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The Dynamics of Innovation

Strategic and Managerial Implications

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Concurrent development and product innovations

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1. Introduction

Concurrent development, or simultaneously executing multiple stages of the product development process, is regarded by many as an efficient and effective method for increasing the speed of innovation (see Figure 1) while also providing a means for containing development costs and improving the quality of the end product (Gilbert 1995; Zairi, Youssef 1995). It has also been referred to as parallel versus linear processing of tasks (Millson et al. 1992), coordinating efforts rather than "throwing the product over the wall" from one stage to another (Brown, Karagozoglu 1993), and as a "rugby" method of constant, multi-disciplinary team interplay rather than a "relay race" method of phase-to-phase progression with functionally specialized and segmented divisions (Smith, Reinertsen 1991; Souder, Chakrabarti 1980; Takeuchi, Nonaka 1986). Consistently, the Institute for Defense Analysis (Handfield 1994) refers to concurrent development "as a systematic approach to the integrated concurrent design of products and related processes including manufacture and support ... [which] causes the developers, from the outset, to consider all the elements of product life-cycle from conception through disposal including quality, cost, schedule, and user requirements."

However, alternative arguments exist in the literature which posit negative effects of concurrent development on these performance dimensions, for instance due to reduced control over the process. For example, concurrent development might drive up costs due to the need to create and maintain more complex communication networks (Graves 1989). Additionally, concurrent development might lower

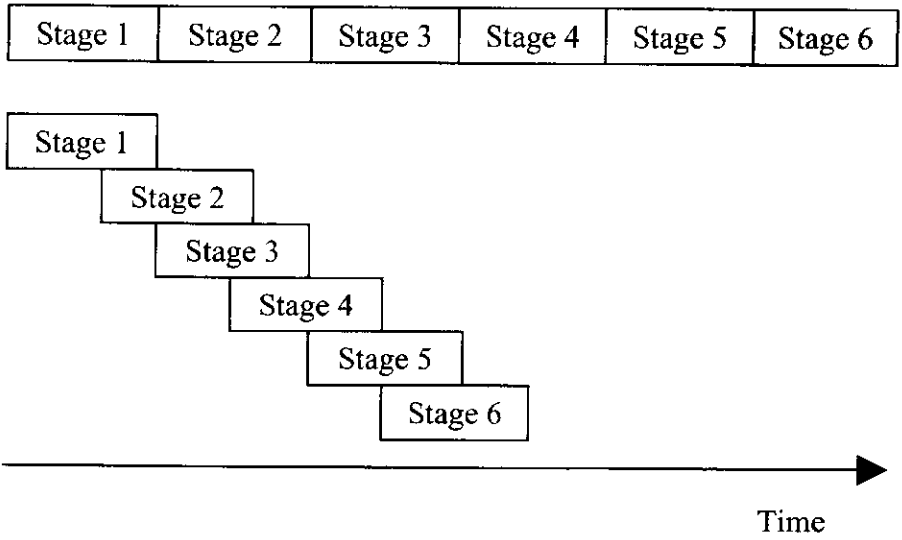

Figure 1: Contrast between non-overlapping (sequential) and overlapping (parallel) product development processes plotted against time of development

product quality because the extra pressure put on workers may cause more mistakes and allow for insufficient time to adapt to the market (Crawford 1992; Handfield 1994). To date, it is unclear which of these perspectives is correct, for the empirical evidence regarding outcomes of concurrent development is inconclusive (Handfield 1994). Thus the research questions we address are threefold:

(1) How does concurrent development influence process speed?

(2) How does concurrent development influence development costs?

(3) How does concurrent development influence product quality?

2. Hypotheses

The conceptual mode illustrated in Figure 2 is used as a basis for empirically testing the three research questions. Given the exploratory nature of the research, hypotheses will adopt the falsifiable assumption that concurrent development has generally positive effects on speed, quality, and costs. That is, they assume that there are no trade-offs between the three dimensions of product development.

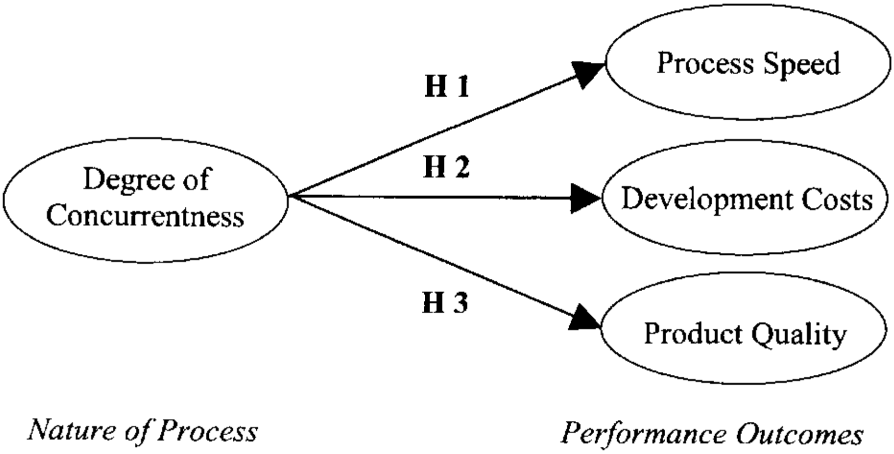

Figure 2: Conceptual model of performance outcomes of concurrent development

2.1 Concurrent development and speed

Concurrent engineering, by allowing the different tasks of the product development process to be carried out simultaneously rather than sequentially, allows developers to consider all the elements of product life-cycle from conception through market launch (Gilbert 1995; Izuchukwe 1992; Kessler, Chakrabarti 1996; Zairi, Youssef 1995). It is thus considered one of the most effective facilitators of innovation speed. This is evidenced by empirical research in the new product development literature (e.g., Terwiesch, Loch 1998) as well as observations in the logistics and operations management literature describing developers' use of computer programs to identify the contribution of overlapping activities to reducing critical paths and slack times (Zhu, Heady 1994). Conversely, a lack of overlap can waste time by forcing downstream tasks to wait for previous stages to be completed in their entirety, thereby lengthening the critical path of projects. It also limits the communications between functions, increasing the number of time-consuming design changes in the production phase of product introductions (Deschamps, Nayak 1992; Vesey 1991). This is because information is communicated in periodic "batches" (versus continuously), necessitating longer time periods to assimilate the information (Blackburn 1992; Clark, Fujimoto 1991; Rosenthal 1992). Thus we propose the following:

HYPOTHESIS 1:
A greater degree of concurrent development will be related to faster new product development.

2.2 Concurrent development and costs

Concurrent engineering seeks to optimize the design and manufacturing process to reduce cost by the integration of activities and parallelism in work practices (Zairi, Youssef 1995). In this sense, it can be viewed as a means toward design efficiency (Reed et al. 1996). Parallel processes can reduce overall development time, thereby helping to cap man-hours (Rosenthal 1992), increase the efficiency of resource utilization (Clark 1989), and reduce costly work redundancy, errors, and recycling (Meyer 1993; Rosenau 1988). Indeed, evidence from the Ford Taurus development project supports the cost-saving potential of concurrent engineering (Gilbert 1995). Moreover, combining concurrent engineering processes with in-process design controls and computer and information technology was recently shown to significantly reduced the costs of product development (Hull et al. 1996). Thus we propose the following:

HYPOTHESIS 2:
A greater degree of concurrent development will be related to lower new product development costs.

2.3 Concurrent development and quality

Concurrent development can also help in increasing the quality of the end product developed, defined as the degree to which it satisfies customer requirement (Clark, Fujimoto 1991). This is because the integration of activities and parallelism in work practices which come from concurrent development tend to facilitate higher rates of communication, learning, and problem solving among project team members (Ancona, Caldwell 1990; Eisenhardt, Tabrizi 1995; Meyer 1993). A more compact process may also improve forecasting and market-fit, primarily because firms are required to project competitor movements, developments in technologies, and demographic trends into shorter time periods (Deschamps, Nayak 1992; Page 1993; Wheelwright, Clark 1992). Indeed, concurrent engineering is considered a key component of an integrated total quality management (TQM) program (Reed et al. 1996). Thus we propose the following:

> **HYPOTHESIS 3:**
> A greater degree of concurrent development will be related to higher quality of the new product developed.

3. Methodology

3.1 Sample

Selection of the research sample is motivated by the objective of being able to generalize the findings of this study beyond (a) the idiosyncratic nature of undeveloped, unconventional product development programs and instead across organizational boundaries, and, (b) the idiosyncratic nature of one or two task/institutional environments and instead across industry boundaries. As a result, the sample consists of large (greater than $50 million in sales) U.S.-based companies in several industries. Large firms were chosen because they are more likely to have established new product development programs as opposed to smaller firms with more idiosyncratic programs. Firms in different industries were chosen because they provided access to a range of environments where product innovation is pursued and hence allowed the study to more broadly examine the implications of concurrent development.

Given these criteria, company names were assembled in a systematic manner following the site selection algorithm developed by Souder and Chakrabarti (1980). Thirty (30) companies were chosen which met the criteria of the study and were headquartered locally, which was a practical research constraint (e.g., travel resources). Site entry letters were sent to the chief executive officer (CEO) or top research and development executive (e.g., VP, R&D) of these firms to provide a general overview of the study, explain the nature of the commitment requested, describe the study's confidentiality policy, and detail the benefits of participation. Two to three weeks later, direct telephone calls were made to these individuals to answer any questions they had about the study and arrange a mutually convenient time for an onsite interview (to secure commitment).

Ultimately, this procedure resulted in ten companies agreeing to participate in the study. The participating companies operated in a variety of industries and had an average of 89,662 employees and an average of $16,014.36 million in sales. Because a variety of industries were sampled, findings are more generalizable than single-industry studies and indicate more general principles of concurrent development which apply across several product types and industrial environments.

The unit of analysis was the new product development project, defined as "a goal directed effort with a readily-identified end in view" (Rubenstein et al. 1976). This enabled us to capture the multiple attributes of actual projects. A total of 86 projects were selected from the ten firms; of this population, questionnaires representing 75 projects were returned (87% response rate). Multiple respondents were polled from each project to increase the validity and reliability of their reports (Kumar et al. 1993). A total of 205 individuals from the 86 projects were identified as potential respondents; of this population, 127 surveys were returned (62% response rate).

3.2 Measures

The four primary variables in the study are concurrent development (i.e., project overlap), innovation speed, development costs, and product quality. They were operationalized in the following manner.

Concurrent Development. The degree to which stages of the development processes were undertaken in parallel was calculated as the sum of the time in months of the stages of the product development project divided by the total product development time. The stages, adopted from Eisenhardt and Tabrizi (1995) are:

(a) Pre-development/planning, which begins with the start of the project and ends with the completion of basic product requirements;

(b) Conceptual design, which begins with the basic concepts and ends with final specifications of the product;

(c) Product design, which begins with the engineering work to take the specifications to a fully designed product and ends with final release to system test;

(d) Testing: begins with component and system test and ends with the release of the product to production;

(e) Process development, which begins with the first process design and ends at the completion of the first pilot run; and

(f) Production start-up: begins with production ramp-up and ends with the stabilization of production.

For example, if the project was undertaken sequentially, the sum of the stage times would equal the total time. Alternatively, if the project was undertaken in parallel (i.e., two or more stages overlapped), the sum of the stage times would be greater than the total time. A higher score indicates a higher degree of project overlap.

Innovation Speed. Speed was operationalized through three relative measures:

(a) speed relative to schedule, or on-time performance (McDonough 1993; Mc Donough, Barczak 1991),

(b) speed relative to similar, previously completed projects in one's organization, or acceleration (Crawford 1992; Millson et al. 1992; Nijssen et al. 1995), and

(c) speed relative to similar projects of competitors, or competitive speed (Birnbaum-More 1990; Vesey 1991).

For each scale, respondents were asked to check off one of 13 boxes describing projects as relatively faster, slower, or equal in speed to schedules, past projects, or competitor projects. The three scales had a moderate degree of internal reliability (a = .6824). When the scales were subjected to principle component factor analysis, they all loaded onto one factor with eigenvalues equal to or greater than one. Thus a weighted aggregate innovation speed variable was derived ranging from one (lowest time / fastest speed) to thirteen (highest time / slowest speed).

Development Costs. Development cost was also measured in three ways, which mirrored the measurement of innovation speed. A project's cost relative to its budget was measured relative to

(a) budget,

(b) similar past projects, and

(c) similar competitor projects.

For each scale, respondents were asked to check off one of 13 boxes describing projects as relatively less expensive, more expensive, or equal in cost to schedules, past projects, or competitor projects. The three scales had a moderate degree of internal reliability (a = .6173). When the scales were subjected to principle component factor analysis, they all loaded onto one factor with eigenvalues equal to or greater than one. Thus a weighted aggregate development cost variable was derived ranging from one (lowest cost) to thirteen (highest cost).

Product Quality. Product quality was also measured in three different ways, again mirroring the measurement of innovation speed. Quality was measured relative to

(a) preset performance specifications,
(b) similar past projects, and
(c) similar competitor projects.

For each scale, respondents were asked to check off one of 13 boxes describing projects as relatively higher quality, lower quality, or equal in quality to schedules, past projects, or competitor projects. The three scales had a moderate-to-high degree of internal reliability (a = .7825). When the scales were subjected to principal component factor analysis, they all loaded onto one factor with eigenvalues equal to or greater than one. Thus a weighted aggregate product quality variable was derived ranging from one (lowest quality) to thirteen (highest quality).

3.3 Analysis

We sought to answer the research questions in two ways. First, and most simply, by testing how important concurrent development is when used alone to predict cost, quality, and speed. The answer to this question is gained by looking at correlation coefficients (SPSS 1994). Thus, bi-variate correlation coefficients were calculated for concurrent development and each of the dependent variables - cost, quality, and speed.

Second, and perhaps more realistically, we tested how well concurrent development predicts cost, quality, and speed when considered along with other relevant independent variables in the innovation process[1]. The answer to this question is gained by looking at regression equations (SPSS 1994). This answer is more complex, however, because any statement about concurrent development is contingent upon the other variables considered in the model. Thus,

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[1] We used the model of innovation antecedents developed by Kessler and Chakrabarti (1996) to motivate variable selection. See Table 3 for a complete list of independent variables in the empirical model.

for each of the dependent variables, an automatic search procedure (or stepping procedure) was used to develop a best (or parsimonious) subset of independent variables to be included in the regression model (Neter et al. 1990). There are several, largely similar analytical approaches to the task of sequentially analyzing all antecedent factors while adjusting for the affects of one another on innovation speed. SPSS (1994) reports that none of these selection procedures are best in any absolute sense. Instead, the choice between approaches should be made on the basis of the objectives of the analysis.

Because we desired to test the influence of the independent variables while simultaneously controlling for the others, backward-elimination was chosen - backward-elimination regression analysis allows the researcher to examine each independent variable in the regression function adjusted for all the other independent variables in the pool (Neter et al. 1990). Specifically, backward-elimination of independent variables starts with all the variables in the equation (as opposed to forward-selection and stepwise-selection, which add variables one at a time) and sequentially removes them. The removal criteria used are probability of F-to-remove (POUT). The POUT procedure removes variables from the regression equation sequentially, beginning with the variable with the highest p-value, and continues to recompute the regression equation and remove variables until all remaining variables have a p-value of less than 0.10 (SPSS default criterion). The final equation represents the parsimonious (or best) regression model.

4. Results

Table 1 reports the descriptive statistics for concurrent development, speed, costs, and quality. Results revealed that all variables had generally broad ranges and central means. Further, tests revealed low degrees of kurtosis (i.e., spiking) and skewness (i.e., imbalance) in their distributions which suggest that there is no significant threat to the assumption of normality.

Table 2 reports the results from bi-variate correlations. Results revealed that, by itself, concurrent development is a poor predictor of cost and quality and only a marginal predictor of speed ($p<.10$).

Variable	Scale	Mean	SD	Max	Min
Concurrent Development	Ratio	2.08	0.79	4.00	1.00
Speed	1-13	5.35	1.39	9.45	2.59
Costs	1-13	6.06	1.21	8.70	2.64
Quality	1-13	7.30	1.38	10.65	4.34

Table 1: Descriptive statistics for concurrent development, costs, quality, and speed

Dependent Variable	r	Sig r
1. Speed	.2437	p< .10
2. Costs	.1102	ns.
3. Quality	-.1222	ns.

Table 2: Bi-variate correlations of concurrent development with costs, quality and speed

Table 3 reports the results for the three backward-elimination regression procedures examining the effects of several potential antecedents on each of these dimensions. Results revealed that

(a) concurrent development was a significant factor in all three parsimonious models, and

(b) concurrent development had *mixed* effects on product innovation outcomes - a higher degree of concurrentness was found to increase process speed ($p<.01$), but it also tended to increase development costs ($p<.01$) and decrease product quality ($p<.05$).

Dependent Variable	B	SE B	Beta (β)	T	Sig T
1. Speed Full Model F = 6.00 ($p<.001$) Full Model $R^2 = 0.44$	1.066	0.295	0.601	3.581	>.001
2. Cost Full Model F = 3.90 ($p<.001$) Full Model $R^2 = 0.61$	0.998	0.284	0.650	3.507	.001
3. Quality Full Model F = 3.81 ($p<.01$) Full Model $R^2 = 0.38$	-0.489	0.230	-0.281	-2.130	.039

Table 3: Effect of concurrent development on costs, quality, and speed taken from three separate backward-elimination regression analyses

Table 4 reports the correlations between concurrent development and the other independent variables inputted into the backward-elimination regression procedures. Results revealed that concurrent development was associated with

(1) greater emphasis placed on speed (versus costs or quality) by top management ($p<.05$),
(2) greater reward system orientation for speed ($p<.10$),
(3) lower clarity (i.e., more ambiguity) surrounding the project goals ($p<.01$),
(4) lower clarity (i.e., more ambiguity) surrounding the product concept ($p<.05$),
(5) more radical innovations ($p<.10$),
(6) lower project member tenure ($p<.01$),
(7) lower authority (i.e., less empowerment) of project teams ($p<.05$),
(8) greater turfguarding ($p<.05$),
(9) greater frequency of testing ($p<.01$), and
(10) lower use of CAD systems ($p<.01$).

	Strategic Orientation - Criteria	
1	Importance of Speed	.2714 *
2	Reward for Speed	.2263 ♈
3	Culture Orientation	-.0568
4	Time-Goal Clarity	-.3734 **
5	Product-Concept Clarity	-.2969 *
6	Top Management Interest in Project	-.2085
	Strategic Orientation - Scope	
7	Project Stream Breadth	.1134
8	Product Radicalness	.2343 ♈
9	External Sourcing of Ideas / Technologies	-.1694
	Organizational Capability - Staffing	
10	Product Champion Presence	-.0163
11	Product Champion Influence	-.1728
12	Project Leaders Position	-.1083
13	Project Leaders Power	-.1924
14	Project Leaders Tenure	-.1596
15	Project Leaders Involvement	-.0101
16	Project Members Education	-.1255
17	Project Members Experience	.0137
18	Project Members Tenure	-.3799 **
19	Project Members Involvement	-.0682
20	Representativeness of Interest Groups	-.0336
	Organizational Capability - Structure	
21	Team Autonomy	-.3046 *
22	Concurrent Development	--------
23	Turf-Guarding	.3087 *
24	Design-For-Manufacturability	.0952
25	Team Proximity	-.1446
26	Milestone Frequency	.0556
27	Testing Frequency	.6508 **
28	Use of CAD Systems	-.4215 **

♈ = $p<.10$
* = $p<.05$
** = $p<.01$

Table 4: List of antecedent factors inputted into the backward-elimination regression procedures and zero-order correlations with concurrent development

5. Discussion

By itself, concurrent development is a non-predictor of cost and quality and a marginal predictor of speed. However, when viewed in the context of other variables active in the innovation process (e.g., strategy, goals, leaders, team proximity, milestones, etc.), concurrent development predicts all three dependent variables at statistically significant levels. These effects, however, are contingent on the other independent variables in the regression equation and are also affected by the correlations of the independent variables (SPSS 1994). They may also suggest the existence of moderated (Baron, Kenny 1986) effects. Thus, these findings provide a more complex, albeit messier answer to the research questions but perhaps a more accurate one.

The comparison of backward-elimination regression models produced several interesting observations. First, it was found that a greater degree of concurrent development *in*creased the speed (i.e., *de*creased the time) of the new product development process ($p<.001$). The beta coefficient for concurrent development ($\beta=.601$) was the highest of the six variables selected for the final regression model, suggesting that its relative importance in predicting speed is high.

Indeed, this finding is consistent with the experiences of many firms experimenting with overlapping activities. Izuchukwe (1992) reports that concurrent engineering practices helped Xerox reduce its time-to-market for new copiers 50 percent, AT&T reduce its time-to-market for a new microprogrammed digital switch by over 40 percent, Boeing reduce its cycle time 40 to 60 percent, and John Deere reduce its new product development time for construction equipment by 60 percent. Hull, Collins, and Likers (1996) report that, when combined with other variables such as design controls and information technology, concurrent engineering processes significantly reduced the time of product development in a research sample of 74 companies. Gilbert (1995) also reports that evidence from the Ford Taurus development project supports the time-saving potential of concurrent engineering.

Second, it was found that a greater degree of concurrent development *in*creased the cost of the new product development process ($p<.01$). The beta coefficient for concurrent development ($\beta=.650$)

was the highest of the eleven variables selected for the final regression model, suggesting that its relative importance in predicting costs is high.

This finding is contrary to Hypothesis 2 insofar as it is consistent with the notion that there is a trade-off in using concurrent development between speed and costs. That is, overlapping activities might speed up the process but it also might cost more to execute (Crawford 1992). Graves (1989) offers four possible explains for this trade-off. First, when steps are overlapped, each task is begun with less information. This results in mistakes and rework, for example on the Xerox 1045 copier project. The greater the overlap, the more tasks are initiated under uncertainty and the greater the subsequent cost penalties. Second, with greater overlap, communication burdens increase and, because of the increased cost of maintaining the more complex communication networks, marginal productivity declines. Third, with greater overlap, there is greater redundancy. That is, more approaches to tasks are undertaken at once, increasing the chances that some will be paid for yet be unsuccessful. Conversely, with more sequential development, the financial risks of failed tasks are limited insofar as only those approaches are tried which precede the discovery of one, which is successful. Fourth, with greater overlap, the network of tasks being completed at any one time becomes increasingly dense. Thus, each successive attempt at further overlap requires the adaptation of a cumulatively greater number of tasks, driving total project costs up.

The opposite effects of concurrent development on speed and on costs may also be explained by examining the relationship between time and money. Several authors (Gupta et al. 1992; Murmann 1994; Vincent 1989) argue that relationship resembles a U-shaped function, in which accelerating development reduces costs up to a point; after that point more expenditures are required to shorten the time to bring products to market (see Figure 3). Shortening development time below the function's minimum (i.e., moving up the "U" to its left) increases costs because of additional coordination expenditures, thereby burning resources because it pushes functions to the limit of organizational capabilities (Vincent, 1989). Alternatively, lengthening development time above the function's minimum (i.e., moving up the "U" to its right) increases costs because of lost learning, reduced motivation, and higher variable expenditures, thereby wasting resources due to dissipated efforts and lapses of attention.

Thus, when firms create an "overly" speedy process through overlapping activities, costs are likely to increase.

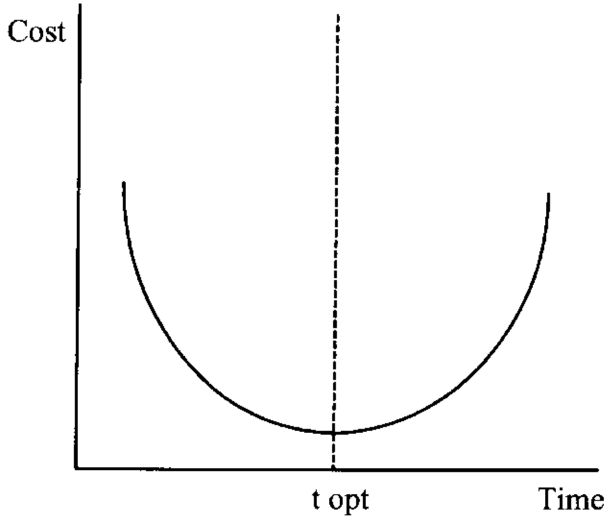

Figure 3: Trade-off between time and money in the new product development process

Moreover, it might be the case that this speed-cost trade-off will be steeper under certain conditions (Graves 1989). One, when there is greater uncertainty in innovation projects (i.e., they are more radical) because greater uncertainty leads to more severe information gaps. Two, with larger firms because of the greater planning and coordination costs involved in overlapping projects. Three, with less experienced firms because they are more likely to make costly mistakes in an accelerated process. Four, with larger projects because there is a denser network of tasks subject to greater compression costs. Thus, when these conditions exist, it might be especially unwise to overlap processes from a cost perspective.

Third, it was found that a greater degree of concurrent development *de*creased the quality of the end product ($p<.05$). The beta coefficient for concurrent development ($\beta = -.281$) was the fourth highest (or fourth lowest) of the seven variables selected for the final regression model, suggesting that its relative importance in predicting quality is moderate. This result is contrary to the prediction of Hypothesis 3. Instead, it reinforces the argument that concurrent development, along with similar techniques designed to speed up innovation processes and cut the time it takes to bring a new product to market, may result in more mistakes (i.e., lower quality). This is because, in many cases, concurrent development allows for insufficient time to adapt already commenced stages to the results of market and beta tests (Crawford 1992). These effects of concurrent engineering may be especially detrimental to the quality of radical innovations (i.e., those involving a greater departure from the status quo), which require more information and learning as well as greater care in execution. Indeed, Handfield (1994) found that concurrent development increased the percentage of defects for breakthrough innovations.

Additionally, this finding is consistent with previously cited research which suggests concurrent development is but *one* component of an integrated total quality management (TQM) program primarily, and it is primarily concerned with process issues and the nature of production (Reed et al. 1996). This is in contrast to other components of TQM concerned with market outcome, or the attraction and retention of customers by satisfying their needs better than rival organizations (i.e., quality).

It is also important to understand that concurrent engineering is generally intended for relatively predictable project environments. In turbulent environments, this practice lacks the ability to gather and rapidly respond to new knowledge as the project evolves. Thus Iansiti (1995) proposes that a flexible approach, in which proactive management increases adaptation capabilities, goes beyond traditional concurrent engineering. That is, concurrent engineering implies the joint participation of different functional groups (i.e., joint problem solving) but not necessarily the simultaneous, reciprocal execution of conceptualization and implementation. As a result, concurrent engineering is not (and should not be) intended to react to technological, demographic, and competitive turbulence in the environment. In other words, concurrent engineering may help execute projects quickly (i.e., speed) but not necessarily help projects adapt to the changing environment in line with user demands (i.e., quality).

Overall, concurrent development was only found to predict speed, costs, and quality when viewed within the context of other variables active in new product innovation. Correlations helped to reveal some of the interrelationships underlying this observation. For example, concurrency was associated with greater emphasis placed on speed (versus costs or quality) by top management and a greater reward system orientation for speed. When top management put speed ahead of quality or costs, concurrent development tended to be adopted more frequently. When rewards were dispersed based on speed-based criteria, concurrent processes tended to reflect this direction. This can be seen to reinforce the notion that concurrent development was primarily used as a tool for speed. In a word, firms got precisely what they emphasized and what they rewarded.

Concurrency was associated with lower clarity (i.e., greater ambiguity) surrounding both the project goals and the product concept. These findings are consistent with the idea that overlapping activities greater degrees of concurrent development tends to make processes more fluent and dynamic, and that it also tends to make issues less clear-cut. Therefore, concurrent development might afford development personnel greater flexibility in their activities but at the sacrifice of lower standardization and less control.

Concurrency was associated with more radical innovations. This is consistent with the idea that frame-breaking changes need to be fast to hit the market first to secure pioneering advantages. Alternatively, more incremental changes adapt already accepted standards and to improve on them in some way (e.g., performance-enhancement or price-reduction), thereby necessitating a lesser need for speed. This suggests that use of concurrent development can be thought of as a strategic issue which needs to be fit to the type of product produced as well as the nature of the market engagement.

Concurrency was associated with lower project member tenure. That is, newer project team members were likely to be involved with overlapped processes whereas members who were relatively more entrenched in their organizations tended to be associated with more traditional processes. This is somewhat intuitive insofar as outsiders are typically more receptive to change than insiders. Consequently, this finding may reflect underlying issues related to human-resource management (e.g., people are matched to processes) or socio-political dynamics (e.g., people determine processes based upon personal factors).

Concurrency was associated with lower authority (i.e., less empowerment) of project teams. In other words, the greater the degree of process overlap, the less power was given to teams and the more power was retained by top management. This could be because concurrent processes need greater coordination and oversight than linear, structured processes. Thus, concurrent development may actually remove decision-making responsibility from the team charged with developing the new product. Of course, it could be the case that this finding reveals a poor (versus inevitable) practice.

Perhaps the results would have been different if concurrent development was combined with empowerment. This suggests that there may be better and worse ways of overlapping activities.

Concurrency was associated with greater turfguarding. That is, the greater the degree of overlap, the more project team members tended to experience functional-area based conflicts and hold fast to department norms and objectives. This "description" of practices is contrary to "prescriptive" arguments and again raises the issue of whether there are better and worse ways to overlap activities. To reap the full benefits of interaction and communication, which come with concurrent development, one may be to reduce the perceived threat of overlap and get people to work together productively. The underlying assumption of this threat-based argument is emotional, whereas the reduction of boundaries and specialized domains of activities may cause project members' defenses to rise and guard their turf as to protect any remaining autonomy, power, identity, and the like. As a result, potential synergies from concurrent development may be reduced.

Concurrent development of products was found to be associated with increased frequency of testing. This means that a greater frequency of testing is required in projects under overlapped processes. Since concurrent development does not follow a linear model, one cannot depend on a few tests at the completion of major milestones in the project. In fact, there are many simultaneous discrete paths to be followed for the product development process. This necessitates testing at the completion of each parallel phase or path. Of course, this adds to the costs of the project.

Finally, we observed that concurrent development projects made less use of CAD (computer aided design) systems. Apparently this may seem to be somewhat surprising. Our explanation is that concurrent development processes involve less formal and discrete transfer of information among the various groups of functional organizations. Since the work of the various groups is very much interdependent, use of CAD systems becomes less important. This may also confirm the view that concurrent development has some inefficient practices embedded in it (Hull et al. 1996). Nevertheless, it raises important questions regarding the efficiencies of alternative communication structures and the positive or negative synergies that arise from the combination of multiple project management techniques.

6. Concluding comments

The mixed results from the regression analyses imply that firms adopt more objective views of concurrent development that consider its potential benefits (e.g., speed) as well as its potential liabilities or trade-offs (e.g., costs and quality). The findings also suggest the question of whether there are better and worse ways of developing projects concurrently. For example, combining concurrent development with a strong emphasis on speed by top management or a narrow silo-orientations among functional areas may produce results quite different than if concurrent development was combined with clear product concepts or strong champion involvement.

Consequently, these results suggest that R&D managers refrain from shotgun approaches to concurrent development and instead, with potential trade-offs in mind, match their development strategy (i.e., whether to use concurrent development and how to use concurrent development) to their project objectives. Thus, concurrent development does not appear to be a panacea and should instead be viewed as a management technique having complex consequences. *Simply, there may be trade-offs in using concurrent practices (i.e., faster speed but higher costs and lower quality) and these trade-offs may be a function of how concurrent development is used (i.e., in combination with what other development techniques).*

It is important to keep in mind that the strength of these implications are conditioned by the low correlations between concurrent development and project outcomes. Thus future research and analysis needs to investigate the complex connections between concurrent development and project outcomes. For example, radicalness may moderate the relationship between concurrent development and speed (Kessler, Chakrabarti 1998). Moreover, these are only suggestions borne from one study of large, U.S.-based firms considering product innovations. Future research considering firms of different sizes, firms in different national contexts, and innovations of different types (e.g., process) (Gopalakrishnan et al. 1998) is needed to clarify important boundary conditions and the subsequent generalizability of the findings.