirical Exploration of the New Product Process Proficiency–New Product Success Relationship

Murray R. Millson
California State University
Monterey Bay, 100 Campus Center
Seaside, CA 93955
mmillson@csumb.edu

ABSTRACT

This study explores the relationship between new product market success and the proficiency with which various stages, as opposed to individual activities, of the new product development (NPD) process are performed. Therefore, this research addresses three major research questions:

(1) During which stage(s) of the NPD process does R&D/manufacturing have the greatest impact on new product market success?
(2) During which stage(s) of the NPD process does marketing have the greatest impact on new product market success?
(3) How do the contributions of R&D/manufacturing and marketing align in the development of new products?

The study sample consists of 131 new product projects from the medical devices, electrical equipment, and heavy construction equipment industries. This study was based on a random sample of the firms operating in these three industries. Study data suggest that R&D/manufacturing and marketing impact new product success at different times during the NPD process. This data supports the need for cross-functional integration between R&D/manufacturing and marketing. Recommendations are provided for NPD managers based on study findings.

Keywords: New product development; new product market success; R&D/manufacturing proficiency; marketing proficiency
1. INTRODUCTION

It has been noted that the development of new products is an essential element associated with the economic growth and prosperity of most organizations [Cooper and Kleinschmidt, 1986; Calantone, Schmidt, and DiBenedetto, 1997; Langerak and Hultink, 2006]. Research has been performed for many years relating to studies involving the level of proficiency achieved during innovation/new product development (NPD) processes [Cooper and Kleinschmidt, 1993; Cooper, 1996; Millson and Wilemon, 2008] and new product market success [Roberts and Burke, 1974; Cooper, 1980; Cooper and Kleinschmidt, 1987; Cooper, 1988; Parry and Song, 1994; Cooper, and Kleinschmidt, 1995; Cooper and Kleinschmidt, 2007]. Recently NPD researchers have focused on such issues as integrating manufacturing practices into NPD processes such as lean [Nepal et al., 2011] and agile manufacturing [Fekri et al., 2008] while continuing to delve into the antecedents of NPD success such as the impact of market orientation [Chang et al., 2010; Ledwith and O’Dwyer, 2009] and the influence of innovation networks [Millson and Wilemon, 2009]. These studies have produced a large body of literature. A major finding of this research is that proficiently performed innovation/NPD activities and processes are associated with the successful development and launch of new products.

In spite of the vast amount of research that has been performed regarding this area of study, there still remain opportunities to fill knowledge gaps in the literature. This study attempts to extend knowledge of the association between new product development (NPD) proficiency and new product market success. In particular, this research examines the relationship between when, during an innovation/NPD process, the proficient execution of R&D/manufacturing activities is most likely to impact new product market success and when the execution of marketing activities is most likely to impact new product market success. Increased support for cross-functional integration between R&D/manufacturing and marketing functions is possible by understanding in what NPD stages the proficient execution of R&D/manufacturing and marketing activities occurs. Answers to the three following research questions will contribute to a better understanding of how innovation/NPD proficiency relates to new product market success. First, during which stage(s) of the new product development (NPD) process does the proficient execution of R&D/manufacturing activities have the greatest impact on new product market success? Second,
during which stage(s) of the NPD process does the proficient execution of marketing activities have the greatest impact on new product market success? Third, how do the contributions of R&D/manufacturing and marketing align in the development of new products?

2. REVIEW OF THE LITERATURE & DEVELOPMENT OF HYPOTHESES

This research investigates the association among three major concepts: NPD R&D/manufacturing process proficiency, NPD marketing process proficiency, and new product market success. The association between NPD proficiency and new product market success is examined to determine whether the NPD stages within which NPD activities are performed lead to successful new products. This study specifically focuses on the proficiency with which R&D/manufacturing and marketing activities are performed and the NPD stages in which such activities are performed.

2.1. NPD Process Proficiency

Booz et al. [1982] added an NPD strategy requirements development activity as the first step in the new product development process which increased the previously identified NPD process of six activities to seven. The six activities previously viewed as forming the NPD process included idea generation, idea screening and evaluation, business analysis (financial), development (product), testing (product), and commercialization.

In 1986, Cooper and Kleinschmidt [1986] presented a sequence of 13 activities thought to be representative of the NPD process. Those 13 activities did not include a strategy requirements development step nor an idea generation step, but did include initial screening, preliminary market assessment, preliminary technical assessment, detailed market study/market research, business/financial analysis, product development, in-house product testing, customer tests of product, test market/trial sell, trial production, pre-commercialization business analysis, production start-up, and market launch.

In 1997, Rochford and Rudelius [1997] used a 12-activity NPD process in their research. This process also did not include a strategy requirements development activity as the first step of the process, but did include idea generation, initial screening, preliminary market analysis, preliminary technical analysis, preliminary production analysis, preliminary financial analysis, market study,
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product development, in-house product testing, customer product testing, market testing, and pre-commercialization.

To this point, researchers have typically studied what was done in the NPD process [Cooper and Kleinschmidt, 1986, 1991] or the importance of the activities that were performed during the NPD process [Rochford and Rudelius, 1997].

In 1997, the new product development process was defined by Calantone et al. as “. . . a set of activities . . . beginning with idea generation and ending with a product launch” (p. 180). This NPD process representation collapsed a larger group of NPD activities into five groups of the previously noted NPD tasks, including pre-development marketing activities, pre-development technical activities, development-marketing activities, development-technical activities, and financial analysis. Calantone et al. [1997], unlike many of the researchers before them, combined marketing and R&D or technical activities to perform their analyses.

With the inception of the Stage-Gate® system, the NPD process was viewed as a series of six activities; namely,

- idea generation, gate-1 (initial screen);
- preliminary assessment, gate-2 (second screen);
- detailed investigation [business case preparation], gate-3 (decision on business case);
- development, gate-4 (post-development review);
- testing and validation, gate-5 (pre-commercialization business analysis); and
- full production and market launch, and post-implementation review [Cooper, 1990, 1993].

Millson and Wilemon [2002] developed a more extensive set of NPD activities, which included a set of 24 tasks:

- new product strategy development
- identification of new product idea sources
- methods for obtaining new product concepts from idea sources
- initial idea screening
- preliminary market assessment/test idea
- preliminary design assessment
- preliminary manufacturability
- assessment concept generation/determination of ideal product
- detailed market study (concept testing)
- business analysis
- development of prototypes and pilot models
- development of detailed pricing, promoting, and distributing strategies
- in-house product testing
- customer product testing
- testing of market/trial sell
- trial production
- pre-launch business analysis
- production start-up
- market launch
- new product market strategy implementation
- customer satisfaction tracking
- monitoring of product reinvention suggestions/changes
- observation of product use/key to redesign
- tracking of product maintenance/key to redesign

These researchers – in addition to including the strategy requirements development activity, as noted in Booz et al. [1982] – also included a series of five activities that were thought to occur after product launch that impact new product market success; namely, new product market strategy implementation, customer satisfaction tracking, monitoring of product reinvention suggestions/changes, observation of product use/key to redesign, and tracking of product maintenance/key to redesign.

Cooper [2008], in an update of the Stage-Gate® system, used an NPD process that includes:
- discovery, gate-1 (idea screen)
- scoping, gate-2 (second screen)
- building of business case, gate-3 (go to development)
- development, gate-4 (go to testing)
- testing and validation, gate-5 (go to launch)
- launch
- review (post launch)
Calantone et al. [1997] used the concept of NPD process proficiency and defined NPD proficiency using a scale that measured respondents’ opinions as to whether a particular NPD task was performed poorly, excellently, or somewhere in between. NPD R&D/manufacturing process proficiency is a subset of overall NPD process proficiency and is defined in the current study as the proficiency with which the technical (R&D/manufacturing) activities of the NPD process are performed. Moreover, of the 24 NPD tasks scrutinized in this study, seven have been classified as R&D or manufacturing activities. Additionally, 13 of the 24 tasks have been classified as marketing activities.

NPD proficiency is defined as how well individual NPD tasks, activities, or stages (groups of activities) are performed. This study focuses on the proficiency with which two major groups of activities are performed within three defined NPD stages. These two groups of activities are entitled (1) R&D/manufacturing activities, and (2) marketing activities. It is thought that the R&D/manufacturing activities that will influence new product market success most significantly will be situated in the development stage. The development stage is the NPD stage during which significant resources are expended and tasks such as initial prototype construction, alpha and beta product testing, pilot product manufacturing, and product production processes are performed.

From this discussion of the literature, the following hypotheses are advanced.

\[ H_1: \text{It is hypothesized that the proficiency with which pre-development stage R&D/manufacturing activities are performed has a significant relationship with new product market success.} \]

\[ H_2: \text{It is hypothesized that the proficiency with which development stage R&D/manufacturing activities are performed has a significant relationship with new product market success.} \]

\[ H_3: \text{It is hypothesized that the proficiency with which launch/commercialization stage R&D/manufacturing activities are performed has a significant relationship with new product market success.} \]

NPD marketing process proficiency, as defined in the current study, represents the proficiency with which the various marketing activities of the NPD process are performed. It is thought that the marketing activities that impact new product market success most significantly will be situated in the pre-development stage. The pre-development stage is the NPD stage during which major customer-related
activities take place, such as product idea identification, initial product screening, product concept development, and detailed market study and concept validation.

From this discussion of the literature, the following hypotheses are formulated.

\[ H_4: \text{It is hypothesized that the proficiency with which pre-development stage marketing activities are performed has a significant relationship with new product market success.} \]

\[ H_5: \text{It is hypothesized that the proficiency with which development stage marketing activities are performed has a significant relationship with new product market success.} \]

\[ H_6: \text{It is hypothesized that the proficiency with which launch/commercialization stage marketing activities are performed has a significant relationship with new product market success.} \]

2.2. New Product Market Success

The new product market success construct has received a significant amount of research attention over the last half century. This research is often depicted as comprising three literature streams which include a variety of studies that depict the evolution of new product market success. This literature is the basis of current understanding of the antecedents and measurement of new product market success. The three literature streams can be described as those that analyze:

1. characteristics of new product failure [Hopkins and Bailey, 1971; Cooper, 1975; Hopkins, 1980];
2. new product success antecedents [Cooper and Kleinschmidt, 2007; Knudsen, 2007; Myers and Marquis, 1969; Globe et al., 1973; Roberts and Burke, 1974]; and
3. factors that differentiate between new product success and failure [Parry and Song, 1994; Zirger and Maidique, 1990; Rothwell et al., 1974; Cooper, 1980].

The studies that comprise these literature streams have examined many salient factors that are thought to impact new product market success. How new product market success is related to NPD process proficiency is a major question that has been frequently mentioned in these studies. Several studies are now reviewed that found many of these factors to be important to new product market success. Cooper [1975], in a study of failed new products launched by 150 varied industrial product manufacturing firms, found new product failure to be associated with a
lack of detailed market research and a lack of competitive analyses. Hopkins [1980] studied 148 industrial product manufacturing firms and concluded that new product failure can be reduced by educating customers, avoiding the over-engineering of new products, and performing market research.

In addition, many years ago, Myers and Marquis [1969] suggested that new product ideas tend to come from outside new product developing organizations, and that NPD information flow and use within firms are important to the success of new products. These results were derived from a study of 567 commercially successful innovations. In their study of 10 successful radical innovations, Globe et al. [1973] found that proficient R&D was important to new product success, in addition to the employment of technical entrepreneurs who act as information bridges among various NPD groups. Cooper and Kleinschmidt [1995] assessed 103 products on a number of dimensions and found that the quality of NPD process execution in addition to the quality of the product itself was important to the success of newly developed products.

Moreover, several NPD researchers who have investigated new product market failures, in addition to new products that achieved success in the marketplace, found that developers of successful new products understood customer needs, performed design and manufacturing activities proficiently, fostered close contacts with end users, and developed effective NPD processes [Zirger and Maidique, 1990; Roberts and Burke, 1974; Cooper, 1980]. Additionally, Parry and Song [1994] discovered that the level of competitive activity, the timing of the product launch (degree of pioneering), and the level of new product process proficiency in the process’s early stages were significantly correlated with new product market success, as were many of the factors noted by previous researchers. Their research involved the study of 258 new product successes and failures in the People’s Republic of China.

From this discussion of the literature, the following hypotheses are presented.

**H7:** It is hypothesized that the proficiency with which development stage R&D/manufacturing activities are performed has a greater impact on new product market success than development stage marketing activities.

**H8:** It is hypothesized that the proficiency with which pre-development stage marketing activities and launch/commercialization stage marketing activities are performed has a greater impact on new product market success.
than pre-development stage and launch/commercialization stage R&D/manufacturing activities.

3. RESEARCH MODEL

The research model comprises three major constructs: R&D/manufacturing process proficiency, marketing process proficiency, and new product market success. The relationships examined in this study are noted in Figure 1.

![Figure 1. Relationship Between R&D/Manufacturing and Marketing NPD Process Proficiency by Stage with New Product Market Success](image)

3.1. NPD R&D/Manufacturing Process Proficiency

For the current study, 24 NPD activities performed by marketing, engineering, research and development, manufacturing, and finance during the process of developing new products [Millson and Wilemon, 2002; Cooper and Kleinschmidt, 1986] were selected. These 24 NPD activities comprise three identifiable stages of the new product development process:

- **Pre-development stage** (10 activities): New product strategy development, identification of new product idea sources, methods for obtaining new product concepts from idea sources, initial idea screening, preliminary market assessment/test idea, preliminary design assessment, preliminary manufacturability, assessment concept generation/determination of *ideal* product, detailed market study (concept testing), and business analysis;

- **Product development stage** (8 activities): Development of prototypes and pilot models, development of detailed pricing, promoting, and distributing strategies, in-house product testing, customer product testing, testing of market/trial sell, trial production, pre-launch business analysis, and production start-up; and
• **Post-development stage** (6 activities): Market launch, new product market strategy implementation, customer satisfaction tracking, monitoring of product reinvention suggestions(changes), observation of product use(key to redesign), and tracking of product maintenance(key to redesign).

From these NPD activities, seven activities are performed by the R&D/manufacturing organizational groups, and they are performed across the three NPD stages. These seven activities include:

• **Stage 1**: Preliminary design assessment and preliminary manufacturability

• **Stage 2**: In-house product testing, trial production, and production start-up

• **Stage 3**: Observation of product use(key to redesign) and tracking of product maintenance(key to redesign)

Table 1 portrays examples of how three of the selected R&D/manufacturing activities were measured, thus demonstrating how R&D/manufacturing proficiency was measured for this study. As noted in Table 1, all of these R&D/manufacturing proficiency measurement scales are Likert-type scales comprising seven points.

### Table 1

**R&D/Manufacturing Process Proficiency Measures**

<table>
<thead>
<tr>
<th>Indicate how well each R&amp;D/manufacturing task was performed during the development of your firm's New Product by circling a number from 1 to 7 on the scale to the right of each statement. Place an &quot;x&quot; on the line to the right of the scale if the task was not performed at all.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = Done Very Poorly to 7 = Done Excellently</td>
</tr>
<tr>
<td>Denote non-performance with an &quot;x&quot; on the line to the right.</td>
</tr>
<tr>
<td>Performed a preliminary design or technical review</td>
</tr>
<tr>
<td>Performed in-house testing of prototypes or samples</td>
</tr>
<tr>
<td>Performed pilot, trial, or test production</td>
</tr>
</tbody>
</table>
3.2. NPD Marketing Process Proficiency

From the same 24 NPD activities noted earlier and performed by marketing, engineering, research and development, manufacturing, and finance during the process of developing new products, 13 activities were selected for the marketing process proficiency scale [Millson and Wilemon, 2002; Cooper and Kleinschmidt, 1986]. These 13 activities include:

- **Stage 1**: Identification of new product idea sources, methods for obtaining new product concepts from idea sources, initial idea screening, preliminary market assessment/test idea, assessment concept generation/determination of *ideal* product, and detailed market study (concept testing);
- **Stage 2**: Development of detailed pricing, promoting, and distributing strategies, customer product testing, and test market/trial sell; and
- **Stage 3**: Market launch, new product market strategy implementation, customer satisfaction tracking, and monitoring of product reinvention suggestions/changes.

Table 2 portrays examples of how three of the selected marketing activities were measured using Likert-type scales comprising seven points.

**Table 2**

**Marketing Process Proficiency Measures**

<table>
<thead>
<tr>
<th>Indicate how well each marketing task was performed during the development of your firm's New Product by circling a number from 1 to 7 on the scale to the right of each statement. Place an &quot;x&quot; on the line to the right of the scale if the task was not performed at all.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = Done Very Poorly to 7 = Done Excellently</td>
</tr>
<tr>
<td>Denote non-performance with an “x” on the line to the right.</td>
</tr>
</tbody>
</table>

| Scrutinized a variety of sources for new product ideas | 1 2 3 4 5 6 7 ___ |
|---|
| Performed a preliminary product market assessment | 1 2 3 4 5 6 7 ___ |
| Performed test marketing or trial selling prior to launch | 1 2 3 4 5 6 7 ___ |
3.3. New Product Market Success

Cooper and Kleinschmidt [1987] suggested 11 metrics that can be used to measure new product market success; namely:

- A global financial success or failure metric
- Perceived profitability measure
- Payback period
- Domestic market share
- Foreign market share
- Relative sales to other recently launched products
- Relative profits to other recently launched products
- The degree to which sales exceeded or fell short of what was expected
- The degree to which a new product’s profits exceeded or fell short of what was expected
- The degree to which a new product created a product category new to the firm
- The degree to which a new product created a market that was new to the firm

For this current research, market success is measured using four of these market success metrics: (1) the degree to which a new product’s profits exceeded or fell short of what was expected; (2) the degree to which sales exceeded or fell short of what was expected; (3) the degree to which a new product created a product category new to the firm; and (4) the degree to which a new product created a market that was new to the firm.

This study focused on market success as viewed through a firm’s major objectives. These four measures were selected in an effort to develop a parsimonious list and also take into account the major organizational outcomes desired from new product launches. All four market success dimensions were measured using seven-point Likert-type scales. Table 3 portrays the new product elements of this study’s market success multi-element scale.

4. RESEARCH METHODS

This section discusses the overall research design and data sources for the current study, along with the sampling frame and sample, the data-gathering process and considerations, and data analysis.
Table 3
New Product Market Success Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>This product's profits were worse/better than expected.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>This product's sales were worse/better than expected.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>

1 = Significantly worse than expectations; 7 = Significantly better than expectations

<table>
<thead>
<tr>
<th>Measure</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>This product allowed us to offer a new line of products to existing markets</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>This product opened up a market(s) new to our firm.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>

1 = Strongly Disagree to 7 = Strongly Agree

4.1. Overall Research Design and Data Source

The purpose of this research is to better understand the relationship between product market success and NPD process proficiency as defined by the proficiency with which R&D/manufacturing and marketing activities are performed during three major stages of the NPD process. To pursue these objectives, a survey instrument was designed to measure these important constructs. Single- and multiple-item Likert scales were used. To perform this study, three major industries were selected from which to gather data; namely, the medical instruments, the electrical equipment, and the heavy construction equipment industries.

The Standard Industrial Classification [1987]/North American Industrial Classification System [2002] nomenclature for the industries selected are:

- The surgical, medical, and dental instruments and supplies industry (SIC 3841 and 3843; NAICS 339111, 339112, and 339114)
- The equipment for public utilities and industrial use industry (SIC 3612, 3613, and 3621; NAICS 335311, 335312, and 335313)
- The construction and mining machinery and equipment industry (SIC 3531 and 3532; NAICS 333120 & 333131)

These industries were selected because of the significant and varied manner by which they impact the world economy by producing equipment such as diagnostic imaging equipment, electrical transformers and switchgear, X-ray machines, earthmovers, hydraulic excavators, and crawler dozers.
4.2. Sampling Frame and Sample

The sampling frame for this study included 1,463 firms representing the three selected industries. The proportions of the three industries in the sampling frame are heavy construction equipment (28.6%), electrical equipment (43%), and medical instruments (28.4%). The proportions of the three industries that responded to this survey are heavy construction equipment (25.2%), electrical equipment (44.3%), and medical instruments (30.5%). The sampling process chosen was simple random sampling without replacement. A sample of 204 firms was randomly selected from the sampling frame of 1,463 firms. The survey instrument comprised both structured and unstructured questions. Answers to structured questions were used in testing the hypotheses. Answers to open-ended questions were used to help understand and explain study results. A university class of working, evening MBA innovation management students was used to pre-test the research instrument.

4.3. Data Gathering Process and Considerations

To obtain the greatest accuracy of new product market success and process proficiency information, the most knowledgeable people associated with the development of new products in the selected industries were needed. To achieve this, chief executive officers and strategic business unit managers from the 204 firms in the sample were contacted, of which 140 agreed to provide data. These executives supplied the names of specific individuals in their organizations responsible for the most and least successful new products recently produced by their organizations. These individuals were then contacted and requested to complete survey instruments. The mail survey contact method was initially used to forward survey instruments to the sample of NPD managers. These managers from new product development, marketing, and R&D organizations possessed first-hand knowledge of new product strategies, markets, and NPD processes necessary for this research.

Of the 280 surveys that were sent (one for each firm’s most successful new product description and one for each firm’s least successful product description), 131 useful responses were received. Therefore, a response rate of 46.8% of new product descriptions was attained. Although there are limits to what can be done to reduce non-response bias associated with mail survey processes, steps were taken to (1) follow up with non-responders by telephone to obtain the greatest
number of responses within a reasonable time frame, (2) contact respondents and verify questionable and missing responses, and (3) perform statistical evaluations on available data to compare respondents with non-respondents based on the timing of the receipt of the survey instruments.

Considering the potential impact of time, sample respondents were requested to report on new products that were launched no more than five years prior to the execution of this study. Survey respondents were also asked to report on products that were launched at least one year prior to the receipt of the study survey instrument so that the market success or failure of these new products would have time to be evaluated by the marketplace.

Because of the rather short time frame from which respondents had to select new product projects for this study, it is believed that all firms in the sample were confronted with virtually equivalent environments that included similar economic, political, and scientific conditions. It is also assumed, therefore, that the contexts within which the firms in this sample developed new products were generally the same. Moreover, it is believed that the conditions of the environments faced by these firms were similar for all of the organizations in the study sample.

4.4. Data Analysis

To analyze this study’s data, regression models based on the relationships depicted in Figure 1 were constructed. These models, comprising the primary study constructs, are portrayed earlier in Figure 1. SPSS regression software was used to perform the statistical analyses.

A list of NPD activities was used comprising 20 items divided among the three NPD stages in the following manner:

- R&D/manufacturing (two-item pre-development stage proficiency scale), marketing (six-item pre-development stage proficiency scale)
- R&D/manufacturing (three-item development stage proficiency scale), marketing (three-item development stage proficiency scale)
- R&D/manufacturing (two-item launch/commercialization stage proficiency scale), marketing (four-item launch/commercialization stage proficiency scale)

Therefore, to perform this study, three R&D/manufacturing proficiency scales and three marketing proficiency scales were constructed from 20 items, along with a single four-item new product market success scale.
5. FINDINGS
This section discusses the Cronbach alpha metrics for research scales, descriptive statistics, the R&D/manufacturing proficiency-market success relationship, the marketing process proficiency-market success relationship, and the R&D/manufacturing and marketing process proficiency-market success relationship.

5.1. Cronbach Alpha Metrics for Research Scales
The reliability of the NPD proficiency scales were determined by calculating coefficient alphas [Cronbach, 1951] based on the data measured by each scale. Coefficient alpha scores related to the proficiency scales, for the most part, exhibit relatively high reliability. The proficiency scales and their associated coefficient alpha scores are shown in Table 4.

Table 4
Cronbach Alpha Statistics Related to Proficiency Scales

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>Cronbach Alpha</th>
<th>Number of Scale Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 Marketing Proficiency</td>
<td>0.799</td>
<td>6</td>
</tr>
<tr>
<td>Stage 2 Marketing Proficiency</td>
<td>0.602</td>
<td>3</td>
</tr>
<tr>
<td>Stage 3 Marketing Proficiency</td>
<td>0.684</td>
<td>4</td>
</tr>
<tr>
<td>Stage 1 R&amp;D/manufacturing Proficiency</td>
<td>0.588</td>
<td>2</td>
</tr>
<tr>
<td>Stage 2 R&amp;D/manufacturing Proficiency</td>
<td>0.731</td>
<td>3</td>
</tr>
<tr>
<td>Stage 3 R&amp;D/manufacturing Proficiency</td>
<td>0.803</td>
<td>2</td>
</tr>
<tr>
<td>Market Success</td>
<td>0.770</td>
<td>4</td>
</tr>
</tbody>
</table>

As shown, four of the seven Cronbach reliability measurements were found to be greater than the minimum level suggested by Nunnally and Bernstein [1994] and Nunnally [1978] of $r = 0.70$, and one scale (stage 3 marketing proficiency) was found to be 0.684. Hair et al. [2010], Robinson et al. [1991], and Nunnally [1978] note that a Cronbach alpha value of 0.60 may be used for exploratory research. These researchers also point out that, as the number of items comprising a scale decreases, the Cronbach alpha can decrease as well. The Cronbach alpha of the stage 2 marketing proficiency scale containing three scale items was found to be.
0.602, whereas the Cronbach alpha of the two-item stage 1 R&D/manufacturing proficiency scale was found to be 0.588. Both of the Cronbach alpha scores are near the 0.60 recommended reliability value.

5.2. Descriptive Statistics

Table 5 presents the descriptive statistics related to the major variables included in this research. Seven scales were used in this research. The means of the seven-point scales ranged from stage 2 marketing proficiency with a mean of 3.42 to stage 2 R&D/manufacturing proficiency with a mean of 4.32. The standard deviations ranged from the stage 2 R&D/manufacturing proficiency with a standard deviation of 1.42 to a standard deviation of 2.06 for stage 3 R&D/manufacturing proficiency.

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 Marketing Proficiency</td>
<td>131</td>
<td>0.00</td>
<td>6.83</td>
<td>3.79</td>
<td>1.44</td>
</tr>
<tr>
<td>Stage 2 Marketing Proficiency</td>
<td>131</td>
<td>0.00</td>
<td>7.00</td>
<td>3.42</td>
<td>1.62</td>
</tr>
<tr>
<td>Stage 3 Marketing Proficiency</td>
<td>129</td>
<td>0.00</td>
<td>7.00</td>
<td>4.24</td>
<td>1.46</td>
</tr>
<tr>
<td>Stage 1 R&amp;D/manufacturing Proficiency</td>
<td>131</td>
<td>0.00</td>
<td>7.00</td>
<td>4.24</td>
<td>1.66</td>
</tr>
<tr>
<td>Stage 2 R&amp;D/manufacturing Proficiency</td>
<td>130</td>
<td>0.00</td>
<td>7.00</td>
<td>4.32</td>
<td>1.42</td>
</tr>
<tr>
<td>Stage 3 R&amp;D/manufacturing Proficiency</td>
<td>128</td>
<td>0.00</td>
<td>7.00</td>
<td>4.10</td>
<td>2.06</td>
</tr>
<tr>
<td>Market Success</td>
<td>131</td>
<td>1.00</td>
<td>7.00</td>
<td>3.96</td>
<td>1.58</td>
</tr>
</tbody>
</table>

5.3. R&D/Manufacturing Process Proficiency-Market Success Relationship

The first question posed in this research was, during which stage(s) of the new product development (NPD) process does R&D/manufacturing have the greatest impact on new product market success? The hypotheses that were developed earlier are:
H1: It is hypothesized that the proficiency with which pre-development stage R&D/manufacturing activities are performed has a significant relationship with new product market success.

H2: It is hypothesized that the proficiency with which development stage R&D/manufacturing activities are performed has a significant relationship with new product market success.

H3: It is hypothesized that the proficiency with which launch/commercialization stage R&D/manufacturing activities are performed has a significant relationship with new product market success.

Each hypothesis was investigated individually using the following regression model:

\[ y_1 = \alpha_1 + \beta_1 X_1 + e_1 \]

where \( y_1 \) = new product market success; \( \alpha_1 \) = regression constant; \( \beta_1 \) = coefficient of \( X_1 \) = NPD R&D/manufacturing process proficiency; and \( e_1 \) = error term.

This equation was used three separate times to individually investigate the association between R&D/manufacturing proficiency and new product market success in the three NPD stages [stage 1 R&D/manufacturing proficiency, stage 2 R&D/manufacturing proficiency, and stage 3 R&D/manufacturing proficiency] involving NPD R&D/manufacturing activities.

The results from the analyses related to this question are shown in Table 6. These data indicate that the proficiency with which R&D/manufacturing activities are performed in the three NPD stages is significantly related to new product market success. Therefore, hypotheses \( H_1, H_2, \) and \( H_3 \) are supported by the study data. Furthermore, it can be seen that R&D/manufacturing activities performed during all three NPD stages are important to new product market success.

5.4. Marketing Process Proficiency-Market Success Relationship

The second question posed in this research was, during which stage(s) of the NPD process does marketing have the greatest impact on new product market success? The hypotheses that were developed earlier are:
Table 6
R&D/Manufacturing Process Proficiency – Market Success Relationship Statistics

<table>
<thead>
<tr>
<th>y₁, y₂, y₃ (Market Success)</th>
<th>F statistic</th>
<th>p value</th>
<th>t statistic</th>
<th>p value</th>
<th>Standard β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 R&amp;D/Manufacturing Proficiency-(X₁)</td>
<td>26.84</td>
<td>0.000**</td>
<td>5.18</td>
<td>0.000**</td>
<td>0.415</td>
</tr>
<tr>
<td>Stage 2 R&amp;D/Manufacturing Proficiency-(X₁)</td>
<td>32.78</td>
<td>0.000**</td>
<td>5.73</td>
<td>0.000**</td>
<td>0.452</td>
</tr>
<tr>
<td>Stage 3 R&amp;D/Manufacturing Proficiency-(X₁)</td>
<td>21.55</td>
<td>0.000**</td>
<td>4.64</td>
<td>0.000**</td>
<td>0.382</td>
</tr>
</tbody>
</table>

†p < 0.1
*p < 0.05
**p < 0.01

H₄: It is hypothesized that the proficiency with which pre-development stage marketing activities are performed has a significant relationship with new product market success.

H₅: It is hypothesized that the proficiency with which development stage marketing activities are performed has a significant relationship with new product market success.

H₆: It is hypothesized that the proficiency with which launch/commercialization stage marketing activities are performed has a significant relationship with new product market success.

Each hypothesis was investigated individually using the following regression model:

\[ y_1 = \alpha_1 + \beta_1 X_1 + e_1 \]

where \( y_1 \) = new product market success; \( \alpha_1 \) = regression constant; \( \beta_1 \) = coefficient of \( X_1 \) = NPD marketing process proficiency; and \( e_1 \) = error term.

This equation was used three separate times to individually investigate the association between marketing proficiency and new product market success in the
three NPD stages [stage 1 marketing proficiency, stage 2 marketing proficiency, and stage 3 marketing proficiency] involving NPD marketing activities.

The data in Table 7 depict the results from the analyses related to the prior question. These data suggest that the proficiency with which marketing activities are performed in the three NPD stages is significantly related to new product market success. Therefore, hypotheses $H_4$, $H_5$, and $H_6$ are supported by the study data, and it can be seen that marketing activities performed during all three NPD stages are important to new product market success.

### Table 7
**Marketing Process Proficiency – Market Success Relationship Statistics**

<table>
<thead>
<tr>
<th>$y_1, y_2, y_3$ (Market Success)</th>
<th>$F$ statistic</th>
<th>$p$ value</th>
<th>$t$ statistic</th>
<th>$p$ value</th>
<th>Standard β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 Marketing Proficiency-(X₁)</td>
<td>26.45</td>
<td>0.000*</td>
<td>5.14</td>
<td>0.000**</td>
<td>0.412</td>
</tr>
<tr>
<td>Stage 2 Marketing Proficiency-(X₁)</td>
<td>17.04</td>
<td>0.000*</td>
<td>4.13</td>
<td>0.000**</td>
<td>0.342</td>
</tr>
<tr>
<td>Stage 3 Marketing Proficiency-(X₁)</td>
<td>41.45</td>
<td>0.000*</td>
<td>6.44</td>
<td>0.000**</td>
<td>0.496</td>
</tr>
</tbody>
</table>

† $p < 0.1$

* $p < 0.05$

** $p < 0.01$

### 5.4. R&D/Manufacturing and Marketing Process Proficiency- Market Success Relationship

The third question posed in this research is, how do the contributions of R&D/manufacturing and marketing align in the development of new products? The hypotheses developed from this research question are:

$H_7$: It is hypothesized that the proficiency with which development stage R&D/Manufacturing activities are performed has a greater impact on new product market success than development stage marketing activities.

$H_8$: It is hypothesized that the proficiency with which pre-development stage marketing activities and launch/commercialization stage marketing...
activities are performed has a greater impact on new product market success than pre-development stage and launch/commercialization stage R&D/manufacturing activities.

To test these hypotheses, each hypothesis was investigated individually using the following regression model:

\[ y_1 = \alpha_1 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + e_1 \]

where \( y_1 \) = new product market success;
\( \alpha_1 \) = regression constant;
\( \beta_1 \) = coefficient of \( X_1 \);
\( X_1 \) = Stage 1 marketing proficiency;
\( \beta_2 \) = coefficient of \( X_2 \);
\( X_2 \) = Stage 2 marketing proficiency;
\( \beta_3 \) = coefficient of \( X_3 \);
\( X_3 \) = Stage 3 marketing proficiency;
\( \beta_4 \) = coefficient of \( X_4 \);
\( X_4 \) = Stage 1 R&D/manufacturing proficiency;
\( \beta_5 \) = coefficient of \( X_5 \);
\( X_5 \) = Stage 2 R&D/manufacturing proficiency;
\( \beta_6 \) = coefficient of \( X_6 \);
\( X_6 \) = Stage 3 R&D/manufacturing proficiency; and
\( e_1 \) = error term.

The data in Table 8 portray the results from the analyses related to the third research question. These data indicate that Stage 3 marketing proficiency is significantly related to new product market success at the \( p = 0.036 \) level when the other five proficiency measures are controlled. The data also suggest that Stage 1 R&D/manufacturing proficiency is significantly related to new product market success when the other five proficiencies are controlled with \( p = 0.096 \). And, finally, Stage 2 R&D/manufacturing proficiency was found to be significantly related to new product market success when the other five proficiencies are controlled with \( p = 0.005 \).
These findings suggest that hypothesis $H_7$ is supported by the data. Hypothesis $H_8$ was only partially supported since the relationship between the proficient performance of marketing activities during the launch/commercialization stage was supported, but the relationship between the proficient performance of marketing activities during the pre-development stage was not. Interestingly, the proficient performance of R&D/manufacturing activities during the pre-development stage in these three industries was found to be significant. Test results also point out that the proficient performance of R&D/manufacturing and marketing activities is important to new product market success during different stages of the NPD process. This research confirms that both R&D/manufacturing and marketing activities need to be proficiently performed; however, it appears
that R&D/manufacturing and marketing should take the lead in different stages of the process.

6. IMPLICATIONS FOR MANAGERS AND SCHOLARS

This research offers scholars and NPD managers in the three industries studied a number of suggestions for improving NPD practices and better understanding the relationship between R&D/manufacturing and marketing process stage proficiency, and new product market success. Major themes are now derived from the findings of this study.

6.1. R&D/Manufacturing Process Proficiency-
Market Success Relationship

The data gathered for this research supports the three hypotheses related to the R&D/manufacturing process proficiency-new product market success relationship; i.e.,

(1) the proficiency with which pre-development stage R&D/manufacturing activities are performed has a significant relationship with new product market success;

(2) the proficiency with which development stage R&D/manufacturing activities are performed has a significant relationship with new product market success; and

(3) the proficiency with which launch/commercialization stage R&D/manufacturing activities are performed has a significant relationship with new product market success.

These findings suggest that it is important to perform R&D/manufacturing activities well in all three stages of the NPD/innovation process. The findings also indicate that there cannot be a period in which R&D/manufacturing proficiency is lacking. These findings do not, however, suggest in which NPD/innovation stage(s) the proficient performance of R&D/manufacturing activities may be more important than marketing activities. This question will be addressed shortly. For now, it is essential to recognize that R&D/manufacturing proficiency is necessary in ALL stages of the innovation/NPD process.
6.2. Marketing Process Proficiency-Market Success Relationship

The research data support the three hypotheses regarding the marketing process proficiency-new product market success relationship; i.e.,

(1) the proficiency with which pre-development stage marketing activities are performed has a significant relationship with new product market success;
(2) the proficiency with which development stage marketing activities are performed has a significant relationship with new product market success; and
(3) the proficiency with which launch/commercialization stage marketing activities are performed has a significant relationship with new product market success.

These findings suggest that it is important that the marketing activities in all three stages of the NPD/innovation process be effectively performed. As noted regarding the proficient performance of R&D/manufacturing activities, marketing activities cannot have an NPD stage in which marketing proficiency is deficient. Again, the findings from these tests do not, however, suggest in which NPD/innovation stage(s) the proficient performance of marketing activities is more essential than R&D/manufacturing activities. That question is addressed in the next section. For now, it is fundamental to recognize that marketing proficiency is important in ALL stages of the innovation/NPD process.

6.3. R&D/Manufacturing and Marketing Process Proficiency-Market Success Relationships

The research data support the three hypotheses regarding the marketing process proficiency-market success relationship; i.e.,

(1) the proficiency with which pre-development stage R&D/manufacturing activities are performed has a significant relationship with new product market success;
(2) the proficiency with which development stage R&D/manufacturing activities are performed has a significant relationship with new product market success; and
(3) the proficiency with which launch/commercialization stage marketing activities are performed has a significant relationship with new product market success.
These findings suggest that it is important that the R&D/manufacturing activities performed in the pre-development and development stages of the NPD/Innovation process be effectively performed, even more so than marketing activities. Additionally, this study’s findings also suggest that it is important that the marketing activities performed in the launch/commercialization stage of the NPD/innovation process be effectively performed, even more so than R&D/manufacturing activities. These analyses in total inform us that the proficient performance of marketing and R&D/manufacturing activities is important during each stage of the NPD process; however, there are times when the performance of one of these function’s activities appears to be more important than the other.

6. LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH

This study has a few noteworthy limitations. First, study findings may not be generalizable to industries other than the heavy construction equipment, electrical equipment, and medical devices industries, or to other than sampled organizations within these three industries. Moreover, Song and Xie [2000] suggest that, for organizations in countries other than those from which the data were obtained for this research, there may be, for example, cultural reasons why these research findings are not relevant. Second, causality has not been assumed in the development of any of these hypotheses. It may appear that innovation/NPD process proficiency directly causes changes in new product market success. However, the degree of new product market success attained by prior new product launches in these three industries may have caused increased R&D/manufacturing and/or marketing process proficiency during subsequent new product development cycles. Third, although this study’s response rate of 46.8% is quite good and steps were taken to ensure a lack of non-response bias, the data associated with the sample of 131 new product projects used in this study may contain some degree of bias that was not detected by the processes noted earlier.

The performance of this study which focused on the medical devices, electrical equipment, and heavy construction equipment industries suggests a number of fundamental questions to guide continued research. Research questions not addressed in this study are listed below. These questions, which were formed as this study unfolded, can shape paths for future innovation/NPD academic research applicable to advancements in medical devices, electrical equipment, and heavy
construction equipment. This small set of questions needs additional study to clarify imprecise circumstances surrounding the relationships regarding innovation/NPD proficiency and new product market success.

- Are there factors that moderate the relationships between R&D/manufacturing process proficiency and new product market success?
- Are there important factors that mediate the relationship between R&D/manufacturing process proficiency and new product market success?
- Are there factors that moderate the relationships between marketing process proficiency and new product market success?
- Are there important factors that mediate the relationship between marketing process proficiency and new product market success?

8. **SUMMARY**

The focus of this study was on two major variables – i.e., innovation/NPD process proficiency, and new product market success. In particular, this research investigated the relationships between R&D/manufacturing process proficiency across three major innovation/NPD stages and new product market success, and marketing process proficiency across three major innovation/NPD stages and new product market success.

Overall, this study’s data suggest that R&D/manufacturing process proficiency in all three major NPD stages is significantly related to new product market success and that marketing process proficiency in all three major NPD stages is significantly related to new product market success. It is apparent that both functions need to perform new product development activities proficiently. However, this study’s data suggest that it is exceptionally important to perform R&D/manufacturing activities proficiently in the new product development pre-development and development stages. This study’s data also suggest that it is extremely important to perform marketing activities in the new product development launch/commercialization stage proficiently. It is hoped that the findings of this study contribute to new product development thought, help practitioners and academics understand how to better prepare for new product development processes, and facilitate the successful entry of new products into the marketplaces related to the industries investigated.
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ABOUT THE AUTHOR

Murray R. Millson is a professor of marketing and MBA program director at California
State University, Monterey Bay. He obtained his B.S. degree in electrical engineering and
his M.S. degree in industrial management from Clarkson University and his MBA and his
Ph.D. from Syracuse University. His research has been published in the Journal of Product
Innovation Management, R&D Management Journal, Industrial Marketing Management,
Technovation, Research•Technology Management, International Journal of Innovation
Management, and Journal of Distance Education. He is the author of Research in Business
and Marketing and the co-author of The Strategy of Managing Innovation and Technology.
He is a registered Professional Engineer in Quality Engineering in California.