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Product development cycle time for business-to-business products

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Abstract

For a number of years, firms have been implementing changes in the way they develop new products, changes that are targeted at reducing overall product development cycle times. And over the years, a number of academics have conducted research trying to understand the factors that are related to *reducing* new product development (NPD) times. But the question remains — just how long does product development generally take in absolute numbers? Information on how long product development takes is helpful to firms for planning and controlling the flow of products into the marketplace and in determining resource needs for NPD. Other than anecdotal data pertaining to particular projects that have been commercialized by particular firms, very little hard data have been reported on this topic. This article analyzes data to quantify average cycle times for physical goods commercialized by business-to-business (B2B) firms. The data are a subset of a much larger data set from the Product Development & Management Association's (PDMA) Best Practices research. The analysis presents average product development cycle times for four different types of projects (new-to-the-world, new-to-the-firm, next generation improvements and incremental improvements), presents evidence of the lack of a relationship between cycle time and success and looks at factors that are associated with differences in the length of product development cycle times.

1. Introduction

While a large number of academic papers have investigated factors that are associated with changes in new product development (NPD) cycle time and quite a few firms have published cycle times for particular projects, there is a dearth of information on just how long NPD takes. This information is highly useful to firms managing portfolios of product development projects [13] and trying to develop aggregate project plans for current and future projects [11]. Without an understanding of how long different types of product development projects take to complete, estimates of the resources necessary to complete project plans and the timing of product release dates to customers may be based more on fantasies or wishful hoping than on reality.

The purpose of this article is to summarize past research on the subject, to present one analysis of how long NPD takes, in general, for business-to-business (B2B) products and how various factors are associated with changes in absolute development cycle times. The analysis uses a subset of the data gathered for the Product Development & Management Association (PDMA, www.pdma.org) 1995 New Product Development Best Practices study [25,26].

Section 2 of this article reviews the literature on product development cycle time. Particulars of the survey research that was conducted are then presented, followed by the descriptive results of the relationships between product development cycle times and various factors. The article closes with implications for management.

2. Literature review

For the last 15 or more years, firms have worried about, and tried to shorten, the time it takes them to get new products[1] to market [4]. These efforts have been driven by both academic findings suggesting that those who are first to market reap structural benefits [25] as well as by increased, and increasingly international, competitive pressures [44]. Initially, anecdotal accounts of individual firm results started

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[1] In this article, the term "products" refers to both services *and* physical goods.

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to appear in the business press in the late 1980s [15,41]. These typically touted a reduction in development time for a particular project of 20–50%, compared to the firm's experience with previous projects.

As these firm announcements began to appear, academic researchers started pursuing case-based and small sample research to better understand the mechanisms that firms might use to lead to decreased development times [33,36,41]. Ultimately, the output of these efforts were numerous factors hypothesized to be associated with cycle time, including issues of project strategy (product complexity, strategic intent, level of innovativeness and technical difficulty), development process characteristics (formality, process structure and steps included), organizational characteristics (team use and assignment level) and firm characteristics (leadership, size and innovation level) [19].

Then, in the mid-1990s, several researchers proposed conceptual models of the composite of factors that influence product development cycle time [8,17,27,30,45], and two teams tested at least part of their frameworks [30,46]. Other researchers empirically tested parts of these frameworks [19,20,31] or relationships between specific factors and cycle time with larger samples [16,37]. In general, the empirical tests of NPD cycle time have looked for associations with project strategy, development process characteristics, organizational factors or firm characteristics (Fig. 1). Exhibit 1 summarizes results from the empirical studies of NPD cycle time.

Nearly all the empirical results relating to project strategy are unsurprising. Newer, bigger, more complex, more technically challenging and more innovative projects are all associated with longer development times or increases in time [1,5,16,19,20,23,28,30]. This suggests that to depend primarily upon strategy to shorten average development times, a firm would need to develop simpler, less complex, more incremental, less innovative and less technically difficult projects. However, while that strategy may reduce product development cycle time, it is unclear what it would do, in the long run, to marketplace or financial success. Would customers be willing over time to accept and pay for a stream of new products that never change much? In some slow-moving industries, perhaps, but certainly not in faster-moving ones.

The valence of the relationship between increased product quality and NPD cycle time is unclear at this time. One research team [24] has found that higher product quality was related to decreases in cycle time, while another found it was associated with increases in time [5]. More research is needed to understand this relationship.

Development process characteristics produce a more complex picture. Many changes in the processes by which products are developed have been implemented over the last 20 years [3,7,22,29,38,39]. Some changes have been made to improve the effectiveness of product development (getting the successful products to market), like new idea screening models [13]. Other changes, such as concurrent engineering [26], have been made to improve the efficiency with which products move to market. The ideal would be process changes that simultaneously improve both effectiveness *and* efficiency, and research shows that some aspects of processes, such as using a formal process and increasing the concurrency of the process [9,10,19, 26,32] have indeed improved both dimensions simultaneously. On the other hand, several other actions that have been taken to improve product development processes, such as increasing the number of customers involved in product development and increasing outside assistance from nontechnical experts, are associated with longer product development cycles [14,30]. Additionally, one process factor has produced conflicting results across two

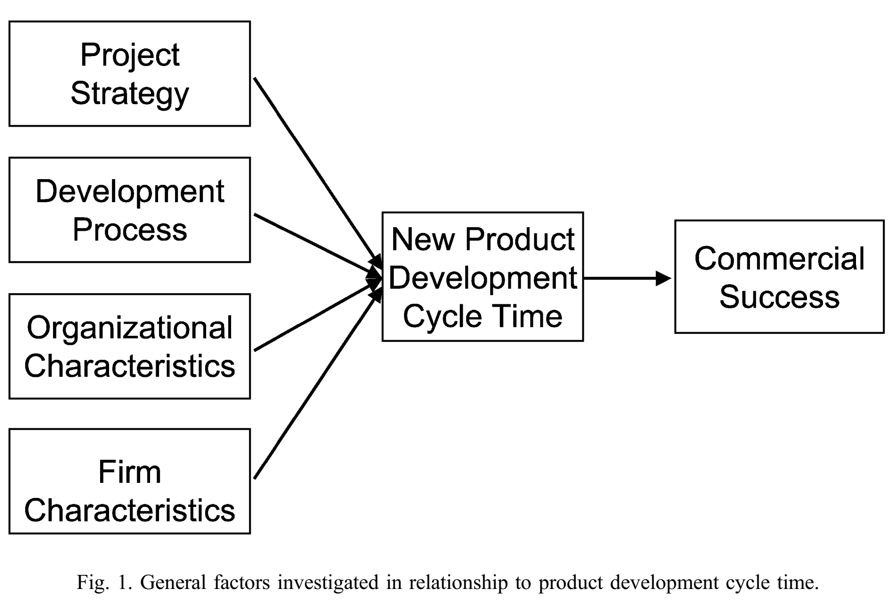

Fig. 1. General factors investigated in relationship to product development cycle time.

Exhibit 1. Summary of NPD cycle time empirical research findings

Factors associated with increases in product development cycle time:

- Project strategy:
  - Increased product complexity [16,19,20,30,37], increased exterior shape complexity [5]
  - Increased number of assembly processes [5]
  - Increased technical difficulty [30]
  - Increased product innovativeness [9,23,28]
  - Increased performance requirements [5]
  - Increased product quality [5], decreased product quality [24]
  - Increased newness (amount of change from previous generation) [1,19,20]
- Development process characteristics:
  - Processes that use design for manufacturability tenets, computer-aided design systems and frequent product testing [26]
  - Higher supplier involvement in the product development process [24], decreasing the number of major suppliers involved in the process [46]
  - Increased numbers of customers involved with the process or prototypes [17]
  - Increased nontechnical outside assistance [30]

Factors associated with reduced product development cycle time:

- Development process characteristics:
  - Clear project goals [26,32], stable project goals [32]
  - Process use [19,20,32]
  - Process concurrency [26]
  - Taking a long-term view [31]
- Organizational factors:
  - Increased dedication of team members [1,46]
  - Cross-functional teams [19,20], increased number of functions participating [46]
  - Integrating across marketing and R&D [42]
  - Teams with members with longer team tenure [31]
  - The ability of a team to record, file and review information [32], integration of knowledge from past projects into this one [42], significant use external sources of information [12]
  - A more participatory management style, for complex projects [12]
- Firm characteristics:
  - Characteristics associated with the firm's industry have an equivalent impact to firm characteristics in their relationship to average cycle times [19]

research teams. At this stage of the research cycle, the valence of the relationship between supplier involvement in the product development process [24,46] with cycle time is unresolved. These results suggest that firms changing development processes will need to monitor the impact of the change on both product development effectiveness (success in the marketplace) and efficiency, and that trade-offs or sacrifices in one may have to be made in the other to achieve other goals.

As can be seen from the references cited in Exhibit 1, over the last two decades, a number of organizational actions have been identified that firms can take to reduce product development cycle time. These recent product development studies have clearly demonstrated positive associations between increasing the cross-functionality and integration levels of teams and shorter product development cycle times. Additionally, increased knowledge levels and dedication also are associated with shorter product development cycle times.

In summary, the empirical results to date show that a rather large number of project strategy, process and organizational factors have been investigated, and some have demonstrated empirical associations with product development cycle time. However, the efforts that have been expended on understanding how specific characteristics associated with the firm or the industry impact NPD cycle time have not resulted in much in the way of significant empirical relationships.

In addition to these findings, a few researchers have investigated relationships between product development cycle time and new product success. Fewer yet have found any statistically significant associations. Lynn and his col-

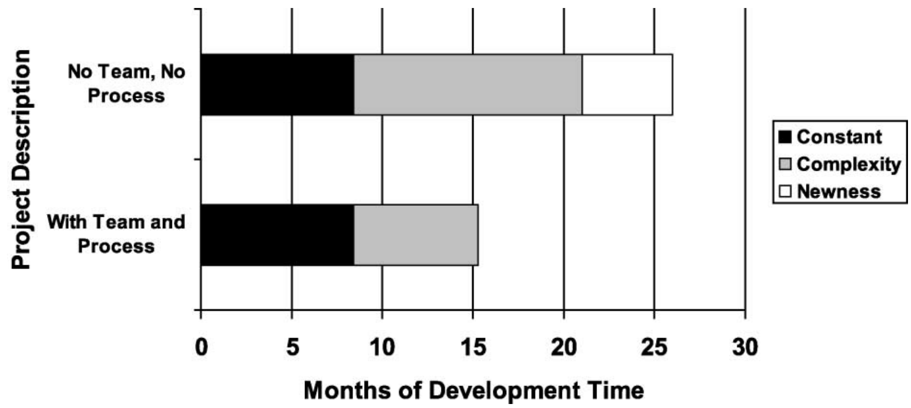

Fig. 2. Expected contributions to development time for the "average" project.

leagues [31,32] found a positive correlation between reductions in managerial perceptions of cycle time performance and a multi-item perceptual construct of success. Additionally, Ittner and Larcker [24] found a positive relationship between average NPD cycle time at the firm level and perceived overall firm performance for the computer industry, but not for data from the automobile industry. Their data did not reveal any relationships between development time and return on assets, return on sales or growth, for either industry. Other research also has not found any association between success and development time upon testing for one [19]. Thus, while many practitioners perceive that decreasing NPD cycle is important to NPD success, there is very little empirical support that substantiates this perception.

Finally, almost all of the research cited above operationalizes the dependent variables reported as scaled perceptions of cycle time, relative measures of cycle time (our firm vs. competition, this project relative to the average or best-in-class project), relative changes in cycle time or project timeliness (actual time compared to original plan). Of the product research cited, only one researcher has investigated and reported relationships with actual absolute project development times [19,20].[2] In this research, specific dates for various points in development processes were culled from firm documents and interviews for 274 projects from 10 firms in four industries. Regression equations were developed that related NPD cycle time (in absolute months) for these projects to project newness [20], project complexity [19,20], development process use [19,20] and cross-functional team use [19,20]. Results for the "average" project in the sample (55% new to the firm in design, delivering three functional capabilities to the user) are presented in Fig. 2. The white portion of the bar represents the portion of development time attributable to project newness. The gray portion is the number of months due to the inherent complexity of the product being developed. Finally, the black parts of the bars are the number of months spent in development that are attributable to other factors.

There is thus very little published analysis of large sample empirical results describing the actual amount of time that NPD takes, in general. This article addresses this gap by presenting descriptive results for product development cycle times for B2B products (physical goods, only), organized in the framework of Fig. 1. The 206 responses analyzed here are the B2B product subset of the data from the 1995 PDMA best practices data set. The original data set also includes consumer goods and both consumer products and business services, which have been eliminated for this analysis.[3] The PDMA has sponsored NPD Best Practices research for the last decade [21,22,34,38,39]. The remainder of this article presents descriptive results for product development cycle time for B2B goods based on these data.

3. Research method

3.1. Survey development

The PDMA Best Practices survey was developed by combining questions from several "best practice" surveys developed since 1982 [3,6,7,36,38,39] and supplemented by additional questions suggested by academics, consultants and practitioners who had been involved in previous NPD Best Practice research. The final survey consisted of nine pages of questions and a one-page cover letter. Questions covered issues surrounding strategy, the product development process, organizing for and leading product devel-

[2] Two other research groups have gathered data on actual development times, rather than perceptions of changes in development time. Zirger and Hartley [46] gathered data in terms of actual months to market. However, their analyses used the comparative variable of time for this project divided by time to market for best in class project. LaBahn et al. [30] gathered data on the total project time and the total man–years in development, but then used a mean of the natural log transformation of the two responses in their analysis. Thus, neither of these papers provide information about absolute values of time to market.

[3] This was done to eliminate some of the heterogeneity in the data. Consumer products do not take as long to develop as business-to-business ones, and services take less time to develop than physical products [21].

opment, tools supporting product development, measuring product development, product development outcomes (including product development cycle time) and background information on the respondents.

3.2. Sample

Responses were received from simultaneous mailings to three separate sources. The mailing lists were chosen to maximize sample diversity in terms of industry while targeting firms likely to be more sophisticated in, and individuals more knowledgeable about, product development. PDMA member respondents are from the practitioner subgroup of the PDMA population. Random samples of two mailing lists were purchased from the American Marketing Association (AMA) and CorpTech. The AMA sample came from those in the database who had checked off the "NPD" interest category. The CorpTech sample consisted of those with "business development," "product development" or "development" in their titles. Additional details for the full sample can be found in Ref. [22].

While the original survey garnered responses from a large number of firms, only 30% of the original total respondent sample are included in these analyses. This is the subset of the full sample that both fit into the demographic category of interest (B2B products) and provided the necessary cycle time information. A total of 116 firms are included in the analysis as summarized in Table 1. The respondents that provided cycle time information did not differ in demographic variables or success outcomes from the B2B respondents that did not provide cycle time information.

3.3. Measures

NPD cycle time was investigated using several sets of questions, all of which are included in Appendix A. The first set of questions asked about cycle times for the firm's more innovative projects, when formal product development processes are used in NPD. Respondents indicated which of a number of possible activities were included in their firm's formal process, and then how long each step in their process took to complete, on average, for their more innovative NPD projects. The set of possible activities was drawn from Ref. [38].

The second set of cycle time questions asked about the average number of months required to complete each of four types of projects: new-to-the world, new product lines, major revisions and incremental improvements, as defined in Ref. [7]. Respondents provided these estimates independently of whether their firm used a formal process or not. Between 78 and 82 respondents (67.2–70.7%) provided information for these variables.

The final two sets of cycle time questions asked about changes to NPD cycle time, compared to 5 years ago. For each of the four project types above, respondents indicated whether their firm's product development cycle was shorter, the same or longer. They then indicated the percentage by which the cycle had increased or decreased.

Success was measured through seven variables that factor analyzed into three dimensions: overall success compared to competitors, success compared to the firm's goals and market/financial success. The specific items are included in Appendix A. In addition to investigating cycle time relationships with dimensions individually, performance above the mean on all three dimensions was used to separate out "The Best" at product development from "The Rest" [21,22]. Of this sample, 35 (30.1%) fall into "The Best," while the remaining 81 (69.9%) constitute "The Rest," which is a comparable proportion to that found in the original sample. Table 2 provides summary statistics for the success measures.

Independent variables were derived from questions investigating how NPD is organized and led, multifunctional team usage, and extent of usage for 9 marketing research tools (such as voice of the customer, conjoint analysis and focus groups), 10 engineering tools (such as CAD and rapid prototyping) and 9 organizational tools (such as team building exercises) [25]. A number of these have been purported to increase the speed of NPD in the literature or popular press.

In reviewing the results of this survey, several caveats should be kept in mind. First, the cycle times reported by respondents are estimated averages. They have not been obtained from the records for specific projects. Furthermore, cycle times have been estimated only for those products that have gone to commercialization. Projects that were can-

Table 1
Demographics by source of the sample

		#	%
Total sample		116	100
Technology	High-tech	51	44.0
Base	Mixed	46	39.7
	Low-tech	19	16.4
	< US$25 million	24	21.3
Sales	US$25 million to US$100 million	32	28.3
	> US$100 million	57	50.5

Table 2
Success by project type

Measure	Full sample	The Best	The Rest
Overall success *	2.7	3.3	2.4
Program goal success **	6.3	7.7	5.8
Market/financial success	46.1%	65.4%	36.6%

Bolded results indicate statistically significant differences in means (ANOVA, $P < .001$).

* 4 = Most successful in the industry, 3 = top 1/3 of industry, 2 = middle 1/3 of industry, 1 = bottom 1/3 of industry.

** 1–9 scale, with 9 = *completely agree* and 1 = *completely disagree*.

Table 3
Average cycle time by development process step: firms with formal product development processes

Process step	# weeks	# months	# in sample
Product line planning	8.3	2.0	70
Project strategy development	8.2	1.9	98
Idea/concept generation	6.5	1.5	95
Idea screening	4.4	1.0	96
Business analysis	7.6	1.8	109
Development	35.4	8.3	117
Test and validation	20.5	4.8	114
Manufacturing development	17.7	4.2	105
Commercialization	19.0	4.5	108
Average total cycle time	115.6	27.2	116
Average total cycle time, for firms whose process includes all nine activities	138.3	32.5	50

celled prior to completion are not included in the data. Additionally, the analysis suffers from sole-source bias, as the same individual provided information about both cycle times and success. These limitations in the research mean that the results must be treated with caution.

4. Results and discussion

This section first reviews the general length of NPD product development cycle time and how cycle time has changed for these firms over the last 5 years. It then analyzes the relationship between cycle time and success. Finally, results are presented for cycle time's association with several other factors.

4.1. Average cycle times

Just how long does product development take for B2B firms? For firms developing products using formal processes, Table 3 presents average cycle times for their more innovative projects, by stage in the process, and then overall, with two different averages reported. The first is the average for the full sample of 116 firms. The second average, in the last row, is the average time for the subset of the firms whose process includes all nine activities.

On average, industrial firms have been taking 2-1/4 years (27 months) to develop their more innovative projects. Those firms that include all nine steps in their process average 5 months longer. The longest process stage, not surprisingly, is development (converting a concept into a working prototype), averaging over 8 months to complete. Three other stages average longer than 1/3 of a year: test and validation (4.8 months), commercialization or launch (4.5 months) and manufacturing development (4.2 months). The bulk of the time spent in NPD (80.1%) occurs once the business case has been approved. However, time spent prior to business case approval, sometimes referred to as the "Fuzzy Front End" (FFE) of product development, is not inconsequential. Each of the five up-front stages takes 1–2 months to complete, with the set of FFE activities constituting 20% of the overall project time (8.2 months).

Over the last several years, a number of firms claim to have spent significant efforts in reducing product development cycle times, as competitive pressures have in-creased. These data confirm those claims. Fig. 3 shows that over 1/2 of the firms in the sample have indeed been successful at decreasing cycle times. These firms have on average reduced cycle times by about 33%, a percentage that is constant across all four project types. Between 30% and 40% of the sample's cycle times have remained nearly constant over the last 5 years. However, nearly 10% have actually suffered increases in cycle time.

4.2. Project characteristics and cycle time

A number of researchers have hypothesized that higher innovativeness is associated with longer cycle times [27], and several have already found empirical support for this hypothesis [1,9,19,20,28]. As Table 4 shows, the more innovative products in this sample also took longer to develop than less innovative products. In these industrial

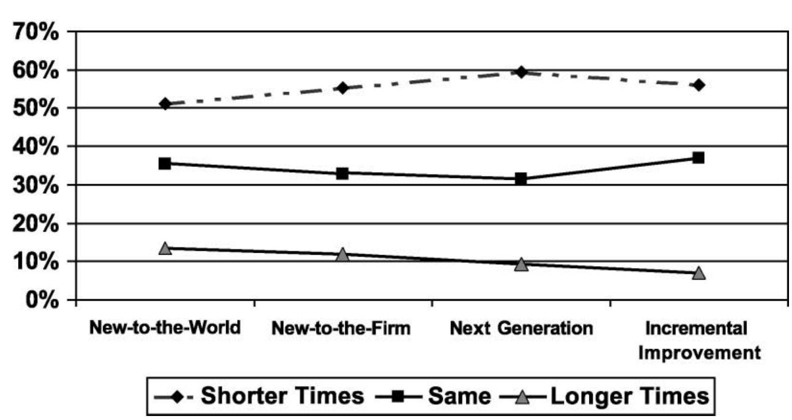

Fig. 3. Percentage of firms with changed cycle times from 5 years ago.

Table 4
Average cycle times by project type

Project type	Cycle time, months
New-to-the-world	53.2
New product lines	36.0
Next generation improvements	22.0
Incremental improvements	8.6

firms, incremental improvements took between 2/3 and 3/4 of a year to develop, while new-to-the-world products required over 53 months (nearly 4-1/2 years). New product lines (new-to-the-firm products) average 3 years, which is slightly longer than the overall average time reported for "more innovative products" in Table 3. Next generation, or large improvement, projects required 22 months (almost 2 years). From the similarity of overall development times, our respondents have likely interpreted the instructions to provide process stage cycle times for the "more innovative" projects of Table 3 as times for new-to-the-firm products.

These data also uncover a statistically significant relationship between cycle time and another project characteristic that previously has been proposed in the literature, but not tested. One of the background questions on the survey asked for the average length of the product life cycle for the firm's products, in years. The PDMA data suggest that product development cycle times strongly correlate with the length of this product life cycle, as hypothesized in Ref. [27]. The correlation between the cycle time of more innovative projects using formal development processes and the length of the stated product life cycle is $\rho = .99$ ($p < .01$). For example, this suggests that, as a washing machine's product life cycle, at 10–15 years, is longer than a new PC's (2–3 years), so is its development time longer.

4.3. Cycle time and success

While a number of researchers have posited a relationship between cycle time and success [2,24,27], few have found empirical evidence to support this contention [24, 31,32]. These data provide no support for a relationship, either. Fig. 4 shows differences in cycle times between the Rest and the Best by project type, the Best being more successful overall than the Rest. None of these differences are statistically significant. The first four columns (cycle time by project type) all suggest that if there were significant differences, the Best would take longer than the rest. However, the final column on the right, which depicts the data for the "more innovative" projects, presents conflicting information. If these differences were statistically significant, the Best would take less time to develop more innovative projects. Correlations between levels of success for any of the seven individual items or three composite variables and cycle time length reveal no statistically significant relationships for any of the cycle time variables.

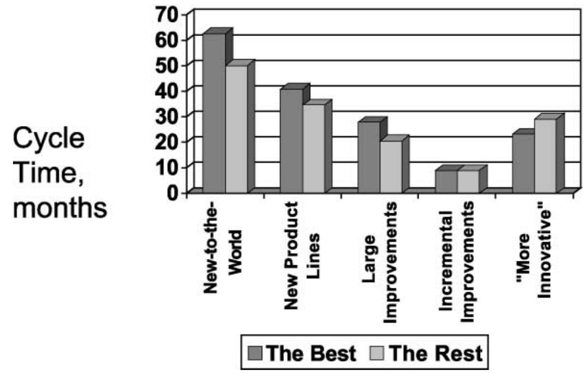

Fig. 4. Cycle time by project type.

In these data, there are no relationships between any measure of success and product development cycle time.

Fig. 5 shows, however, that more of the Best firms have reduced cycle times than have the Rest in the last 5 years. On the other hand, as Fig. 4 illustrates that the development times of the Best are only now equal to those of the Rest of the firms, this result must mean that the Best started out with slower development times 5 years ago, and have only "caught up to the rest of the field" through their cycle time reduction efforts.

The pattern of cycle time reduction across project types differs between the two samples. Moving from less innovative to more innovative project types, the percentage of the Best firms reducing cycle times increases. However, more of the Rest of the firms have reduced cycle times for the less innovative projects than for the more innovative projects. The difference in the percentage of firms reducing times between the two groups thus is larger (although still not significantly so) for more innovative projects than for less innovative projects. For example, nearly 75% of the Best firms have reduced product development cycle times for the new-to-the-world products that they have developed over the last 5 years, versus less than 45% for the Rest. As these projects take inherently longer than less innovative projects, the Best would seem to be focusing their change efforts where there is the biggest opportunity for a visible impact. On the other hand, even though more of the Best

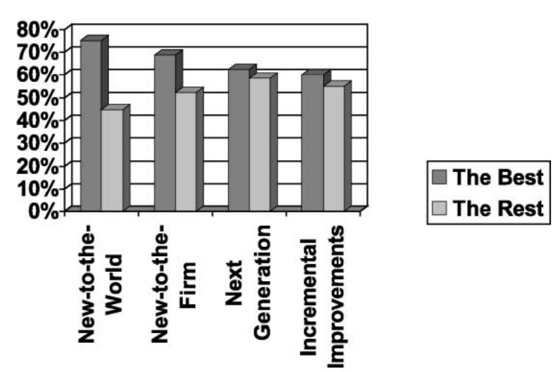

Fig. 5. Percentage of firms reducing cycle times in the last 5 years.

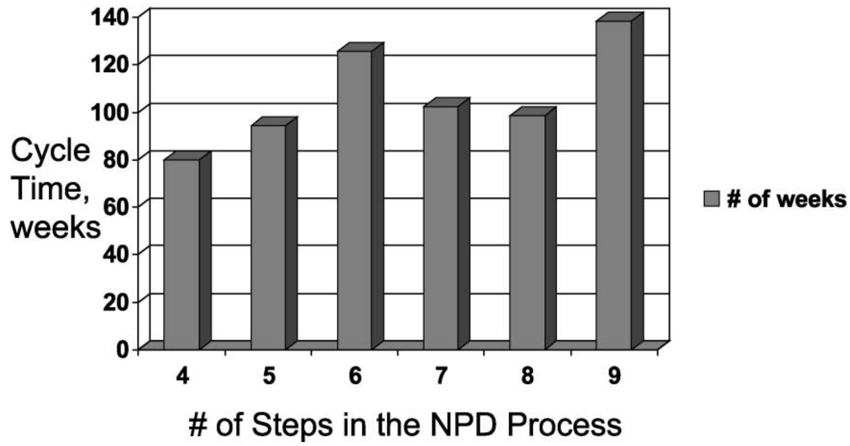

Fig. 6. NPD cycle time by number of steps in the process.

have reduced cycle times, there is no difference between the Best and the Rest in how much time they have eliminated from the development cycle, when they have done so. Both groups of firms have taken about 33% of the time out of product development cycles, for each type of project.

4.4. Product development processes and cycle times

A number of researchers have posited, and previous research has found that formal development processes are associated with shorter product development cycle times [19,20,32]. Unfortunately, as all of the firms who responded with cycle time information also had formal product development processes, these data cannot be used to quantify how implementing a formal process relates to product development cycle time.

These data do, however, suggest some of the time/success trade-offs that firms seem to have made. Previous analysis of the full PDMA sample found that "The Best" firms had more sophisticated product development processes that included more steps. However, Table 3 shows that firms with processes that are "complete," that is, they consist of the full set of activities listed, take nearly half a year longer to complete — 32.5 months in total or 5 months longer than the average project. Fig. 6 shows that processes with fewer steps tend to have shorter development times. Including more steps in a firm's process may take longer, but thus also may be associated with higher overall success in the long run. These data suggest that it may not be doing things faster by skipping process stages that are associated with success, but rather doing more of the right things.

4.5. Organizational factors and cycle time

Relationships between project leadership and NPD cycle time [32] and project organization and cycle time [45] have been developed, but not yet confirmed empirically. The survey included a number of questions about how product development is organized and led in firms. While the results again are not statistically significant, there are some interesting trends in the data when analyzed by project type, as presented in Table 5. Five separate types of organizational structures were included in the survey. Respondents indicated which of the structures were used in their organization.

A functional structure for organizing NPD, where all the responsibilities for NPD reside within one functional area, is superior for handling routine problems, well-known technologies, stable environments, low product evolution rates and well-defined markets [43]. Another structure that also works well for evolutionary product development is a divisional or strategic business unit (SBU) structure in which each division is responsible for commercializing new products. All of the functional resources needed to complete development are under the control of the SBU general manager. An SBU structure works best when there are diverse market needs that need to be met.

Table 5
Cycle times vary by organizational structure (months)

Organizational structure	New-to-the-world	New product lines	Next generation improvements	Incremental improvements
Organized within a function	51.2	35.3	*24.4*	*8.8*
Organized within an SBU	50.6	36.3	*24.8*	*9.5*
NPD	*73.1*	*45.9*	**18.9**	**6.6**
New product committee	**46.7**	**32.1**	**20.8**	**5.7**
NPD process owner	**46.5**	**27.9**	**19.1**	*8.4*

Bold and larger font denotes faster cycle times.
Italics and smaller font denotes slower cycle times.

While these two structures may be the most effective for less innovative projects that are commercialized to maintain the ongoing business [43], such as next generation and incremental improvements, in these data they seem to be associated with longer development cycle times, especially for less innovative projects. For the two more innovative project types, these organizational forms are in the middle of the cycle time range. Next generation project cycle times are 4–5 months (20%) longer, when the projects are completed within one functional group, such as R&D or engineering or by a group having NPD responsibility only within the SBU. Functional and SBU cycle times for incremental projects are 30–50% longer than those for other structures that are less parochial in nature. In using these organizational structures for less innovative projects, firms seem to be trading off using structures that are more effective in producing successful products, at the expense of speed to market.

Two other organizational forms evolved around 20 years ago specifically to meet product development program needs [6]. A permanently staffed new products department is charged with the responsibility of recommending new product objectives, planning programs, making screening decisions and directing the progress of projects through all stages of development. The full-time responsibility of people in this cross-functionally constructed department is NPD. Relegating NPD responsibility to a new product committee is a precursor structure to the new product department. This committee is charged with evaluating and coordinating new products at firm, however, the personnel on this committee fulfill this task only part time, and have other (frequently functionally oriented) tasks for which they are responsible.

Table 5 shows that new product committees are associated with some of the shortest cycle times across all four project types. This finding is very interesting when you consider that the committee members working within this structure have no authority, but all the responsibility, for ensuring products get developed and put on the market. One reason this structure perhaps could be associated with shorter cycle times is because committee members, without formal power to force people to do the necessary work, must continuously interact with and encourage those doing the work, using persuasion and interpersonal skills rather than formal power or position. A more continuous and personal involvement between the management committee and the development staff could in turn increase project saliency to the developers and thus increase the level of effort expended upon NPD versus other (more functional) tasks.

NPD departments are associated with shorter cycle times for both next generation and incremental improvements. Separate departments are able to bring quickly to bear all the resources required to speed new product improvements to market, when the purpose of those projects is to maintain, refresh, and grow the ongoing business. However, NPD departments simultaneously are associated with the longest cycle times for products that the firm has never developed or marketed before, new-to-the-world as well as those that are merely new-to-the-firm. This finding is unexpected, especially when compared to shorter committee cycle times.

Several possible explanations exist for this seemingly incongruous set of findings across the committee versus department structures. One could be that NPD committees are used when less technically difficult or less complex projects (with therefore inherently shorter cycle time ones) are undertaken, but the very difficult or very complex projects are assigned to the NPD department, which has authority, formal power and resources.

Another potential explanation could be that committee members, who have the responsibility to ensure that NPD happens, but none of the authority or direct resources to get it done, are used to ferreting out resources from around the firm as needed, as none are assigned directly to them. Perhaps, they thus learn to coordinate and execute NPD with the minimum amount of resources possible, one of which is time. When facing the need to develop a new technology, they network around the firm until they find the resources with the requisite capabilities, then quickly bring them to bear on the project. The NPD department, on the other hand, has resources assigned to it, usually on a longer term or permanent basis. However, when faced with developing a new technology that the people in the department have not developed previously, they may end up trying to develop the technology with the resources they have, rather than networking throughout the firm to tap the most appropriate resource to undertake the development task.

Organizationally, a more recently developed way for NPD responsibility to be assigned within the organization is by creating a process-oriented NPD structure, with process owners [18,35,40]. NPD process owners are responsible for developing, documenting, improving and deploying the firm's formal NPD process. They also facilitate process use across the firm. Table 5 shows that these structures are associated with shorter NPD cycle times for all types of projects, except incremental improvements. Process owners ensure that the NPD process is followed in the way it was intended. For more innovative and newer projects (ones with more complexity), following the process may mean not "forgetting" particular steps and then going back and filling in those steps at a later date, with a concomitant delay added to the project. Or, following the process may ensure that tasks are overlapped, as appropriate, rather than being completed sequentially. For incremental improvements, following all of the steps of the process, on the other hand, may lengthen the time to market as many NPD processes are constructed for dealing with the complexities of more innovative projects.

In summary, these data preliminarily suggest that, with the exception of the NPD committee structure, which appears always to be associated with fast times to market, different organizational structures may be more appropriate for different kinds of NPD projects if product development cycle time is important to manage. When cycle time is important, perhaps, times might be shorter if the organization used a committee or NPD department structure, for projects that are not new to the firm. However, for newer to the firm projects, committees or process owners may help shorten NPD cycle time. The NPD department appears to be better at supporting fast incremental and next generation development than it is at supporting fast newer to the firm development. The traditional functional and SBU organizations may not be effective in obtaining reduced cycle times for any project type.

Only two additional relationships between cycle time and organizational factors were found in the data. A number of other organizational factors were investigated, but not found to relate to any of the cycle time measures, including: use of cross-functional teams, colocating teams, using champions to lead teams, using various different rewards and incentive structures, using project management systems or use of matrix organizations.

The extent that team building exercises are used correlates with *increased* cycle time for new-to-the-world projects ($\rho = .26$, $p < .05$), which was a surprise. One would think that more integrated teams would be associated with faster times, not slower, especially since the most innovative projects undertaken, new-to-the-world projects, inherently have a significant amount of uncertainty, the reduction of which should benefit from increased integration across team members. This uncertainty can lead to high levels of conflict between team members as they work to reduce the uncertainties. However, some evidence suggests that excessive team harmony can lead to lower NPD success, as harmonious team members do not want to criticize or take actions that may ensure the best development decisions are made, but that decrease harmony [43]. Similarly, perhaps teams with significant levels of team-building exercises built into their projects spend more time in development maintaining these relationships during the rest of the project than they should, with a resulting increase in overall development time.

Alternatively, perhaps team-building exercises are used only for teams that started off with no interpersonal relationships, or even negative relationships, among the team members at initiation. Teams with good integration or relationships (perhaps because a number of the members had worked together previously) at initiation did not need to take the time to build relationships prior to starting on the "real work" of development. Those initiated with conflict already manifest had to first overcome the conflict before they could get down to work.

Finally, in team management, increased use of heavyweight managers, leaders who have broad responsibility and the clout to exercise strong direct and indirect influence across all functions and activities in the project [10], is correlated with *increased* cycle times for next generation improvements ($\rho = .22$, $p < .05$). In this leadership structure, heavyweight project managers are the sole party responsible for managing the NPD process across all functional areas. They have full responsibility for coordinating development and the political power to back up their actions, which they wield as necessary to get the job done. These managers operate using the antithesis of a participatory management style, which previously has been shown to relate to decreased cycle time [12]. The PDMA results thus support previous project leadership findings. Powerful leaders managing autocratically are associated with longer NPD cycle times, especially for next generation improvement projects. Managing in a more participatory style may be one more mechanism for reducing cycle times.

4.6. Product development tools and cycle time

Questions about the frequency of use for nine specific market research tools (such as focus groups and customer site interviews), and nine specific engineering design tools (such as computer aided design and rapid prototyping) were included in the survey. Only one market research tool and two engineering design tools exhibited significant relationships with product development cycle time. In each case, increased use of the tool is associated with *longer* development times.

In the marketing research tools, conjoint or trade-off analysis, is associated with increased cycles times for new product lines ($\rho = .33$, $p < .01$), next generation ($\rho = .31$, $p < .01$) and incremental improvement ($\rho = .36$, $p < .01$) projects. Trade-off analysis determines which feature sets or set of feature levels customers prefer based on the price they are willing to pay. This technique is more prevalently used in consumer goods than in B2B goods. The hope in applying this method is to optimize the feature offering of the product, although the PDMA data do not show any relationship between trade-off analysis and increased success. Again, this may be another example of a technique implemented to increase success in the marketplace, but at the cost of slowing time to market. Alternatively, firms may use conjoint analysis only on their neediest or most complex projects, where uncertainty in feature design is highest, and cycle times are inherently longer due to the nature of the project, not the use of the market research tool.

Two tools associated with computer-based analysis also are associated with lengthened development time: simulation and computer-aided engineering. These findings substantiate results previously reported by others [26]. Simulation tools, computer-based tools that forecast overall product behavior under various dynamic conditions, are correlated significantly with increases in cycle time across all four project types (ρ ranges from .23 for next generation projects to .35 for new product lines) and for the more innovative projects ($\rho = .25$, $p < .01$). Computer-aided engineering tools analyze specific properties of proposed designs. Some tools compute stress levels at various points in the

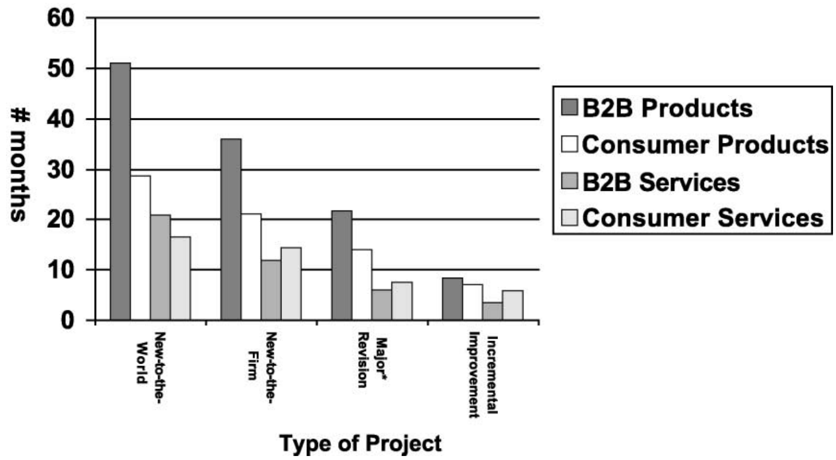

Fig. 7. NPD cycle time by market and product type.

design, and others compute loads at specific positions. There are a number of different types of engineering analyses that can be done. Increased computer-aided engineering correlates with increases in total time to market for the more innovative projects using formal product development processes (ρ = .22, p < .05). While these tools could be used to speed product development cycle time, by eliminating the number of prototypes that must be built and tested, firms seem to be either using them to improve the effectiveness of the product designs, at the expense of getting to market quickly, or they are using them only on the more complex projects that are inherently longer.

4.7. Firm and industry characteristics and cycle time

Very little in terms of firm or industry characteristics, within the sample of B2B physical goods, were associated with the length of the product development cycle time. Indeed, within this sample, cycle time differs statistically only with the size of the firm. Cycle times for more innovative projects with formal processes for small and medium enterprises (sales < US$100 million) are 90.0 weeks (21.2 months). Large enterprises, with sales greater than US$100 million, average 142.0 weeks (33.4 months) or over a full year longer, a difference that is statistically significant (p < .05). The popular press has often suggested that smaller, more entrepreneurial firms move faster than larger, more bureaucratic ones. These data would seem to substantiate that common assertion.

Within the B2B sample, firm innovation strategy, product development program strategy and whether the firm produces high-tech or low-tech goods is unrelated to NPD development cycle time. As has been previously reported in the literature, it is difficult to find industry-level characteristics that significantly relate to differences in cycle times.

However, there are a number of significant differences in average cycle times between B2B goods and other types of projects. Fig. 7 presents cycle times for the full PDMA sample split into four separate groups: B2B goods, B2B services, consumer goods and consumer services. In general, services take about half the time of manufactured goods to develop, although for the overall sample, most of these differences are not significant because of the high variability across the very broad set of industries in the study. Consumer goods always take less time to develop than B2B goods, although the relative difference between the two shrinks as one moves from considering the more innovative to the less innovative types of projects. Finally, there is no difference between cycle times for consumer versus B2B services. Perhaps, consumer services take equally as long because they must be engineered to be robust across a population of less well-educated customers, compared to business services.

5. Managerial implications

This paper describes how long product development cycle time is, for B2B goods, which generally take more time to develop than consumer goods or services or B2B services. Within the B2B sector, the data are derived from many different industries, so these results will differ from cycle times at any particular firm. However, these results may help firms set expectations for typical lengths of times the "average" industrial firm spends developing different types of projects, and for how pursuing different project strategies may relate to expected differences in cycle times. Having this understanding should allow firms to better plan the timing for release to the marketplace of their new products.

Probably, the most interesting result is the lack of relationship between success and product development cycle time, whether success is measured by each of the seven individual items in the survey, by the three factors derived from these items or by comparing the Best and the Rest. This finding is contrary to what is frequently cited in the management literature and popular press as the reason many firms are trying to decrease product development cycles. Firms may have found that speeding development on a particular project to hit a window of opportunity led to higher success than they expected on that project. However, shorter development times, on average, have not been demonstrated, here or in most other research on product development cycle times, to relate to increased overall success in NPD. Pursuing shorter development cycles may provide other benefits to a firm, such as decreased development costs or allowing their personnel to participate on more projects over their career with the firm. Firms would be better advised to investigate whether shorter times provide these benefits, and if so, use them as the rationale behind putting effort into shortening cycle times rather than using the success argument.

This is the first analysis that has found any relationship or trends between organization of the development function and product development cycle time. Different structures appear to be better at minimizing cycle times for different kinds of projects. That product development committees are always associated with shorter average cycle times at firms is a new finding. Firms may want to move the responsibility for more of their product development projects, especially less innovative ones, to a committee structure. This research also suggests that process owners may be a good structure for managing more innovative projects when time to market is important. However, thinking back to previous research, some structures that are more effective at achieving success may also lead to slower projects. Managers will need to think carefully about making trade-offs between whether success or time to market is more important for each project, before they place the project in one or another organizational structure.

Finally, these results also highlight how careful managers need to be in implementing changes in various aspects of product development. Some tools and techniques that have been implemented to increase NPD effectiveness may adversely impact its efficiency, as was found with computer simulation and conjoint or trade-off analysis. This suggests that managers will want to track both effectiveness and efficiency impacts when making changes in how they develop new products so that they can make informed decisions about whether an effectiveness increase is worth the efficiency decrease also associated with the change.

There are clear limitations in these figures, as pointed out earlier. Much more work remains in understanding product development cycle times and the factors that affect them. Many issues could not be addressed by the variables in this survey. Hopefully, from this base, others will be able to move our knowledge further in ways that are additionally useful to managers.

Appendix A. NPD cycle time and success questions

The development of a new product is often described as a series of interdependent and possibly overlapping stages. Below are descriptions of several development activities.

a. Please place an “X” in the first column if your organization’s **formal** product development process includes this activity ***for the more innovative projects***.
b. Please indicate the typical length of time (in weeks) spent on each activity ***for those more innovative projects***.

	Process includes	# of weeks spent
Product line planning: Analyze the firm’s current project portfolio vis-a-vis the competitive arena	☐	_____ weeks
Project strategy Development: Delineate the target market, determine market need, attractiveness	☐	_____ weeks
Idea/concept generation: Identify opportunities and initial generation of possible solutions	☐	_____ weeks
Idea screening: Sort and rank solutions, eliminate unsuitable and unattractive options	☐	_____ weeks
Business analysis: Evaluate the concept financially, write business case, prepare protocol/development contract	☐	_____ weeks
Development: Convert concept into a working product	☐	_____ weeks
Test and validation: Product use, field, market and regulatory testing with customers	☐	_____ weeks
Manufacturing development: Developing and piloting the manufacturing processes	☐	_____ weeks
Commercialization: Launching the new product or service into full scale production and sales	☐	_____ weeks

For each of the following project categories, please indicate how long it typically takes to develop a new product from concept to formal market introduction:

	Development time
New-to-the-world products/services	_____ months
New-to-the-firm products	_____ months
Major revisions/next generation products	_____ months
Incremental improvements	_____ months

Overall, are your development times longer, shorter or about the same as 5 years ago?

New-to-the-world projects	Longer □	Shorter □	About the same □
New-to-the-firm products	Longer □	Shorter □	About the same □
Major revisions/next generation	Longer □	Shorter □	About the same □
Incremental improvements	Longer □	Shorter □	About the same □

By about what percentage have these development times changed in the last 5 years at your firm?

New-to-the-world projects	_____ % longer or shorter than 5 years ago
New-to-the-firm products	_____ % longer or shorter than 5 years ago
Major revisions/next generation	_____ % longer or shorter than 5 years ago
Incremental improvements	_____ % longer or shorter than 5 years ago

A.1. Overall success:

Please mark the one phrase best describing your organization's overall new product success as compared with your primary competitors over the past 5 years. Would you say you are...

□ The most successful in our industry
□ In the top third of our industry
□ In the middle third of our industry
□ In the bottom third of our industry

A.2. Success compared to the firm's goals: ($\rho = .74$, $P < .01$)

How much do you agree that the following statements describe your organization?

	Completely disagree				Neutral		Completely agree		
Our new product program meets the performance objectives set out for it	1	2	3	4	5	6	7	8	9
Overall, our new product program is a success	1	2	3	4	5	6	7	8	9

A.3. Market/financial success: (Chronbach's $\alpha = .78$)

For your new products program, please estimate, for the past 5 years:

■New product sales as a percentage of total sales:	_____ %
■New product profits as a percentage of total profits:	_____ %
Based upon your organization's definition of a successful new product, about what percentage of all the new products introduced into the market during the last 5 years were successful?	_____ %
What percentage would you estimate were successful in terms of their profitability to the organization?	_____ %

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