DETERMINANTS OF IT USAGE AND NEW PRODUCT PERFORMANCE

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ABSTRACT

Explosive growth of information technologies (IT) has prompted interest in examining the role of IT in new product development (NPD). Through desk-top software and web-based tools, IT has been used to aid idea generation and product testing as well as for NPD activities such as process and portfolio management. Recent research suggests, however, that a gap exists between IT availability and usage. Given the importance of IT in creating business value through the development of new products and services, this study seeks to identify factors that affect IT usage. Further, anecdotal evidence and conceptual studies intimate that the usage of IT tools for NPD can shorten time to market, improve product quality, and increase productivity. However, empirical substantiation of this impact is mostly non-existent. The current study investigates the relationship between IT usage and two measures of new product performance, speed to market and market performance.

Employing a mail survey methodology, our study uses data from a sample of practitioner members from the Product Development & Management Association (PDMA) to examine the effect of project risk, existence of a champion, autonomy, innovative climate, IT infrastructure, and IT embeddedness on the extent of IT usage. This data is also used to explore the impact of IT usage on speed to market and market performance.

The results indicate that project risk, existence of a champion, and IT embeddedness positively affect the extent of IT usage for NPD. Additionally, IT usage positively and significantly influences the performance of the new product in the market place. Surprisingly, and contrary to popular belief, IT usage does not have any impact on speed to market.

An important implication of our study is that IT usage influences performance but not in the way managers expect. Specifically, IT usage does not seem to affect speed to market but rather positively impacts the performance of the new product in the marketplace. This result suggests that IT usage in NPD provides far more value to firms than previously thought and provides evidence to support greater investments in IT for product development efforts. Other implications of our study are that unless IT is embedded into the NPD process and champions for IT tools exist, chances are that IT won’t be used and its benefits will not be realized.

INTRODUCTION

There has been explosive growth in the development of information technologies (IT) for product development as technology has advanced and the importance of a formal new product development (NPD) process has been recognized. These technologies consist of desk-top software and web-based tools for different stages of the NPD process such as idea generation and testing as well as for various NPD activities such as process and portfolio management. In spite of the efforts vendors have taken to develop high quality IT tools, research suggests that companies are fairly immature in their use of IT for product development (Adams-Bigelow 2004; Barczak and Sultan 2006). For example, the recent Comparative Performance Assessment Study (CPAS) by the Product Development & Management Association (PDMA) found that less than 20% of the "Best" firms used web-based market research tools and product portfolio management software while less than 40% used groupware software to support their project teams (Adams-Bigelow 2004). Likewise, Barczak and Sultan (2006) observed that NPD project teams tended to use simple, easy-to-use ubiquitous tools such as e-mail, MS Office, and Excel/Access databases rather than more sophisticated and more complex tools.

This gap between IT availability and usage with regard to NPD activities raises the question: what factors influence IT usage for product development? Recent studies in the IT field argue that an important aspect of IT work is to create business value through the development of new products and services (Farrell 2003; Weill et al. 2002). Moreover, IT is considered to be a source of various capabilities (including innovation capability) that can provide potential competitive advantages for a firm (Farrell 2003; Sambamurthy and Zmud 2000). Identifying the factors that influence IT usage is crucial from the point of view of facilitating research and development activities that enable firms to achieve business goals.

Examination of the broader, related question of whether or not IT usage impacts new product performance, has largely been limited to anecdotal evidence and conceptual studies that suggest that IT can reduce cycle time, increase productivity, improve product quality, and enhance collaboration and communication in NPD (Bowden 2004; Ozer 2000). The one exception to this is an empirical study by Durmusoglu et al. (2006) who found that neither high nor low frequency of IT use is associated with NPD cost, speed, and/or flexibility. However, their study had a sample size of only 42 respondents and did not investigate the impact of IT usage on commercial performance. In the IT literature, the relationship between IT usage and performance has largely been overlooked (Devaraj and Kohli 2003). Thus, empirical examination of the relationship between IT usage and speed to market as well as the market performance of the new product appears to be essential.

Drawing on concepts and insights from the NPD, adoption, and IT literatures, our study identifies six factors that are hypothesized to positively influence IT usage: project risk, existence of a champion, autonomy, innovative climate, IT infrastructure and IT embeddedness. This research also investigates the relationship between IT usage and two measures of new product performance: speed to market and market performance. The study hypotheses are tested using data collected through a mail survey from the Product Development & Management Association (PDMA) practitioner member database.

Our research model and findings seek to make several contributions to theory and practice. First, this study identifies antecedents to IT usage so as to provide new product managers with actions they can take to increase IT usage for product development efforts. Second, our research question relates to the broader theme of IT's role in creating an innovation capability that results in business value. Our study builds on this theme and extends it by focusing on the relationship between IT usage and two measures of new product performance, speed to market and market performance.

The remainder of this article is structured as follows. First, the conceptual framework and hypotheses are presented. Next, the research methodology is explained and results are discussed. The article ends with a discussion of managerial implications, limitations, and suggestions for future research.

CONCEPTUAL FRAMEWORK

Figure 1 presents a model that shows six antecedents to IT usage. IT usage refers to the use of various IT tools, in a given NPD project, for different NPD activities (communication & collaboration, product development, project management, information & knowledge management, and market research & analysis) across three stages of the NPD process (fuzzy front end, development & testing, launch/commercialization).
The precursors to IT usage are considered by previous literature to have an important impact on ITs' role in NPD (Ozer 2004; Sethi et al. 2003; Waarts et al. 2002) and in innovation adoption (Agarwal et al.1997; Kwon and Zmud 1987). Our model also proposes that IT usage will have a direct effect on new product performance; more specifically, on speed to market and market performance. Below, the various components of our model and our hypotheses are discussed. Table 1 provides a summary of key literature regarding each variable in our model.

Antecedents to IT Usage

Project Risk

Risk is defined as uncertainty about future events and the magnitude of potential failure (March and Shapira 1987). NPD projects that are strategically important to the firm have a high degree of risk and their failure could have devastating results. To reduce risk, project teams may gather and disseminate necessary market information via the internet, as an example, to enable more effective decision-making (Teo and Choo 2001). Organizations likely to adopt IT systems generally have aggressive management willing to take financial and organizational risk (Grover 1993). Therefore, for higher risk projects, project teams will be more likely to employ IT tools to a greater degree to gather information and facilitate coordination so as to ensure a successful project.

H1: The greater the risk of the product being developed, the higher the IT usage in NPD projects.

Existence of Champion

Prior research suggests that the existence of a champion has a positive impact on innovation adoption (Beath 1991; Ettlie et al. 1984; Grover 1993). Specifically, enthusiastic and committed individuals often play an important role in overcoming resistance to an innovation, securing resources for the innovation, and promoting the innovation (Ettlie et al. 1984; Maidique and Zirger 1984). Similarly, the literature on IT suggests that an important antecedent to implementation of an IT system is the existence of a champion (Beath 1991; Grover 1993).

Our focus is on champions at the project level because these individuals are most likely to use new IT tools and influence team members to utilize them as well. Champion support positively impacts the use of NPD processes and thus, the internal workings of

NPD in a firm (Markham and Griffin 1998). IT champions are the individuals on the project team who are most likely to see the value of a particular IT tool even without full knowledge of that tool. As a result, these champions take it upon themselves to be responsible for using the tool, promoting its benefits to other team members (Beath 1991), and even training peers how to use the tool. Without a champion or multiple champions on a project, the team is less likely to try new features of an existing tool or try out new tools. Thus, the existence of a champion for specific IT tools will lead to greater IT usage.

H2: The more likely the existence of a champion for specific IT tools, the higher the IT usage in NPD projects.

Autonomy

Autonomy refers to the degree to which the project team is able to make its own decisions. Prior research indicates that the degree of centralization (i.e., concentration of decision-making) is negatively related to innovation adoption (Grover 1993; Grover and Goslar 1993; Moch and Morse 1977). High centralization means that project teams have little autonomy to make decisions and thus resist organizational attempts to implement innovations (Grover 1993). Thus, project teams that have little freedom in making decisions regarding their project and product are likely to lack the motivation to experiment with new IT tools or with additional features of available tools. They may even refuse to use particular and sophisticated IT tools unless expressly demanded to do so by senior management. By contrast, project teams with greater decision making authority will feel that they have more control over their work and will want to ensure that the project and product are successful. As a result, they are likely to take greater initiative in trying out new tools and new features of existing tools to improve the development of the new product. In the IT literature, pushing down decision-making has been found to positively influence an organization's knowledge of IT innovations so that these tools can be used in support of firm activities (Boynton et al. 1994). Thus, firms that give greater decision authority to project teams will lead to greater IT usage to help meet project goals.

H3: The greater the autonomy of the team, the higher the IT usage in NPD projects.

Innovative Climate

Climate is defined as the degree to which the organization is supportive of creativity and tolerant of differences in thinking and perspective (Scott and Bruce 1994; Siegel and Kaemmerer 1978). An innovative climate is one that supports creativity, is not risk averse, is willing to try new things, and exemplifies open communication among employees across functions (Cooper et al. 2004; Siegel and Kaemmerer 1978). Frambach and Schillewaert (2002) argue that the degree to which "an organization is receptive to new products or ideas will influence its propensity to adopt new products" (p. 165), however, they have no empirical evidence to support this contention. In fact, a culture that values creating and sharing knowledge is a key driver of knowledge management in the R&D process (Ambrecht et al. 2001). Similarly, culture has been found to play a key role in IT implementation (Lai and Mahapatra 1997).

Project teams that operate within an innovative climate are likely to look for new and different ways to solve problems and to enhance productivity. These inclinations can drive team members to search for and experiment with new, sophisticated and possibly risky IT tools for various activities throughout the NPD process. On the other hand, teams that function in a more conservative and reserved environment are less likely to be motivated to try new ways of doing things through the use of IT. Such teams will tend to behave and undertake their work as they always have, using existing tools and methods. Thus, project teams that exist in organizations with an innovative climate will use more IT in their NPD efforts.

H4: The more innovative the climate of the firm, the higher the usage of IT in NPD projects.

<u>IT Infrastructure</u>

Infrastructure refers to the computer hardware, software, and human resources necessary to support wide distribution of IT tools as well as to the sophistication of the infrastructure (Sethi et al. 2003). The presence of a well-developed IT infrastructure is considered a major business resource (Keen 1991; McKenney 1995) that enables R&D (Weill et al. 2002) and continuous improvement of existing products (Duncan 1995). Infrastructure facilitates cross-functional processes (Sambamurthy and Zmud 1992), such as NPD, by enhancing connectivity across various functional groups (Keen 1991).

Little, if any, research has focused on the association between IT infrastructure and IT usage. However, a firm's technological strengths have been shown to impact positively on innovation adoption (Grover 1993; Maidique and Zirger 1984). In addition, organization support (i.e. attitude of senior management, provision of training and other resources) has a positive relationship with computer usage (Anakwe et al. 2000). In fact, such support is positively related to frequency of use and number of applications used (Anakwe et al. 2000). A lack of support from management will inhibit the use of knowledge management tools (Ambrecht et al. 2001).

Based on the aforementioned research, in firms with an IT infrastructure to support NPD, project teams would have reliable IT systems and access to the same IT tools. Personnel would be available to support the infrastructure and provide guidance to users. The existence of a high quality infrastructure would allow team members to more easily and quickly share necessary project-related information. These benefits would drive IT usage as project teams learned the advantages of using the infrastructure to accomplish their work.

H5: The greater the sophistication of the IT infrastructure and the greater the extent to which it supports distribution of IT tools, the higher the IT usage in NPD projects.

IT Embeddedness

Embeddedness refers to the degree to which IT tools play a significant role in the development of new products and in the sharing of information amongst project team members, and are used to manage the interdependencies of the NPD project team (Sethi et al. 2003). In other words, embeddedness (or assimilation as it is called in the IT literature) refers to the extent to which IT has been implanted into specific business activities (i.e., new product development) and its effectiveness in enabling those activities (Armstrong and Sambamurthy 1999). IT must become a *routinized* component of people's work and a firm's business processes before they can exhibit any significant business value (Boynton et al. 1994; Thomke 2006). Firms characterized by high embeddedness presumably will have integrated IT tools into their NPD process (Sethi et al. 2003). However, Waarts et al. (2002) found that IT integration had a negative significant impact on late adoption of ERP. In other words, the likelihood of later adoption of ERP systems decreases when firms have integrated their IT functions adequately because the value of such a system is not as strong.

Though conceptually related and highly correlated (See Table 3), IT embeddedness and IT usage are not the same thing. The key difference between IT embeddedness and IT usage centers on whether or not the IT tools are routinized into the NPD process. Usage of a particular tool may be due to individual team member and project choice to improve efficiency and effectiveness and thus, can be independent of what the organization requires in terms of the formal NPD process. When IT tools are assimilated into the NPD process, usage of such tools is likely to be dictated by the organization and the process itself.

In firms which have embedded specific IT tools into their NPD process, project team members will have some degree of familiarity with those tools and know which tools are appropriate for particular activities. High levels of embeddedness will also likely result in most, if not all projects, using the tools. As well, team members will use the tools for the multiple projects in which they are engaged. On the other hand, if IT tools are not embedded in the NPD process, particular IT tools may be used only for narrow applications and only by certain NPD personnel motivated by their own internal needs and frustrations with existing tools and systems. Thus, the degree of embeddedness of IT in the firm is likely to influence IT usage.

H6: The greater the embeddedness of IT in the firm, the higher the IT usage in NPD projects.

Effect of IT Usage on New Product Performance

The relationship between IT use and performance has been considered critical in the IT field (Delone and McLean 2003). In this study, performance consists of two measures: speed to market and market performance.

Speed to Market

Speed to market refers to the time taken to bring a product from idea conception to market launch. The shorter this cycle time, the faster the product is brought to market. Anecdotal evidence and conceptual research suggests that the use of IT tools can increase the speed with which products are brought to market (Bowden 2004; Ozer 2000; Sethi et al. 2003). Specifically, technologies such as the internet enable NPD teams to gather, store, use and disseminate market and product information more easily and quickly (Teo & Choo 2001).

However, an empirical study found that more frequent use of IT tools in NPD does not generally seem related to better NPD outcomes (Durmusoglu et al. 2006). Specifically, Durmusoglu et al. (2006) found that neither low nor high frequency use of IT tools is associated with low or high NPD speed. Though this empirical study contradicts accepted thinking, its' small sample size of small and medium businesses and use of nonparametric statistical tests signifies the need for further examination of the relationship between IT usage and speed to market. Moreover, no IT studies investigate the relationship between IT usage and speed to market (cf. Osei-Bryson and Ko 2004).

H7: Greater usage of IT tools during the development of a new product project will lead to faster speed to market.

Market Performance

Market performance refers to the degree to which the new product meets expectations with regard to sales, market share, profitability, market performance, and customer satisfaction (Sarin and Mahajan 2001). In the IT area, the findings regarding investments in IT and firm performance (Osei-Bryson and Ko 2004) are inconsistent. Some have found a positive, direct association while others have found no relationship or no direct link (Osei-Bryson and Ko 2004). Yet support has been found for a significant, positive relationship between IT usage and financial and quality performance (Devaraj and Kohli 2003). No empirical studies in the NPD field have been undertaken which investigate the relationship between IT and financial performance.

IT tools, such as the internet, enable project teams to collect, share, and utilize high quality market information in the development of a new product (Ozer 2000; Teo and Choo 2001). This, in turn, enhances the quality of the decisions made with regard to the new product (Ozer 2000; Teo and Choo 2001) resulting, potentially, in products that meet organizational and project goals. Therefore, it seems reasonable to predict that greater IT usage will result in higher commercial performance of the new product.

H8: Greater usage of IT tools during the development of a new product project will lead to higher market performance.

METHOD

Our sample was drawn from the mailing list of 1371 PDMA practitioner members in the U.S. and Canada. Respondents, who held the title of Director, Manager, Project/Program Manager, and Vice-President, were asked to use a new product/service launched within the past two years as the basis for completing the survey. Each respondent received a post card informing them of the survey. One week later, each respondent was mailed a letter explaining the purpose of the study, a copy of the questionnaire, and a return envelope. About ten days later, a reminder post card was mailed. A month after the initial survey was sent, an e-mail blast was sent. After accounting for incomplete surveys, a total of 212 surveys were received, resulting in a 15.5% response rate.

Table 2 presents the sample characteristics. Companies participating in the study came from a variety of industries with average annual sales of $2.68 billion and an average of 3270 employees. Thirty-six percent (36%) of respondents based their survey responses on the development of a consumer product while fifty-two percent (52%) based it on development of an industrial product. The characteristics of our sample compare favorably with past studies that have used PDMA practitioner members as respondents (Griffin 1997; Griffin and Page 1996). For example, Griffin (1997) reported that 91% of the firms in her study developed physical goods and 9% focused on services. Griffin and Page (1996) stated that 56% of their respondents had R&D/Engineering backgrounds, 19% were from Marketing, and only 6% had Manufacturing expertise.

The average length of time respondents had been in their job was 4.75 years. This combined with the fact that all were members of PDMA, a professional association for NPD practitioners, indicates that the key informants were qualified to respond to the survey about a recent NPD project. Seventy-four percent (74%) of firms used some form of a cross-functional stage-gate process to develop their new products. Average core team size was 8 members with 67% of core team members being located in the same building.

Non-response bias was assessed by comparing early (first quartile) and late (fourth quartile) respondents (Armstrong and Overton 1977). A comparison of the two groups did not reveal any significant differences in means for our focal constructs.

Our unit of analysis is the NPD project level – a level that has been lacking study (Lai and Mahapatra 1997); yet the level at which most IT usage currently occurs (McGrath and Iansiti 1998). The project level is an appropriate level to study because NPD is undertaken most often by cross-functional NPD teams who need to share important product, market, and technical information and much research examining the determinants of new product performance are also at the project level (Montoya-Weiss and Calantone 1994). In the IT literature, Devaraj and Kohli (2003) argue that a detailed level of analysis (i.e. NPD project level) provides a better chance of detecting the impact of IT.

Measures

Measures were drawn from existing studies and adapted where necessary. Preliminary versions of the survey were given to two academic colleagues for their feedback and comment. The final draft questionnaire was pre-tested with 11 executives in NPD and/or IT. Feedback from these executives pertained mainly to ambiguities or difficulties in responding to the items and suggestions for adaptations to ensure clarity. The instrument was revised accordingly.

To measure IT usage, respondents were given a table with a variety of IT tools used for the following activities: communication and collaboration, product development, project management, information and knowledge management, and market research and analysis. Different tools were provided for each activity, for example, e-mail and web meetings for communication and collaboration; product design and NPD process tools for product development; scheduling software and tracking projects for project management; Excel/Access databases and shared drives/project rooms for information and knowledge management; and secondary data and online needs surveys for market research and analysis. Respondents were asked to check the tools used for each activity across three stages of the NPD process (fuzzy front end, development and testing, launch). The number of checks for each respondent was summed for all tools in all activities across each stage of the NPD process to determine the extent of IT usage for that project. This approach is similar to that used by Grover and Goslar (1993) and Moch and Morse (1977). Research suggests that self-reported usage measures correlate well with actual usage (i.e. objective) measures of use (Taylor and Todd 1995).

Measures of the dependent variables and the antecedents as well as the sources of the measures are included in Appendix 1.

Unidimensionality, reliability and validity

Anderson and Gerbing (1991) recommend examining the scales for unidimensionality, reliability, convergent validity and discriminant validity after data collection. To obtain unidimensionality within each multi-item scale, inter-item correlations and corrected item-to-total correlations for each item were calculated, taking one scale at a time. Items for which these correlations were not significant ($p<0.01$) were eliminated. Principal axis factoring explored the unidimensionality of each purified scale, using an eigenvalue of 1.0 and factor loadings of 0.25 as the cut-off points. Computing reliability coefficients explored the reliability of each purified, unidimensional scale. When the coefficient alpha was smaller than 0.7, the item with the lowest corrected item-to-total correlation was eliminated until meeting the 0.7 level. In total, 10 items were dropped after this exploratory step. Descriptive statistics on the variables included in the study are provided in Table 3.

The Harman's one factor test was conducted, where all the measures were entered into a single factor analysis as recommended by Podsakoff and Organ (1986). No single factor that could account for the majority of the covariance in the measures emerged, providing evidence that common method bias was not a major problem in this study.

Convergent validity of the scales was investigated by estimating two confirmatory factor models (CFA-models) using ML-estimation in LISREL. This approach was selected in order to fit the constraints of a ten to one ratio of sample size to parameter estimates. Convergent validity was indicated by the fact that the items loaded significantly ($t > 2.0$) on their corresponding latent construct. The first CFA-model contained the items pertaining to the two new product performance variables. One item from the speed-to-market scale had to be dropped. The remaining model showed a good fit to the data ($\chi^2 = 19.48$ (df. = 13); GFI = 0.97; NFI = 0.96, NNFI = 0.97, CFI = 0.98, χ^2/df = 1.50, RMSEA = 0.05). The second CFA-model included the items measuring the six antecedent factors. One item each from the autonomy and IT infrastructure scales, and two items from the innovative climate scale were dropped. The remaining model produced an adequate fit to the data ($\chi^2 = 456.92$ (df. = 237); GFI = 0.85; NFI = 0.89, NNFI = 0.93, CFI = 0.94, χ^2/df = 1.93, RMSEA = 0.07).

Discriminant validity across the scales was assessed by estimating two-factor models for each possible pair of scales twice: once constraining the correlation between the latent variables to unity, and once freeing the parameter. The results of a chi-square difference test, to assess whether the chi-square of the unconstrained model was significantly lower ($p<0.05$) than that of the constrained model, provided evidence for discriminant validity. Together the results of the tests indicated a sufficient degree of unidimensionality, reliability and validity. Based on this evidence, the constructs were formed by averaging the responses to each item in a particular scale.

Several variables were controlled for in our analysis: number of employees, formality of the NPD process, and product newness.

RESULTS AND DISCUSSION

Our hypotheses and conceptual framework were tested with a series of regressions. First, the effect of the antecedents on the extent of IT usage was examined (See Table 4A). The results show that project risk, existence of a champion and IT embeddedness have a significant, positive relationship with IT usage, thereby supporting H1, H2 and H6.

The positive influence of project risk on IT usage suggests that project teams use IT to a greater extent when the product/project is important to the firm and its failure could seriously negatively impact the firm. This finding supports previous IT research which argues that teams gather and disseminate information via various IT tools to reduce risk and enable better decision-making (Teo and Choo 2001).

Our finding regarding the existence of a champion illustrates the importance of having enthusiastic and committed individuals who promote and support usage of particular IT tools. This result is consistent with prior research demonstrating the importance of a champion to innovation adoption (Beath 1991; Ettlie et al.1984; Grover 1993).

The positive relationship between IT usage and the degree to which IT is embedded in the NPD process of the organization highlights the importance of IT integration. IT integration and embeddedness, in turn, is necessary if IT is to be used to its maximum advantage (Thomke 2006; Waarts et al. 2002).

The lack of evidence to support relationships between the other antecedents (e.g., autonomy, innovative climate, IT infrastructure) and IT usage indicates that previous research on the factors that impact adoption may not adequately explain IT usage. Of particular interest is the lack of any significant finding regarding IT infrastructure and IT usage as recent IT literature suggests that IT infrastructure is a major resource (Keen 1991) and capability of a firm (Weill et al. 2002). One explanation may be that project teams in this sample are using IT tools for NPD activities; however, these tools may not necessarily be part of the organization's infrastructure but rather only accessible to only some NPD personnel.

Next, the impact of IT on two measures of new product performance: speed to market, and market performance, was investigated (See Table 4b). Surprisingly, no relationship was found between IT usage and speed to market (disconfirming H7). This finding is contrary to anecdotal evidence (Bowden 2004; Ozer 2000) yet supports one empirical study (Durmusoglu et al. 2006). An explanation for this result may be that using IT for NPD activities is not sufficient for achieving efficiency or that long term usage of specific IT tools may be necessary to attain efficiency advantages. It may be that it takes time for team members to acclimatize themselves to the tools and their functions. Thus, initially, usage of IT tools may actually increase time to market. Over time, familiarization with the tools can reduce this cycle time but maybe not significantly from the average time to market.

Our results do show, however, that IT usage is positively and significantly related to market performance (thereby confirming H8). This finding is significant as it suggests that the value of IT usage for product development is different than has been previously thought. Specifically, it appears that greater usage of IT in a particular product development effort will lead to greater market success of that product when launched. An explanation for this result may be that use of particular IT tools enhances crossfunctionality and cooperation amongst team members thereby leading to better product designs that meet customer needs.

MANAGERIAL IMPLICATIONS

This study sought to examine the antecedents of IT usage and whether or not IT usage influences new product performance. Our results offer the first empirical evidence that the extent of IT usage during the NPD process positively influences performance but not in the way managers expect. Specifically, IT usage does *not* seem to affect speed to market but rather positively impacts the performance of the new product in the marketplace. This result suggests that IT usage in NPD provides far more value to firms than previously thought; that is, IT usage impacts the commercial success of the product. Thus, instead of focusing on speed to market as the rationale for greater investments in and usage of IT in NPD, new product and IT managers need to utilize the positive impact of IT usage on market performance as justification for their arguments.

Another implication of our findings is the need for IT to be embedded in the NPD process. This finding reinforces Thomke's (2006) contention that unless IT is embedded into people's work and processes, it won't be used and its benefits will not be realized. As a result, firms (and projects) that want to increase their usage of specific IT tools need to incorporate and integrate those tools into their development process such that these tools are routinely used for multiple activities and stages of their NPD process. Providing training, encouraging champions, supplying support, and requiring use of various tools can enable such tools to become embedded within all product development efforts. Companies and projects that fail to do so may find themselves spending lots of money on IT hardware and software without reaping any of the advantages of such spending.

Relatedly, to increase IT usage, new product managers need to encourage, facilitate, and possibly appoint, champions for particular IT tools they wish their NPD personnel to utilize. This is particularly necessary, if as indicated above, a firm chooses to assimilate specific IT tools into their development process. Even without a high level of IT embeddedness, however, the time constraints under which NPD teams work and the multiple projects they work on, would seem to warrant a need for IT champions as individual project team members are unlikely to experiment with new tools or sophisticated features of existing tools.

The positive influence of project risk on IT usage suggests that project teams utilize IT to gather and share market, technical, and project information. This, in turn, helps to reduce the uncertainty and fear of failure associated with risky projects. Thus, new product managers need to encourage teams developing risky projects to experiment with and utilize different IT tools to enable better information gathering, exchange, and decision-making. This can be done in a variety of ways including providing resources for teams to buy software for specific NPD activities, providing training on particular IT tools, creating forums for discussions about successful and unsuccessful use of particular tools, and rewarding projects for experimentation.

LIMITATIONS AND FUTURE RESEARCH

This research is subject to the limitations inherent in cross-sectional designs, particularly the use of single informants. However, our focus on a specific issue - the role of IT in the NPD process- helps mitigate this weakness. As well, the study showed that the informants were well qualified to report on the variables in the study.

Most measures in this study have been used in previous research. However, the measures of existence of a champion, IT infrastructure, and IT embeddedness are new. While our initial operationalization of these measures is acceptable, it is likely that they can be improved. Future research should incorporate and refine these measures as they have received theoretical but little empirical attention.

The present study provides a snapshot of IT usage across company sizes and industry types. Thus, the results cannot be generalized to specific businesses or to firms employing certain NPD strategies. Future research should examine IT usage in various industry sectors to determine if the antecedents to IT usage and the relationship between usage and new product performance are industry specific.

The sample is restricted to North American companies from the U.S. and Canada thereby limiting the generalizability of the results to other countries and continents. Future research should explore the research questions by utilizing samples of firms from other geographic parts of the world such as Europe and Asia.

The lack of a significant relationship between IT usage and speed to market is surprising and warrants further investigation. Future research may wish to explore whether or not the length of time a specific tool has been used in the NPD process influences this relationship.

Finally, though our regression results show significant influences of particular contextual factors on IT usage, future research should analyze the relationships between the antecedent contextual factors and IT usage, and between IT usage and product performance by using structural equation modeling (SEM) to generate a more complete picture of the nature of these relationships.

Acknowledgement
The research reported on in this article was supported by the Product Development & Management Association as part of the 2005 PDMA Research Award granted to Professors Barczak and Sultan. We are grateful to Serge Rijsdijk for his assistance in data analysis.

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Table 1. Summary of Key Previous Research Related to Variables in Study

Variable	References in Literature	Methodology	Results
Project Risk	Teo and Choo (1991)	Survey, 129 companies, CEOs/Managing Directors	Usage of the internet improves the quality of information which in turn leads to strategic benefits (revenue generation, cost reductions, and managerial effectiveness)
	Grover (1993)	Survey with 216 responses from CIOs and IS directors	Having aggressive management that is willing to take risks is positively related to adoption.
Existence of Champion	Beath 1991	Interviews with 15 IT champions	IT champions operate as other champions do- they promote their ideas actively through informal processes by explaining and educating.
	Ettlie et al. (1984)	Interviews with 90 managers, survey of 147 managers from the food processing industry	Innovation champions predict adoption of radical innovations.
	Grover (1993)	Survey with 216 responses from CIOs and IS directors	Existence of a champion is a strong determinant of customer-based interorganizational systems.
	Maidique and Zirger (1984)	Two surveys of senior managers of U.S. electronics firms and in-depth case studies of 20 of these firms	Product champions were not significantly related to new product success or failure. Management support played a more important role than product champions.
Autonomy	Grover (1993)	Survey with 216 responses from CIOs and IS directors	Participatory decision-making is positively associated with adoption of an interorganizational system
	Grover and Goslar (1993)	154 senior-level IS executives primarily from finance and manufacturing firms	Environmental uncertainty and decentralization of decision making have a significant, positive impact on the adoption and implementation of telecommunications technologies
	Moch and Morse (1977)	Hospital administrators and Chiefs of Medicine; 12 innovations studied; 489 hospitals responded	Decentralization affects the adoption of hospital innovations. Size of organization impacts adoption.

Innovative Climate	Armbrecht et al. (2001)	Semi-structured interviews in 19 companies with key executives involved in knowledge management	One key driver of knowledge management in R&D is a culture that values creating and sharing knowledge
	Cooper et al. (2004)	Site visits with 5 companies; survey of 105 business units	A climate/culture of open communication, not being risk averse, and provision of resources for creative work separates best from worst performers
	Lai and Mahapatra (1997)	Meta-analysis of research on IT implementation between 1976 and 1995	Organizational culture plays a key role in IT implementation
	Siegel and Kaemmerer (1978)	Students and faculty from a number of different schools; 3 phase study	Development of a reliable and valid tool comprising five dimensions to measure organizational innovativeness. The dimensions include: support of creativity, tolerance of differences, and personal commitment.
IT Infrastructure	Anakwe et al. (2000)	170 employees from 9 organizations in Nigeria	Organizational support is positively related to daily computer usage and frequency of use. Organizational support refers to positive attitude towards microcomputers, endorsements by senior management to provide training, and IT consulting support.
	Grover (1993)	Survey with 216 responses from CIOs and IS directors	Having a strong IT infrastructure is positively related to IS adoption.
	Maidique and Zirger (1984)	Two surveys of senior managers of U.S. electronics firms and in-depth case studies of 20 of these firms	Firms with technological superiority have greater new product success than firms without such capability.
	Weill et al. (2002)	Interviews, surveys and personal visits, 180 e-business initiatives from 1990 to 2001	Investments in specific infrastructure capabilities are needed to implement particular business initiatives; one cluster of capabilities focuses on IT-R&D which includes the business' search for new ways to use IT to create business value
IT Embeddedness	Boynton et al. (1994)	Survey, 132 firms, senior IT executives	Knowledge of IT facilitates information exchanges and and joint problem solving that enable organizations to use IT for higher-order business value; pushing down decision-making contributes to IT knowledge

	Thomke (2006)	72 major car projects launched between 1980 and 1999	New IT tools increase problem-solving capacity as well as productivity. However, new tools must be integrated into the work that needs to be done in order for firms to reap these benefits.
	Waarts et al. (2002)	2647 respondents from 10 countries and 6 industries; IT managers and financial managers involved in IT purchase decisions	IT integration is not associated with early adoption of ERP and is negatively associated with late adoption of ERP
IT Usage and Perfomance	Devaraj and Kohli (2003)	8 hospitals; 36 monthly periods	IT usage is positively associated with hospital revenue and quality (patient mortality)
	Durmusoglu et al. (2006)	Mail survey, 21 dyads of IT dept head and NPD team leader	Neither low nor high frequency of IT usage is associated with NPD cost, speed and/or flexibility. High IT usage is associated with low NP quality and vice versa.
	Osei-Bryson and Ko (2004)	Existing dataset from Brynjolfsson and Hitt	Investments in IT must pass a minimum value before they impact positively on productivity

Table 2. Sample Characteristics

SIC Code		Number of Employees		Sales in Dollars		Respondents	
31 Food & Textile Manufacturing	5.2%	0-100	23.5%	0-$100 million	30.3%	Marketing	30.7%
32 Wood, Oil, & Chemical Manufacturing	15.6%	101-500	34%	$101- $500 million	32.1%	R&D	31.6%
33 Electronic, Computer, & Medical Device Manufacturing	29.2%	501-1500	17%	$501m -$1 billion	13.4%	Engineering	22.2%
51 Information	10.4%	1501-5000	12%	> $1 billion	24.2%	Manufacturing	2.4%
52 Finance & Insurance	6.6%	>5000	14.5%			Other	12.3%
56 Administrative Services & Waste Management	3.8%						
Other	29.2%						

Table 3. Correlation Matrix and Descriptive Statistics of Measures

Variables	1	2	3	4	5	6	7	8	9
(1) Speed to Market	**.75**								
(2) Market Performance	.24**	**.77**							
(3) IT Infrastructure	.17*	.06	**.88**						
(4) Innovative Climate	.31**	.20**	.21**	**.87**					
(5) Autonomy	.21**	.29**	.22**	.38**	**.87**				
(6) Embeddedness of IT	.15*	.11	.44**	.24**	.05	**.87**			
(7) Project Risk	.03	.21**	.09	.09	.06	.19**	**.87**		
(8) Existence of champion	.08	-.04	.23**	.02	.02	.27**	-.01	**.91**	
(9) IT Usage	.02	.24**	.29**	.11	.18**	.43**	.24**	.39**	N.A.
Mean	**2.62**	**3.28**	**3.26**	**3.17**	**3.88**	**3.19**	**3.75**	**2.52**	**26.79**
Standard Deviation	**.87**	**.78**	**.86**	**.79**	**.85**	**1.07**	**.82**	**1.06**	**12.05**
AEV	.45	.53	.59	.50	.70	.69	.62	.77	N.A.
# of Items	4	3	5	7	2	3	4	3	N.A.

Notes: * $p < .05$; ** $p < .01$. Diagonal elements in bold are composite reliabilities. There is no coefficient alpha for IT Usage because it is not a scaled construct but rather a sum of IT tools used in all three stages of the NPD process. Means are on a 1 – 5 scale where 1 = Strongly Disagree and 5 = Strongly Agree. AEV = average extracted variance. Number of items remaining after purification.

Table 4A
Determinants of IT Usage

Regression Model 1

	IT Usage (standardized betas)
Degree of risk	.16**
Existence champion	.29**
Autonomy	.10
Innovative climate	-.02
IT infrastructure	.04
IT embeddedness	.27**
Number of employees	.02
Product newness	.06
Formality of process	.15*
R^2	.35
Adjusted R^2	.32
F-value	11.75
N	202

*p < .05; ** p <.01

Table 4B
Affect of IT Usage on New Product Performance

	Reg Model 2	**Reg Model 3**
Dependent Variables	**Speed to Market**	**Market Performance**
IT Usage	.02	.24**
R^2	.00	.06
Adjusted R^2	.00	.05
F-value	.13	12.67
N	211	211

*p < .05; ** p <.01

Appendix 1. Items for Measures

Measures and Sources	Description
Antecedents to IT Usage	
Project Risk (Sarin and Mahajan 2001) Coefficient alpha = .86	Our organization has a lot riding on this project The outcome of this project has high strategic value for our organization. Poor market performance by this product will have serious consequences for our business Our organization has made a significant investment in the development of this product
Existence of Champion (New Scale) Coefficient alpha = .92	One member of the project team (which includes the team leader) was committed to introducing and using IT tools. One member of the project team (which includes the team leader) was committed to encouraging others to use IT tools. One member of the project team (which includes the team leader) was committed to training others in how to use particular IT tools
Autonomy (Sethi 2000) Coefficient alpha = .84	The project team had a major role in making important decisions about the product. The project team was allowed to do the project work it deemed fit. *Senior managers outside the team often interfered with the team's work. (R)
Innovative Climate (Scott and Bruce 1994) Coefficient alpha = .88	*Creativity is encouraged in this organization. An individual's ability to function creatively is respected by the leadership of this organization. The main function of members in this organization is to follow orders, which come down through channels. (R) *In this organization, a person can get in a lot of trouble by being different. (R) A person can't do things that are too different in this organization without provoking anger. (R) The best way to get along in this organization is to think the way the rest of the group does. (R) People in this organization are expected to deal with problems in the same way. (R) This organization is open and responsive to change. *This organization seems to be more concerned with the status quo than with change. (R) The reward system in this organization benefits mainly those who don't rock the boat. (R) *Assistance in developing new ideas is readily available in this organization. *There are adequate resources devoted to innovation in this organization. *In this organization, there is adequate time available to pursue creative ideas.
IT Infrastructure (New Scale) Coefficient alpha = .86	This organization's computer data storage (e.g., servers, databases) is of high quality. This organization's intranet is of high quality. This organization's extranet is of high quality. The IT personnel who operate and support the IT infrastructure are

	well-qualified to do so. *In this project, we used the latest IT tools available. In this project, we used the most sophisticated IT tools available. *All product development personnel have access to the same IT tools used for new product development. *The IT tools used for this project were appropriate for the NPD activities for which they were used.
Embeddedness of IT (New Scale) Coefficient alpha = .86	Information technology (IT) tools play a significant role in the development of new products in this organization. In this organization, information technology (IT) tools play a significant role in managing the interdependence of different functions and groups during the development process. In this organization, IT tools play a significant role in the exchange and sharing of information amongst NPD project team members.
New Product Performance Speed to Market (Olson, Walker and Reukert 1995; Sarin and Mahajan 2001) Coefficient alpha = .75	*This product was developed much faster than other comparable products developed by our organization. This product was developed much faster than similar products developed by our nearest competitors. This product could have been developed in a shorter time. (R) The product concept formation (i.e. opportunity identification and product design) took longer than expected (R) The product development phase took longer than expected for this product. (R) *The product commercialization (ie., market testing, production, distribution, promotion, sales) took longer than expected (R)
Market Performance (Sarin and Mahajan 2001) Coefficient alpha = .72	*Level of sales achieved *Customer satisfaction with the product *Market performance of the product relative to its competition Chances of the product being a success in the market Level of initial market penetration (market share) Projected financial profits on this product

Notes: R = reverse coded. * Item was deleted during purification. All variables are measured on a 5 point scale where 1= Strongly Disagree and 5 = Strongly Agree except Market Performance which was measured on a 5 point scale where 1 = Far below expectations and 5= Far above expectations.

Figure 1
Conceptual Model