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COMPARISON OF INTERNET-BASED TECHNOLOGY CONTRIBUTION TO PRODUCT QUALITY IN GLOBAL AND LOCAL NPD TEAMS

Companies invest in Internet-based technologies (IBT) hoping to improve performance of their NPD processes, especially in terms of product quality. The objective of this study is to verify whether the use of Internet-based technology contributes to product quality and whether this contribution is different for projects executed by local versus global NPD teams. The proposed hypotheses are tested using data collected from 278 NPD projects conducted by Canadian and American manufacturing companies.

Introduction

New product performance is widely recognized as a critical factor in securing long-term survival, competitiveness and sustained commercial success of firms (Brown and Eisenhardt, 1995; Deschamps and Nayak, 1995; Biemans, 2003) and therefore receives significant attention from academics and practitioners. However, despite a vast amount of research and recommendations, the failure rates of new product introductions are considered very high and companies in many industries struggle with new products that do not meet quality or cost objectives, are late to market, or are not meeting customers' expectations (Pillai and Rao, 2000). Poor NPD performance is often attributed to a number of challenges such as increased competition, shorter product cycles, growing complexity of technologies and new products, more demanding customers with rapidly changing requirements, and significant increase in the dispersion of knowledge involved in the NPD process (Rothwell, 1994; Pillai and Rao, 2000; Kerssens-van Drongelen and Bilderbeek, 1999; Kerssens-van Drongelen *et al*., 2000; Haque and Pawar, 2003).

Faced with the rapidly changing environment and the necessity to effectively manage the increasingly collaborative nature of product development, firms are looking for different strategies and tools to support their NPD efforts. Among the recently developed tools, Internet-based technologies (IBT) are considered very promising. The literature confirms that there is a significant and increasing trend towards implementation of Internet-based technologies in NPD projects aimed at improving different dimensions of NPD performance (e.g., Iansiti and MacCormack, 1997; Antonelli *et al*., 2000; Dahan and Srinivasan, 2000; Malhotra *et al*., 2001). The consensus appears that due to its ease of use, wide availability, low cost, and common standards, the Internet has the potential to greatly improve NPD activities in many ways (e.g., Ozer, 2003; Sethi *et al*., 2003; Howe *et al*., 2000). However, at the same time, numerous companies who invested in Internet-based technologies hoping to achieve better results in their new product development activities, did not gain the expected benefits. A number of researchers highlighted the need for conceptual modeling and empirical investigation regarding the relationship between IBT use and different dimensions of NPD performance (Kessler, 2003; Barczak *et. al*., 2007).

There are several theoretical models that link Internet use with NPD performance in general and new product quality in particular (Ozer, 2003, Sethi et al., 2003; Kessler, 2003) and few empirical studies that test this relationship in the context of IT use or ICT use (encompassing Internet use). However, most of the discussion is still on the theoretical or case-study basis and simply postulates a number of potential benefits related to IBT use during new product development, such as more effective collection and use of information during product development, facilitation of collaboration of different people involved in product development, or greater information exchange to name a few (e.g., Ozer, 2003; Sethi et al., 2003; Howe et al., 2000).

Building on the existing innovation, organizational theory, and IT research, this study proposes a model of IBT's impact on product quality dimension of NPD performance. The present study seeks to make a number of contributions to theory and practice. First, it synthesizes and extends previous disparate and fragmented theoretical studies on the relationship between Internet-based technology use and new product quality and provides a comprehensive conceptual framework of this relationship. Secondly, it tests the proposed model empirically. Thirdly, it looks at differences in IBT contribution to product quality between projects executed by local versus global NPD teams. In the following section the conceptual framework and the proposed hypotheses are presented. Next, the research methodology is explained and the results of the model's testing using data on 278 NPD projects are provided. The article concludes with a discussion of the implications of the study's findings and suggestions for future research.

Theoretical Model and Research Hypotheses

Internet-Based Technology Use

The Internet and Internet-based technologies (IBT) have been receiving a significant attention from practitioners and academics since the Internet became publicly available. However, there is a lack of agreement on the all-encompassing list of Internet-based technologies or their potential classification, mostly due to the fact that these technologies evolve rapidly and new applications become available very often. Broadly speaking Internet-based technologies (IBT) are web-enabled or Internet-enabled technologies or tools using Internet protocols (Munkvold, 2003) and include a variety of electronic communication, information/data management, and collaboration tools (e.g. electronic mail, instant messaging, videoconferencing, Intranets, Internet-enabled project workspaces/systems/tools, distributed virtual networks and file sharing systems, web-enabled groupware, or design or modeling tools for distributed teams).

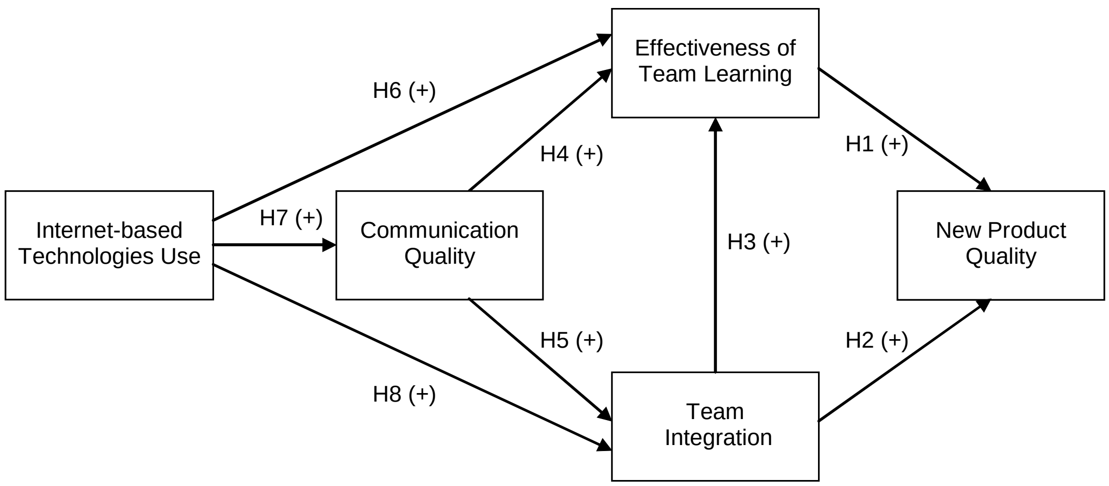
The definition of Internet-based technology use in NPD project adopted in this paper is adapted from the definition of IT use provided by Boynton et al. (1994) and states that Internet-based technology use in NPD project is the extent to which the project team deploys Internet-based technologies to support NPD project activities and processes. In order to overcome the weaknesses of previous conceptualizations of Internet use or IBT use as one dimensional and very narrow, this research proposes conceptualization of IBT use as a four-dimensional construct consisting of IBT use for data and information management, IBT use for collaborative team work, IBT use for external partner/supplier/customer involvement and IBT use for project management and control. These dimensions were developed based on an extensive literature review and consultations with academics and practitioners in the NPD area. This new conceptualization of IBT use proposed in this research provides several benefits: reflects the wide variety of Internet-based technology applications across NPD projects in different industries, reflects that applications may be internally or externally focused, and recognizes that specific project teams might choose to emphasize particular types of applications given the nature of the project or their experience with Internet-based technology.

Model Overview

There are not many theoretical models explaining the role of Internet and Internet-based technologies in NPD. The few that were identified (Ozer, 2003; 2004; Kessler, 2003; Sethi *et al*., 2003; Pavlou and El Sawy, 2006) haven't been tested empirically yet. The framework proposed in this study suggests that IBT use has an indirect effect on new product quality through improvement of effectiveness of team learning, team integration and team communication quality. The model outlining the proposed relationships is presented in Figure 1.

Figure 1

Proposed Model of IBT Use Impact on New Product Quality



The outcome variable for the model is new product quality defined as the degree to which product performance, attributes, or features satisfy customer requirements (Clark and Fujimoto, 1991; Deschamps and Nayak, 1995). It is widely agreed that product quality is one of the most important dimensions of NPD performance necessary for firm's competitiveness and success (Brown and Karagozoglu, 1993; Wheelwright and Clark, 1992; Kessler and Chakrabarti, 1998). The proposed model postulates two direct determinants of new product quality: effectiveness of team learning and team integration as well as two indirect determinants: communication quality and IBT use.

Effectiveness of Team Learning

In this study, team learning is defined, after Nonaka and Takeuchi (1995), as the collective activity of gathering, retaining, sharing, interpreting, and applying knowledge during a project execution to address project tasks and problems in order to achieve the common goal of the team. Following earlier research, it is further conceptualized as a three dimensional construct consisting of information acquisition, knowledge sharing, and knowledge application (Edmondson, 1999; Lynn *et al*., 2000). Information acquisition encompasses acquiring and storing relevant information for product development (Akgün *et al*., 2006). Information sharing is expressed by the level of shared understanding, i.e. consensus on the meaning of the information and its implication for the project (Brockman and Morgan, 2003). Finally, knowledge application refers to information utilization for decision making and problem solving (Akgün *et al*., 2006). Previous studies have shown that team learning positively influences performance of teams in organizations (e.g., Fiol and Lyles, 1985; Edmondson, 1999; Cohen and Levinthal, 1990; Sarin and McDermott, 2003). Since product quality is one of the dimensions of NPD team performance, it can be argued that effectiveness of team learning would contribute to new product quality. Consequently, the following positive effect is hypothesized:

H1: Effectiveness of project team learning is positively related to new product quality.

Team Integration

The definition of team integration adopted in this research is based on the work by Lawrence and Lorsch (1967) and states that team integration is the degree of unity of efforts of team participants. Notably, this definition of integration views it as an outcome (i.e. the state of integration defined as the extent to which unity of efforts has been achieved), as opposed to integration viewed as a process by which this state was achieved. This research also adopts the conceptualization of integration proposed by Feldman (1968) and distinguishes three dimensions of integration: functional integration (the degree of coordination of group members' activities required to progress towards the goal), normative integration (the degree of consensus among group members concerning a number of group-relevant behaviours) and social integration (level of cohesiveness, i.e. the reciprocal liking of group members). The important role of team integration in improving team performance is widely postulated in the literature (Mintzberg, 1979; Lawrence and Lorsch, 1967; Galbraith, 1977; Thompson, 1967). NPD project team integration has repeatedly been found important contributor to both effectiveness of team learning and new product quality (e.g., Cooper, 1983; Moenaert *et al*., 1994; Souder and Moenaert, 1992; Swink and Song, 2007). Therefore, the following hypotheses are forwarded:

H2: Project team integration is positively related to new product quality.
H3: Project team integration is positively related to effectiveness of project team learning.

Communication Quality

For the purpose of this research, communication quality during the NPD project is defined, after Lievens and Moenaert (2001) and Moenaert *et al*. (2000), as the degree to which relevant and understandable information reaches the intended information receivers in time and it is further conceptualized in terms of timeliness (Waller, 1999), reliability (Hoegl and Wagner, 2005), openness (Hoegl and Gemuenden, 2001), accuracy (Hoegl and Wagner, 2005), and effectiveness (Mohr and Spekman, 1994). It is widely recognized in the literature that effective communication between partners is essential for NPD performance (Rogers and Agarwala-Rogers, 1976). Communication is viewed as a means for the exchange of information among team members and between team members and their environment (Pinto and Pinto, 1990). The importance of communication in NPD is supported by the information processing theory, which views communication as a significant facilitator in dealing with uncertainty and functional interdependencies during the information processing required by the innovation project (Thompson, 1967; Souder and Moenaert, 1992). It is therefore widely argued that effective team learning as well as high levels of team integration depend to large degree upon the quality of the communication during the project execution (Clark and Fujimoto, 1991; Moenaert and Souder, 1990). As a result, the following hypotheses are proposed:

H4: Project team communication quality is positively related to effectiveness of project team learning.
H5: Project team communication quality is positively related to project team integration.

IBT Use in New Product Development

With the developments in Internet-based technologies, a large number of studies dedicated to the Internet's role in NPD have been conducted. It has been postulated, among others, that the Internet-based technologies can be effectively implemented and used in order to obtain inputs from internal and external customers (Iansiti and MacCormack, 1997); collect competitive intelligence (Teo and Chow, 2001); test new product prototypes (Dahan and Srinivasan, 2000); communicate with experts around the world (Howe *et al.*, 2000); support learning and knowledge management (Teo and Chow, 2001; Ozer, 2003); coordinate NPD activities (Ozer, 2003); disseminate information within the firm more efficiently; and use it to make more informed decisions (Teo and Chow, 2001). Application of the Internet-based technologies to different activities within NPD projects is in turn hypothesized to lead to improvement in NPD project performance in terms of improving the development process and the new product quality (Howe *et al*., 2000). Despite the extensive discussion of benefits of IBT use in product development, the existing literature provides no large scale empirical evidence on the link between IBT use and any of NPD performance dimensions. The existing discussion is also not very precise: areas of application of the technology are confused with benefits that can be obtained from it and there is lack of well-developed comprehensive frameworks. In order to address this lack of a framework the current study proposes a model stating that IBT use has indirect impact on new product quality, through improvement of effectiveness of team learning, team integration and communication quality. It is therefore hypothesized that:

H6: Internet-based technology use is positively related to effectiveness of project team learning.
H7: Internet-based technology use is positively related to project communication quality.
H8: Internet-based technology use is positively related to project team integration.
H9: Internet-based technology use is positively related to new product quality.

Local Teams versus Global Teams

Team proximity, defined as geographical dispersion of team members (Carbonell and Rodriguez, 2005) is a very important characteristics of NPD projects. In this study a distinction is made between local teams and global teams. According to definitions provided by McDonough *et al*. (2001), local NPD teams consist of individuals who work together in the same physical location or several locations in close proximity; while global teams are compromised of individuals who work and live in different countries and are culturally diverse. More and more often companies are relying on NPD teams that are dispersed throughout the world mostly due to global dispersion of company's resources and facilities and the difficulty and expense associated with relocating these resources and facilities to a central location; as well as in order to be able to handle the increased complexity in product development and gain access to the needed expertise (Boutellier *et al*., 1998).

While global teams may have the potential to offer higher performance, they often fail to realize that potential (McDonough *et al.*, 2001). This lower than expected performance is often related to the fact that global teams face greater challenges than local teams. Among these challenges are the difficulty in achieving an effective level of integration and in fostering effective communication among team members (McDonough *et al.*, 2001). The geographical dispersion of team members makes communication among them quite complex. As a result, dispersed teams significantly increase the team's communication and integration requirements (Subramaniam *et al*., 1998). The studies on distributed teams have found that Internet-based technologies were useful in facilitating or even enabling communication across groups and employees located at dispersed geographical locations. As a result, literature review indicates that Internet-based technology use as well as its impact on new product quality differs depending on the proximity of NPD team members. It is therefore expected that Internet-based technologies will play significantly more important role in projects were teams consist of members dispersed geographically (global teams) as opposed to projects were teams consist of collocated members (local teams). The following hypothesis is therefore proposed:

H10: The positive relationship between Internet-based technology use and new product quality is greater for projects conducted by highly dispersed (global) teams compared to projects conducted by collocated (local) teams.

Methodology

Data Collection and Sample

The sampling frame for this study comprises of managers of product development projects from Canadian and American manufacturing companies. To enhance the generalizability of the findings, a sampling frame that is a cross-section of several industries where the use of Internet-based technologies is more likely was chosen. The industries selected for this study are represented by the flowing North American Industry Classification System (NAICS) codes and include: machinery manufacturing (NAICS Code of 333), computer and electronic products manufacturing (NAICS Code of 334), electrical equipment, appliance, and component manufacturing (NAICS Code of 335) and transportation equipment manufacturing (NAICS Code of 336). Lists of organizations have been obtained from two commercial directories: the *Scott's Online Directory* for Canadian manufacturing organizations and the *Manufacturers News, Inc. Directory* for American manufacturing organizations. The actual selection of the units to be contacted followed the probability sampling design. 1000 organizations were randomly selected (following simple random sampling process) from the list of companies obtained from the Scott's Online Directory. Similarly, 1500 organizations were randomly selected (following simple random sampling process) from the list of companies obtained from the Manufacturers News, Inc. A survey kit, including a cover letter, a questionnaire, and a self-addressed return envelope (stamped for Canadian participants) was developed and mailed to R&D managers from the randomly selected companies. A total of 2500 survey kits were mailed. In order to further encourage participation, a follow-up phone calls to the appropriate persons were made. In the end, 278 usable surveys were returned, resulting in usable response rate of 11.3%.

Measures

The questionnaire included the measurement items for all the constructs, several demographic questions and open ended question regarding NPD practices. Wherever possible, measurement items were adapted from existing scales from the literature. Using scales that have been tested in previous studies is recommended, because it helps to assure instrument reliability. All of the scales were refined or developed in collaboration with project managers and scholars knowledgeable in the area of product development. This allowed modification of questions that were not clear and identification of potential problems with the design of the questionnaire regarding wording or format. The measures of each construct were developed using multiple items and Likert-type scales (1=strongly disagree to 5= strongly agree) with exception of measures of product quality. The items used to measure the constructs included in the research model and their sources are reported in Appendix 1.

Characteristics of the Sample

The organizations that responded to the survey represented all of the four industries that were selected to be in the sampling frame. Majority (167) of the organizations were from Canada and the remaining 111 from the United States. The size of the companies that participated in this study ranges from 5 employees to over 2000 employees. Majority of the companies (87.8% of the sample), had less than 1000 employees. Majority of the respondents filled out the questionnaire with respect to innovation projects that were completed within the last 2 years (174 projects, representing 62.6% of the sample) or were near completion (92 projects, represented 33.1% of the sample). The remaining 11 projects were completed between 2 and 5 years ago and 1 project was completed more than 5 years ago. Project teams responsible for these projects were very different in terms of size and diversity. There were different functional groups represented on development teams, including marketing and sales, research and development (R&D), purchasing, engineering/design, manufacturing, quality assurance, and customer support. The development projects included in the sample were executed by teams consisting of the average of 14.35 members, with standard deviation equal to 18.25 (N = 277). In case of 73 projects (26.3% of the sample) all the team members were located in one building or office. The team members in 46 projects (16.5% of the sample) were located in several locations across one city. The remaining projects had team members located in several cities within one country (74 projects representing 26.6% of the sample) or in more than one country (85 projects representing 30.6% of the sample). The internet based technologies most often used in project execution included: email, teleconferencing, Internet-based project workspace and file sharing systems, and Internet-based document management systems.

Results

Data Screening

Before the testing of hypotheses, data screening was performed in order to improve confidence that the main analysis will produce valid conclusions. Analysis of the missing data indicated that all variables contained less than 10.5% of missing information, with majority containing less than 4% of missing data. In order to address this issue, FIML (full information maximum likelihood) estimation was applied. The choice of FIML was motivated by the results of earlier Monte Carlo simulations indicating the superiority of FIML over other methods of handing missing data (i.e., listwise deletion, pairwise deletion, data imputation) as the method leading to the lowest rate of convergence failures, least bias in parameter estimates, and lowest inflation in goodness of fit statistics (Enders and Bandalos, 2001; Brown, 1994). Further data screening indicated that there are no outliers in the data and that it meets the normality assumption required to use SEM approach.

Measure Validation

In order to test the model, the two-step procedure recommended by Anderson and Gerbing (1988) was followed, which recommends measurement model assessment prior to testing of the hypotheses. The measurement scales were examined for unidimensionality, validity and reliability. Unidimensionality and validity were demonstrated by confirmatory factor analysis (CFA) as recommended by Anderson and Gerbing (1982). All standardized loadings were significant at $p<0.01$, indicating that the items did adequately reflect their corresponding constructs. The advantage of this approach is that the full-information estimation methods for the confirmatory factor model jointly assume internal consistency and external consistency for any specified model to arrive at parameter estimates. As a result, assessment of the measurement model provided by CFA represents a sufficient condition for unidimensional measurement. (Anderson *et al.*, 1987). However, given that unidimensionality alone is not sufficient to ensure the usefulness of a scale, the reliability of the composite scores was investigated after unidimensionality has been acceptably established. For this purpose, the values of composite reliability and average variance extracted were calculated for all the constructs. Analysis of the results (see the Appendix) indicated that the values of composite reliability and average variance extracted for all the constructs were greater that the recommended thresholds of 0.70 and 0.50 respectively. Discriminant validity was further confirmed using an approach proposed by Fornell and Larcker (1981) who suggested that the shared variance between any two constructs should be less than the variance extracted by either of the individual constructs.

Hypotheses Tests (Main Effects Model)

In order to test the hypotheses, a structural model linking IBT use, communication quality, effectiveness of team learning, team integration and product quality was estimated using LISREL software. Table 1 presents correlations between all the constructs.

Table 1

Correlations between Latent Constructs

Variable	1	2	3	4	5
1. IBT use	1				
2. Communication Quality	0.35	1			
3. Effectiveness of Team Learning	0.53	0.70	1		
4. Team Integration	0.40	0.66	0.76	1	
5. Product Quality	0.38	0.53	0.72	0.63	1

The overall fit of the model to the data was good, based on the analysis of RMSEA index: (RMSEA = 0.036, 90% confidence interval for RMSEA = (0.031; 0.042); p-value for test of close fit (RMSEA<0.05) = 1.00). Investigation of the residuals and modification indices also indicated that there are no local cases of poor fit. The model explains 53% of the variance in product quality, 69% of the variance in effectiveness of team learning, 48% of the variance in team integration and 12% of the variance in communication quality.

The proposed hypotheses were examined based on the path coefficients and their significance levels, as well as based on the total effect sizes among the constructs in the model and their significance levels. The estimates of direct effects (standardized path coefficients), indirect effects and total effects between the variables and the results of hypotheses testing are presented in Table 2.

Table 2

Standardized Test Results of the Structural Equation Model

Path	H	Direct Effect	Indirect Effect	Total Effect	Conclusion
Effectiveness of Team Learning → Product Quality	H1	0.57	– –	0.57	supported
Team Integration → Product Quality	H2	0.19	0.26	0.45	supported
Team Integration → Effectiv. of Team Learning	H3	0.46	– –	0.46	supported
Communication Quality → Effectiv. Team Learning	H4	0.32	0.27	0.59	supported
Communication Quality → Team Integration	H5	0.60	– –	0.60	supported
IBT Use → Effectiveness of Team Learning	H6	0.23	0.29	0.53	supported
IBT Use → Communication Quality	H7	0.35	– –	0.35	supported
IBT Use → Team Integration	H8	0.20	0.21	0.40	supported
IBT Use → Product Quality	H9	– –	0.38	0.38	supported

Note that all effects are significant at 0.05 level.

H1 and H2 were both supported, suggesting positive effects of effectiveness of team learning and team integration on product quality as it was expected based on previous studies. When comparing the magnitude of the effects of team integration and effectiveness of team learning on product quality, effectiveness of team learning has the greater total effect on product quality. H3 suggesting positive effect of team integration on effectiveness of team learning was also confirmed. The next two hypotheses (H4 and H5) indicating positive effect of communication quality on effectiveness of team learning and team integration were confirmed as well. Finally, the last four hypotheses (H6-H9), suggesting a positive effect of IBT use on effectiveness of team learning, communication quality, team integration, and product quality were also supported. IBT use has only direct effect on communication quality, while it has both direct and indirect effects on effectiveness of team learning and team integration. It also only indirect effect on product quality. The analysis indicated that IBT use explains 12.3% of the variance in communication quality, 28% of the variance in effectiveness of team learning, 16% of the variance in team integration, and 14.4% of the variance in product quality.

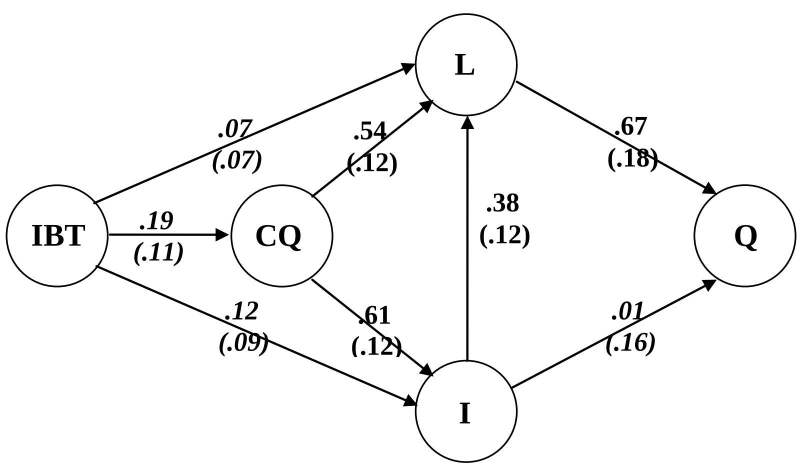
Comparison of IBT Role in Local and Global Teams

The variable of team proximity was captured by asking the respondents to indicate where the NPD project team members were located: in one building/office; in several locations but one city; in several cities but one country; and in more than one country. In order to conduct a comparison between two groups characterized by high and low team proximity, the following two categories were introduced: local teams and global teams. Local teams included teams that were either located in one building/office or in several locations within one city (119 cases). The global teams, on the other hand, encompassed projects that were executed by teams located in several cities (locations) within one or more countries (159 cases).

Next, two models were estimated: one for local teams and one for global teams. The obtained unstandardized estimates for local teams and global teams are presented in Figure 2 and Figure 3, respectively. Estimation of the two models indicated several insignificant paths. All these paths were kept in the models, given the following rationale: the values of the paths were usually greater than 0 and t-statistics were often close to the cut-off value of t=1.96. Therefore, the lack of significance of a given path may be related more to the small sample size, and not to the lack of significance of the path. All the path coefficients that were insignificant but were kept for the analysis are indicated in italics in Figure 2 and Figure 3. The model for local teams has a good fit to data (RMSEA= 0.061) and explains 3.8% of variance in communication quality, 72% of variance in effectiveness of team learning, 41% of variance in team integration, and 43% of variance in new product quality. The Internet-based technology use accounts for 3.8% of variance in communication quality, 6.9% of variance in effectiveness of team learning, 5.6% of variance in team integration and 3% of variance in new product quality.

Figure 2

IBT Use and New Product Quality: Model for Local Teams



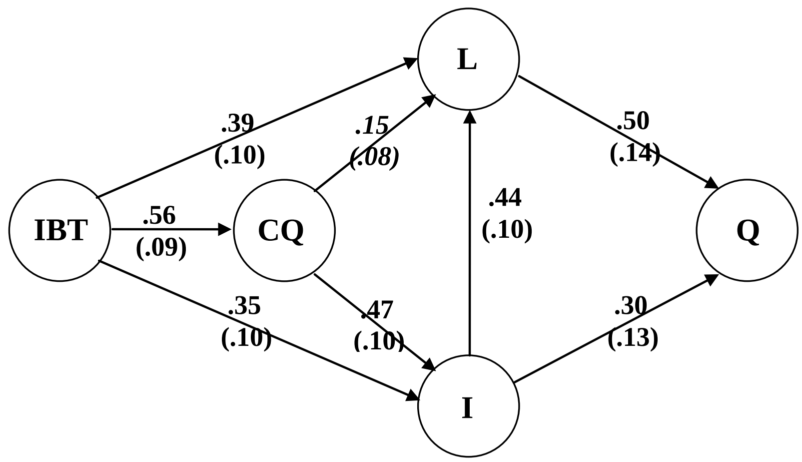
χ^2 = 1216.45 df = 842 RMSEA = 0.061 n = 159

Variable	Direct Effect	Indirect Effect	Total Effect	R^2(IBT)	R^2(model)
IBT→CQ	.19(.11)	----	.19(.11)	3.8%	3.8%
IBT→L	.07(.07)	.19(.09)	.26(.11)	6.9%	72%
IBT→I	.12(.09)	.12(.07)	.24(.11)	5.6%	41%
IBT→Q	----	.18(.08)	.18(.08)	3%	43%

The model for global teams also has a very good fit to data (RMSEA= 0.047). It explains much more variance in dependent variables than the model for local teams: 32% of variance in communication quality, 74% of variance in effectiveness of team learning, 53% of variance in team integration and 57% of variance in new product quality. The Internet-based technology use accounts for 32% of variance in communication quality, 756% of variance in effectiveness of team learning, 38% of variance in team integration and 31% of variance in new product quality.

Figure 3

IBT Use and New Product Quality: Model for Global Teams



χ^2 = 1143.31 df = 842 RMSEA = 0.047 n = 159

Variable	Direct Effect	Indirect Effect	Total Effect	R^2(IBT)	R^2(model)
IBT→CQ	.56(.09)	----	.56(.09)	32%	32%
IBT→L	.39(.10)	.36(.07)	.75(.12)	56%	74%
IBT→I	.35(.10)	.26(.06)	.62(.10)	38%	53%
IBT→Q	----	.56(.09)	.56(.09)	31%	57%

In order to test the hypothesis 10, i.e. to determine whether the impact of Internet-based technology use on new product quality is greater for products developed by global teams compared to products developed by local teams, a series of z-tests was performed. The differences between direct and total effects obtained for global teams and direct and total effects obtained for local teams were calculated and their significance verified through a comparison to the one-tailed test statistic $z_{.05}$=1.645. All the calculated values are reported in Table 3.

The following observations can be made:

- Direct effect of IBT use on communication quality is significantly higher for global teams than for local teams.
- Both the direct and total effects of IBT use on team integration are significantly higher for global teams than for local teams.
- Both direct effect and total effect of IBT use on effectiveness of team learning are significantly higher for global teams than for local teams.
- There are no significant differences between the two groups (local teams versus global teams) as far as the effects of team integration and effectiveness of team learning on new product quality are considered.

- The total effect of IBT use on new product quality is significantly higher for global teams than for local teams (β_1=.56, β_2=.19, z=1.94).

Table 3
Hypothesis Testing: Innovative Products versus Incremental Products

	B1	**SE(B1)**	**B2**	**SE(B2)**	**Z**	
IBT→CQ	.56	.09	.19	.11	**2.60**	S
CQ→Integration	.47	.10	.61	.12	**-0.90**	NS
CQ→Learning	.15	.08	.54	.12	**-2.70**	S
IBT→Integration	.35	.10	.12	.09	**1.71**	S
IBT→Integration(T)	.62	.10	.24	.11	**2.56**	S
IBT→Learning	.39	.10	.07	.07	**2.62**	S
IBT→Learning(T)	.75	.12	.26	.11	**3.01**	S
Integration→Learn	.44	.10	.38	.12	**0.38**	NS
Integration →Quality	.30	.13	.01	.16	**1.41**	NS
Learning→Quality	.50	.14	.67	.18	**-0.75**	NS
IBT→Quality(T)	.56	.09	.18	.08	**3.16**	S

- B1 and SE(B1) are values obtained for the model estimated for projects executed by global teams
- B2 and SE(B2) are values obtained for the model estimated for projects executed by local teams
- (T) indicates total effects
- S indicates a significant difference between two groups, NS indicates a non-significant difference between two groups

Discussion

The primary aim of this study was to investigate the impact of IBT use on new product quality. It was hypothesized that IBT use has a positive indirect impact on new product quality through improvement of communication quality, effectiveness of team learning and level of team integration. It was also postulated that the strength of these relationships will be different depending on NPD team proximity. In order to test the proposed hypotheses, a measurement model was developed based on an extensive literature review and a series of discussions with industry specialists and then statistically tested based on the collected data. The data analysis supported all of the hypotheses. Support for H1 and H2 stating the positive effect of effectiveness of team learning and team integration on new product quality was expected and is consistent with previous studies in NPD area. However, retesting of these relationships was critical in the context of this study in order to investigate the indirect effect of IBT use on new product quality.

This research offers a number of findings regarding the role of IBT use in new product development. It confirmed that the Internet-based technology use directly contributes to communication quality. Next, it indicated that IBT use influences effectiveness of team learning and team integration not only directly, but also indirectly, through the improvement of communication quality. This research also confirmed the hypothesis about the positive effect of IBT use on new product quality.

The positive impact of IBT use on new product quality is widely postulated in the theoretical literature in the NPD field (e.g., Howe *et al*., 2000; Sethi *et al*., 2003; Ozer, 2004). Despite the general agreement on the potential benefits of IBT use in NPD projects, the relationship between IBT use and new product quality has not been empirically tested so far. At the same time, practitioners are struggling to better understand the benefits that can be achieved through the use of Internet-based technologies and justify investment in these technologies. As one of the respondents in this study indicated “We have looked at the software available to help improve NPD data sharing. It always came down to it: Is it worth it? We were never able to justify the purchase of a tool”. Therefore, this study not only furthers the academic knowledge on the IBT effect on new product quality but also provides a number of insights for practitioners. First of all, by confirming the positive effects of IBT use on communication quality, effectiveness of team learning, team integration, and new product quality, this study shows that Internet-based technologies can be used to improve NPD performance. Secondly, it indicates that the role of IBT depends on the type of development team: IBT use can have much greater influence on new product quality in global teams, as compared to local teams.

Important implication from this study is that although IBT use does have a positive effect on new product quality, it is not its only determinant (it explains only 14.4% of variance in new product quality). It is also important to note that the model explains 53% of variance in new product quality. It indicates that there are a number of other factors that contribute to new product quality, some of which were identified in earlier studies (e.g., availability of resources, senior management support, and project leader). Some of these factors may adversely affect new product quality, even if Internet-based technologies are deployed and used extensively. Therefore, it is important for the managers to recognize that the IBT contribution depends on a number of factors and its implementation is not a sufficient condition to guarantee improvement in new product quality.

Limitations

Although the findings of this research support the proposed hypotheses, the results must be treated with caution due to some limitations of the analysis related to research design, data collection and generalizability of the results. Fist of all, the measures of the different constructs were derived mostly from previous research. However, the measurement instrument of IBT use is new. Although the proposed operationalization of IBT use is acceptable and was supported by CFA analysis, it likely can be further improved and should be tested in settings different from the context of this study. Secondly, the data were collected using only one respondent to provide information regarding a given NPD project. This leads to the concern regarding the common method variance (Podsakoff *et al*., 2003) which can inflate correlations between variables measured with the same method. Although self-report cross-sectional questionnaires are considered a valuable first step in studying phenomena of interest (Podsakoff *et al*., 2003) once the preliminary investigation (as the one conducted in this study) is completed, other methodologies should be applied to further test self-report studies and theories. Finally, this study relied on perceptual measures, given the fact that it is very difficult to obtain objective measures for the constructs that were investigated. In particular, the validity and reliability of the instruments used to measure the constructs depend upon the respondents’ knowledge of the facts. Although all care was taken to ensure that the respondents were knowledgeable of the projects they evaluated, future studies are recommended to further test the validity and reliability of the measures.

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Appendix A

Confirmatory Factor Analysis Results for the Measurement Model

Constructs and Items	Loading	t-Value	Indicator reliability
INTERNET-BASED TECHNOLOGY USE (ρ = 0.81; VE = 0.513) (new scale)			
Data and Information Management (ρ = 0.883; VE = 0.66)	0.64		0.41
Please indicate the extent to which Internet-based technologies have been applied by the project team members to access and request product data and other information.	0.57	n/a	0.32
Please indicate the extent to which Internet-based technologies have been applied by the project team members to exchange messages with one another.	0.88	10.28	0.77
Please indicate the extent to which Internet-based technologies have been applied by the project team members to send, forward, receive, and reply to messages from other team members.	0.91	10.44	0.83
Please indicate the extent to which Internet-based technologies have been applied by the project team members to exchange files or documents with one another.	0.85	10.08	0.72
Collaborative Teamwork (ρ = 0.917; VE = 0.79)	0.78		0.61
Please indicate the extent to which Internet-based technologies have been applied by the project team members to conduct virtual meetings of distributed team members.	0.83	n/a	0.69
Please indicate the extent to which Internet-based technologies have been applied by the project team members to provide virtual work environment for sharing resources and information.	0.91	18.90	0.83
Please indicate the extent to which Internet-based technologies have been applied by the project team members to provide virtual work environment for performing activities jointly and simultaneously.	0.92	19.22	0.85
External Partner Involvement (ρ = 0.927; VE = 0.81)	0.62		0.39
Please indicate the extent to which Internet-based technologies have been applied by the project team members to communicate and exchange ideas with external partners/suppliers/customers.	0.90	n/a	0.81
Please indicate the extent to which Internet-based technologies have been applied by the project team members to obtain inputs and feedback from partners/suppliers/customers.	0.93	23.23	0.86
Please indicate the extent to which Internet-based technologies have been applied by the project team members to provide data sharing with external partners/suppliers/customers.	0.87	20.40	0.76
Project Management (ρ = 0.913; VE = 0.728)	0.80		0.64
Please indicate the extent to which Internet-based technologies have been applied by the project team members to coordinate activities performed by team members.	0.76	n/a	0.58
Please indicate the extent to which Internet-based technologies have been applied by the project team members to monitor project schedule and budget.	0.87	15.34	0.76
Please indicate the extent to which Internet-based technologies have been applied by the project team members to conduct performance monitoring and assessment.	0.90	15.90	0.81
Please indicate the extent to which Internet-based technologies have been applied by the project team members to perform risk assessment activities.	0.87	15.15	0.76
COMMUNICATION QUALITY (ρ = 0.904; VE = 0.70) (Mohr and Spekman, 1994)			
Communication among project team members was timely.	0.80	n/a	0.64
Communication among project team members was open.	0.81	15.25	0.66
Communication among project team members was accurate.	0.87	16.51	0.76
Communication among project team members was effective.	0.86	16.22	0.74

EFFECTIVENESS OF TEAM LEARNING (ρ = 0.946; VE =0.853) (Akgün *et al.*, 2006; Brockman and Morgan, 2003)			
Effectiveness of Information Acquisition (ρ = 0.783; VE = 0.553)	0.95		0.90
The project team displayed a high level of competence in acquiring the information needed to develop the product.	0.81	n/a	0.66
The project team acquired the information needed to develop the product from a variety of sources.	0.80	14.04	0.64
The project team gathered sufficient relevant internal and external information regarding customers, markets, technologies, and competitors during the project.	0.60	10.16	0.36
Effectiveness of Knowledge Sharing (ρ = 0.819; VE = 0.603)	0.92		0.85
The project team was successful at distributing information needed for task completion among the team members.	0.82	n/a	0.67
Project team members were well aware of where specialized knowledge is located and needed in the project.	0.78	13.69	0.61
Project team members developed a similar understanding of the role the acquired information would play in developing the product.	0.73	12.80	0.53
Effectiveness of Knowledge Application (ρ = 0.884; VE = 0.604)	0.90		0.81
The project team had the ability to incorporate lessons learned during the project into the final product.	0.68	n/a	0.46
The project team had the ability to translate customer needs into product design specifications.	0.78	11.77	0.61
The project team was able to effectively respond to changes in customer needs.	0.85	12.45	0.72
The project team was able to effectively respond to changes in technological environment.	0.80	11.90	0.64
The project team was very good at joint problem solving.	0.77	11.74	0.59
TEAM INTEGRATION (ρ = 0.919; VE = 0.793) (Malone and Crowston, 1994; Mohr and Spekman, 1994; Koufteros *et al*., 2005)			
Functional Integration (ρ = 0.825; VE = 0.695)	0.78		0.61
Activities performed by different project team members were well coordinated.	0.82	n/a	0.67
The resources were allocated within the team effectively.	0.85	13.54	0.72
Normative Integration (ρ = 0.899; VE = 0.642)	0.90		0.81
Project team members had common vision and goals.	0.76	n/a	0.58
Project team members shared resources to complete tasks.	0.78	13.57	0.61
Project team members achieved goals collectively.	0.88	15.49	0.77
Project team members worked together as a team.	0.83	14.65	0.69
Project team members sought integrative solutions.	0.75	12.87	0.56
Social Integration (ρ = 0.884; VE = 0.658)	0.98		0.96
Project team members recognized each other's talents and expertise.	0.77	n/a	0.59
Project team members helped each other to more effectively perform their tasks.	0.81	14.26	0.66
Project team members got along well with each other.	0.84	14.84	0.71
Project team members perceived their problems as mutual problems.	0.82	14.32	0.67
PRODUCT QUALITY (ρ = 0.811; VE = 0.593) (Clark and Fujimoto, 1991)			
Please rate your product quality as compared to quality goals at the start of the project.	0.74	n/a	0.55
Please rate your product quality as compared to quality of similar past products in your organization.	0.84		0.71
Please rate your product quality as compared to quality of similar competitor products.	0.72		0.52