

Measuring International Product Development Performance

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Abstract

New product development (NPD) has become critical to the growth and future prosperity of organisations. Managing an international product development environment is very demanding, as it requires managing the physical separation of marketing, design and manufacture, meeting constrained cost targets, achieving compressed time to market and dealing with increasing complexity in order to be effective. A major challenge is measuring and comparing product development projects. In recent years, interest has increased among practitioners and researchers to develop balanced performance measurement systems that incorporate both financial and non-financial measures. In this paper we compare and contrast the findings from a study on performance measurement for NPD carried out in 1996, with results from a further study carried out in 2001. We then present a refined performance measurement model for NPD and conclude by noting lessons learned and suggesting future directions for both research and practical applications in the international context.

Keywords

International performance measurement, NPD measurement and management.

Introduction

A considerable number of studies have been carried out in order to understand the determinants of new product success and failure. New product development (NPD) and the rate of NPD are considered a crucial factor in a company's success (Sethi *et al.*, 2001). At the same time, the home-based resources that have long enabled organisations to compete effectively in international markets (Dunning, 1980) are no longer adequate to ensure competitiveness of companies. Competition is now global, so companies harness knowledge from sources in multiple countries in order to generate new products, as well as to build operational know-how and technological strength (Subramaniam and Venkatraman, 2001). This involves quickly and accurately identifying changing customer needs; developing more complex products to satisfy those needs worldwide; and providing better customer service, while also utilising the power of technology in managing performance and reliability (Cooper and Kleinschmidt, 1995). NPD has thus become critical to the growth and prosperity of international firms.

Success also depends on the ability to translate objectives into a winning formula. Performance measures are used to help organisations achieve this by ensuring thorough evaluation, control and improvement of operations. Both academics and practitioners agree that reliance on traditional financial measures of performance is inadequate for today's operating environment.

Accordingly, the purpose of this research was to monitor the evolution of performance measures that assist with NPD. An initial study was carried out in 1996, with a further study being carried out in 2001 to revisit the performance measures and their evolution during the five years. Our results show that although measures for product design and development have been neglected in the past, organisations are now turning towards them to gain a competitive edge. We feel that our resulting framework for measuring NPD performance - developed by drawing on results of this investigation - makes a positive contribution to this important but under-researched area. Finally, in our conclusions, we look to the future and discuss the pivotal issue of how measures are collected and used.

Context of performance measurement for NPD

Traditional measures

As well-documented in previous studies (Driva *et al.*, 1999; White 1996), measures used to evaluate a company's performance have traditionally been largely financial, based on management accounting systems. These traditional measures have stood the test of time because they are easily understood, familiar to senior management and can be easily obtained (McKenzie and Shilling, 1998). Financial measures also have the advantage of being 'precise and objective' (Parker, 2000).

As 50% of new products that are introduced each year fail (Sivadas and Dwyer, 2000), significant arguments against traditional measures of performance have widely been reported (Dixon *et al.*, 1990; Waggoner *et al.*, 1996; White, 1996). They are often based on outdated cost management systems with 'lagging' metrics, not related to corporate strategy and contradictory to continuous improvement (Ghalayini *et al.*, 1996). According to Neely (1999), these measures encourage short-termism and local optimisation, while failing to

provide data on customer needs, responsiveness and competitors in global markets. Traditional measures are also criticised for being intended for middle and senior management and mainly used for monitoring performance rather than improving it (Lynch and Cross, 1991).

Various authors, most notably Kaplan and Norton (1996) have argued that a modern organisation must adopt a balanced set of performance measures. This has become increasingly important, due to the growing relevance to international markets in NPD. This so-called Balanced Business Scorecard approach has now been widely adopted.

NPD performance

These days most products are developed for international markets, meaning that they can be sold simultaneously in multiple markets. These products thus contain both features that are standardized across markets and those that are responsive to individual local markets (Subramaniam and Venkatraman, 2001; Bartlett and Ghoshal, 1989; Cateora and Ghauri, 2000). As explained by Wong (2002), in addition to local customisation, timely rollout of international product development projects is also a key issue for consideration. Simply stated, delays in project completion, lead to commercialisation delays, thus jeopardising product launch success.

Measuring NPD performance is not easy. Research & Development, which is central to NPD success, can be difficult to assess financially, as projects tend to be long term and there is generally a time lag in realising benefits (Hart, 1996). Additionally, identifying individual member's contributions to NPD team and local and international subcontractors' contribution to financial outcomes is very awkward. These reasons partly explain why it is important to gauge NPD performance using a combination of financial and non-financial measures. To further complicate matters, NPD performance should be measured at two levels; the individual project level and the corporate program (i.e. macro) level (Cooper and Kleinschmidt, 1995).

Griffin and Page (1996) also recognised the need to measure NPD at both project and corporate/program levels. Their approach is different in that they consider that the most appropriate set of measures for assessing project and corporate success depends on the project strategy and the company's business strategy. They assert that different business strategies require different measures of overall NPD performance. For example, a company that values being first to market must measure success differently to a company that focuses on maintaining a secure market niche.

Driva *et al.* (1999) found that visibility of data is a problem in companies that currently monitor performance measurement. Data for measures often exists in one form or another but is not always extracted by those who could benefit from the information. Here, a 'Performance Measurement for Product Development Methodology' was formulated to assist in selecting and implementing NPD performance measures. This consists of a six-step implementation framework and accompanying practical workbook.

Formulation of a comprehensive set of measures that would be applicable to all manufacturing organisations or even to all firms in one sector is unrealistic, if not impossible. Mahajan and Wind (1992) stated that 'shortcomings of measurement approaches are centred around the fact that they are time-consuming' and in any case still fail to capture all factors. This may be true but it is important to remember that time and effort is required to initiate

and manage any change. However, designing a tool that aims to ‘capture all factors’ - in all situations, domestic as well as international - is rather ambitious given the vast range of requirements of modern organisations.

In summary, measures used in many of today’s organisations are often lagging indicators, only concerned with revising the outcome of the individual project and integrated NPD effort, rather than providing guidance on what needs to be consistently measured to ensure they are successful. There is no one set of measures that will remain definitive over time. Performance measures, just like the organisation itself, should be flexible to change. A more rounded evaluation of NPD projects requires operational measures that dynamically track progress and performance (leading metrics), preferably on a real-time basis, indicating appropriate course of action to ensure that the outcome is successful.

Research approach

A questionnaire-based survey was conducted in 1996 to assess the breadth of use in companies of NPD performance measures for product development and to identify prevailing practices. Great care was taken to select participants from a variety of sources in order to ensure a mixture of responses. Relevant manufacturing organisations were chosen from membership of professional intuitions, respondents to previous surveys carried out by our academic department and the FAME (Financial Analysis Made Easy) database. All those selected had Standard Industrial Classification (SIC) codes prefixed by 3 i.e. engineering. Only those companies carrying out their own design and development were considered (where type of business was obvious). Respondents were from manufacturing organisations based in Europe, USA and Japan.

The first stage of the research was to review the existing body of work i.e. literature, methodologies and tools available. This verified that the area had been under-researched and highlighted where there was a need for further work. It also contributed to the design of the postal questionnaire. A combination of qualitative and quantitative methods (questionnaires, case studies and interviews) were required to allow for large scale and in-depth information to be collected.

Questionnaires

The questionnaires sought to determine the need for performance measurement during NPD and reveal which measures are currently used, which are needed and where improvements can be made. There were two sections; general and product development information (including company size, activities, organisation, communication and teamwork) and performance measures (including types of measures, frequency and management). Firstly, factual questions were presented, moving on later to opinions and values. Hence, a combination of open and closed questions was used. The closed quantitative questions requested either ticks in boxes (multiple choice) or a rating of factors. Where respondents were asked to rate factors, 5 point Likert scales were used (Kidder and Judd, 1986). In order to capture more qualitative responses that did not fit into the pre-defined options, free space was provided at the end of every question for comments. The final question also provided an opportunity to voice any additional issues that had not been covered, through an open-ended

comments section. Respondents were encouraged to be as honest as possible - aided by the option to remain anonymous.

A follow up questionnaire was then carried out with a similar (but not identical) group of companies in 2001 and the results were compared and contrasted to identify any gaps, overlaps and changes. Data collected for both questionnaires was largely categorical (i.e. non-parametric nominal data) and analysis was carried out using SPSS.

In the 1996 study, follow up interviews and case studies allowed for greater exploration of the issues. The research process was then rounded off by encapsulating the themes brought out by the data analysis into a model. Hence, the results from the second questionnaire were used to refine the original model to assist firms in selecting performance measures for international product design and development.

In 1996, questionnaires were sent to 580 manufacturing companies both in the UK and internationally. Of the 137 useable responses, most were either departmental managers / project managers (65%) or managing / technical directors (32%). Over 80% of respondents indicated that their organisation would benefit from increased use of performance measures during design and development, with only 21% believing that all the performance measures used in their company were understood. Over 60% of respondents designed and developed products on the same site as manufacturing. The fact that nearly 40% have split the two reflects a growing trend in the globalisation of companies. Only 3% of respondents were very satisfied that there were enough measures currently monitored in their organisation. More significantly, 50% were not satisfied. Clearly, measurement had not reached saturation point in the vast majority of the companies, as 85% believed that no unnecessary measures were made. So how had things changed in the five years since this survey?

In 2001, questionnaires were sent to 300 manufacturing companies. Of the 75 respondents, 20 had more than five years experience with performance measures, which adds value to the quality of the information obtained. The main reasons for introducing measures were; to monitor performance (95%), to identify areas that need attention (83%) and, to strengthen accountability (61%). Reasons mentioned for not introducing measures were; lack of resources/expertise (29%), 'lack of fit' with company culture (22%) and lack of appropriate systems (17%). Encouragingly, 96% intend to continue developing and using performance measures (respondent bias should be noted). Major benefits were identified as determining cost/performance relationships (65%), meeting targets (65%), enhanced understanding of the business (61%), and achievement of better customer service (55%). Respondent profiles from both surveys are shown in Table I.

(Take in Table I)

Findings

In both surveys, respondents indicated which performance measures they currently use. Measures were ranked according to popularity, with 1 being used by most companies. This is shown in Table 2. These results are interesting because there has been quite a shift in the top ten positions over the five-year period. There are some similarities, with project costs (total cost and actual against budget) and on-time delivery remaining high-ranking measures. However, there are also some striking differences. Customer service did not appear in the 1996 measures but is now seen as a primary issue for product development, with both number of customer complaints and customer satisfaction rating being top ten issues. This reflects the

increasing power of the customer in most marketplaces, with more sales channels being opened up (e.g. Internet buying). Perhaps surprisingly, given the increased time pressures for most product launches, lead time to market has slipped down the ranking, as has supplier lead times/delays.

(Take in Table II)

In 1996, respondents were also asked to indicate which measures they would like to use in the future. The top responses were number and nature of bottlenecks (24%), number of design changes to specification (23%), number of design defects detected at development stages (22%), percentage of project time spent in meetings (20%) and development costs of products that don't get to market (18%). It is interesting to note that all five of these are 'negative' performance measures, rather than those focusing on achievements and successes. Of these, only a variation of design defects (scrap level) appears in the 2001 top ten. This may be due to the fact that the others are not straightforward quantitative measures, or perhaps that implementing an accurate and repeatable measurement system is difficult.

A comparison of who introduced performance measures – shown in Figure 1 - indicates that while it is still largely a top management initiative, there has been a shift towards the operational end of the organisation i.e. those that implement them. In 1996, top management (MD plus corporate directives) accounted for over 60% of introductions of performance measurement systems in companies.

(Take in Figure 1)

Encouragingly, in 2001, once the measurement system had been introduced, 50% of respondents used teams to develop and manage it. Teams typically consisted of; senior managers (50%), lower level personnel (26%), and product specialists (18%). Consultants, customers and shareholders were also involved but to a lesser degree.

In terms of how measures are reported and communicated throughout the organisation, team meetings and reports remain the most popular methods. However, as one would expect, there was a huge increase in email reporting from a relatively low 16% in 1996 to 52% in 2001.

In 2001, the main shortcomings of performance measures were that they are overly focused on the past (30%) i.e. lagging metrics. This finding, coupled with the feeling of too much emphasis on financial issues (26%), indicates that companies are still basing their measurement systems on accounting-based measures of performance. As companies struggle with problems such as the overload of information (26%) and recording of erroneous/imprecise results (24%), it appears that they have not yet managed to specify appropriate metrics. One issue is the difficulty in altering metrics to reflect business changes.

The studies provided an interesting comparison of company measurement practices and increased our understanding of how performance measurement has developed in the intervening period. Overall, the two groups did not differ substantially in the types of measures currently being used. The findings of 2001 agree with the 1996 survey, where identification and interpretation of customer needs and customer satisfaction were placed as two of the most important measurement factors that they would like to capture. In 2001, this was starting to happen. In addition, firms would like to use measures to better understand the business. Overall, it appears that there is still some way to go before NPD measurement systems are felt to be accurate and responsive to business needs. It is believed that the lack of

measures that assist with NPD adversely affects the company performance and hence future success.

A refined performance measurement model for product development

Further to the findings above and drawing on existing research and lessons learned, we propose a generic four-step model for measuring NPD performance. The model – shown in Figure 2 - addresses the managerial process and the organisational mechanisms through which NPD is performed. The rationale underlying this model is that NPD output performance is a direct driver of business success. Similarly, NPD output performance is driven by NPD *process* performance - that is the operational management of development projects. The model identifies three core processes; product development, process innovation, and planning. The enabling processes (deployment of human and financial resources, effective use of systems and tools, cross-functional integration, and top management leadership and commitment) feed into and support NPD process performance.

(Take in Figure 2)

The outcome from these core and enabling processes is performance at the project level and the resulting competitiveness in the market. It is important to understand that process performance is a key driver of output performance, but not directly of business success. NPD processes determine at which cost, speed and quality levels new products can be introduced. However, the way products are priced, marketed and sold internationally will determine business growth, profits and hence success. (Loch *et al.*, 1996).

Each dimension of the model is explained below and key measures identified.

Enablers

International resourcing - concerns the mechanisms and organisational processes for recruiting, developing, evaluating and rewarding human resources required, along with funding of NPD / R&D projects. It is widely accepted that human resources are becoming increasingly international and represent the most important aspect for successful management of NPD. Funding requires 'stability' (to prevent the plug being pulled part way through), along with flexibility - so that short-term opportunities can be employed (Chiesa *et al.*, 1996). This is reflected in the increase of human resources management outsourcing using sub-contractors.

Systems and tools - to support the NPD process. There is now a wide range available including simulations, CAD, Quality Function Deployment (QFD), Failure Mode Effect Analysis (FMEA), Design for 'x' (Dfx) and rapid prototyping. Appropriateness and complexity required largely depends on circumstances.

Global integration - reflects the early involvement of all stakeholders; suppliers, distributors and business units from other countries in the group, and the use of appropriate integration 'mechanisms'. The most widely used mechanisms for facilitating two-way communication between team members include; meetings, reporting (often through electronic communication networks) and sharing of common technology systems (Ghuri, 1999).

Management commitment - has long been recognised as a vital success enabler. Top management needs to set goals and direction for NPD, champion the corporate effort to

achieve best practice for each core process and set ‘stretch goals’. Central to this commitment is the creation of a culture and climate that encourages concurrency of the NPD activities. This is difficult to quantify objectively but some suggested measures are listed in Table III.

(Take in Table III)

Core Processes

Here we assess the quality of management of the core processes of product development, innovation and project management, focussing on the NPD project level. Suggested measures are listed in Table IV.

Product development - has been defined as the process whereby new product concepts are taken through the phases of development, prototyping, testing and manufacturing, to successful launch and support of the product. It is suggested that measurement of product development should focus on the appropriateness of activities and tasks involved in the contributing processes of concept generation, design performance and product performance at international level. Several distinct categories can be identified within each performance dimension. For example, the manufacturability, testability and ergonomics of a product can gauge design performance. Similarly, product performance can be measured on key criteria such as cost, functional performance and responsiveness to international markets.

Innovation - A major success factor for ongoing NPD is the continual evaluation of new products and new processes to produce them. Product designs, development processes, requirements, systems and tools need to be employed and continuously improved as part of an organisation-wide innovation strategy. Measurement of performance across the innovation process addresses the appropriate application of existing technologies, tools and techniques for developing improved products and production methods. It also addresses the selection and acquisition of technologies, as well as the exploitation of technical knowledge worldwide to better match manufacturing capabilities with market needs.

Project management – is an integral part of all NPD projects, as they invariably require cross-functional and international groups to work together. Effective management of project resources is thus an important element for success. There are many project management tools available to monitor and predict project outcomes (e.g. Gantt charts, network diagrams, etc.). However, the degree of utilisation and effectiveness of such tools is largely company-specific, as well as project-specific. Measurement in this area allows us to address the appropriateness of the planning, directing, and control mechanisms of both human and technical resources, for achieving specific objectives of development projects. Projects need also to be marketed within and outside the company (Cova *et al.*, 2002).

(Take in Table IV)

Project output

Measurement of project output performance is required, not only for assessing the contribution of individual NPD projects at a company level, but also the efficiency with which the new product has been developed. We have adopted a generic approach to measuring NPD project outcome performance by proposing measures that address dimensions of customer, financial and technical performance as shown in Table V.

(Take in Table V)

Firm success

Although measurement at the project level yields great insights and lessons for NPD output success, it is also necessary to move assessment to the ‘macro’ firm level to obtain an overview of activities. Project level success alone, does not after all guarantee to increase the company’s competitiveness. As stated by Cooper and Kleinschmidt (1995) ‘process performance can be high but if the wrong output performance dimensions are emphasised, business success will remain poor’. Suggested company-level measures are shown in Table VI, with the unit of analysis being firm performance, which aggregates individual NPD project performance results.

(Take in Table VI)

We believe that this model, based on earlier studies and the results of this research, offers a well-rounded approach to determining NPD program performance dimensions. The model distinguishes between measures that gauge NPD *project* performance and those that are primarily used for assessing the NPD *program* performance. While we have not yet fully tested the model’s validity, we suggest that it could be used as the basis for developing an NPD best practice audit. This could be used as a framework to benchmark against competitors, other business units or industry best practice.

Implementation (of the model)

Having established important dimensions for evaluating product development performance and proposed relevant measures for doing so, the next step is to propose how a company can implement this. We believe that previous work in this area (Pawar and Driva, 1999 and Driva *et al.*, 2000) provides a solid framework for implementing a performance measurement system for NPD.

This Performance Measurement for Product Development (PMPD) implementation framework focuses on product development activities and describes the major steps that an internationally-active company needs to follow when introducing and managing a performance measurement system. Implementation is achieved through appointing a ‘task force’ (comprised of a cross-functional group closely involved with product design and development) and following the six stages of the framework, from need evaluation through to monitoring and refinement. The strength of this framework lies in the proposal that it should not be treated as a blueprint, but rather as a basic template upon which to build. Various tools, techniques and checklists are also included from which to select and adapt to suit the company-specific situation.

Discussion

Organising for international NPD is now recognised as a largely non-standard, complex and demanding activity, with a clearly-focussed business strategy being placed at the core of a best-practice system implementation. Increasingly, performance measurement is viewed by

management as an integral part of the NPD process, rather than as an 'add-on'. High performing companies know the importance of measures in defining goals and expectations of NPD projects but successfully promoting NPD performance measures in today's globalized company remains a challenge for many organisations.

As we have seen, while top managers' needs are important, they should not be the sole focus in the design of a measurement system. Buy-in, dissemination and implementation across all levels of the organisation – including customers and suppliers internationally - are also required in order to ensure success. Measures directly relevant to operations must be accepted and widely used at the operating level and in this case, the NPD team level. To achieve this, the NPD measurement system must be designed by everyone affected, particularly those that carry out the operations, report the data and act on the results. Our results indicate that in the five years since the first survey was carried out, opinion has shifted towards this way of thinking.

Effective communication is of vital importance when monitoring NPD performance at the global level and one approach is to have an 'information broker'. This individual can document the use of performance measures, collate and report results to managers, and provide feedback to team members. In this way, commitment to the system is strengthened.

Frequency of reporting results is an issue that affects motivation and success of measurement systems. This is very much a company-specific issue but in general, too much reporting is time consuming and a distraction to the team, while too little can make the results irrelevant and/or the measurement is a waste of time (Pawar and Driva, 1999).

Given the number of critical dimensions that make up NPD performance, a balanced combination of quantitative and qualitative measures is required when assessing NPD projects and programs. Additionally, a balanced system should incorporate both measures that record negative aspects and success measures. So-called 'compound measures' comprising several criteria should be avoided as they can hide underlying trends and lead to the wrong conclusions.

When approaching an overhaul of a firm's performance measurement system, or when introducing measures for the first time, it is important to 'chunk' the implementation into manageable phases. Measures cannot be introduced overnight, and a successful system cannot simply be a replica of another organisation's performance measurement system. It is much better to concentrate on the core processes first, as these will provide the most tangible results (e.g. achievement of milestones, production costs as a percentage of turnover). Once this is underway, expand to include the enablers, output criteria and finally overall firm-level success criteria. Designers and users of performance measurement systems must appreciate that there are limitations to even the best-designed system and that results must not be blindly followed without caution (Pawar and Driva, 1999).

Finally, it is important to emphasise the role of refinement of project planning, reviewing and reporting. As far as possible, performance data collection, data management and analytical reporting should be built into the information systems of NPD projects and managed by the team members. Project review procedures should be developed to document and discuss results, assess progress towards targets, determine (any necessary) management action to be taken and implement continuous improvement.

Conclusions

This paper builds on previous work of measuring performance to assist with NPD. Results from a study carried out in 1996 were compared with those from a recent study. An operational generic four-step model was then proposed to address the managerial processes and the organisational mechanisms through which NPD is performed. This model suggests an 'enablers-process-output-success' chain for assessing NPD performance. An implementation methodology was also proposed and ways to promote performance measurement in NPD were described.

We found that although the majority of the surveyed companies do now incorporate performance measures in their operations, measurement of NPD is still 'uneven'. Awareness of measurement is higher today than in 1996 but successful implementation remains a thorny issue. This indicates that unless product development performance moves up the corporate training agenda and an international dimension is brought into NPD development, inconsistency of measurement will remain an issue for future generations of projects.

Managerial implications

We found that although the majority of the surveyed international companies do now incorporate performance measures in their operations, measurement of NPD is still 'uneven'. Awareness of measurement is higher today than in 1996 but successful implementation remains a thorny issue. This indicates that unless product development performance moves up the corporate training agenda, inconsistency of measurement will remain an issue for future generations of projects.

With such a close link between NPD performance and a firm's overall success in international markets, managers need to do more than simply assess the contribution of product development to the company's domestic or unit level business performance. This means that transparency of measures at the individual project level must be high. Support and training must be given to ensure that they are well-managed throughout the firm and stay on track.

Technology is developing rapidly and this is starting to change the way that performance measures can be recorded. Mobile devices such as pocket pcs and mobile phones mean that measurement at source is now possible; i.e. the input of values as they are happening. Pocket PCs have received an enthusiastic response from the market, since their launch in early 2001. IDC, the market research group, has forecast that the market in the UK alone will double to 30m units sold by 2004 from 13.5m in 2001 (Financial Times, 2001). Add to this the worldwide proliferation of accurate bar code scanner data - allowing feedback tracking along the supply chain - and one can see that measuring NPD projects on a global scale is now a reality. However, what remains to be seen is whether the all-important associated management issues are also being tackled.

We envisage that the emergence of these devices will extend the use and usability of measurement systems beyond the usual constraints associated with the PC, so that measurement 'at source', with a much reduced risk of transcription errors, will become standard practice. Most importantly, this much shorter feedback cycle from recording to collation and reporting, allows for actions to be effective that can influence current rather

than just future projects. This new technology could, at last, mean the end of backward looking, purely domestic lagging metrics and the adoption of more valuable, real-time international performance measurement systems.

Future directions

We intend to follow up the study again in the near future. This time, we will overcome the limitations listed above by sampling much wider, with a more international scope. Since the first study was carried out, there is more interest in measuring NPD performance. However, the actual methods of recording and, most importantly, interpreting measures are still under-researched. We believe that in order to make a performance measurement system more accepted as part of the company culture, this now needs to be tackled.

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Tables and Figures

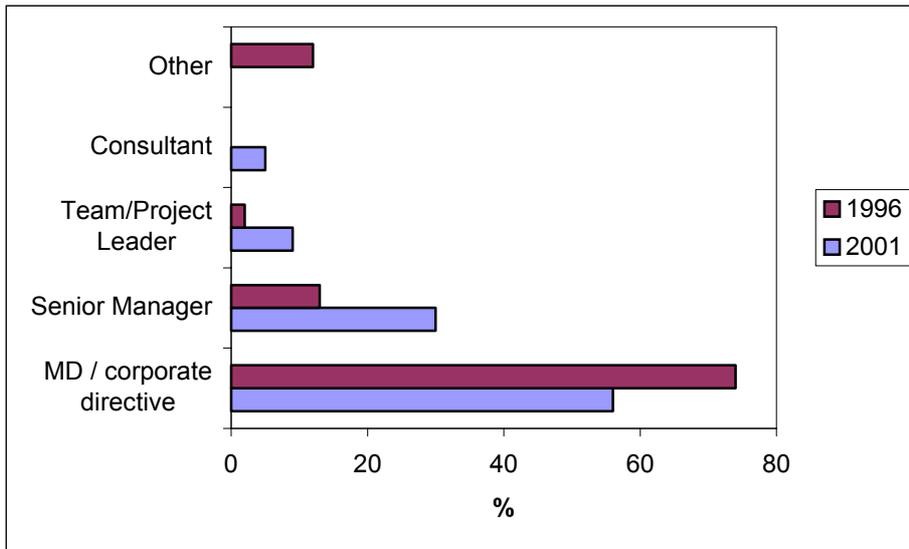


Figure 1: Who introduced measures

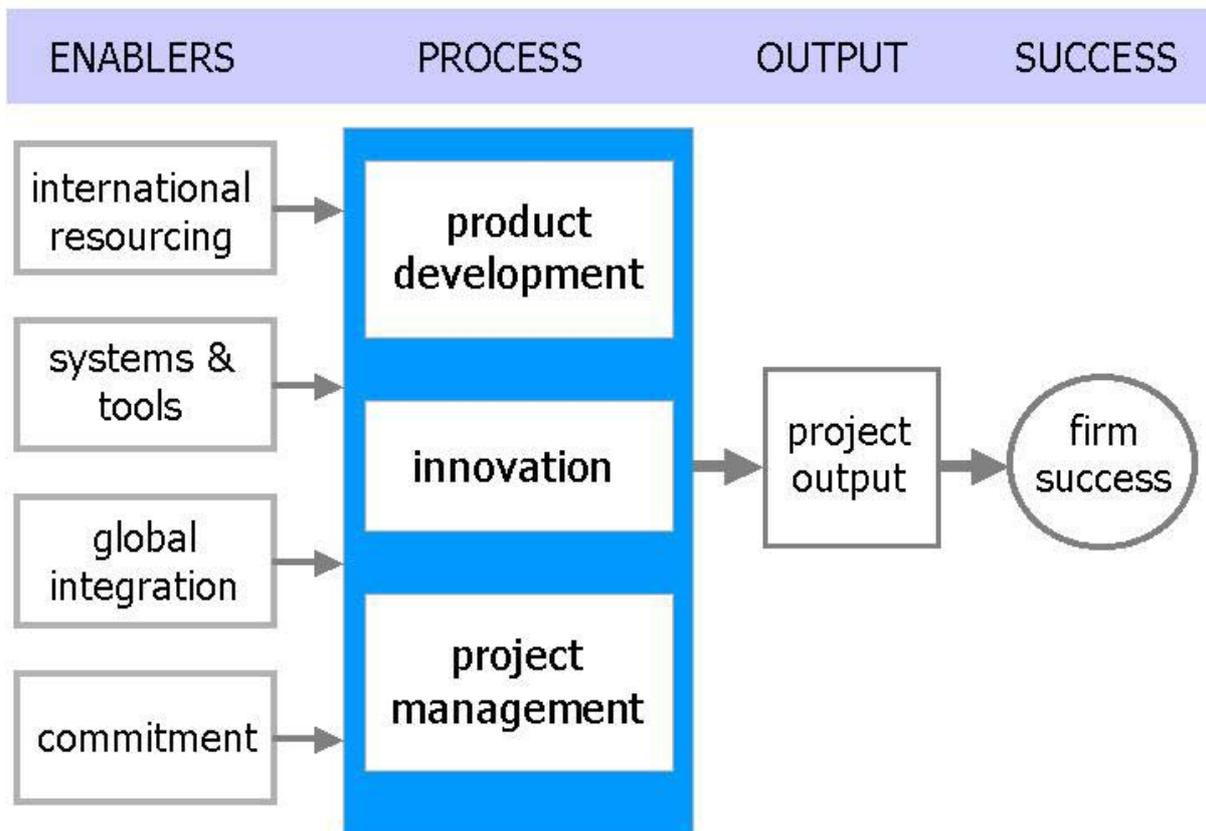


Figure 2: The performance measurement model for NPD

	Survey Date	
	1996	2001
Sample size (response rate)	580 (24%)	300 (25%)
Number of usable responses	137	75
Number of employees	<300 % >300 %	<300 80% >300 20%
Company sectors	54% manufacturing/mechanical 19% electrical/electronic (others; defence 8%, rubber/plastics 8% and textiles 5%)	57% manufacturing/mechanical 47% electrical/electronic (others; miscellaneous)
Production process*	41% batch 22% project /one of a kind 37% mass / continuous	67% batch 52% project /one of a kind 30% mass / continuous

* *Please Note:* respondents were asked to tick as many as appropriate

Table I: Respondent profile

Performance measure	1996	2001
Total cost of project	1	9
On-time delivery of project/product	2	1
Actual project cost against budget	3	3
Actual vs. target time for project completion	4	10
Lead time to market	5	12
Field trials prior to production	6	-
Projected profitability analysis	7	-
Product failure rates	8	7
Supplier lead times/delays	9	-
Reasons for failures on the market	10	-
Level/Number of customer complaints	-	2
Customer satisfaction rating	-	4
Scrap level	-	5
Labour productivity	-	6
Utilisation of resources	-	8

Table II: Ranking of performance measures according to current use

ENABLERS			
International Resourcing	Systems & Tools	Global Integration	Commitment
% projects delayed due to lack of funding	% products on CAD database	% project time spent in meetings	% employees involved in NPD projects
% projects delayed due to lack of human resources	% engineers (designers with access to CAD)	% product data on shared database	% of employees aware of NPD project's goals
R & D budget as % of turnover	% projects organised using project mgt tools (e.g. QFD, FMEA)	Early cross-functional involvement (marketing, purchasing, etc)	% engineers /designers trained in team-building
% engineers / designers involved in cross-training	% engineers (designers trained to Df ^x techniques)	early customer involvement	number of pages in annual report devoted to NPD
employee satisfaction	number of certified processes	early supplier involvement	number of organisational layers (top to bottom)

Table III: 'Enabling' metrics

CORE PROCESSES		
Product Development	Innovation	Project Management
number new products ideas (or enhancements) per year	% product new features	average project duration
manufacturing cost	% down time reduction	average deviation from project duration targeted
average time - concept to final specification	% decrease in set-up times	average deviation from project budget
average product life cycle (time)	% reduction of products in pipeline	achievement of milestones
production cost as % of turnover	% decrease in number of 'bottlenecks'	frequency of progress reviews
development cost as % turnover	% reduction in quality costs	concurrence of phases as % of total project duration
number parts per product	number of patents	time spent on each stage of development
number customer complaints (internal & external)	technology acquisition cost per new product	supplier lead times

Table IV: Core processes metrics

PROJECT OUTPUT		
Customer	Financial	Technical
customer satisfaction (features, appearance, etc)	total cost of project	lead time to market
number of new customers	return-on-sales	actual product quality performance vs. predicted
value/price to the customers	return-on-investment	product met quality guidelines
product failure rates	new product sales as % of total sales (also 'profit')	Actual vs. target time for project completion
revenue growth	time to break even	production cycle time
market share growth	sales to break even	innovativeness rating

Table V: Project output metrics

FIRM SUCCESS
Number of new products released annually/ specified time period
Number of projects completed annually/specified time period
Sales before and after project
Profit before and after project
% Sales from products introduced in the last 3-5 years
% Profits from products introduced in the last 3-5 years
Ratio of successful/unsuccessful projects
Profitability relative to competitors

Table VI: Overall firm performance metrics

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