Speed-to-Market and New Product Performance Trade-offs

Barry L. Bayus

When pressed to accelerate a development effort, more than a few managers have responded in terms such as “Good, fast, cheap . . . Pick any two.” Time-to-market decisions clearly play an important role in determining the ultimate success or failure of a new product. Just as clearly, however, speed to market is not the sole determinant of success. The seemingly offhanded “Pick any two” response points to the tradeoffs that product development managers must make in their decisions about development time and costs.

Barry Bayus discusses the relationship between product development time and costs, and he formulates a mathematical model that simultaneously considers the decisions regarding time-to-market and product performance levels. He applies the model to two competitive scenarios, and he identifies the optimal entry timing and product performance decisions for various market, demand, and cost conditions.

In the first scenario, a firm must decide whether to accelerate development efforts to catch a competitor that has just introduced a new product. Analysis of the tradeoffs among the various parameters in the model suggests that fast development of low-performance products is optimal under the following conditions: a relatively short window of market opportunity, a weak competitor, and relatively high development costs. For example, if the competitor is weak, high performance levels are not necessary and the firm can safely reduce time-to-market. Under the same scenario (that is, accelerating development to catch a competitor), the analysis suggests that fast development of products with high performance levels is optimal under conditions of relatively high sales and relatively flat development costs.

In the second scenario, the firm must decide whether to speed development efforts to beat the competition to market. Analysis of the various tradeoffs for this scenario suggests that first-to-market status for a product with a high performance level is optimal under the following conditions: a relatively long window of market opportunity, relatively high sales, and relatively flat development costs. With a long product lifecycle, stable margins, and high sales, the firm can generate sufficient revenue to offset the increased cost incurred in speeding a high-performance product to market. Beating a competitor to market with a low-performance product is never optimal for the cases considered here.

Address correspondence to Barry L. Bayus, Kenan-Flagler Business School, University of North Carolina, CB 3490, Chapel Hill, NC 27599, (919) 962-3210. Barry_Bayus@UNC.edu.
Introduction

Time-based competition is the latest mantra being touted as the way to achieve a competitive advantage in today’s dynamic environment [7,9,42,61,65]. Although most of the case studies described by Stalk and Hout [62] in their pioneering book deal with customer order entry, production, and delivery cycles, reducing cycle times in the new product development process has also become a critical objective for most companies [4,12,13,19,20,68]. For example, in his recent annual-report letter to General Electric shareholders, CEO Jack Welch emphasized that speeding new products to market was a corporate priority [31].

To support the belief that speeding new products to market is necessary in today’s environment, spectacular success stories of companies that have dramatically reduced their development times have been reported [27,53]. Assuming that a firm wants to speed-to-market, much has been published on the approaches and techniques that can be used to accelerate the new product development process [24,48,52,55,60,70,72].

However, most managers intuitively know that trade-offs between time-to-market, development costs, and product performance exist1 [17,23,24,51,60,69]. For example, Motorola’s pocket pager, NeXT’s computer workstation, AGFA Compugraphic’s text/graphic imagesetter, and Northern Telecom’s small business phone system all traded-off explicit time targets to meet product quality and development cost goals [56]. Although Proxima wanted to be first to market with its DLP projector, its development team delayed introduction to ensure that product performance was superior [10]. On the other hand, Xerox developed its 1045 copier on an accelerated schedule in the early 1980s, only later to discover a major design problem that eventually cost more than $1 million [39]. GE pushed the development of a new refrigerator compressor too fast, later incurring a $450 million loss and replacement costs associated with over one million defective compressors [46]. Chrysler’s Neon compact car was rushed to market before sufficient road tests were completed. Chrysler had to twice recall the car within the first month of sale; resulting in dampened consumer and dealer enthusiasm for the Neon [25].

Recently, a few studies have begun to quantify these trade-offs by investigating normative decisions under various scenarios. These efforts attempt to analytically identify the conditions when it is (and especially when it is not) in the best interests of a firm to speed-to-market with a new product. Cohen, Eliashberg, and Ho [15] consider a mathematical model of the time-to-market decision given an exogenous development expenditure level (and thus, a fixed product performance level). They consider the situation in which a competitor is already in the market and a firm develops a new product to replace their existing product. They also limit their attention to the case in which market demand and price are constant. Based on their analyses, Cohen, Eliashberg, and Ho [15] find that it is better to delay market entry to develop a superior new product when margins are high and the category demand is large. Bayus, Jain, and Rao [6] study a game-theoretic model of entry timing and product performance level decisions in a duopoly. They consider a situation in which both competitors are not currently in the market, and price and market demand are assumed to be constant. Based on their analyses, the firm’s entry timing and product performance decisions depend on the asymmetries in the competitors’ market estimates and development efficiencies (i.e., firms that have higher market estimates and development efficiencies than their rival enter first and have high product performance levels).

This article continues this stream of normative research by relating various market, demand, and cost conditions to “optimal” (i.e., profit maximizing) time-to-market and product performance decisions. To accomplish this, a mathematical model which simultaneously considers the development time and product

---

1 Some companies however, may not be aware of these trade-offs, e.g., Figgie International has sued the Boston Consulting Group for “erroneous market studies and flawed strategies” dealing with BCG’s famous “time-based competition” strategy [45].

---

BIOGRAPHICAL SKETCH

Barry L. Bayus is Professor of Marketing at the Kenan-Flagler Business School, University of North Carolina at Chapel Hill. After receiving his PhD in Operations Research from the Wharton School, he joined RCA as a senior member of their corporate staff working on market forecasting approaches. He has also been a member of the business school faculties at Cornell University and the Wharton School. He has published numerous papers in various academic and business journals, including Journal of Product Innovation Management, Journal of Marketing Research, Journal of Marketing, Marketing Science, and Management Science. His recent research is concerned with new product development issues such as speed-to-market, product life cycle management, new product preannouncements, product line management in dynamically changing markets, and the role of software in creating customer value.
performance level decisions is formulated and analyzed. Two cases that are representative of actual competitive situations are studied: (1) a competitive product is already on the market and the development decisions center around catching the competitor, and (2) a competitive product is expected in the future and the decision focuses on whether to beat the competitor to market. In contrast to the published literature, this article relates optimal entry timing (i.e., first to market, fast follower, follower) and product performance (high, low) decisions to specific market, demand, and cost conditions for various competitive situations.

The remainder of this article is organized as follows. In the next section, the relationship between product development time and costs is discussed, and the cost function used in the analysis is given. A model of the time-to-market and product level decisions is then formulated and analyzed for the two competitive situations. Based on this analysis, optimal entry timing and product performance decisions are also characterized for various market, demand, and cost conditions. Finally, the last section discusses the analytical findings in light of observed marketplace phenomena and outlines some areas for future research.

**The Development Time-cost Tradeoff**

The relationship between time and cost in new product development is a critical component of the speed-to-market decision. As shown in Figure 1, the time-cost trade-off for a specific development project is generally approximated by a U-shaped function [28,44,60]. For development times less than the minimum of this curve ($\Delta_{\text{min}}$), development costs increase at an increasing rate as the project time is compressed. Several arguments support increasing costs in this region. As more people are added to a project, diminishing returns are observed because overall productivity drops due to the additional communication and training necessary for new team members (Brooks [11] has called this the mythical man-month). Traditional network or PERT analysis of R&D activities also leads to a convex time-cost trade-off since more severe time compression must be accomplished by "crashing" activities with larger costs [54]. Taking a probability approach (e.g., how many technical approaches should be concurrently scheduled to complete an R&D project, given that each has some probability of success), Scherer [57] finds that total project costs increase as development time is reduced. Concurrent engineering has also been found to be more expensive than sequential development [1]. In addition, the limited published empirical work is consistent with a strictly convex relationship [8,14,37,38,50,66]. Development times longer than $\Delta_{\text{min}}$ result in increased development costs due to decreasing know-how and motivation, additional setup costs as technical people shift between projects [8,44]. Graves [26] provides an excellent review of this literature.

Companies that are currently to the right of $\Delta_{\text{min}}$ (noted as $\Delta_{\text{now}}$ in Figure 1) can always improve their new product development effectiveness by trying to reduce development time since faster development is associated with reduced costs. This may help explain the many reported examples of dramatic reductions in development time. Based on their consulting experiences with numerous companies, Smith and Reinertsen [60] confirm that many firms do seem to face this situation. For companies operating to the left of $\Delta_{\text{min}}$, an objective of maximizing profits (i.e., the sum of gross profits less development costs) gives an optimal development time $\Delta^*$ (see Figure 1)$^2$. Note that in general $\Delta^*$ does not equal $\Delta_{\text{min}}$ since faster development costs more but allows greater and earlier capture of profits.

For analysis purposes, costs are generally assumed to be increasing as development time is accelerated. If development time increases past the minimum of the development time-cost trade-off curve (i.e., to the right of $\Delta_{\text{min}}$ in Figure 1), costs are also assumed to

---

$^2$ It is interesting that many companies believe they operate to the left of $\Delta_{\text{min}}$ [28].

---

```
Figure 1. The Development Time-Cost Trade-off.
```
increase. Thus, the following U-shaped development cost function is used:

$$c(Q, \Delta) = Q(\alpha - \beta \Delta + \Delta^2)$$  \hspace{1cm} (1)

Here, $Q =$ product performance level$^3$

$\Delta =$ development time (where $\Delta = 0$ is the smallest feasible time to "crash" a project)

$\alpha =$ maximum cost to "crash" a project

$\beta/2 =$ minimum cost development time

($=\Delta_{\text{min}}$)

Given a certain development time, higher product performance levels are assumed to have proportionately higher development costs (i.e., there is a family of cost curves). This assumption is consistent with prior empirical findings [26,27,66].

**Model and Analysis**

In this section, a model of "your" firm's time-to-market ($\Delta$) and product performance (Q) decisions is formulated and analyzed. To focus on the critical trade-offs involved, some aspects of the new product development process are simplified. The implications of relaxing various assumptions are also discussed.

Two firms (you and a competitor) are considered in the model development and analysis. Industry demand is assumed to follow the usual product life cycle pattern with sales initially low but increasing to a peak level$^4$. Figure 2 shows the general demand situation modeled, where

$$a =$ product introduction time (a = $t_e$ if competitor is first-to-market; a = $\Delta$ if you are first-to-market)

$\rho \tau =$ industry sales growth rate

$\tau + a =$ time of peak sales

$T + a =$ time of product withdrawal

Time $t = 0$ is the earliest start date for your new product development and $\Delta$ (your product development time) is a decision variable. Here, the product has a lifetime of $T$ and the total market size is $\rho \tau$. Sales declines at the end of a product's lifetime are not explicitly considered, but this will not change the qualitative nature of any results to be discussed since the analysis concentrates on identifying your optimal time-to-market ($\Delta^*$) during sales growth (i.e., before the time of peak sales, $\tau + a$ in Figure 2). In addition, market expansion with a competitive product entry (e.g., when both competitors are in the market) is not modeled. Again, the qualitative nature of the results will not be affected since market expansion is associated with a larger total market size. Future research might consider a more complex situation in which a firm has a sequence of products with overlapping life cycles associated with sales growth and decline.

For this analysis, product selling price and costs are combined into an average product margin. Product margins are assumed to decline exponentially over time$^5$: $m = e^{-\epsilon t}$, where $m =$ average product margin at introduction and $\epsilon =$ time trend coefficient. Further, since possible pricing strategies are not emphasized in this article, margins across firms are assumed to be equal. Thus market share, $s(Q, Q_c)$, is only a function of your product performance level (Q) and that of the competitor ($Q_c$). Firms are assumed to maximize profits (i.e., gross profit, calculated as your share of the area under the industry demand curve once your product is in the marketplace, less development costs). Future research might consider a more complex model with different product margins, advertising expenditures, and distribution advantages across competitors.

**Case 1: Catch the Competition**

Consider the following scenario. While attending a recent industry trade show, you find that a key competitor has introduced a new product. Although your company does not currently serve the market targeted

---

$^3$ Consistent with empirical studies of new product development projects, product performance is assessed relative to customer perceptions. Although product performance is multi-dimensional (e.g., notebook computer performance can be evaluated according to CPU speed, memory, graphics, battery life, size/weight, etc.,), an "overall" indicator for performance is analyzed (e.g., see the price/performance charts in any PC trade publication). Quality indices are also reported by Consumer Reports, J.D. Powers, and other rating sources for numerous goods and services. Future research can model product performance as a vector and consider the various trade-offs in time-cost and performance that might exist.

$^4$ Original equipment manufacturers (OEM) sales are not explicitly modeled. Generally, the OEM sales pattern is initially low for a longer period of time, with sales rising very quickly once the product is designed into the larger system and the OEM ships in quantity [60]. Within the model framework in this article, some key characteristics of this situation are represented by a large industry sales growth rate ($\rho$) together with a small time to peak sales ($\tau$).

$^5$ As discussed by Smith and Reinertsen [60], average selling prices typically decline proportionally to the rate of improvement in price-performance of the product's underlying technology. Their experience suggests that typical price declines for semiconductors are 25-30% per year; computer printer prices fall around 15% per year; and prices for mechanical systems fall about 5% per year. Product costs also decline over time, usually following the industry learning curve. Following Smith and Reinertsen [60], a sophisticated cost model based on learning curves and cumulative volume is not used in this analysis. Instead, costs are assumed to decline over time at a constant rate, and discounting is not explicitly considered. Thus, declining prices and costs are combined into one variable for ease of interpretation.
with this product, the profit potential is very promising and the underlying technology is not outside your firm’s capabilities. Once back in your corporate office, you and your senior staff wrestle with the following decision: Should we accelerate our development efforts in order to catch the competition?

IBM faced a similar scenario in the personal computer market in early 1980. Apple and Tandy already had products in the marketplace, and demand was expected to explode [33]. Barco, at one time the worldwide market share leader in high performance industrial projection systems, also had to make a similar decision when Sony unexpectedly introduced a new projector at a key trade show [41]. At a reported cost of $100 million, Ford has recently accelerated its plans to have a driver-side rear sliding door on its Windstar minivans in response to Chrysler’s already available option [64]. As Levitt [36] points out, most companies will have to catch a competitor at some point during their history.

Mathematical details of the model and analysis of this case are in Appendix A. Although closed-form solutions for the optimal decisions are obtained, it is impossible to establish any simple analytical relationship between your optimal time-to-market ($\Delta^*$) and product performance level ($Q^*$), and the parameters representing market, demand, and cost conditions (i.e., a comparative statics analysis). As a result, numerical methods are used to study these conditions over a wide range of parameter values that are feasible.

For convenience, $t_c$ (which equals a in Figure 2) was set to 0 and $m$ was set equal to 1 in all the numerical analyses. The remaining eight parameters were systematically varied within nine market scenarios (short, medium, long life cycles and low, medium, high sales growth). This generated 189 separate cases that were analyzed. These numerical results were then summarized by regressing standardized values of the parameters on the calculated optimal development times and product performance levels. Table 1 contains the regression results. In all cases, the regression equations and coefficients are statistically significant.

Based on the coefficient signs in Table 1, the fast development of products with low performance levels is optimal when:

1. there is a relatively short window of market opportunity, i.e.,
   - product lifetimes ($T$) are short
   - the time to peak sales ($\tau$) is small
   - average product margins are sharply declining over time ($\epsilon$)

2. the competitor is relatively weak, i.e.,
   - the competitor has a low performance product ($Q_c$)
   - you have a marketing advantage ($\gamma$) over the competitor

3. development costs are relatively steep, i.e.,
   - the minimum cost development time ($\beta$) is small
   - the maximum cost to crash a project ($\alpha$) is large

If product life cycles are compressed and/or margins are sharply declining, new products should be developed quickly since there is limited time in which to obtain revenues. As a result of the accelerated development process, products with low performance levels are marketed. If the competitor is weak, products with high performance levels are not required and thus time-to-market can be reduced. If development costs are steep (i.e., the slope of the development time-cost curve to the left of $\Delta_{min}$ in Figure 1 is large), it is too expensive to develop a product that has a high performance level. The resulting low performance product can thus be brought to market quickly.

In general, optimal development time and product performance levels are positively related. This implies that fast new product development (i.e., small $\Delta$) is usually associated with products that have low performance levels (and conversely, products with high performance levels require long development times). This analytical finding is consistent with the empirical findings that new firms [58] and small manufacturing firms [1] pursuing less technically ambitious products are faster to market. This is also consistent with recommendations to use incremental innovation as a way to reduce product development time [60].

The coefficient signs in Table 1 also indicate that
Table 1. Standardized Regression Results for the Numerical Analyses of Case 1: Catch the Competition
(t-statistics in parentheses)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Optimal Development Time</th>
<th>Optimal Product Performance Level</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window of Market Opportunity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T$ (product lifetime)</td>
<td>0.24 (9.13)*</td>
<td>6.86 (11.89)*</td>
<td>The fast development of products with low performance levels is optimal when:</td>
</tr>
<tr>
<td>$r$ (time to peak sales)</td>
<td>0.13 (5.03)*</td>
<td>3.76 (6.52)*</td>
<td>(1) product lifetimes are short, (2) the time to peak sales is small, or</td>
</tr>
<tr>
<td>$e$ (average product margin rate of decline)</td>
<td>-0.03 (-2.63)*</td>
<td>-1.46 (-5.43)*</td>
<td>(3) average product margins are sharply declining over time.</td>
</tr>
<tr>
<td>Sales Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho$ (sales growth rate)</td>
<td>-0.26 (-21.64)*</td>
<td>7.60 (28.18)*</td>
<td>The fast development of products with high performance levels is optimal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>when the sales growth rate is large.</td>
</tr>
<tr>
<td>Competitive Advantage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Q_c$ (competitor’s product performance)</td>
<td>0.10 (8.28)*</td>
<td>1.24 (4.59)*</td>
<td>The fast development of products with low performance levels is optimal when:</td>
</tr>
<tr>
<td>$\gamma$ (your marketing advantage over the</td>
<td>-0.04 (-2.98)*</td>
<td>-0.46 (-1.70)</td>
<td>(1) the competitor has a low performance product, or (2) you have a</td>
</tr>
<tr>
<td>competitor)</td>
<td></td>
<td></td>
<td>marketing advantage over the competitor.</td>
</tr>
<tr>
<td>Development Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$ (minimum cost development time)</td>
<td>1.12 (87.64)*</td>
<td>3.24 (11.33)*</td>
<td>The fast development of products with low performance levels is optimal when:</td>
</tr>
<tr>
<td>$\alpha$ (maximum cost to crash a project)</td>
<td>-0.08 (-6.00)*</td>
<td>-3.87 (-13.53)*</td>
<td>(1) the minimum cost development time is small, or (2) the maximum cost to</td>
</tr>
<tr>
<td>constant</td>
<td>3.39 (281.5)*</td>
<td>25.23 (93.9)*</td>
<td>crash a project is large</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.98 (1124.7)*</td>
<td>0.87 (155.1)*</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at 0.05 level or better.

the fast development of products with high performance levels is optimal when:

1. sales are relatively high, i.e.,
   - the sales growth rate ($\rho$) is large

2. development costs are relatively flat, i.e.,
   - for certain values when the minimum cost development time ($\beta$) is small and the maximum cost to crash a project ($\alpha$) is small

When sales levels are high, the resulting revenues can pay for the increased costs associated with the fast development of high performance products. If development costs are relatively flat, then it is not too expensive to develop products with high performance levels and speed them to market.

Because the explanatory variables are standardized, the relative influence of each model parameter can be found by comparing the coefficient magnitudes. The results in Table 1 indicate that the cost parameter $\beta$ (minimum cost development time) is the most critical factor in the optimal development time, and the sales growth rate ($\rho$) and market lifetime ($T$) are the most important variables in the optimal product performance level. Not surprisingly, the sales growth rate and market lifetime are also the most critical determinants of profits and market share (these regressions are not shown, but are available from the author). This is consistent with the empirical literature which has analyzed order of entry data [67].

Given the managerial interest in establishing appropriate objectives for their development teams, it is useful to compare the practical suggestions for speeding up new product development with the "optimal" results from this analysis. One guideline that has received much attention is Hewlett-Packard’s break-even time (BET) metric [30]. In terms of the model, optimal time-to-market ($\Delta_{BE}$) and product performance levels ($Q_{BE}$) can be obtained by minimizing the time it takes for a new product to break-even ($T_{BE}$). Numerical analyses for the separate cases underlying Table 1 (not shown in this article) show that $\Delta_{BE}$ is always less than $\Delta^*$ and $Q_{BE}$ is always less than $Q^*$. Using a different model formulation, Cohen, Eliash-
berg, and Ho [15] also find that minimizing $T_{BE}$ results in premature product introduction. Graphically, $\Delta_{BE}$ would be to the left of $\Delta^*$ in Figure 1. Thus, an objective of minimizing the time for a product to break-even gives rise to new product development that is too fast and results in suboptimal profits and market share.

**Case 2: Beat the Competition**

Unlike the previous scenario, suppose that you return from the industry trade show with information that indicates an impending new product introduction by a key competitor. Again, your firm does not currently have a product entry in the target market, but the profit opportunity cannot be ignored and the underlying technical requirements are within your capabilities. The key decision now becomes: Should we "crash" our development efforts in order to beat the competition to market?

This scenario is similar to the situation faced by Motorola around 1980 when IBM needed a central processor chip to run its personal computer. Intel launched "Operation Crush" to beat Motorola's design to market, ultimately winning IBM's business and a dominate share of the CPU chip market [18, 71]. Applied Materials, a leader in the development and production of semiconductor manufacturing equipment, also had to make a similar decision when there were persistent rumors that a competitor was 10–12 months ahead of their development schedule for a new piece of semiconductor wafer fabrication equipment [32].

Mathematical details of the model and analysis of this case are in Appendix B. Again, it is impossible to establish any simple analytical relationship between your optimal time-to-market and product performance level, and the market, demand, and cost parameters. Thus, numerical methods over a wide range of feasible parameter values are used to study this scenario.

For convenience, $t_c$ was set equal to 7 and $m$ was set equal to 1 in all the numerical analyses. As before, the remaining eight parameters were systematically varied within nine market scenarios, generating 189 separate cases. These numerical results were then summarized by: (i) estimating a logistic regression of the standardized parameter values on the first-to-market versus wait decision (i.e., a binary dependent variable), and (ii) regressing the standardized parameters on the optimal product performance level. These regression results are in Table 2. As indicated by the model chi-square value and the F-statistic, these equations fit the underlying data very well. The coefficient magnitudes in Table 2 indicate that the sales growth rate ($\rho$), and thus the total market size, is the most critical determinant of the speed-to-market and product performance decisions.

Based on the significant coefficient signs in Table 2, being first-to-market with a product that has a high performance level is optimal when:

1. there is a relatively long window of market opportunity, i.e.,
   - *product lifetimes* ($T$) are long
   - *the time to peak sales* ($\tau$) is large
   - *average product margins* are slowly declining over time ($\epsilon$)
2. sales are relatively high, i.e.,
   - *the sales growth rate* ($\rho$) is large
3. development costs are relatively flat, i.e.,
   - *the minimum cost development time* ($\beta$) is large
   - *the maximum cost to crash a project* ($\alpha$) is small

If product life cycles are long, margins are stable, and/or sales levels are high, then sufficient revenues can be obtained to pay the increased costs associated with speeding a high performance product to market. If development costs are relatively flat (e.g., see Figure 3), then it is not too expensive to beat the competitor to market with a product that has a high performance level.

It is important to note that it is generally not optimal to beat a competitor to market with a product that has a relatively low performance level. Balancing the trade-offs involved in these decisions leads to the primary desire of developing a product that has a high performance level. If the potential revenues associated with a high performance product versus the increased costs of accelerating the new product development process is favorable, then you can decide to beat the competitor to market. If the trade-off is not favorable, it is better to delay introduction by continuing to develop a higher performance product than to be first-to-market with a product that has a relatively low performance level.

**Summary**

A summary of the various results from considering these two competitive situations together is in Figure 4. Note that being first to market with a product that has a low performance level is never optimal for the cases considered in this article. If there is a relatively
Table 2. Estimation Results for the Numerical Analyses of Case 2: Beat the Competition

<table>
<thead>
<tr>
<th>Parameter</th>
<th>First-to-Market (^1) (chi-square in parentheses)</th>
<th>Optimal Product Performance Level (^2) (t-statistic in parentheses)</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window of Market Opportunity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (product lifetime)</td>
<td>2.44</td>
<td>1.82</td>
<td>Being first-to-market with a product that has a high performance level is optimal when: (1) product lifetimes are long, (2) the time to peak sales is large, or (3) average product margins are slowly declining over time.</td>
</tr>
<tr>
<td></td>
<td>(9.2)*</td>
<td>(8.10)*</td>
<td></td>
</tr>
<tr>
<td>(\tau) (time to peak sales)</td>
<td>3.12</td>
<td>1.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(13.2)*</td>
<td>(8.55)*</td>
<td></td>
</tr>
<tr>
<td>(\epsilon) (average product margin rate of decline)</td>
<td>-0.92</td>
<td>-1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.2)*</td>
<td>(-9.55)*</td>
<td></td>
</tr>
<tr>
<td>Sales Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\rho) (sales growth rate)</td>
<td>6.97</td>
<td>3.45</td>
<td>Being first-to-market with a product that has a high performance level is optimal when the sales growth rate is large.</td>
</tr>
<tr>
<td></td>
<td>(24.4)*</td>
<td>(30.71)*</td>
<td></td>
</tr>
<tr>
<td>Competitive Advantage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Q_c) (competitor’s product performance)</td>
<td>0.22</td>
<td>0.49</td>
<td>None.</td>
</tr>
<tr>
<td></td>
<td>(0.7)</td>
<td>(4.75)*</td>
<td></td>
</tr>
<tr>
<td>(\gamma) (your marketing advantage over the competitor)</td>
<td>-0.00</td>
<td>-0.17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(-1.60)</td>
<td></td>
</tr>
<tr>
<td>Development Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\beta) (minimum cost development time)</td>
<td>1.13</td>
<td>1.24</td>
<td>Being first-to-market with a product that has a high performance level is optimal when: (1) the minimum cost development time is large, or (2) the maximum cost to crash a project is small.</td>
</tr>
<tr>
<td></td>
<td>(4.5)*</td>
<td>(11.82)*</td>
<td></td>
</tr>
<tr>
<td>(\alpha) (maximum cost to crash a project)</td>
<td>-1.95</td>
<td>-1.62</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(17.1)*</td>
<td>(-14.78)*</td>
<td></td>
</tr>
<tr>
<td>constant</td>
<td>2.79</td>
<td>15.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(12.5)*</td>
<td>(147.0)*</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Based on a standardized logistic regression \((-2LL = 63.4; \chi^2 = 197.4*)\).

\(^2\) Based on a standardized regression using only the 102 cases (out of the original 189) for which the optimal strategy is first-to-market (\(R^2 = 0.92; F\)-statistic = 135.3*)).

\(^*\) Significant at 0.05 level or better.

Figure 3. Shifting the Development Time-Cost Curve.

long market window of opportunity or you have flat development costs (i.e., a very efficient new product development process), then your optimal strategy is to develop a product with a high performance level and enter the market first if possible; otherwise, you should follow at a later time. If there is a relatively short market window of opportunity, weak competition, or you have steep development costs (i.e., a very inefficient new product development process), then your optimal strategy is to be a fast follower with a low performance product.

Discussion and Conclusions

By analyzing the profits and costs of new product development, this article identifies the market, demand, and cost conditions associated with the speed-to-market and new product performance decisions. Importantly, the product performance consequences of reducing development times is also directly considered. The resulting analytical findings extend the published literature by giving specific conditions under which fast new product development may and may not be desirable. These results also quantify the trade-offs that managers have intuitively stated: good, fast, cheap . . . pick any two [47].
It is clear from the introduction that many companies in diverse industries around the globe are emphasizing the accelerated development of new products. Casual observations of the marketplace further suggest that firms in many industries are engaging in the fast development of products with relatively low performance levels. For example, the business press is replete with examples of planned product proliferation strategies \(^6\) [29,49,59]. Moreover, the greater number of new products has not necessarily meant a proportionate increase in performance. In fact, very few of these products seem to be “new” [22,35,43]. Additionally, companies are stressing target pricing which can result in the development of low cost products with limited features [21].

The analytical findings in this article show that the fast development of products with low performance levels is optimal for markets with short product lifetimes, sharply declining margins, or weak competitive offerings. It is interesting that these market conditions correspond to the reasons for the importance of speed-to-market generally given by the business press and corporate executives. As Stalk and Webber [63] note, however, blindly following this kind of strategy can lead to “a strategic treadmill” where companies are “condemned to run faster and faster but always staying in the same place competitively.” As a result of cost and profit pressures, they report that many Japanese companies are retreating from their exclusive reliance on time compression and the resulting increase in product variety (e.g., Japanese consumer electronics companies are eliminating 25 models of VCRs and 19 models of televisions, and automobile manufacturers are extending their product cycles from 4 to 5 years). As noted in Bayus [5], it is also important to carefully consider whether market conditions (presumably outside the firm’s control) have led to the emphasis on speeding new products to market (and the associated focus on incremental improvements), or has the wide-

---

\(^6\) It is interesting to note that this is not really a new strategy. In June 1955, Grey Advertising’s newsletter stated “…the stream of new products and new variations of old products which is being forced down the consumer’s throat is so swollen that there is great danger of indigestion…” [3].
spread attention placed on speeding up the development process (and the mandated corporate objectives of cycle time reduction, BET, increasing the percentage of sales due to "new" products, etc.) led to a proliferation of products with low performance levels, short lifetimes, and sharply declining prices. Since the model structure analyzed in this article only considers a product with a single technology generation, future research might study the normative decisions associated with technology platforms and product lines.

According to the analysis in this article, there are at least two ways to break away from this "dark side" of speed by concentrating on the fast development of products with high performance levels. Identifying large markets that desire products with high performance levels (and thus can support the increased expenditures required to accelerate their development) is one way. Of course, this means increased effort and attention should be given to understanding the needs and wants of customers. In fact, this is the same general recommendation given by Stalk and Webber [63] in their discussion of the third stage of time-based competition. Thus, more analytical and empirical research on the effects of demand uncertainty on product development decisions is needed.

A second way to break away from the competitive pack is to better understand the development time-cost trade-off. The analysis in this article suggests that the shape of a firm's development time-cost curve influences the optimal development time and product performance level (i.e., reducing the maximum costs to crash a project makes higher performance products more desirable; reducing the minimum cost time-to-market makes a faster development time more desirable). It is generally assumed that all the proposed techniques and approaches for speeding up the development process (e.g., isolated facility/skunk works, multifunctional teams, concurrent engineering, Quality Function Deployment, Design for Manufacturing and Assembly, Computer Assisted Design, Computer Simulated Testing) actually lower costs. However, research to date has not examined the direct effects of these techniques on development costs [34]. In fact, very little empirical research has considered a firm's development cost function [26]. In particular, the analysis here implies that a firm should implement the techniques/approaches that "flatten" their development time-cost curve (see Figure 3). But which techniques lower development costs, and more importantly, which approaches shift the development time-cost curve appropriately? This would seem to be an area for future empirical research that has great potential payoffs.

The financial support of the CATO Center for Applied Business Research (formerly the Kenan Institute's Center for Manufacturing Excellence) is gratefully acknowledged. The comments of Tom Hustad and the anonymous reviewers also helped to improve the exposition of this article.

References


47. O’Donnell, C. Comments during a panel discussion at the University of North Carolina’s Center for Manufacturing Excellence forum *Speed to Market: The Good, the Bad and the Ugly.* (1994).


Appendix A

The basic model structure for this case comes from Figure 2, with $a = t_c$ and $t_c \leq \Delta^* \leq \tau + t_c$. Based on an extensive empirical literature, market share is modeled as (see [16] for a review):

$$s(Q, Q_c) = \frac{\gamma Q}{\gamma Q + Q_c}$$

where $\gamma = \text{your "marketing" advantage over the competitor (e.g., if } Q = Q_c, \gamma > 1 \text{ means that you will obtain a market share greater than 0.5; } \gamma = 1 \text{ represents the case of symmetric competitors). This "attraction" model formulation is related to the widely used logit model (via a log-transformation) that was developed in discrete choice theory [40].}

For a development time of $\Delta$ and a product performance level of $Q$, your gross profits are

$$\pi_{\text{catch}} = \left[ \int_{\Delta}^{\tau+t_c} \rho(t-t_c)m e^{-et} dt + \int_{\tau+t_c}^{T+t_c} \rho \pi m e^{-et} dt \right] s(Q, Q_c)$$

(A1)

Integrating, (A1) becomes

$$\pi_{\text{catch}} = \left[ \frac{1}{e^t(e^{-e\Delta} - e^{-e(\tau + t_c)})} + \frac{1}{e}((\Delta - t_c)e^{-e\Delta} - \tau e^{-e(T + t_c)}) \right] \rho m s(Q, Q_c)$$

(A2)

To determine your optimal product development time ($\Delta^*$) and optimal product performance level ($Q^*$), net profits are maximized:

$$\text{MAX}_{Q,\Delta} \Omega_{\text{catch}} = [\pi_{\text{catch}}(Q, \Delta) - c(Q, \Delta)]$$

(A3)

The objective function (A3) is analyzed by applying standard calculus methods. After simplification, first- and second-order conditions result in the following system of two equations:

$$\Delta^* = \frac{\beta(Q^* + Q_c) - \rho \gamma m e^{-e\Delta^*}}{2(Q^* + Q_c) + \rho \gamma m e^{-e\Delta^*}}$$

(A4)

$$\rho \left[ \frac{1}{e^t(e^{-e\Delta^*} - e^{-e(\tau + t_c)})} + \frac{1}{e}((\Delta^* - t_c)e^{-e\Delta^*} - \tau e^{-e(T + t_c)}) \right] \frac{\gamma Q_c}{(\gamma Q^* + Q_c)^2} - \alpha + \beta \Delta^* - (\Delta^*)^2 = 0$$

(A5)

Note that $\Delta^*$ is a function of $Q^*$, and thus the optimal development time considered jointly with the product performance level decision will generally not be equal to the development time calculated from a problem with $Q$ fixed exogenously (e.g., as in [15]).
Appendix B

The decision of whether to beat a competitor to market requires a comparison of the returns for two possible strategies: (1) optimal profits (less development costs) associated with a “first-to-market” strategy, and (2) optimal profits (less development costs) associated with a “follower” strategy. Returns from the second strategy can be calculated using the model in Appendix A with \( t_c \) not equal to zero. Thus, a model for the first-to-market strategy must be formulated. The market, demand, and cost conditions under which beating a competitor to market is optimal can then be identified by comparing the two strategies.

The basic model structure for a first-to-market strategy is similar to the model in the previous section, and therefore the same notation is used. In Figure 2, \( a = \Delta \) (your product introduction time) and \( \Delta \leq t \leq \tau + \Delta \).

Gross profits (less development costs) for this strategy can be calculated as your share of the area under the industry demand curve. For a development time of \( \Delta \) and a product performance level of \( Q \), your gross profits are

\[
\pi_{1st} = \int_0^{t_c} \rho(t - \Delta)m e^{-\epsilon t} dt + \int_{t_c}^{\tau + \Delta} \rho(t - \Delta)e^{-\epsilon t} dt + \int_{\tau + \Delta}^{\rho \tau} \rho e^{-\epsilon t} dt m s(Q, Q_c) \tag{B1}
\]

Integrating, (B1) becomes

\[
\pi_{1st} = \left[ \frac{1}{\epsilon^2}(e^{-\epsilon \Delta} - e^{-\epsilon t_c}) + \frac{1}{\epsilon}(\Delta - t_c)e^{-\epsilon t_c} \right] \rho m + \left[ \frac{1}{\epsilon^2}(e^{-\epsilon t_c} - e^{-\epsilon(\tau + \Delta)}) + \frac{1}{\epsilon}(t_c - \Delta)e^{-\epsilon t_c} - \tau e^{-\epsilon(\tau + \Delta)} \right] \rho m s(Q, Q_c) \tag{B2}
\]

Your optimal product development time (\( \Delta^{**} \)) and optimal product performance level (\( Q^{**} \)) under this “first-to-market” strategy are found by maximizing net profits:

\[
\text{MAX}_{\Delta, \Omega} \Omega_{1st} = [\pi_{1st}(Q, \Delta) - c(Q, \Delta)] \tag{B3}
\]

The objective function (B3) is analyzed by examining the first- and second-order conditions. After simplification, the following system of two equations is obtained:

\[
\frac{\rho m}{\epsilon} \left[ e^{-\epsilon t_c} - e^{-\epsilon \Delta^{**}} \right] + \frac{\rho m}{\epsilon} \left[ e^{-\epsilon(\tau + \Delta^{**})} - e^{-\epsilon t_c} + \tau e^{-\epsilon(\tau + \Delta^{**})} \right] \frac{\gamma Q^{**}}{\gamma Q^{**} + Q_c} - 2\Delta^{**} + \beta Q^{**} = 0 \tag{B4}
\]

\[
\rho m \left[ \frac{1}{\epsilon^2}(e^{-\epsilon t_c} - e^{-\epsilon(\tau + \Delta^{**})}) + \frac{1}{\epsilon}(t_c - \Delta^{**})e^{-\epsilon t_c} - \tau e^{-\epsilon(\tau + \Delta^{**})} \right] \left( \frac{\gamma Q_c}{(\gamma Q^{**} + Q_c)^2} - \alpha + \beta \Delta^{**} - (\Delta^{**})^2 \right) = 0 \tag{B5}
\]

Finally, the first-to-market decision can be made by comparing (A3) and (B3): if \( \Omega_{1st} \geq \Omega_{catch} \) then it is optimal to accelerate your product development process to beat the competition to market; otherwise it is optimal to follow the competitor.