Idea Generation and Successful New Product Development*

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ABSTRACT

The successful generation and flow of new ideas is critical to the innovativeness of any organization. This is quite a distinct issue from the sourcing of market need information – which is generally obtained directly from customers – and the locus of innovation, which is often industry or sector dependent. Data on 126 new durable goods products (1992-3) were used to test a model of new product idea sourcing. New product success was significantly promoted by technical success ($p<.001$), and sourcing ideas from ***first-line R&D managers*** ($p=.03$) and ***marketing*** ($p=.012$), which generally supports the literature in this field. However, significant, inverse effects on new product commercial success resulted for ***general managers*** ($p=.03$), the ***finance*** function ($p=.02$) and ***government*** ($p=.05$) idea sources. R&D intensity (percentage of sales spent on R&D) was found to be significantly correlated with technical sourcing of new product ideas which tends to validate these results. ***Production*** acts in a supporting role for idea sourcing, significantly through customer ($p<.05$) and technical colleagues ($p<.01$).

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The successful generation and flow of new ideas is critical to the innovativeness of any organization. This is quite a distinct issue from the sourcing of market need information—which is generally obtained directly from customers. In firms that have formalized research and development, and across countries that have firms investing in R&D, these investments pay-off significantly in improved productivity (Lichtenberg and Siegel, 1991). This return on private investment in R&D is substantially larger (seven times larger at the national level) than investment in capital equipment and structures (Lichtenberg, 1992). Where do ideas for successful new projects originate? How are ideas converted into winning innovations? And what is the role of manufacturing in the early stages of new product development? These are the questions we attempted to answer in this research for the durable goods sector.

Idea generation in R&D has enjoyed a rich history of empirical research beginning in late the 1950's under the "idea flow" rubric (Rubenstein, 1958). This work expanded to a full-blown research stream on idea generation, represented by the "market pull vs. technology push" studies in the 1960's and 1970's, respectively (e.g., Baker, Siegman and Rubenstein, 1967; Mowery and Rosenberg, 1979). This work continues on into the 1980's and 1990's (e.g., Conway and McGuinness, 1986; Bar, 1989; Rubenstein, 1992; Baker, Green and Bean, 1985; Ettlie, 1992). These latter two empirical studies are reviewed in-depth in order to get a representation of the current research in the field.

Baker, et al (1985) studied 211 R&D projects in 21 companies of four industries (steel, agricultural chemicals, food processing and industrial chemicals). An idea was defined as "a potential proposal for undertaking new technical work, which will require commitment of significant organizational resources." Idea generation was defined as the "coming together of an organizational need, problem or opportunity with the means of satisfying the need, solving the problem, or capitalizing on an opportunity," (Baker, et al, 1985, p. 35).

The authors were particularly interested in how individuals articulated performance gaps that defined the need for a new idea. They found, significantly, that

1) marketing and the customer are more likely to be the source of new product ideas while new process projects are more likely to originate from production, engineering or technical services;
2) technical sources inside or outside the firm were not found to be related in a statistically significant way to project type, although they represent the largest number of ideas for new projects (142 of 726 ideas);
3) the source of ideas is related to success of new product projects but not for processes or a mix of products and processes;
4) new product projects are least likely to succeed when R&D is the sole source of the first idea (35% success rate), and most likely to succeed when marketing and/or the customer is involved in the first idea (65% success rate), but single source idea projects are not necessarily more likely to fail or succeed for new products;
5) when R&D was the sole source, the project was less well defined, technically more complex, and riskier, as would be expected; and finally,
6) not all new ideas are submitted because regular R&D tasks often take precedence; early thoughts are typically not well developed or incomplete which are not rewarded by managers, (cf., Jelnik and Schoonhoven, 1990, esp., pp. 177-178).

Ettlie (1992) studied the designing-manufacturing linkage for 39 domestic manufacturing modernization projects (i.e., flexible manufacturing and flexible assembly) in batch production plants. Product and process changes are highly interrelated in these durable goods industries. In most cases, product have to be changed to accommodate new flexible automation, or new flexible automation is justified to launch new products. The significant findings showed that the greater the proportion of time spent on concept development (effort), the higher new manufacturing system utilization, cost per part reduction and new system inventory turns. There was a significant correlation between the degree of use of contextual cross-functional coordination and cooperation mechanisms (like meetings to resolve information and computer-integrated manufacturing issues, and use of productivity teams) for the projects studied productivity teams) for the projects studied and proportion of time spent on development. Finally, a significant inverse relationship between concept development effort and the ratio of design to manufacturing engineers was found. That is, in firms with more design engineers per manufacturing engineer (e.g. 4 to 1), the less time is spent on concept development for these plant modernization projects. This suggests the number of design and manufacturing engineers becomes more balanced, the more devoted proportionately to concept development.

This last result, all other things being equal, is quite interesting in light of Van Maanen and Kunda (1989, p.56) observations and case studies on emotional expression and organizational culture that "teamwork is... more emotionally trying than solo performance." Since idea generation is at least in part defined as a solo activity (Jelinek and Schoonhoven, 1990, p.177), why would more balance between engineering professionals be associated with increased effort in concept development? Does it make it easier to see the benefits of more concept development effort by highlighting downstream impacts of design choices? Does imbalance reduce the perceived need for early coordination and "filtering," as Jelinek and Schoonhoven (1990) refer to it, in the early stages of Silicon Valley projects? Or does more balance just allow more resources for early screening of projects? These questions remain unanswered at this point.

Case Histories of Idea Generation

There have been a number of recent accounts of the idea generation process for new products in companies. W.R. Grace finds that the "fuzzy front end" of the new product development (what they call the PDP, the product development process), requires special attention so that the more traditional "stage-gate" methodologies do not "drive out creativity and major innovation," (Siadat, 1996, p. 37). W. R Grace attempts to focus idea generation on a single problem or opportunity but "in response to its chief executive's articulated vision for growth, profitability and survival," (p. 37). The resulting ideas are typically quite divergent and go through exploratory research stage next (which represents about 5-10% of the R&D budget). This initial research screening process gives special attention to accidental discovery of new technologies, clarification of market need and matching technology and market need.

At Great Lakes Hybrids, Inc., in Ovid, Michigan, the company has learned that the founding idea for a firm is not the end of innovation but the beginning. Further, the founding father eventually has to relinquish the creative process to other company employees. Typically, idea generation is stimulated by one overriding challenge like "quality issues," which has a focusing effect on the process. And ideas can come from anywhere, as the company found out. Passing around a bottle of wine on one occasion, Mr. Mike Stephenson noticed the vineyard's owner's name was right on the label which eventually led to the Signature Seed premium brand for Great Lakes (Greco, 1998).

Siemens recently experimented with an idea competition in the Corporate Technology group to stimulate the new concept generation process (Schepers, Schnell and Vroom, 1999). Siemens finds that about 1-3 % of new ideas make it out of the idea competition stage of the new product development process. This is similar to the literature that reports about 3-4% of ideas surviving this stage, and only about 1 in 3000 ideas becoming commercially successful (Stevens and Burley, 1997). A check list for screening new ideas standardizes the evaluation process and uses 21 criteria, organized into five categories: customer, market, competencies, time scale and strength & weaknesses.

Two important lessons emerged from the Siemens experience with idea competitions. First, ideas that are initially screened out of the process need to be archived for potential future use in "idea pools," and this requires special work and discipline to accomplish. There is a strong tendency to just discard these ideas even when they may be very useful in the future. Second, an idea that is converted to a proposal for general improvement is handled by a well-established process. And evolutionary product development ideas are assigned to product managers in the firm. Ideas that lead to new corporate ventures have to be handled by a specially defined innovation process within the business groups because of the higher risk and greater business potential. In other words, the type of idea, radical or incremental, is matched with the type of development process.

Source of Innovation versus Idea Generation

For any one group of firms or technologies or industry sector, the 1ocus of innovation does not inform idea generation processes within a given firm or valued added chain (Porter, 1985). For example, von Hipple (1988, p.43) tested a derivative of Schumpeter's theory that "those who succeed at innovating are rewarded by having temporary monopoly control over what they created." For von Hipple, this translates to a prediction that the functional source of innovation is based on the innovation type--firms that can expect to capture an attractive rent will innovate. For example, in scientific instruments, von Hipple (1988, p.44) found that 77% of innovations came from users, who are best able to capture exclusive rents. For engineering plastics, 90% of innovations came from manufacturers who could protect their inventions, and for wire termination equipment, 56% of innovations originated from suppliers who could sell their equipment to many manufactures. In each case, the type of innovation determined which firm had the most to gain by innovating. Yet, within each firm or firm type, the idea for innovation had to spring from someone or group. The theory of locus of innovation does not predict which group or person it will be.

The Resource-based Theory of the Firm

Application of a resource-based view of the firm requires going beyond what economists typically include in this category: labour, capital and land. A resource is defined as "anything which could be thought of as a strength or weakness of a give firm," and the fundamental question asked by the theory is "under what circumstance will a resource lead to high returns over longer periods of time?" Wernerfelt (1984, p.172).

Products require the use of resources. New products often require new technology. In theory, it is possible to specify a resource profile of a firm and determine the optimal product-market activities. The more diversified the firm is or can become, the more useful such a theory because it is a special case of the traditional theory of factor demand, but in this case, resources such as technological skills do not exhibit traditional properties in models such as declining returns to scale. An example of the theory is the economies of scope concept (Panzar and Willig, 1981; Milgrom and Roberts, 1990).

Taking technology as a special resource category raises several interesting derivative issues for resource-based theories. In particular, which technology should be the basis of diversification? A general proposition of the theory for large firms is that strategy involves "striking a balance between the exploitation of existing resources and the development of new ones," (Wenerfelt, 1984, p.172). This theory can be developed to show when sequential entry into markets (e.g., going international from a position of strength in a product and technological resources) is desirable. This reduces to determining when the first market is large relative to the second, when the second market uses less of the resources, and when the first product uses a lot of the first resources (Wernerfelt, 1984, p. 179).

Challenges remain for resource-based theories. Products are relatively easy to identify as compared to resources, and the theory does note tell us how to combine resources across divisions. Few, if any firms have mastered technology sharing schemes or for the best technology sharing schemes for best technology resource allocation. Further, those that are successful have great difficulty achieving success quickly (Rubenstein, 1989). Most firms evolve strategies over long periods of time like technology centers at Dow Chemical which were first instituted in 1965.

An excellent example of this proposition is given in work by Dierickx and Cool (1989). The authors argue that asset stock accumulation and sustainability are the key to competitive advantage. They cite the case of Canon versus Xerox corporation in the copier business. “Capitalizing on its stock of R&D, Canon was able to 'design service out of the product’ thereby substituting superior product design for Xerox's extensive service network,” Dierickx and Cool (1989, p.1509). With this substitution, Xerox's service network become somewhat obsolete, and customers defected. Xerox responded to this challenge with a new product line of “service free” copiers (Jacobson and Hillkirk, 1986).

Kazanjian and Drazin (1989) tested and generally supported the stage of growth progression model for 71 technology based new ventures in the computer and electronics industry. These firms generally progress from one to another of the four stages (conception and development, commercialization, growth, and stability) of growth in about 18 months. However, there are some noticeable exceptions to this pattern. Some firms regress, some move faster than predicted. This suggests a central tendency rather than a developmental imperative, and stage transition is also likely to be influenced by environment, structure, leadership and strategy. However, their overall discriminate analysis was significant and a total of 64 or 72% of the ventures were classified correctly (91% of stage 1 firms, 72% of stage 2 firms, 67% of stage 3 firms and 69% of stage 4 firms). Further, Robinson, et al. (1992) hypothesized that firms with superior skills and resources pioneer new markets a found support for this comparative advantage thesis for 117 diversified entrants. These results imply that the resource-based theory of the robust enough to apply to rapidly growing and pioneer firms, generally.

Kogut and Zander (1992) suggest that firms learn new skills by recombining their current capabilities, which might explain the transition between stages in the Kazanjian and Drazin (1989) results. Growth occurs, Kogut and Zander (1992) argue, by building on social relationships that exist currently within the firm. This strongly supports the resource-based theory of the firm and suggests that the behavior of organizations is predictable from their past capabilities.

Chen and MacMillian (1992) found that in a situation where the influence of corporate-business relationship on intra-industry competition is low, as in the U.S airline industry which is comprised of single or dominant industry firms, the attackers and responders to competitive moves gain share at the expense of nonresponders. However, the high incidence of nonresponse in their data (only 103 of 856 actions provoked one response) suggests more “serious attention should be paid to the resource-based view of firms...according to which firm attributes, often idiosyncratic and thus nonimitable, may impede competitive responses,” (Chen and MacMillian, 1992, p.568).

Stimulating Idea Generation

The question of whether or not creativity can be stimulated or enhanced is not a new one. But the notion that productive idea generation in organizations can be stimulated systematically, especially with computer-assisted technologies, is a relatively new issue. Both experimental methods and emerging, formal, standardized intervention methodologies have appeared that deserve review.

Massetti (1996) reports on an experiment used to evaluate the performance of two popular creativity support applications, with particular attention to the concept of idea fluency. Idea fluency is the notion in the creativity literature that some people (who are more creative) tend to generate more ideas than other individuals, even though many of these ideas are not ultimately useful. It is as if creative people are more willing to experiment with many more ideas openly before the solution is actually found to solve a problem (Ettlie and O’Keefe, 1982). The two methods compared were both variants on computer-based tools for creativity enhancement: IdeaFisher, which uses a generative focus used to stimulate idea association, and Ideatree, is a software with an exploratory focus, which allows people to polish and embellish or emphasize ideas. Subjects have to be familiar with computer usage, of course, or the methods can actually inhibit creativity.

Judges rated answers (compared against each other rather than by some absolute standard) on a task of solving the problem of homelessness. Highly idea fluent subjects generated significantly more creative ideas than less fluent subjects. Subjects using the computer software outperformed (control) subjects using paper and pencil methods, but the two software methods did not produce different results. However, subjects expressed greater satisfaction with the exploratory (versus generative) software. Fluency did not affect software satisfaction.

Aiken, Sloan, Paolillo, and Motiwalla (1997) did find a difference between two electronic meeting techniques, which favors galley writing over individual poolwriting because of the former’s ability to show all group comments to users for the task of improving a local private school. Aiken and Vanjani (1997) subsequently found that a virtual group outperformed a fact-to-face group using electronic meeting technology, which supports geographically separated but computer linked groups process work. Virtual groups generated significantly more unique, quality comments than face-to-face groups, but the task may not be comparable to an idea generation setting. Sutton and Hargadon (1998) have reported that idea generation and brainstroming studies that find group meetings to be less effective than working alone underestimate the other positive outcomes of group sessions. In a study of a product design firm, the authors found evidence of these other positive organizational outcomes from group brainstroming sessions like enhancing organizational memory, providing skill variety for designers, and supporting an attitude of wisdom (acting with knowledge while doubting what one knows).

The role of leadership in facilitating idea generation has also been investigated. Although leadership seems to have less of an impact on normal group meeting performance (Barkhi, Jacob, Pipino, and Pirkul, 1998), transformational leadership style has been shown in one study to significantly enhance originality in an idea generation task (Sosik, 1997). Transformational leadership was characterized by behaviors such as intellectual stimulation (e.g., questioning assumptions), individualized consideration, inspirational motivation, and idealized influence to consider broader implications of ideas generated.

Idea Generation and New Product Development

In simplest terms, a research, development and engineering organization can be thought of as performing two tasks: project-*originating* and project-*doing* (Rubenstein, 1992). The latter is often taken for granted and is the focus of most activity. The former—the idea generation and development capability--is more mysterious and difficult. A steady stream of high-impact ideas is thought to be a key to the success of any company. If new technology is involved, then ideas that exploit or acquire rare technological resources may mean the difference between success and failure; survival and demise.

Resource-based theory specifically predicts that early mover advantage from new ideas creates difficulty for competitors that have to acquire the same resources—the resource position barrier. Technological leadership via better new ideas is actually the slogan of one company (GE). Therefore, the following proposition is offered for testing.

Hypothesis 1: Successful new products are sourced primarily from a combination of internal (R&D) and external through marketing sources.

In a review of ideation in R&D and entrepreneurship Rubenstein (1992, p. 19) recounts the case of his encounter with a middle manager in a high-tech company during a seminar. The company was highly dependent upon government contracts and lead by a founding CEO who was a dynamic entrepreneurial type and ver receptive to any new ideas from new businesses. The issue involves diversification, as might be expected in an era of the peace dividend, in this case, branching out into the information technology market. The first reaction to such an idea is that it is a "fanciful notion, rather than an idea for technical work or new markets." The notion did not meet the traditional definition of an idea: "a suggestion, recommendation or proposal that includes both a need and technical means of addressing that need," Rubenstein (1992, p. 19). Rubenstein reflects on this incident and says that at the very beginning of the idea generation process, it may not be necessary to have a clear vision of the need and technical means in order to "address a new business or technical idea." The author suggests that the 'idea' for diversification at the early stages of the process has significant implications for skill mix in the firm, suggesting specific technologies needed to enter the field (new to the firm). These technologies may have been sufficient to actually start the company, which grew to its present size because the CEO and founder would give ideas a hearing and support early explorations. Taking this and the R&D manager as the key boundary spanner in R&D (Betz, 1987, pp. 195-197), the following proposition is offered for testing:

Hypothesis 2: Among R&D sources, it is the first-line R&D manager that sources the most successful new products in durable goods.

The rationale for this hypothesis can be explained from one of the most comprehensive, empirical studies completed on idea generation (Souder, 1987). This project compiled life cycle data on 289 new product innovations in 53 companies selected randomly from product, size and R&D structure stratification. Ten industries were represented: metals, glass, transpiration, plastics, machinery, electronics, chemicals, food, aerospace, and pharmaceuticals. A random sample of successful and unsuccessful innovation projects was also accomplished.

Souder (1987, p. 74) found that internally generated ideas lead to more successful outcomes than externally sourced ideas. For example, R&D sourced ideas succeeded 39% of the time, marketing sourced ideas succeeded 64% of the time and management sourced ideas succeeded 51% of the time as measured by whether or not the project met or exceeded commercial expectations. In contrast, supplier sourced ideas succeeded only 31% of the time and customer sourced ideas for this sample of companies and projects succeded only 36% of the time.

Souder (1987, p. 154) also notes that the top-down approach to project management and selection works best when both the technology and markets are well understood. This is consistent with Daft's (1978) dual core model of innovation which suggests that sources of innovations depend on their type—technical innovations are sourced from the technical core of the firm and administrative changes are most often suggested by management. He found that teams and taskforces tend to produce above average results no matter what the conditions for markets and technologies. Especially in the case of new products, where development work is the key issue, this finding is consistent with research results on technical gatekeepers by Allen, et al (1979). They found that the "two-step" flow model of technical information worked best for development projects, and broad-based individual flow between bench scientists worked best for research projects. Service R&D was handled best by management in the Allen, et al (1978) model, consistent with Souder's findings.

Finally, Souder (1987, P. 197) concludes that "the success of new product innovation depends greatly on the collaborative roles played by the R&D and marketing parties, "and on the "flexibility" of these roles as they vary by conditions. Customers still need to provide market information, but these needs have to be embodied in new product ideas—a critical, creative step in the innovation process. Therefore, a balance between the marketing and R&D is essential to new product success. Therefore, the following two propositions are offered for testing:

Hypothesis 3: Successful new products exhibit a pattern of new ideas from the marketing function.

Hypothesis 4: The more R&D intensive the firm, the more likely new product ideas will be sourced from the technical functions.

These two hypotheses, taken together, strongly suggest that balance between the marketing and R&D function at the beginning of the new product development process is very important to promote successful outcomes for new products. The more radical the new technology, the more important this balance is. If either marketing or R&D dominate the new product development process, the probability of a successful commercialization will be degraded in this view.

The Role of Manufacturing in Idea Generation

The traditional role of manufacturing in product development has been secondary. Manufacturing usually has received blueprints in hand-off fashion and then goes to work to fill orders. However, with the advent of concurrent engineering, representatives of manufacturing (usually manufacturing and skilled trades) are placed on teams to help design products and processes together. Many U.S and Canadian, as well as German and Japanese companies have been doing this since the mid-1980's. There is even some emerging empirical evidence, other than case anecdotes, that concurrent engineering really works to improve performance (e.g., Ettlie, 1994). However, what most writers fail to observe is that concurrent engineering teams usually start with general specifications or requirements that are provided by other members of the organization. It is these general requirements that result from the idea generation process—that part of parallel or concurrent engineering that is not concurrent.

What is the role of manufacturing in idea generation? Ettlie and Warner (1992) found that in only 4 (9%) of 43 companies reported any type of early manufacturing involvement in a new product development project. This was involvement in the concept development stage, not in general, as in the mailed survey, and it was found that in 3 of these four cases, early manufacturing involvement usually takes the form managers or engineers that are between job assignments, assigned by corporate directives to idea generation groups. These are not typical teams or well-organized efforts. There seemed to be little concern for manufacturing involvement in new product development before concurrent engineering begins. Therefore, the following hypothesis was offered for testing:

Hypothesis 5: Production acts in a supporting role to marketing and R&D during the idea generation stage of new product development in durable goods.

One has to assume, based on this limited empirical evidence, that the role of manufacturing in idea generation is limited to a supporting role—not part of the central, core development effort at the very early stages. It is likely to be informal and supportive or marketing and R&D

METHODOLOGY

A total of 481 eligible, address-screened cover letters and questionnaires were mailed to firms taken from a Compustat tape in August and again in October, 1992. The cover letter was addressed to the chief technical officer (CTO) or chief executive officer (CEO) of the top R&D performing companies (based on R&D intensity—R&D spent as a percentage of sales) in domestic, durable goods manufacturing. R&D performing firms were sought so as to increase the incidence of new product development activity in the population of firms investigated. The questionnaire was divided into two major subparts—background or general information and then information regarding the introduction of the company's "last major new product."

A total of 126 usable questionnaires were returned, and 50 cases were determined to be ineligible after returned mail could not be delivered or through personnel transfer or turnover determinations after follow-up phone calls. This resulted in a response rate of 29%.

Response Bias

Since the resulting 29% response rate was somewhat below earlier surveys of this type (47% in Ettlie, et al, 1984, and 35% in Ettlie and Warner, 1992), an evaluation of response bias was undertaken. There was no significant difference (other than expected sample--proportionate industry differences) in respondent versus nonrespondent answers in phone callbacks to a random sample of two dozen firms reached for the first five questions on the survey. These five questions covered respondent title, principal products (SIC codes), number of employees, percent shipments out of the country, and outsourcing percentage.

In a test of responses by SIC code (population vs. sample), SIC codes 20-30 were grouped into one category, 31-34 were grouped, 35, 36, and 37 stand alone, and 38-39 were grouped for cell size reasons. The Chi-Square = 2.26 ($p = .77$) which is not significant. The population and sample did not differ in response pattern by SIC. In the test of firm size in the population and the sample (archival data taken from Compact Disclosure), for population as compared with sample on number of employees, $z=0.84$, $p = .19$, n.s., and for firm nonrespondents vs. firm respondents, $z = 0.98$, $p = .16$, n.s. For net sales, population vs. sample, $z = 1.3$, $p = .09$, n.s., and for firm non-respondents vs. firm respondents, $z = 1.08$, $p = .13$, n.s. Finally, for net sales increase (1988 -1992), which is used to validate the dependent variable, for the population versus the sample, $z = 0.59$, $p = .72$, n.s., and for the nonresponding firms vs. responding firms, $z = 0.68$, $p = .75$, n.s. Therefore, we concluded that the sample and population were not significantly different and that no observable response bias was evident in these data.

To further analyze response bias the assumption that late respondents are like nonrespondents (Johnson, Lehmann and Rome, 1990) was employed. The four questionnaires which were returned after the cut-off deadline of February 1, 1993 (which were returned on 2/20/93, 3/16/93, 3/31/93 and 4/26/93) were compared to the total sample ($n = 126$) on the first three quantitative questions used for other call back analysis. The results indicated virtually no difference in average number of employees (14,291 vs. 11,040), exports (39.5% vs. 31.6%) and outsourcing percentages (45.7% vs. 49.3%).

The frequency distribution of respondents by job title was as follows: 1) general managers, 53 (42%); 2) manager or supervisor, 36 (29%); 3) engineer, 4 (3%); 4) staff, 1 (1%); and 5) missing, 32 (25%). Industries represented were as follows: 1) 25% electrical machinery (SIC 36); 2)16% Instruments (SIC 38); 3)16% transportation equipment (SIC 37); 4) 12% machinery (SIC 35). There was no significant difference in the frequency distribution by SIC code in the original list targeted for the survey, and proportion of responses by category.

Industry Distribution by Product

The distribution of industries in the survey by products nominated and ordered by representation was as follows: Electrical Machinery (SIC 36) had 31 cases (24.6%); Instruments (SIC 38) had 20 cases (15.9%); Non-electrical machinery had 15 cases (11.9%); Transportation equipment (SIC 37) had 10 cases (7.9%); Stone, Clay & Glass (SIC 32), Primary Metals (SIC 33), Fabricated Metal (SIC 34), and Misc. Manufacturing (SIC 39), all had 4 cases each (3.2%). The remainder of the sample had two or fewer cases each from the Food (SIC 20), Wood (SIC 24), Furniture (SIC 25), Paper (SIC 26), and Chemical (SIC 28) industries. Industry differences are discussed later (Table 5).

Respondents

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Idea Sources for New Products

The idea-generation instrument used in the questionnaire was adapted by permission from a survey instrument copyrighted by Stephen G. Green and M. Ann Welsh which was previously derived from Baker and Green (1985). This adapted instrument covers the recent products and projects of a firm as to origin (16 possibilities such as R&D staff, Marketing/Sales/Distribution and General Management, etc.), as well as intended user, source of market need information, changes throughout project history, etc. Commercial success and technical success items are also included from this previous survey used in Baker, et al (1985), discussed below. Multiple idea sourcing was possible in this format. Percentage frequency of mention for each source is listed in Table 1. For example, Marketing was mentioned 59 (47%) times, general management was mentioned 31(25%) times, etc.

R&D Intensity

R&D intensity was provided from the information on the sample data tape from Compustat. It is measured as the most recent information available on the percentage of sales spent on R&D.

Technical Success

Among several outcome questions, three items were included near the end of the questionnaire for the purpose of gauging technical success: “Was the new product a technical success? (We define technical success as achievements of technical performance required in the project specification.);” “Was technical success achieved at or very near budgeted cost?” and “Was technical success achieved during the required time period?” The response format for both questions was “Yes (scored 3),” Too soon to tell (scored 2),” “No (scored 1)” and “Don't Know (eliminated as missing).”

Two additional items were included as proxy measures of technical success concerning design change requests and actual design changes before product introduction. The number of requests and actual changes was entered in a space provided (“fill in number”). These items were adapted from Baker, et al (1986) and Ettlie and Rubenstein (1987).

Commercial Success

Commercial success of these new products was measured by responses from items three on the questionnaire. The first item read: “Overall, was the new product a commercial success (met commercial success expectation)?” Respondents answer too soon to tell, ”yes,” “no,” or, “don't know.” The second question read: “Which one of the following statements best describes the return on investment (ROI) for the new product to date (circle only one):” “Below total costs,” “about equal to operating costs,” “about equal to total costs,” “moderately above total costs,” “a good multiple of investment,” and “don’t know.” The third item was: “Was market share attained by the new product above, about the same as or below expectations?” Responses offered for circling were “Market share above expectations (scored 4)”; “Market share about the same as expectations (scored 3)”; “Market share below expectations (scored 2);” “Too soon to tell (scored 1);” and “Don’t know (excluded along with missing data).” These items were adapted from Baker (1986) and Ettlie and Rubenstein (1987). Market success was significantly correlated with market share growth (see Ettlie, 1997).

The distribution of answers for the first question was 72 for “yes” (57%); 39 for “too soon to tell.” (31%) and 9 for “no,” (8.7%) with 4 (3.2%) firms not answering. This distribution is comparable to a review of eight empirical studies of product success by Crawford (1987) which found that a 40% new product failure rate to be typical (much lower than most people generally assume).

If technical success measures (five) and commercial success measures (three) are taken together as indicators of outcomes of new product introduction, the relationships between idea sources and product performance can be evaluated. This is reported next.

RESULTS

The correlation matrix was generated using SPSSx for the sixteen sources of new product ideas and the eight new product performance outcomes (four technical success and three commercial success measures), as well as, R&D intensity is presented in Table 1 below. R&D first-level supervision new product ideas was significantly correlated with commercial success with r=.18 (n=122, p=.002). This result is quite important if one considers that R&D first-line is only mentioned 10 times (8%) in the sample. Nine (90%) of those ideas were commercially successful. Marketing/Distribution/Sales ideas were significantly correlated with market share, with r=.18 (n=97, p=.037), and technical success within budget, r=.15 (n=122, p=.046). Marketing ideas were commercially successful in 39 (66%) of the 59 cases it was mentioned. These preliminary results support all four hypotheses.

[Table 1]

Perhaps even more interesting were the results in this correlation matrix (Table 1) that show the negative impact of some idea sources on new product success. General management idea origin was significantly and inversely associated with return on investment (ROI), with r=-.22 (n=78, p=.023), market share, with r=-.24 (n=97, p=.01), and commercial success, with r=-.20 (n=122, p=.012). Finance and government representatives had a similar negative pattern. Finance and commercial success were inversely related, with r=-.20 (n=122, p-.015). Government idea origin was significantly and directly correlated with actual design change requests (a negative performance outcome), with r=.20 (n=73, p=.043); and inversely correlated with commercial success, with r= -.21 (n=122, p=.0l).

In order to control for intercorrelations between various performance measures and among idea sources, two step-wise regressions were run (mean substitution for missing data). The first regression, taking return on investment (ROI) as dependent, is summarized in Table 2; and a second regression, taking commercial success as dependent, and eliminating predictors entering the first regression, is reported in Table 3. Significant intercorrelations for just the successful idea origins (not shown in Table 1, 2, or 3) were as follows: R&D first-level supervision origin was significantly correlated with R&D staff (r=.25 p<.01); inversely correlated with engineering (r=-.16, p<.05); and inversely correlated with customer origin (r=-.26, p<.0l). Marketing/Distribution/Sales was significantly and directly correlated with production (r=. 17, p<.05) and customer origin (r=.38, p<.01).

[Table 2,3]

In the first regression for ROI (Table 2), four variables enter in this order: market share, commercial success, technical success within budget, and the number of design change requests for the new product before fully released to production (median=5, average=19, sd=32 design change requests). All variables enter in the predicted direction and in total they account for 30% (28% adjusted for degrees of freedom) of the variance in ROI.

In the second regression equation (Table 3), commercial success is taken as dependent and ROI, market share, technical success within budget and design change requests were deleted from the independent variable pool, based on the results of the first regression. Six predictors enter this step-wise regression, accounting for 28% (25% adjusted for degrees of freedom) in commercial success and they enter with signs consistent with the zero-order correlation results (Table 1). In order of entry, these predictors were technical success (b=.542, se=.118); government representative idea origin (b=-.609, se=.308); R&D first-level supervision idea origin (b=.409, se=.187); marketing idea origin (b=.249, se=.102); finance idea origin (b=-.994, se=.431); and general manager idea origin (b=-.257, se=.118).

These regression results support hypothesis three. Successful new products, in durable goods manufacturing are launched by companies that take a balanced, dual-core approach to innovation. For example, R&D first-level supervision and marketing contribute uniquely to explaining the variance in new product commercial success. Further, the administrative core (general managers) as well as finance and government representatives are significantly unsuccessful in sourcing ideas for successful new products. Finally, as would be expected (Souder, 1987), technical success is a necessary but not sufficient condition for commercial success (Tables 2 and 3).

In order to test proposition four further, that R&D intensity and idea sourcing are related based on the dual-core theory of innovation, the correlations for these variables appear in Table 1. R&D intensity is significantly and inversely correlated with general manager idea origin, with r=-.16 (n=120, p=.036) and directly related, significantly, to VP of R&D idea origin, with r=.20 (n=120, p=.015). These results support proposition four, which is an extension of dual-core theory.

The Role of Production

In order to test hypothesis five, that production has an indirect, supporting role in the idea generation process, rather than a direct, and significant role during the early stage of new product development, a correlation matrix of information source mentions was constructed and summarized in Table 5. The statistically significant correlations in this matrix are highlighted in bold entries for clarity. Note that the sources with three or fewer mentions (e.g., production is one of these along with finance) are indicated with a footnote and results involving these data should be interpreted with caution.

[Table 4]

Among the most important patterns in this matrix is the clustering of R&D sources and, separately, the marketing-customer sources (r=.39, p<.01), as would be expected. For example, R&D first-line ideas and R&D staff are significantly intercorrelated (r=.28, p<.05). General manager ideas are significantly correlated with V.P. of R&D sources, technical services and technical consultants--that is, other general manager sources or boundary spanning activity information.

Production sources were significantly correlated with finance and technical colleagues. But production ideas were also significantly with customer ideas (r=.21, p<.05). These results generally support hypothesis production acts only indirectly in the idea generation phase of new product development, similar to the findings of Ettlie and Warner (1992).

This suggests that the production-customer-marketing interface is the key to understanding the role of manufacturing in the early stages of new product development-not the technical (R&D) side of the house. Since the frequency of ideas is so small (only three documented ideas were reported as sourced in production), caution should be exercised in interpreting these results. But this finding is in general agreement with other results reported by Ettlie and Johnson (1994) indicating that the marketing-manufacturing interface requires re-evaluation for clues in continuous improvement and opportunities for competitive advantage development.

Industry Differences

Although this has been a study of idea generation and not the locus of innovation-ideas are always developed before they are introduced commercially--it is useful to show the pattern of idea sourcing by industry and compare these patterns with von Hipple's findings on the sources of innovations (von Hipple, 1988). The idea sources in the current sample (complete data for 99 cases) are presented for the major industry categories in Table 5 below.

[Table 5]

Von Ripple found that 77% of innovations came from users (customers) in the instrument industry. For SIC 38 (instruments), a total of 6 ideas for 20 cases, or 30% of the firms in that industry, were sourced from customers. The single most important source of ideas in instruments, according to respondents in this sample was marketing (8/20 or 40%). Taken together, this would add up to 70%, but there is no assurance that additivity is applicable in this survey.

The finding that marketing, by simple frequency count, is more important than customers for ideas (not innovations, per se) in instruments, is, however, an interesting finding. The effort required to convert ideas from customers into new product is typically considerable. Furthermore, customers are important sources of new product ideas in the machinery (SIC 35, 7/15), electrical equipment (SIC 36, 13/31), and, especially, in transportation equipment (SIC 38, 8/10) and primary metals (SIC 33, 2/4). These findings do not support von Hipple’s theory that the locus of innovation is dependent on the major product-industry grouping. Even more importantly, marketing is an important source of ideas in these industries. In all but one case (SIC 37), marketing exceeds customers as a source of new ideas. Finally, it should be recalled that it is marketing and first-line R&D managers that account for the most successful new product introductions. Customers, like production, appear to play a supporting role in this early stage of the new product development process.

DISCUSSION

The successful generation and flow of new ideas is critical to the innovativeness of any organization. This is quite a distinct issue from the sourcing of market need information--which is generally obtained directly from customers--and the locus of innovation, which is often industry or sector dependent. The source of ideas for new products in the durable goods sector was evaluated using a survey sample of 126 R&D performing firms during 1992-1993. Significantly, it was found that ideas for recent, successful new products tended to be sourced at the first level of R&D supervision and by marketing, distribution or sales which confirms previous research in this area. Ideas originating from general managers, finance, or government representatives were significantly more likely to associated with new products that failed. Management and policy implications of these results are presented.

The management implications of these results are three-fold. First, theory and conventional wisdom and practice which suggests balanced emphasis on marketing and R&D gate keeping approaches to new product introduction is strongly supported by these results. Teamwork and taskforce approaches to new product development are reinforced by these findings. In addition to the R&D-marketing interface issue and the continued empirical support for the marketing-customer relationship, a new emerging theme in the results of this study indicates a marketing-production relationship, which was statistically significant for idea origin. Considerable amount of attention has been lavished on the RD&E-production connection recently (e.g., Wheelwright and Clark, 1992) but we know little about the particulars of the marketing-production connection. Future work on this topic appears to be warranted.

Second, a caution for general managers emerges from these results. Direct involvement in the early stages of new product introduction is not recommended in the durable goods sector. General managers have another important function in the NPD: to establish a clear strategic vision and create a supportive posture for innovation (Siadat, 1996). There are two exceptions to this generalization. Companies founded upon the idea of the first CEO, are typical and are not the same as the continuing, institutionalized innovation process. For example, the idea for a profitable, private sector, small-package overnight delivery service was Mr. Frederick Smith’s notion that started Federal Express (Stasch, Lonsdale, and LaVenka, 1992). More recently, there is evidence that there is another narrow exception to the tendency for general manager ideas for new products to be less successful than other sources. However, this applies <u>only</u> to platform innovations and <u>only</u> to the senior R&D management in the firm, not other general managers (Koen and Kohli, 1998). There is no evidence available to date that contradicts the overall conclusion of the current study that general managers ought to stick to strategic vision and other long-range decision domains like key hires and promotions that affect the new product development process.

The other caution is for the finance function and government outsiders, which should not be encouraged to brainstorm ideas for new products. This is the job, in the typical success case, for R&D and marketing. Finance can make sure the resources are available for innovation and government can set reasonable targets for social welfare, but rarely can these two sources be effective in generating new product ideas to solve problems.

Third, although customers can supply market need information, they are unlikely to be the source of successful new product ideas in durable goods. Emphasis on creative conversion of market needs to product ideas is a core competence worth nurturing in any organization, and this is especially true in the durable goods sector of the economy. Production also plays a supporting role in this early stage of the new product development process. Forcing production too far up stream would be a mistake. Manufacturing can get direct feedback from customers on product performance, which is valuable for the next generation of products and from suppliers of process technology.

There are two important policy issues that surface in these results, as well. First, government representative sources of new product ideas are likely to fail in durable goods. Perhaps the government has other roles in stimulating innovation in durable goods, but new product suggestions is not one of them. Second, much has published lately about alliances and cooperative research and development enabled by federal legislation but there has been little research has been done on idea generation pattern in these alliances. This issue deserves research attention.

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TABLE 1: Correlation Matrix and Descriptive Statistics[@]

		Design Change Requests	Actual Design Changes	ROI	Market Share	Comm. Success	Technical Success On-Time	Technical Success within Budget	Technical Success	R&D Intensity
1.	R&D Staff Idea (24%)	-.19	-.02	.06	-.09	.00	.10	.04	.11	.13
2.	R&D First-Line Idea (8%)	-.14	-.13	.09	.01	.18*	-.02	-.11	-.01	-.08
3.	R&D Middle Management (14%)	-.16	-.00	.11	.04	.04	-.02	.03	.07	.03
4.	VP R&D Idea (20%)	-.12	-.12	-.08	-.14	-.14	.01	.11	-.11	.20*
5.	General Management Idea (25%)	.00	.04	-.22*	-.24**	-.20*	.01	-.01	-.01	-.16*
6.	Market/Distrib./Sales Idea (47%)	.07	.19	.01	.18*	.14	-.05	.15*	-.00	.05
7.	Production Idea (2%)	.04	.09	.07	.03	.04	.11	.12	.06	-.13
8.	Engineering Idea (24%)	-.02	-.04	.02	-.10	.03	.06	.08	.07	.06
9.	Finance Idea (2%)	.04	.07	-.01	-.16	.20*	.09	.10	.06	.30**
10.	Tech Services Idea (1%)	-.06	-.05	.07	-.03	.07	-.14	-.14	.04	.07
11.	Customer Idea (24%)	.02	.10	.12	.07	-.04	-.07	.05	.09	.13
12.	Government Rep. Idea (3%)	.09	.20*	-.07	-.15	-.21**	.13	.03	.08	.17**
13.	Supplier Idea (2%)	.12	.02	-.01	-.16	-.12	.06	.06	-.05	.30**
14.	Univ. Consult. Idea (2%)	.12	.01	.03	-.06	-.12	-.00	.12	.07	-.02
15.	Industry Consult. (2%)	.12	.02	-.13	-.06	-.14	.08	-.02	-.03	.02
16.	Tech. Colleague (2%)	-.08	-.05	-.09	-.05	-.10	.09	.09	.06	.29**
	Mean	19.3	10.9	4.88	2.3	1.5	1.69	1.70	1.19	6.8%
	s.d.	31.9	23.4	1.56	1.15	0.66	0.95	0.92	0.43	6.7%
	(Median)	(5.0)	(2.0)	(5.0)	(2.0)	(1.0)	(1.0)	(1.0)	(1.0)	(4.65%)

[@](frequency % in parentheses)
**p<.01
*p<.05

TABLE 2: Regression Summary: ROI Dependent (n=126)*

Variable Entered		b	se	Beta	t	p
1.	MarketShare	.615	.180	.300	3.41	.0009
2.	Commercial Success	.427	.154	.245	2.77	.0065
3.	Tech. SuccIBudget	.231	.099	.177	2.32	.0223
4.	Design Change Req.	-.008	.004	-.175	-2.30	.0232
5.	(Constant)	1.296	.459		2.82	.0056

*R-square=.2997. R-square adjusted for degrees of freedom=.27655, F=12.95 (p<.001).
Mean substitution for missing data used.

Table 3: Regression Summary: Commercial Success Dependent (n=126)*

Variable Entered		b	se	Beta	t	p
1.	Technical Success	.524	.118	.357	4.58	.0000
2.	Gov. Representative Idea	-.609	.308	-.165	-1.97	.0502
3.	R&D First-Line Idea	.409	.187	.172	2.19	.0307
4.	Market/Dist./Sales Idea	.249	.102	.192	2.45	.0159
5.	Finance Idea	-.994	.431	-.192	-2.30	.0230
6.	General Manager Idea	-.257	.118	-.171	-2.17	.0320
7.	(Constant)	.922	.342		2.29	.0081

*R-square=.2832. R-square adjusted for degrees of freedom=.24702, F=7.83 (p<.001).
Mean substitution for missing data used.

TABLE 4: INTERCORRELATIONS OF IDEA SOURCES (N=99)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.	R&D Staff Idea	1.0															
2.	R&D First -Line Idea	**.28***	1.0														
3.	R&D Middle Mgmt.	.09	.14	1.0													
4.	V.P. R&D Idea	**.28***	.10	**.24***	1.0												
5.	General Manager Idea	.14	-.11	.03	**.30****	1.0											
6.	Marketing/Sales	-.05	-.11	-.05	-.07	.02	1.0										
7.	Production Idea@	.18	-.06	.09	.07	.04	.19	1.0									
8.	Engineeing Idea	-.05	-.19	-.04	.04	.02	.09	.18	1.0								
9.	Finance Idea@	.09	-.05	-.06	.12	-.08	.15	**.39****	**.25***	1.0							
10.	Tech Services Idea@	.18	-.03	**.24***	**.21***	.18	-.09	-.02	-.06	-.01	1.0						
11.	Customer Idea	.06	**-.28****	-.06	-.12	-.11	**.39****	**.21***	**.25***	.17	-.08	1.0					
12.	Government Idea@	.04	-.06	-.07	.07	.04	.07	-.03	.04	**.39****	-.02	.09	1.0				
13.	Supplier Idea@	.09	-.05	-.06	.12	-.08	.01	-.03	.09	**.49****	-.01	.03	**.39****	1.0			
14.	Univeraity Idea@	.09	.05	.14	.12	.09	.01	-.03	-.08	-.02	-.01	.17	-.03	-.02	1.0		
15.	IndustryConsultant	.09	-.05	-.06	-.07	.09	-.13	-.03	-.08	-.02	-.01	.03	-.03	-.02	-.02	1.0	
16.	Tech. Colleague@	**.25***	-.05	.14	**.30****	.09	.15	**.39****	**.25***	**.49****	-.01	.17	**.39****	**.49****	-.02	-.02	1.0

**p<.01 (Pearson r, two-tailed test, n=99)
* p<.05 (Pearson r, two-tailed test, n=99)

@ Note that three or fewer ideas were mentioned for this source.

TABLE 5: INDUSTRY DIFFERENCES AND IDEA SOURCES@

	IDEA SOURCE															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Industry (SIC)	R&D Staff	R&D 1st Line	R&D Mgr.	R&D V.P.	Gen. Mgr.	Mkt. Sales	Production	Engr.	Finance	Tech Serv.	Customer	Gov.	Supplier	Univ.	Consultant	Tech Colleague
Stone, Clay(32)	3/4	2/4	0/4	0/4	0/4	1/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4
Primary Metals (33)	1/4	0/4	1/4	0/4	0/4	3/4	1/4	0/4	0/4	0/4	2/4	0/4	0/4	0/4	0/4	0/4
Fab. Metal (34)	0/4	2/4	1/4	0/4	0/4	1/4	0/4	1/4	0/4	0/4	1/4	0/4	0/4	0/4	0/4	0/4
Machinery (35)	2/15	1/15	1/15	2/15	2/15	8/15	1/15	4/15	1/15	0/15	7/15	0/15	1/15	0/15	0/15	0/15
Elec. Equip.(36)	10/21	3/31	4/31	10/31	8/31	14/31	0/31	10/31	1/31	0/31	13/31	1/31	1/31	2/31	0/31	1/31
Trans. Equip. (37)	2/10	0/10	1/10	0/10	3/10	5/10	0/10	4/10	0/10	0/10	8/10	2/10	0/10	0/10	0/10	0/10
Instruments (38)	3/20	1/20	5/20	3/20	7/20	8/20	0/20	4/20	0/20	1/20	6/20	0/20	0/20	0/20	2/20	0/20
Misc. Mfg. (39)	1/4	0/4	1/4	1/4	1/4	2/4	1/4	1/1	0/4	0/4	1/4	0/4	0/4	0/4	0/4	1/4
TOTALS:	22/99	9/99	14/99	16/99	21/99	42/99	3/99	24/99	2/99	1/99	38/99	3/99	2/99	2/99	2/99	2/99

@ Each entry indicates the frequency that an information source was mentioned for a new product by industry category. SIC 20-28 deleted because of small sample size (less than 5 cases)