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An Interim Report on Measuring Product Development Success and Failure

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This article represents findings of a PDMA task force studying measures of product development success and failure. This investigation sought to identify all currently used measures, organize them into categories of similar measures that perform roughly the same function, and contrast the measures used by academics and companies to evaluate new product development performance. The authors compared the measures used in over seventy-five published studies of new product development to those surveyed companies say they use. The concept of product development success has many dimensions and each may be measured in a variety of ways. Firms generally use about four measures from two different categories in determining product development success. Academics and managers tend to focus on rather different sets of product development success/failure measures. Academics tend to investigate product development performance at the firm level, whereas managers currently measure, and indicate that they want to understand more completely, individual product success.

Background

Key to understanding a firm's position vis-à-vis new product development is being able to measure the "success," or alternatively "failure," of individual products and overall development programs. This branch of research extends back at least to 1964 when the National Industrial Conference Board published an article entitled "Why New Products Fail" [12]. Then in 1968, Booz, Allen, and Hamilton published its research findings as their report, *Management of New Products* [6], increasing interest in the mechanisms which spur on success. Since then, numerous researchers have followed in Booz, Allen's footsteps, trying to specify techniques for improving product development success through various research methods. Indeed, the importance of this area of management research is indicated by the number of research articles published—seventy-seven were collected for this study [1 through 77]. Between the *Journal of Product Innovation Management (JPIM)* and yearly *Proceedings* from its international conference, the PDMA alone published five articles concerned with this subject in 1991 [24,33,52,58,69].

At the "academic" research paper sessions held at the 1990 PDMA International Conference, several of the researchers presented studies involving issues associated with new product development success. Each researcher used different measures for delineating success. While each paper was interesting, the group listening to the presentations found that using different success/failure (S/F) measures made it difficult to draw generalizations across the investigations.

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BIOGRAPHICAL SKETCHES

Abbie Griffin, Associate Professor of Marketing and Production Management, joined the University of Chicago's Graduate School of Business in 1989. She earned a B.S. in Chemical engineering from Purdue University in 1974, an M.B.A. from Harvard University in 1981, and a Ph.D. from the Massachusetts Institute of Technology in 1989. Her research interests are in measuring and improving processes for developing new products. This is her third article in the *Journal of Product Innovation Management.*

Albert L. Page is an Associate Professor of Marketing in the College of Business Administration at the University of Illinois, Chicago. Prior to joining the faculty there he was on the faculty of the School of Management, Case Western Reserve University. He earned the M.B.A. and Ph.D. degrees in marketing from Northwestern University. His research and teaching interests span the fields of product planning, industrial marketing, and strategic market planning, and he has published widely on these topics including three earlier articles in the *Journal of Product Innovation Management.* He has also been a consultant to corporate clients on may occasions. Dr. Page is a long-time member of the Product Development and Management Association. He is currently serving as its President-Elect.

The research and analysis reported here was born out of questioning the appropriateness of various S/F measures at the 1990 conference.

A research proposal was approved by the PDMA board to study the measures of S/F in new product development. The initial goal of the investigation was to recommend a set of "approved" measures for academic researchers. The purpose was to bring some rationality into future product development success/failure research which would give

- practitioners and researchers reading the literature the ability to compare findings across researchers and research projects;
- researchers who used the measures a higher probability of publishing their results when they followed the measurement guidelines (especially those who were young or new to the field); and
- practitioners a clearer view of the best performance measures to use to more effectively measure and benchmark the performance of their own organization.

This article is an interim report that identifies and structures into a useful framework the myriad measures of product development success and failure, and compares those measures used by product development practitioners and managers to those used by academic researchers. The task force hopes that ultimately this research on how S/F is measured will bring academic researchers and industry practitioners together onto a common ground for evaluating S/F. A future report will present recommendations on appropriate measures for both groups.

Research Methods and Data Collection

Shortly after the 1990 International Conference, the PDMA assembled the Measures of Success and Failure Task Force (Table 1). Since then, the task force has completed the steps outlined in Table 2.

Obtaining Measures of Success and Failure

Measures of product development success and failure were obtained independently from the literature and companies. Over a four-month period task force members identified articles that reported measures of success and failure, and extracted each measure used by each researcher. This generated 46 different S/F measures as reported in 77 articles generated out of 61 different research projects. Some projects, for instance those of Cooper, are reported in multiple articles. For analytical purposes, the unit of analysis is the research project, not the articles reporting the results.

The S/F measures actually used by companies were obtained through surveys of practitioners attending two PDMA conferences, the 1991 International Conference in Boston, MA, and a local one-day conference the next month in Chicago, IL. The questions used in the predominantly open-ended survey can be found in Table 3. A total of 50 responses were obtained, generating thirty-four different S/F measures which are currently used by firms (question 4). The respondents indicated, however, that they would like to be using a total of forty-five different measures (question 5).

A total of seventy-five measures[1] of product development success and failure were generated across the two questions in the survey and the literature review. As Figure 1 indicates, only sixteen, or 21% of the measures are common across all three sources. These sixteen measures can be thought of as the ones that everyone is using and wants to use—they are the core S/F measures. Throughout this paper, these core measures will be printed in bold type to help readers easily identify them.

[1] The complete listing of these measures can be found in the Appendix.

Table 1. Members of the PDMA Success/Failure Task Force

Task Force Member	Affiliation
George Castellion	Solid State Chemistry Associates
Merle Crawford	University of Michigan
Anthony di Benedetto	Temple University
Deborah Dougherty	McGill University
Laurence Feldman	University of Illinois, Chicago
Abbie Griffin[a]	University of Chicago
Thomas Hustad	Indiana University
Albert Page[a]	University of Illinois, Chicago
Martin Schwartz	Miami University
Allan Shocker	University of Minnesota
William Souder	University of Alabama, Huntsville
H. Clifton Young	University of Alberta

[a] Task force co-chairs.

More explicit differences across the data-gathering methods will be explored more fully later.

Since the sample surveyed is a convenience sample, we expect these respondents to exhibit bias compared to the results that would be obtained from a random sampling of companies. The individuals attending PDMA conferences are probably those more interested in improving the process of new product development, and thus we expect that our sample consists of representatives of firms that are

- more likely to measure success/failure in the first place; and
- interested in using more different measures when they do measure S/F

than would a randomly selected set of respondents. Generalities drawn from the practitioner-based findings presented here, therefore, should be considered as tentatively applicable *only* for firms that take an active interest in measuring and improving new product development.

Forming Structures of Similar Measures

From the outset, the task force postulated that a number of different specific measures were used by firms and researchers in trying to quantify several distinct overall dimensions or aspects of product development success and failure. Many of the seventy-five S/F-identified measures seemed rather similar in nature. For instance, measures identified in the literature include market share, customer acceptance, customer satisfaction, number of customers adopting, and test market trial rate. While each one conveys a distinct meaning, these measures all seem to be trying to quantify how well a product meets the needs of the customer.

In order to help further cross-researcher and cross-company correspondence in S/F measurement, the task force felt it was important to determine whether there were any underlying dimensions of product development success and failure. If underlying dimensions could be identified, then regardless of which specific measures were used to quantify the firm's performance in a particular dimension, we might ultimately be able to help firms determine whether they were missing any aspects of measurement that would help provide them with a more balanced view of their performance.

We used a two-step process to impute, and then test to validate, the independent dimensions of new product development success and failure. The forty-six S/F measures identified in the literature were formed into a structure using two of the Japanese "Seven Management Tools" [51]. These techniques group similar attributes together and separate groups of different attributes using a bottom-up group consensus process [39,40]. The task force, consisting of "experts" in product development, was the group that produced the consensus structure.

The group consensus process is used for several purposes in the U.S., the most frequent of which is to usefully structure large numbers of customer needs into a hierarchy for Quality Function Deployment (for details on QFD, see [37]). Although presented in greater detail elsewhere [39,51], the basic steps of the group consensus process are outlined here. The process uses two steps to develop a similarity structure from a set of statements, customer needs, or in this case, S/F measures.

Table 2. Task Force Action Steps

Time Frame	Tasks
November 1990	Task force co-chairs selected Task force assembled
December 1990 to April 1991	Culled measures from the literature Developed a preliminary bibliography
April 1991	Task force structures measures
October 1991	Company survey of S/F measure use (at PDMA international conference)
November 1991	Company survey of S/F measure use (Chicago regional PDMA conference)

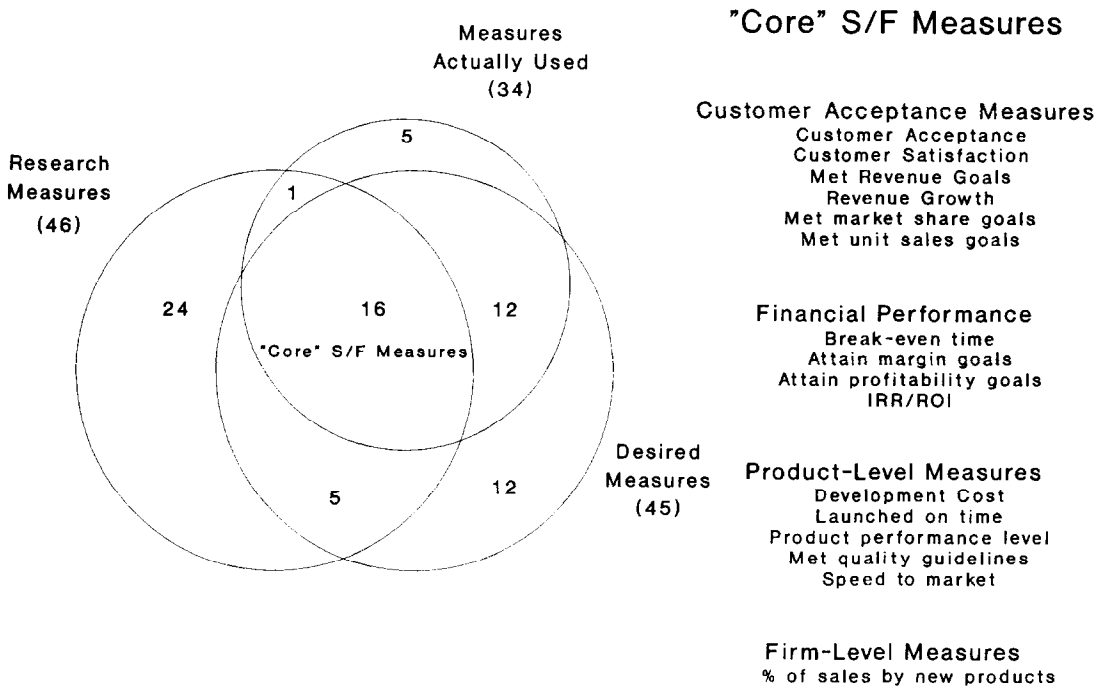

Figure 1. Overlap across identified measures.

First the task force separated the measures into groups of similar measures. A Post-it note© containing an S/F measure was read by a task force member and placed on a wall. Another S/F measure was read, and if deemed by the group to be "similar" to the first, in some way, it was placed near the first S/F measure. If the measure somehow differed, in the eyes of the task force, it was placed on the wall in a different spot. Measures were read, and either placed on the wall near other measures already there, or used to start a new category of measures, until all 46 measures were up on the wall in groupings.

Once all the measures were in groups on the wall, the measures within each group were structured into a hierarchy. Detailed S/F measures resided at the bottom of the hierarchy with general definitions of subgroups above them, and then an overall definition of the category at the top of each group. The task force read all the measures within one group, and either selected one as the overall exemplar describing the group or wrote up a general title that defined the measures within the group. This process resulted in five general categories of S/F measures:

- Measures of firm benefits
- Program-level measures
- Product-level measures
- Measures of financial performance
- Measures of customer acceptance

Validation tests indicate that the structure generated by the task force experts consists of five rather independent categories of S/F measures. The expert-generated structure was tested against corporate responses to question 5 on the survey (how firms would like to measure S/F). The corporate responses were classified into the categories generated by the task force experts. Then the responses were correlated to determine whether there were any significant relationships across the predetermined categories. The only statistically significant correlation ($p < 0.05$) across the categories occurs between program and product measures, and at $\rho = 0.29$, the correlation is low, even though it is significant. The lack of correlation across the categories suggests that the five groupings constitute almost completely independent groups of measures.

The second test of the expert-generated structure was factor analysis. Factor analyzing the corporate responses, which have been classified into the expert-generated categories, produces a two-factor solution when the factor cutoffs are limited to an eigenvalue greater than 1[2]. Generating a five-factor solution forces the responses into five orthogonal (independent) sets

[2] This is the most common decision rule for determining how many factors obtain. The two factors so generated are orthogonal and account for 48.3% of the variation in the data.

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Table 3. Company Survey for Success/Failure Measures

Please help us understand what measures of product development success and failure companies use by filling out this short survey during the conference.

BACKGROUND INFORMATION

1. Which *one* of the following categories best describes your job function:
   ____ Marketing
   ____ R&D/Development
2. Which *one* of the following categories best describes your company:
   ____ Marketing-driven
   ____ Requires balanced inputs between marketing and technology
   ____ Technology-driven
3. Does your organization measure the success or failure of its new products?
   ____ Yes
   ____ No
   ____ Do not know
4. If yes, what measure(s) are currently used in your division or organization to measure the success or failure of new products? Please be as specific as possible in describing the measures and how they are obtained.
5. From your functional perspective in your organization, what measures do you think would best evaluate the success or failure of the new products your organization introduces? Please list all the measures you think would be most applicable, and why they are the best or most appropriate.
6. If your answers in question 5 differ from those in question 4, please tell us why you think your organization does not use the measures you feel are best?

of responses. When a five-factor solution is forced onto the data, 89.5% of the total variation is accounted for by the solution, each factor reduces the variation in the data by at least 10%, and each category of S/F measures loads neatly onto just one factor with a factor loading score above 0.98. We find this test of independence surprisingly high and we, therefore, conclude that the two sets of factors are the same.

Both correlating and factor analyzing the data validate that the categories or dimensions of S/F measures created by the experts are almost completely independent of one another and measure different aspects of product development S/F. In the rest of this article we assume that the five dimensions do indeed represent independent sets of measures, and accept this structure for the rest of the analyses conducted. In the next section we compare the measurement categories developed here to those resulting from two other pieces of research.

Comparing Our Structure to Other Researchers' Structures

Two of the papers reviewed in this study [16,41] also attempt to organize a set of S/F measures into a useful framework of (more or less) independent dimensions. The structure we obtained subsumes and augments Cooper's structure [16], and further integrates two of the three aspects broached but not dealt with simultaneously in Hauschildt's analysis [41]. Table 4 illustrates how the overarching dimensions of each analysis compare.

Hauschildt [41] compared the measures used by thirty investigators looking at the success of innovations. He found that the measures dealt with several independent aspects of measurement: the scope of the measurement, the attributes of the innovation, and the process stage at which success is measured. Hauschildt arrived at his structure judgmentally, and did not use any sort of statistical test to validate the result.

In his paper, he discusses each measurement aspect independently, and presents typologies for each, but does not synthesize across the aspects, except to conclude that "there are many different aspects of the measurement, depending on the respective stage of the innovation process." He also proposed that it "is therefore not possible to effect the measurement of success with the help of a single criterion," a proposition also supported by our analysis.

The scope of the measurement refers to the unit of analysis of the measurement: the project, the program, and the firm. Our structure also acknowledges differences in the scope of the measurement and separately considers program and firm measures. Our customer, financial, and product categories are all aspects of project-level measures. Hauschildt's attributes of the innovation, mostly items at the project level of analysis, split into three dimensions: technical, eco-

Table 4. Comparing Measurement Structures

Task Force		Cooper [16]		Hauschildt [41]
Firm	↔	Success Rate	↔	Firm / Other
Program	↔	Program impact / Overall performance	↔	Program
Customer / Financial	↔			Economic Effects
Product	↔			Technical Effects

nomic, and other effects. The technical effects dimension covers the kinds of issues in our product-based category, whereas the economic effects consist of both the customer acceptance and financial measures. The "other" category covers strategic aspects of firm-level indicators.

Cooper [16] factor analyzed responses for eight measures used in his research, resulting in three orthogonal multifactor dimensions of success. However, compared to the task force structure, these multifactor dimensions constitute only a portion of the information desired because Cooper's research focuses on management's ability to commercialize a succession of successful new products. Cooper's measures capture only three independent dimensions of firm and program-level outcomes, and do not analyze S/F at the project level. Thus, his structure fits in as a subset of the overall picture of required measurements to help firms and researchers better understand product development S/F.

In summary, the structure developed and used extensively by Cooper fits nicely into the program and firm-level categories of the task force structure. The task force structure is also quite in line with the categories presented by Hauschildt. Our factor analysis of the S/F measures indicates that the five dimensions developed are indeed independent and measure different aspects of S/F.

What Measures Are Used Compared to Those Desired

What Do Firms Do and Want to Do?

Both academics and practitioners accept that measuring product development success and failure is important. Over three-fourths of our corporate respondents (thirty-eight out of fifty) measure new product S/F. Given that there are no federal reporting requirements for product development, this result indicates that measuring and improving product development is strategically important enough to U.S. firms to force them to find ways to quantify their performance. The sheer volume of academic S/F research suggests that academics also find the question of new product success and its measurement an important research question.

However, neither group currently uses a set of measures that spans all five measurement categories. Each group focuses on only a couple of the five categories of measures, and academics measure somewhat different aspects of product development performance than practitioners. Academic research on product development S/F seems to target different questions than practitioners seem to answer with the way they measure S/F.

Determining whether product development is successful or not is not a trivial task as it is a multidimensional question. Neither practitioners nor academics base their assessment of product development performance on just one measure. Based on responses to question 4 in our survey, firms who measure S/F use, on average, 3.7 measures; two customer acceptance measures, almost one financial measure. While about three-fourths of the group also use a product-related measure, the other one-fourth of the group uses a firm-level measure. No respondent indicated use of any program-related S/F measure.

From the literature analysis, academic researchers use and report about three measures of S/F per study, slightly fewer measures than firms track. On average, each research study reports one product-related measure, two-thirds of the researchers report a customer acceptance and a firm-level measure, one-half report financial data, and the remainder (20%) add a measure of program effectiveness.

In telling us what S/F measures would allow them to best evaluate the success or failure of new products in their organization (answers to question 5 in the survey), firms indicate they would use about the same mix of categories as they currently use. If they could, about one-fourth of the firms would shift from a product-based to a firm-level measure. Otherwise, the current mix of categories of measures is viewed as adequate by our respondents.

We also found that the way S/F is measured does not vary with differences across the variables collected in the survey which classify firms along different characteristics (mainly questions 1 and 2). The number of measures used by firms does not vary in total or across the categories by function of the respondent or whether the firm is technology- or marketing-driven, or a balanced mix of technology and marketing. The number of measures that firms would like to use also does not vary in total or across the categories by respondent function or the focus of the firm. The number of measures a firm would like to use also does not differ by whether the firm now measures S/F or not.

At the level of the individual measure, however, firms would change some of the specific measures used, if they could. Figure 2 demonstrates that the only category where the number of measures currently used is the same as the number the firms would like to use

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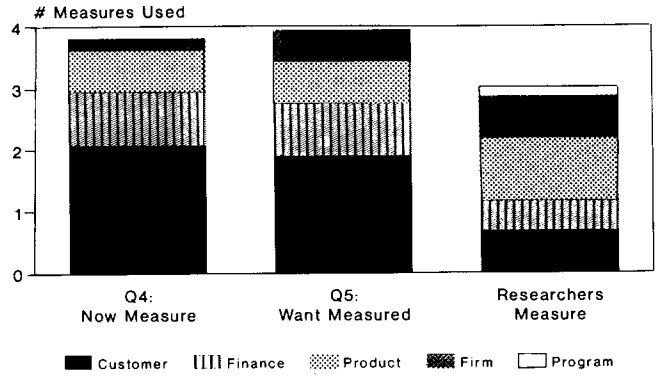


Figure 2. Total responses by category for those who measure S/F.

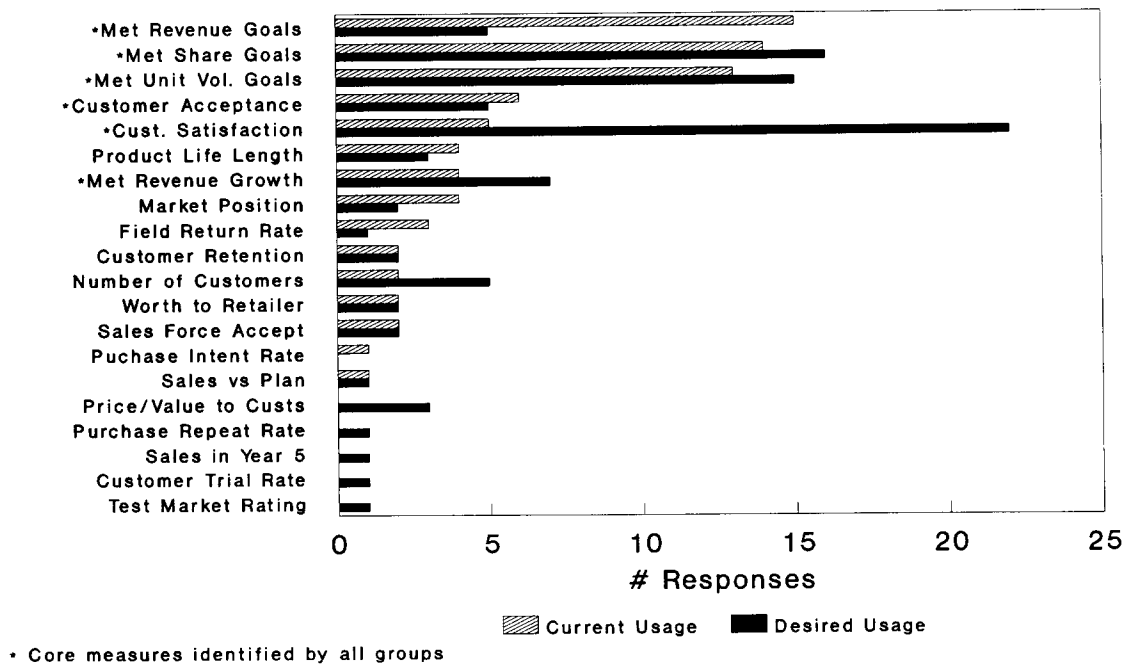
is in the financial dimension. If they could, firms would pare down the number of product-related measures, and concentrate more on fewer measures within the category. They would add quite a number of firm-level measures to help them better evaluate S/F. Figures 3 through 6 indicate which specific measures within each category are used most frequently and contrast the frequency of what firms now measure to what they would like to measure. These Figures demonstrate that the financial measures are the only category that would not change any of the specific measures used, although the emphasis among them would change. Note that the horizontal axes for all of these figures are scaled to 25 respondents (50% of our sample) to ease frequency comparisons across the categories. A graph containing specific program measures is not included because firms do not now use program-level S/F measures.

Firms evaluate the success of their products with customers (Figure 3), using a combination of two measures. At least one of the two measures quantifies revenue, share, or volume. The other measure comes from a large number of different potential ways of measuring product development success from the customer's viewpoint. Firms are somewhat unhappy with their current customer acceptance measures. If they could, firms would still use two measures of customer acceptance, but would shift their focus from revenue to customer satisfaction. They also are interested in a number of other measures in addition to those already cited to try to gain a better overall understanding of how well their products meet customer needs.

The current financial measures of product development performance meet the needs of firms (Figure 4). Firms currently use one measure and would like to focus even more than they currently do on product development profitability and the financial measures which include investment and the monetary value of time (IRR and ROI).

Product-related performance measures (Figure 5) are the most idiosyncratic category of success mea-

Figure 3. Measures of customer acceptance; number of citations/measure.



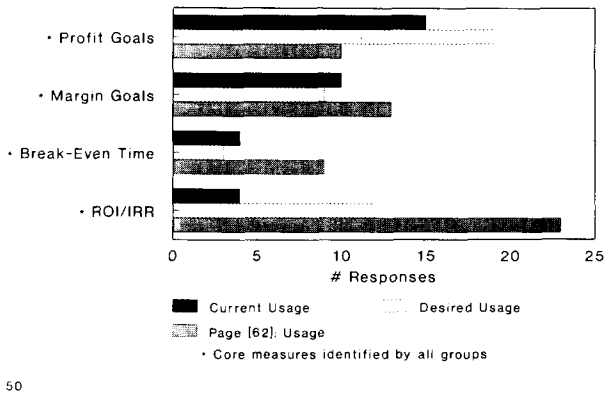


Figure 4. Measures of financial success/failure; number of citations/measure.

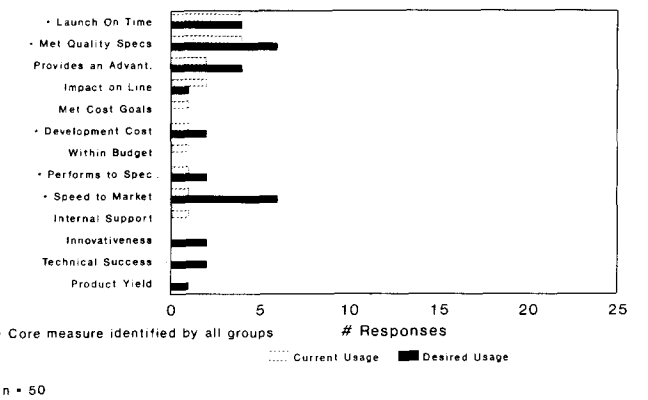


Figure 5. Measures of product-level S/F; number of citations/measure.

sures. Every firm has their favorite product-based measure, with little agreement across firms on which measures are, overall, most useful.

Firm-level measures are the most under-utilized set of measures used by companies, and the category to which many firms would like to both add new measures and increase the amount of performance measurement (Figure 6). The only two measures now used are new product sales as a percent of total sales, and some measure of the strategic fit of a project.

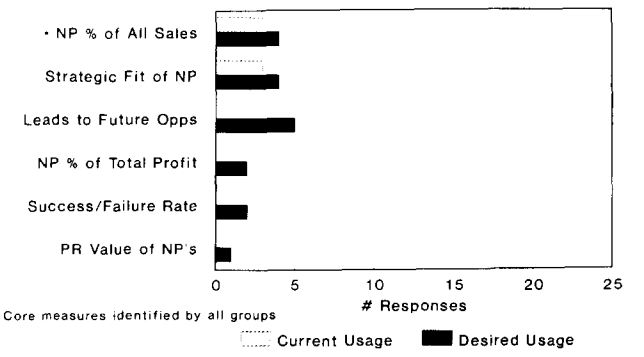
Comparing Researchers and Companies

As Figure 7 illustrates, the measures used by academic researchers in assessing success and failure differ from those used or desired by industry.[3] Table 5 demonstrates that while there is no significant difference in the total number of measures used per study by academics compared to per firm by practitioners, the split of what kinds of measures are used within that total differ significantly across the two groups. In general, our corporate respondents are more interested in measures associated with the success and failure of individual projects. Academics are more interested in the overall success of product development programs and their impact at the firm level, perhaps reflecting their research interest in the overall ability of different product development processes to repeatedly deliver successful products.

Table 6 lists the three core S/F measures used equally by both researchers and companies. In each of the three most-measured dimensions of S/F, there is overlap in the use of only one specific measure per category. Table 6 also shows which specific measures are used significantly more by each set of people. All the measures used more by companies than by researchers belong to the sixteen core measures. However, more than half the measures used by researchers more than by practitioners are not core S/F measures—although academics use them in their research analyses, firms either do not want to use them in the future (completed in budget) or do not now use them (the other three noncore measures).

The differences between the sets of measures used by researchers, as compared to those used by firms, more than likely reflects differences in access to data. It is far easier for a company to collect and benchmark very proprietary data such as customer acceptance and satisfaction on a routine basis than it is for an outside researcher to do so. Researchers evaluate S/F based on what they can gather directly from measuring or assessing the product, or on what data they can

Figure 6. Measures of firm-level success/failure; number of citations measure.



[3] Note that the results in the column labeled Page [62] will be discussed later.

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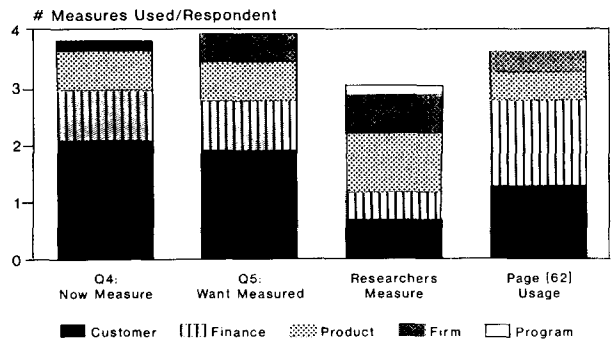

Figure 7. Total responses by category for those who measure S/F.

persuade companies to provide to them. Companies may be far more likely to reply when asked about subjective or overall assessments of success than they are to impart proprietary share, volume, margin, or customer satisfaction data for individual products.

Firms, on the other hand, seem less likely to aggregate data across possibly disparate operating groups for their internal development program decision-making processes. Individual project data are more widely used than aggregate data at responding firms. Perhaps interdivision rivalry has decreased the availability of aggregate performance data.

Why Companies Do Not Measure Success and Failure

The last question on the survey to our practitioner respondents asked them to tell us why their firms do not currently measure the aspects of product development that would most help them evaluate development performance. The 50 respondents came up with 51 mentions of why they do not use the S/F measures they deem most useful, or why they do not measure S/F at all. The responses were coded into the categories of Table 7.

An interesting speculation arises from the data. The few respondents (four out of thirty-eight) who cite "no time to take the measures" as a reason for not measuring what they would like to have already, use more S/F measures than other firms in the data ($\rho = 0.28, p < 0.05$). Perhaps the more a company measures product development success and failure, the more they realize how much time it takes to get "the right" measures of success and failure and the more they

Table 5. Measures Used by Academics and Industry

S/F Measure Category	Number of Mentions by Category: Firm Data	Researchers
Customer	78	42[a]
Finance	33	29[a]
Product	22	63[a]
Firm	6	41[a]
Program	0	10[a]
Total number	139	184[a]
Sample size	38	61[a]
Average number per respondent	3.7	3.0

[a] Two-tailed t test shows the means differ, $p < 0.05$.

Table 6. Measures Used by Researchers and Companies

Used by Both Researchers and Companies

Met revenue goals (customer)
Met profit goals (financial)
Got to market on time (product)

Companies Use More[a]	Researchers Use More[a]
Customer Measures	Firm-Level Measures
• *Market Share*	• *% of Sales for New Products*
• *Volume*	• Success/Failure Rate
• *Customer Acceptance*	
• *Customer Satisfaction*	
	Product-Related
Financial Measures	• *Performance*
• *Margin Level*	• *Speed to Market*
	• Completed in Budget
	• Subjectively "successful"
	• Technically successful

Italics denote core measures—those identified by all groups.
[a]Two-tailed t test shows the means differ, $p < 0.05$.

Table 7. Why Companies Do Not Measure Development Success and Failure

Number of Mentions	Percent of Total	Reasons for Not Measuring
19	37	Have no systems in place to measure S/F
8	17	Company culture does not support measuring
6	12	No one is held accountable for results
5	10	Do not understand the development process
5	10	Short-term orientation, cannot wait for results
4	8	Have no time to measure results
3	6	Measuring is unimportant

Table 8. Where Culture Prevents S/F Measurement

Firm Core Competency	Percent Citing Culture	*n*
Marketing-driven	6	18
Balanced	5	19
Technology-driven	46	13

$F = 5.3$; $p < 0.01$.

recognize they are not taking the time to do it right. Companies who still do not intensively measure S/F as yet may not realize how difficult and time-consuming it is to record measures of S/F.

Some of the reasons given for not measuring S/F vary in interesting ways with demographic aspects of the firms surveyed. Personnel in marketing-driven firms, for example, are significantly more likely to cite that they do not have time to measure S/F results, than are personnel from technology-driven firms. However, technology-driven firms have cultures which are significantly less conducive to measuring S/F outcomes than balanced or marketing-driven firms, as demonstrated in Table 8.

There also seems to be a slight bias in which functions deem measuring "unimportant." No one in a marketing function said their firm did not measure new product S/F because the firm believes measuring is unimportant. A small portion (three of twenty-six) of the technology-function respondents said their firms did not measure new product S/F because measuring is unimportant. Thankfully, no respondents who said their firms thought measuring S/F was unimportant came from firms which already measure new product S/F.

Table 9 lists a number of nearly significant findings within the survey data. "Nearly significant" means that relationships between variables were significant between the 0.05 and 0.10 level for correlations, differences across means, or *t* tests. These trends suggest that there may be some inherent differences in the way marketing-driven and technology-driven firms measure new product S/F. Care must be taken in interpreting these because of the small sample sizes and lack of statistical significance in the findings.

How Firms and Researchers Combine Measures

Firms average 3.7 measures of S/F, with two of those measures being customer acceptance and one financial. However, as we found in talking with managers from a few leading companies, not all firms adhere to these averages. The examples presented in Exhibit 1 illustrate several different ways companies told us they combine measures. We were interested in determining whether any identifiable groups of firms with different measurement orientations could be identified from our data. Using factor analysis we have investigated what groups form based on

- what firms currently measure;
- what firms would like to measure; and
- what measurements researchers use.

Analysis Method

To form differentiating groups from the data we factor analyzed the responses for each of the categories of S/F measures our respondents now use together with the reasons they provide for not measuring S/F. The statistical analysis produced a five-factor solution accounting for 66% of the variation in the data, as shown in Table 10. Respondents were assigned to factors based on their factor scores so that we could

Table 9. Nearly Significant Findings between Variables (Trends: $0.10 > p > 0.05$)

Question 4 trends (What do you measure now):

- Marketing-driven firms tend to measure S/F more than do technology-driven firms
- Technical personnel tend to use more product-based S/F measures
- "Inability to wait for results" is more likely and "No understanding of the new product process" is less likely to be cited as a reason for not measuring S/F for firms with more ways they already measure S/F.

Question 5 trends (What would you like to measure):

- Firms that do not currently measure S/F are more likely to want to implement firm-level measures of S/F than firms that already measure S/F
- Technology-driven firms are more likely to want to implement product-related measures of S/F than are marketing-driven firms

Question 6 trends (Why don't you measure what you want):

- Firms that already measure S/F ware more likely to cite lack of accountability for results, and a short-term orientation with no patience to wait for results as reasons for not measuring the results they really want more than do firms that do not yet measure S/F.
- Technology-driven firms are more likely not to measure because they "do not understand the development process."

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Exhibit 1. How Specific Firms Combine Measures

Example 1

An office products manufacturer takes an uncomplicated approach to measuring S/F. It appraises the S/F of its new products with measures of customer acceptance and financial performance. The customer acceptance measures used are unit and dollar sales, while the financial performance measure is the gross profit contribution of the new product. The firm does not gauge overall success of its new products program with either program measures or firm-based measures.

Example 2

A large telecommunications company measures S/F in three categories in evaluating new services: customer acceptance, program, and firm benefits. Since it is difficult to estimate the true cost of a new service deployed over the same systems, wires and cables, revenues are scrutinized in both the short (one year) and long (four- to five- year) terms as measures of customer acceptance. Development program success is measured from trends in individual service development cycle times, with goals to reduce them by some percentage each year. Firm-based benefits are measured as the percent of current sales contributed by services introduced in the last five years.

Example 3

A major consumer packaged goods firm has invested several years of effort in determining just what product development variables to measure. They feel that knowing what aspects of product development to measure and providing incentives to motivate the organization to improve those results is key to driving the success of the whole organization. In fact, they feel this issue is so important that their approach to measuring product development is proprietary and they would not discuss the details of what they measure with us.

identify what proportion of the sample aligned with each factor in the solution.

The factor analysis was repeated using the responses indicating what S/F measures respondents would like to use, if they were available. Again, a five-factor solution was obtained (accounting for 89% of the variation in the data), and respondents were assigned to factors based on their factor scores (Table 11).

We also factor analyzed the researcher data to determine whether there were any discernible measurement patterns. The data consisted of how many measures in each S/F measurement category each researcher reported using. For the sixty-one projects, the analysis produced a three-factor solution which accounted for 81% of the total variation in the data (Table 12).

Results—How Firms and Researchers Measure Success and Failure

Each factor analysis of responses from firms produced three groups of measurers (the "Those Who Would Measure" groups in Tables 10 and 11) which focus on different aspects of product development S/F. However, by comparing the measurer categories across Tables 10 and 11, one can see that firms would measure S/F differently than they currently do, if they could use the measures they wished.

Firms in both analyses also fall into two nonmeasuring groups. Currently, about 24% of the firms in the sample do not measure product development S/F. And even in the future, 16% of the total sample indicated that they still would not be interested in measuring S/F. That means that only one-third (8% out of 24%) of those who do not now measure envision measuring S/F in the future.

The nonmeasurers fall into two camps. "Not There Yet" firms have organizations that are not yet ready to measure S/F. They are in the process of developing the cultures, processes, and accountability requirements necessary to allow S/F measurement to take place. "It's Not Necessary" firms have organizations that are satisfied with the current situation because they do not think measuring is important or do not want to wait for results. As shown in Table 11, the core group of "It's Not Necessary" firms (about 4% of the total sample) will continue to be satisfied with the status quo and not measure. However, almost half of the "Not There

Table 10. Actual Measurement Focus of Firms

Percent of Total	Measurement Focus	Categories Measured
Those who measure (76% of the total)		
86	Balanced end results	Customer and financial
12	Product-focused	Product, no time for other dimensions
2	Overall outcomes	Firm-based, because no one is held accountable for individual projects
Those who do not measure (24% of the total)		
86	Not there yet	No culture, no process, and no accountability
14	It's not necessary	Unimportant, and will not wait for results

Table 11. Measurement Focus, If Firms Could Measure What They Wanted

Percent of Total	Measurement Focus	Categories Measured
Those who would measure (84% of the total)		
86	Outwardly focused	Customer measures
9	Swamped bottom-liners	Like to use financial measures, but do not have time
5	Inwardly focused	Product and program
Those who still would not measure (16% of the total)		
75	Not there yet	No culture, process or accountability
25	It's not necessary	Unimportant, and will not wait for results

Yet" firms would start measuring S/F in the future. This group apparently believes that they will learn enough about product development in the future to be able to start measuring S/F outcomes. These former "Not There Yet" firms move into the measuring categories of Table 11.

How those who currently measure S/F combine measures. Over three-quarters of our sample already measure success and failure. However, only 2% of those firms focus on overall outcomes from product development. The remainder evaluate S/F at the level of the individual product (Table 10).

The vast majority (86%) of firms who already measure success and failure focus on obtaining a picture of the balanced end results of individual products. They measure whether the customer's needs have been met while simultaneously producing financial results for the firm. The office products manufacturer we talked to fits into this measuring category. Focusing on these measures would seem to be an intuitively useful way to run a business at the product level, even if it does not tell you how the firm is doing overall.

The remaining 12% of our firms focus S/F measurement on product outcomes. These measures tend to be available immediately upon completion of the project. They focus on these measures because they claim they have no time to obtain other kinds of measures. Although also evaluating product development at the individual product level, these firms have focused on a less powerful dimension of success and failure than the firms who concentrate on customer and financial measures. These firms risk being successful in the dimension they are measuring, but as the specific measures detailed in Figure 5 illustrate, product-based measures are frequently unconnected with whether the product is salable or profitable.

How firms would combine measures if they could measure what they wanted. When the responses indicating what measures firms would use if they could were factor analyzed with the reasons they do not currently use those measures, the nature of the three categories of measurers changes significantly (Table 11). All of the firms would depend predominantly on individual product measures, and most of the firms (86%) would now focus primarily on customer acceptance measures of performance. Nearly 10% would focus on just the financial aspects, and a third inwardly focused group (5%) would use a combination of product and program measures.

The groups formed in the factor analysis of what firms would measure, if they could, differ from the previous set of factors in that the firms seem to split into groups of less diverse measurers. The majority of firms would use only customer acceptance measures rather than both customer and financial measures. We would expect that this narrower focus would give them a less complete picture of the overall performance of each new product commercialized, providing only an external view of how well the product meets customer needs. Companies moving to eliminate the financial analyses in conjunction with the customer acceptance analyses might find that they are commercializing highly satisfactory, yet unprofitable, products to the long-run detriment of their firm.

One reason for the change of structure in the factor-analysis-produced groups may be that this sample includes the responses of our "Not There Yet" respondents who do not now measure S/F. These firms may be coloring the structure of the categories because they do not yet know the value of different kinds of S/F measures, and because they have little or no idea of what kinds of measures are actually obtainable at their companies. Thus, with their addition of what they would measure, if they could, our sample of respondents group into sets of firms with simpler measuring schemes.

Table 12. Focus of S/F Measurement Researchers

Percent of Total	Measurement Focus	Categories Measured
38	Product-focused	Product measures
34	Balanced end results	Customer and finance measures
28	Strategic outcomes	Program and firm measures

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Eliminating the 12 respondents who don't now measure S/F and re-analyzing the responses of the remaining 38 respondents indicating what they would measure if they could through factor analysis supports the thesis that including these "Not There Yet" measurers induces a narrower view of the performance world. This re-analysis of the subset of the total sample produces a four factor solution which accounts for a total of 61% of the variation in the data (Table 13). This analysis does not produce a solution in which categories of S/F measures neatly load onto one, and just predominantly one, factor. The finance, product-based, and firm categories of S/F measures all load about equally onto more than one factor. Importantly, this means that multiple groups of people would like to use different categories of measures in varying combinations, and suggests that in the future evaluations of product S/F will be even more multidimensional than now. The top two groups of firms in Table 13 focus on only individual project performance, but would measure it using multiple categories of measures. The bottom two groups of Table 13 would focus on one measure that monitors total performance across the firm, and one that provides some type of individual-level internally based measure, either profit or product-related performance.

By eliminating the nonmeasurers, we get a clearer picture of what dimensions of measures "knowledgeable" firms would use to measure S/F, if they could. We find they would make several specific changes. First, the number of firms who would measure how well the firm does in product development across the firm would increase sharply. Second, firms would always like to use multiple categories of measures of S/F, at least one of which focuses on some aspect of the individual project.

From these analyses, the firms would like to measure a broader set of S/F categories than they currently measure. However, the number of different groups formed by the factor analysis indicates that there is only partial agreement across firms on what categories produce the most useful results. By combining customer and financial measures, firms obtain a good picture of performance at the individual project level. It is when firms look to measure success across the firm that several different approaches emerge.

How researchers combine S/F measures. As Table 12 illustrates, the three groups obtained from the researcher factor analysis are nearly identical to the three groups of firms who already measure S/F (as in Table 10). However, the concentration of researcher interest differs greatly from that of the firms. Just over two-thirds of the researchers evaluate S/F at the individual project level, compared to the 98% of the firms who analyze S/F at the product level. Slightly more than half the researchers analyzing project level results concentrate on product-related outcomes of success and failure, probably reflecting the popular attention to development speed to market and the easier availability of data. The other half focus on a balanced set of customer and profit measures similar to those used by the bulk of individual measurers.

Table 13. Focus of What They Would Measure, for Firms Who Measure Now

Percent of Total	Measurement Focus	Categories Measured
74	Balanced end results	Customer and financial
10	Profit and performance	Product and finance
8	Distributed profit	Finance and firm-level
8	Distributed performance	Product and firm

Comparing researchers and practitioners. The largest difference between the focus of researchers and firms arises because almost one-third of the researchers evaluate S/F from an overall or strategic perspective, compared to only 2% of the firms surveyed. A large percentage of researchers is interested in bottom-line investigations of what firms do to routinely propel a series of profitable projects through the product development process and out the corporate door. These researchers try to determine what techniques and tools keep the new product stream flowing with commercially advantaged products. The researchers are then able to recommend those means to firms interested in improving new product development. The end result of researcher S/F investigations is both a discovery of general solutions applicable across firms and further dissemination of those solutions to other interested firms.

The firms surveyed are predominantly interested in measuring how any particular project has proceeded. One use of these numbers may be to determine how well the team performed so that work evaluations and promotions can be made. The project manager's job is to get the product to market using any means at their disposal. They investigate and adopt any method or technique they come across during the project which they believe will improve their probability of launching a successful product, and they are most interested

in measures that indicate how well they performed on their individual project. Thus, due to the nature of the new product management job, we expect that product development personnel at the business level of the organization may remain focused on measures of success at the individual project level.

Summary. Both firms and researchers indicate that measuring product development S/F is a multidimensional question. At this point, there is only partial consensus on the most useful combination(s) of S/F dimensions. Those who measure S/F at the individual product level concentrate on a balance of externally driven customer acceptance measures and internally focused financial measures, which on the face of things could provide them with a balanced outlook of success. Some percentage of companies would like to maintain an individual-level measure, but also simultaneously measure how well the firm does overall in product development.

One way the analyses could be interpreted is that firms seem to become more sophisticated over time in the way they measure product development S/F. This hypothesis is partially supported by two findings. First, we found suggestions in the data that the more S/F measures a firm uses, the more likely they are to say they have no time to take the measures they want to use. This correlation possibly implies that as firms take more measures (become more sophisticated in measuring), they discover other measures that they believe would provide them with even better data, but that would take too much time to collect.

Additional support is provided by including the firms who do not now measure S/F into the factor analysis of what they would measure if they could (Table 11). This analysis produces groups with simple measuring schemes. But reanalyzing the data without those nonmeasuring respondents produces a much more multidimensional set of measuring schemes for each group derived in the analysis. Those who now measure would move even more toward multidimensional measuring, if the means were available. Additional research that specifically investigates how measurement evolves at firms over time is required before we feel that this hypothesis is fully supported.

The concentration of researcher activity has focused as much on the overall impact of product development as on individual measures. The data researchers have been able to obtain from corporations may have colored the research questions they chose to investigate, and the proprietary nature of much of the individual project level data have led them to focus on different questions than those now being addressed by companies. Whether it is more appropriate to focus on individual project-level measures, overall measures, or some balanced set of S/F measures is a question that remains to be addressed in the next phase of this research program.

Comparing Our Results to the PDMA Best Practices Results

In 1990 the PDMA surveyed their members concerning how their organizations developed new products. The purpose of the study was to determine what methods and practices differentiated the top-performing product developers from other firms. Two open-ended questions from this Best Practices Study [62] investigated how companies measure S/F. The first question asked whether financial objectives were measured in new product development S/F, and if so, then what measures were used. The second question asked what additional nonfinancial definitions were used in ascribing the labels success and failure. We expect that the Best Practices data are biased compared to our data in that the percentage of financial measures will be higher than that in the general population because this was the focus of an entire question.

A total of 189 respondents supplied information to these questions. These respondents were PDMA members and, therefore, we would expect them to be more interested in measuring product success and failure than people from a randomly chosen set of firms, just as we expect for our open-ended survey respondents.

A total of 76% of Page's respondents (144 out of 189) indicate they monitor development performance using, on average, 2.0 financial measures. A total of 155 of the sample (82%) indicate that they each use an additional 1.6 nonfinancial measures of S/F in monitoring performance. Only 18% of Page's respondents do not measure S/F, compared with our 24%.

Figure 7 shows how the responses of Page's survey fit into the task-force categorizations[4] and compares his overall findings with ours. As expected, Page's sample indicates more use of financial measures, with fewer overall measures reportedly used per firm (but

[4] Some of the categories Page labeled as "financial" actually fell into other categories according to the scheme used by the task force. The data are analyzed following the task-force categorization.

not significantly different) than in the task-force survey. Page's respondents emphasize the measures that incorporate the time value of money (ROI/IRR and break-even time) as illustrated in Figure 4.

Summary and Future Plans

This interim report of the findings of PDMA's Success/Failure Task Force is presented with several purposes:

- To identify all currently-used S/F measures.
- To construct and validate a set of categories of S/F measures that seem to perform roughly the same function.
- To identify trends in use of S/F measures.
- To compare the measures researchers use to those used by firms.

To date we have found the following:

- Measuring S/F generally is multidimensional.
- Five independent dimensions of S/F performance have been identified: firm-, program-, and product-level measures, and measures of financial performance and customer acceptance.
- Practitioners use about four measures from a total of two different dimensions, most frequently customer acceptance and financial performance.
- Researchers use slightly fewer measures, about three, from one to two dimensions. The particular dimensions used differ across three different clusters of researcher focus.
- Researchers have focused more on overall firm impacts of S/F, whereas companies focus on the S/F of individual projects.

Ultimately, our goal is to be able to recommend what categories of product development success and failure should be measured, and which measures within categories are the most powerful indicators of S/F. The next phase of this research will address those questions.

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APPENDIX: Success/Failure Variable List[1]

CUSTOMER-ACCEPTANCE MEASURES

CUSTACT[1]	**Customer acceptance**
CUSTSAT	**Customer satisfaction level**
CUSTRTN	Customer retention rate
EXPORT	% of sales exported
INTENT	Purchase intent rate prior to market introduction
NUMCUST	Customer count, number of customers
OFFMKT	Taken off market
PRDTLIF	Length of product life
PRISVAL	Price/value as measured by the customer
RELSALE	Relative sales level
REPTRAT	Purchase repeat rate
RETAIL	Importance of the product to the retailer
RETURNS	Return rate from the field or customers
REVGOAL	**Met revenue goals**
REVGROW	**Revenue growth**
SALACPT	Sales force acceptance
SALEYR5	Met minimum revenue level by year 5
SALVARY	Variance of sales from plan
SEGTPSN	Market position; Industry success rate (ranking in market, ie #1)
SOMGOAL	Met market share goals
SOMYR1	Year 1 market share
TRIAL	Purchase trial rate
TSTRATE	Product sales rate in test market
VOLUME	Met sales volume goal (units, not revenue)

MEASURES OF FINANCIAL PERFORMANCE

BEAR	Break-even time after release
BETIME	**Break-even time (from start of project)**
MGNGOAL	**Attains margin goals**
PIGOAL	**Attains profitability goals**
RELPI	Relative profits
RETURNF	Return factor
ROI	**Internal rate of return or return on investment**

PRODUCT-LEVEL MEASURES

AUTOMAT	How easy is it to automate the production process
CMPTRXN	Competitive reaction
COMPTAD	Provides us with a sustainable competitive advantage
COSTGOAL	Meets our cost goals
DEVCOST	**Cost of developing the product**
DEVEFF	Development efficiency
DISAPNT	Measure of failure—First disappointment during the development
EASYMFR	Ease of manufacture
INBUDGT	Launched in budget
INNOVN	Level of innovation achieved
ONTIME	**Launched on time**
PERFORM	**Technical performance of product, performs to spec**
PERFREL	Relative product performance
PROBSUC	Probability of success
PROGRES	Development project progress vs milestones
QUALITY	**Met quality guidelines**
SPDMKT	**Speed to market**
SUBJSUC	Management's subjective assessment of success
SUPPORT	Ability to accrue political support within the firm
TEAMSAT	Team satisfaction
TECHAWRD	Product received an award denoting technical excellence
TECHSUC	Technical success of the product
XIMPACT	Impact on sales of other products; % cannibalization
YIELDS	Product yield rate through the manufacturing process

FIRM-BASED MEASURES

EXTNDBL	Can be line-extended—leads to future opportunities
FITSTRT	Strategic fit with business
HITOPP	Hit a window of opportunity
NUMNEW	Number of new products
PCTHIPI	% of products with high profits
PCTPIPN	% of profits under patent protection
PCTPINEW	% of profits provided by products less than 5 years old
PCTSLNEW	**% of sales provided by products less than 5 years old**
PCTSLPN	% of sales under patent protection
PRVALUE	PR value; amount of free advertising created by the product
SUCFAIL	Success/Failure rate of new products

PROGRAM MEASURES

5YROBJ	Program hit our 5-year new product objectives

EXCEEDS	Program exceeds our objectives
IMPACT	Impact of the new product program on corporate performance
PRCSROI	Return on investment for the new product development process
PROGOVER	Overall success of the product development program
PROGPI	New product program profitability
PROGSALE	New product program sales
SUBJIMP	Subjective importance of our new product program

[1] The 16 success/failure measures printed in **bold** are the "core" measures of S/F—they were used in already-published articles and were identified in the surveys of both the academic research as well as by practitioners.