The Impact of IT Usage on Collaborative New Product Development Performance

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Abstract

Fast introduction of new products at low cost is essential for being successful in today's industrial business environment. New product development (NPD) practitioners increasingly rely on information technology (IT) aiming to achieve lower costs, higher quality, and greater speed to market. A little is known about the effect of various IT tools on NPD performance and exploring this would ease effective deployment of IT resources in innovation programmes. This study uses data collected in Product Development Management Association's 2012 Comparative Performance Assessment Study, from 453 firms across different countries and industries. Direct and indirect effects of four types of IT tools on financial and time performance of NPD projects are examined using partial least squares path analysis. Results suggest that three IT types indirectly improve NPD performance by increasing collaboration, although no direct impact tested is significant. The study implies that extensive use of IT tools significantly contributes to improve collaboration which is vital for reducing development times and increasing financial returns of NPD projects.

Keywords

NPD collaboration, IT usage, financial performance, product development time

INTRODUCTION

Success of today's companies mainly depends upon their ability to introduce new or improved products to the market speedily at a relatively low cost. Promising ideas and required expertise to develop new products may be present with company's stakeholders such as suppliers, customers, competitors, or staff. Collaboration is a strategy that many companies deploy when introducing new products through integration with two or more external and/or internal parties (Büyüközkan et al. 2012). Collaboration extends the scopes of the concepts – networking and cooperation, by allowing partners to share information, resources, and responsibilities in order to achieve common goals, creating a joint value (Camarinha-Matos et al. 2009). Firms may collaborate at any stage of the product development process namely, conceptualization, product development, and commercialization. Information and communication technologies including tools for face-to-face communication provide the key means for communication and processing required information between new product development (NPD) partners (Curşeu et al. 2008; Montoya et al. 2009). Face-to-face meeting has been recognized as the best medium of communication in NPD projects specifically for exchanging tacit knowledge which needs more human involvement for being effectively transferred (Badrinarayanan et al. 2008; Thomas 2013). However, as the number of virtually involved partners increases, NPD teams find less opportunity to meet face-to-face and tend to rely more on IT tools for collaboration in terms of sharing of resources, knowledge, skills, risks and benefits (Lockwood et al. 2013).

Both specifically designed IT tools for NPD tasks and common tools that can also be used for other organizational functions are deployed in NPD programmes. Design and development IT tools such as, CAD, object-based modelling, collaborative CAD, product life cycle management (PLM) systems, virtual prototyping systems, and product data management systems are primarily made for aiding NPD activities. These tools perform major NPD tasks such as creating visualization, analysis and simulation of designs, storing and sharing

of critical product/project data, validating and testing designs. Communication and collaboration tools (e-mail, video conferencing), project management systems, and market research/analysis tools are the common IT tools which are largely utilized in NPD programmes but designed for accomplishing a range of many other organizational activities as well. IT tools allow partners to collaborate in NPD projects through efficient processing and sharing of large volumes of information. However, this accessibility to product related information sometimes create issues such as leakage of proprietary knowledge and loss of control when more parties are collaborated in NPD projects (Hoecht et al. 2006; Littler et al. 1995). Furthermore, increased dependency on IT tools incurs significant costs to companies and the usefulness may depend on contexts of NPD projects such as complexity, level of collaboration, and degree of involvement of partners (Kawakami et al. 2011; Peng et al. 2014). Real-time communication, concurrent operations, and increased information access facilitated by intensive use of IT are expected to overcome social, technical and organizational barriers in collaborative NPD (Boutellier et al. 1998; Swink 2006). However, all IT tools used in collaborative NPD programmes do not equally facilitate achievement of these objectives and the impact on project performance may significantly vary across tools and project contexts (Peng et al. 2014). Therefore, most studies that addressed IT usage in NPD have considered one or a few selected IT types such as customer relationship management systems (Hadaya et al. 2009), knowledge management tools (Vaccaro et al. 2010), or communication tools (Thomas 2013).

However, existing empirical evidences for the impact of IT usage on NPD performance are inconsistent. For example, In a study focusing on various NPD facilitating IT tools, Barczak et al. (2007) found a direct positive effect of IT usage on market performance and no significant impact on speed to market. Direct negative effects of usage of some product design tools (e.g., CAD systems) (Kessler et al. 1999) and Web-based communication/collaboration tools (Oke et al. 2010) on product development speed is also evident. Durmuşoğlu et al. (2011) found a positive effect of simple communication tools (e.g., e-mails) product development and knowledge management tools (e.g., decision support systems, file transfer protocols) on NPD effectiveness but no significant impact of media rich communication tools (e.g., Web meetings). According to Thomas (2013), Web-based communication/collaboration tools have a negative effect on supplier knowledge exchange during collaborative NPD projects and therefore, over reliance on these tools is not suitable.

Although the direct effect of IT usage on projects' final outcomes such as financial and time performance are not as strong as managers expect (e.g., Barczak et al. 2007; Oke et al. 2010), a considerable positive effect of several IT tools on NPD collaboration is evident (Peng et al. 2014; Vilaseca-Requena et al. 2007). A positive effect of collaboration on NPD project success has also been previously proven (Mishra et al. 2009). Therefore, research investigating the impact of IT tools on NPD performance have considered collaboration as a mediator variable (e.g., Banker et al. 2006; Vilaseca-Requena et al. 2007). However, these studies have focused on either usage of a specific IT tool (e.g., PLM software) or a group of IT tools (e.g., marketing IT). Therefore, this study suggests that NPD collaboration could represent the transitional link between any IT type used in NPD programmes and the performance of these programmes. This defines the main objective of the study as investigating the direct and indirect impact of four key IT categories – market research/analysis tools, communication/ collaboration tools, knowledge/project management tools, and product design/development tools – on NPD performance. Data collected by Product Development Management Association (PDMA) (based in Chicago, IL, USA) in their 2012 Comparative Performance Assessment Study (CPAS), is a rich source of recent data on a range of NPD practices and tools used in firms in different parts of the world. The present study obtained data on various IT tools used in NPD programmes and relevant performance measures from the CPAS database, to address the following research question:

- How does NPD collaboration mediate the relationship between IT usage (use of different IT tools) and financial performance and time performance of NPD projects?

The rest of the article is organized as follows. First, the research model and formation of hypotheses are presented. Then, the methodology adopted in the study is explained in detail. Next, the results obtained in the path analysis performed are presented and discussed. The theoretical contributions, managerial implications, and limitations of the study are presented in the last two sections.

RESEARCH FRAMEWORK AND HYPOTHESES

A research model has been developed to address the research question concerning the mediating effect of NPD collaboration on the relationship between IT usage and NPD performance. The model tests both direct and indirect effects of four IT types on NPD performance in terms of financial performance and product development time. The following sections describe the basis for the relationships being investigated, the constructs selected, and the development of hypothesis.

IT Usage

Although IT usage has been suggested as a vital factor for achieving higher NPD performance, evaluation of usage of IT tools within a NPD project does not seem straightforward. In earlier studies addressing the use of IT in NPD programmes, the usage has been evaluated differently. For example, Barczak et al. (2007) have considered overall usage of all IT types in NPD programmes to study the impact on market performance and speed to market. Some other researchers have considered individual IT tools (e.g., Durmuşoğlu et al. 2011; Thomas 2013) or categories of IT (e.g., Peng et al. 2014). Representation of IT usage in terms of frequency, proficiency, and intensity of use is another alterative (Silva et al. 2013). The Likert scaled data on IT usage, available in the CPAS (2012) database represent overall usage of various IT tools in NPD programmes. These data are used to assess the use of four IT types – market research/analysis IT, communication/collaboration IT, knowledge management/project management IT, and product design/development IT – the main independent variables in the proposed research model. This classification is based on the NPD facilitating IT tools categories considered in recent studies (e.g., Kawakami et al. 2011; Peng et al. 2014). The study investigates the impact of usage of the four IT categories on NPD performance dimensions described below.

NPD Performance

NPD performance represents the degree of successfulness of a project in terms of development time, financial performance, quality, and innovativeness. The CPAS (2012) database contains data on profitability and average product development time of NPD programmes. In prior IT-related NPD studies performance of NPD projects has been evaluated via new product quality, financial (market) performance, speed to market (time performance), and NPD effectiveness (e.g., Barczak et al. 2007; Durmuşoğlu et al. 2011). Since these are the key concerns of NPD practitioners, for which data are also available in the CPAS (2012), financial performance and product development time are included as dependent variables in the conceptual research model. Figure 1 shows the research model and hypotheses developed in order to examine the direct and indirect impact of IT usage on two performance indicators – financial performance and product development time. The constructs are labelled in the model as illustrated in Figure 1.

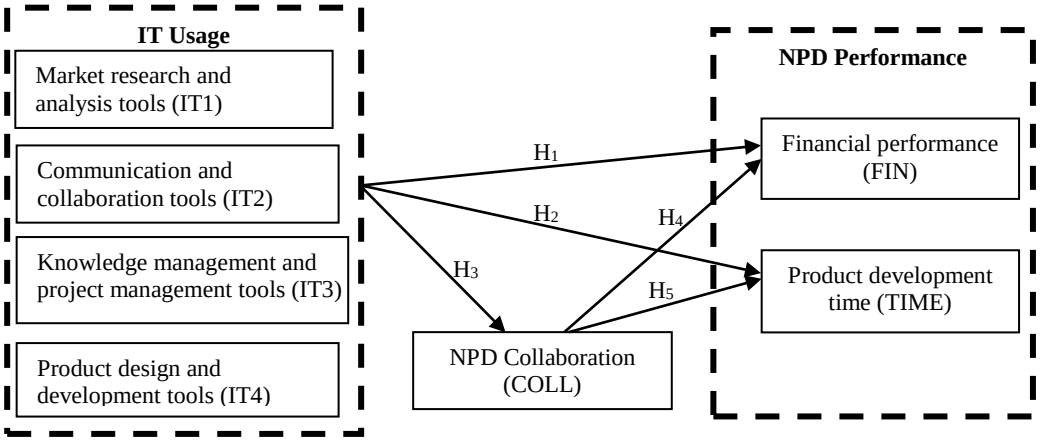

Figure 1. Model for Evaluating the Impact of IT usage on Collaboartive NPD Performance

Importance of investigating the impact of IT usage on NPD projects' commercial or financial success has been highlighted in several studies (e.g., Barczak et al. 2007; Thomas 2013; Vaccaro et al. 2010). However, a few of these studies have focused on the direct impact of IT usage on the financial performance. For example, in a study which has no particular focus on NPD projects, Devaraj et al. (2003) observed a positive impact of IT usage on a firm's financial performance. This finding has been extended by Barczak et al. (2007) who found a positive effect of IT usage on market performance operationalised to represent financial success of NPD projects. According to Banker et al. (2006), implementation of PLM software has a direct positive effect on product development cost reduction. Supporting this, a direct positive effect of knowledge management IT tools on NPD project's financial performance has been observed in another study (Vaccaro et al. 2010). Empirical evidences for both significant and insignificant direct effects of IT tools in other categories, on market performance are also available (e.g., Durmuşoğlu et al. 2011). Based on these premises, the present study attempts to empirically establish positive direct effects of the four IT types considered on financial performance through testing the following hypothesis with recent CPAS (2012) data.

H1a: Usage of market research and analysis IT tools will increase the financial performance of the projects.

(H1b, H1c, and H1d represent similar hypotheses concerning the effects of communication/collaboration tools, knowledge management/project management tools, and product design/development tools respectively

A consistency has not been observed in literature in relation to the impact of IT usage on time performance of NPD projects. For example, Barczak et al. (2007) found no significant effect of IT usage on speed to market of a new product. In a study examining knowledge management IT tools, Vaccaro et al. (2010) revealed that higher levels of reliance on these IT improves speed to market. Negative impact of Web-based communication and collaboration IT tools (Oke et al. 2010) and product development tools such as CAD systems (Kessler et al. 1999) on time performance of NPD projects is evident in some studies. Increased social interactions and negotiations which take a long time to establish with coordination complexities through IT may delay NPD process when firms mainly rely on media rich communication channels (Oke et al. 2010; Thomas 2013). However, use of widely available simple communication tools such as telephone, e-mail, and face-to-face communication would be rather efficient but may not be much prioritized in large-scale global projects (Boutellier et al. 1998). Since available empirical evidences are contradictory and confusing, the impact of different IT tools on product development time would need further exploration with more recent data. This study uses the CPAS (2012) data to test the following hypotheses which posits positive impact of all IT types on the time performance (indicated by lower product development times) of NPD projects.

H2a: Usage of market research and analysis IT tools will decrease the development times of new products.

(H2b, H2c, and H2d represent similar hypotheses concerning the effects of communication/collaboration tools, knowledge management/project management tools, and product design/development tools respectively

The Role of NPD Collaboration

Inadequacies and inconsistencies in the available knowledge on the direct relationship between IT usage and different NPD performance dimensions call for exploration of some intermediate variables (mediators) affecting this relationship. Organizations collaborate in their NPD endeavours mainly for reducing the risk of negative effects of uncertainties involved in these projects (Büyüközkan et al. 2012; Littler et al. 1995). Intense use of IT tools for design, development, prototyping, and commercialization activities in the product development process may improve the collaboration with firm's stakeholders, in these stages (Awazu et al. 2009). NPD collaboration which refers to the degree of involvement and integration of internal cross-functional teams and external partners such as suppliers and customers within projects, helps firms to achieve higher levels of project performance (Mishra et al. 2009). Increased levels of virtuality and variety of partnerships in collaborative teams could be a major reason for the increased requirement for IT tools in NPD projects (Lockwood et al. 2013). According to Rai et al. (2006), supply chain integration through IT usage helps to improve a firm's financial performance. This is further supported by Banker et al. (2006) who identified the mediator role of collaboration in improving the positive impact of PLM software implementation on NPD performance. However, extant empirical evidences for the direct impact of communication/collaboration IT tools and knowledge/project management IT tools on collaboration are somewhat contradictory. Media rich communication/collaboration tools (e.g., Web-based tools, and video conferencing) and project/knowledge management tools (e.g., file transfer, project management systems) have not been proven as effective as basic tools (e.g. e-mails and voice mail) in knowledge exchange between dispersed NPD partners (Boutellier et al. 1998; Thomas 2013). However, the above literature broadly suggests that NPD collaboration could be supported by increased use of IT tools in NPD programmes. Therefore, the following three hypotheses are developed to test the positive indirect impact of IT usage on financial and time performance of NPD projects, through collaboration.

H3a: Usage of market research and analysis IT tools will improve NPD collaboration.

(H3b, H3c, and H3d represent similar hypotheses concerning the effects of communication/collaboration tools, knowledge management/project management tools, and product design/development tools respectively)

H4: Higher levels of NPD collaboration will increase the financial performance of NPD projects.

H5: Higher levels of NPD collaboration will decrease the development times of new products.

METHODOLOGY

As stated earlier, data collected in the PDMA's 2012 NPD best practices survey (CPAS) were used in this research. The five main hypotheses developed to answer the two research questions addressing the impact of IT usage on collaborative NPD performance were tested using partial least squares – structural equation modelling (PLS-SEM) approach. Inexistence of sufficient theory concerning the relationship between IT usage and NPD performance and the resulting need for exploration were the prominent motives for the selection of variance based PLS-SEM approach (Hair et al. 2012; Henseler et al. 2009). Originally the sample contained 453 surveys collected from firms from various organizational and project contexts. A sample of 350 cases was selected, which had less than 5% of missing values under each variable considered, as this is the proportion recommended to have no significant effect on the PLS-SEM result (Hair et al. 2011). Ability to handle both single and multi-item constructs was the main model-specific reason for the selection of PLS-SEM method. SmartPLS 2.0 M3 software was used to perform the PLS path analysis. In the path model, the levels of usage of four IT categories were the predictors while considering financial performance, and product development time as the dependent variables. NPD collaboration was included as the mediator variable for the relationship between IT usage and NPD performance.

Measures

Thirteen (13) IT tools on which data have been collected in the CPAS (2012) were considered in this study. These tools were divided into four categories – IT1 (Market research and analysis tools), IT2 (Communication and collaboration tools), IT3 (Knowledge management/project management tools), and IT4 (Product design and development tools) – as shown in Table 1. Measurement items used for all the other model constructs and corresponding factor loadings are also provided in the table. Details on the selection of these items based on their validity and reliability inspections are explained in the next section.

Table 1. Measurement Items Used and Factor Loadings

Construct	Measures	Factor Loading
IT1[a]	(1) Consumer needs/ requirements analysis software	0.758
(Market research and	(2) Online focus groups, Online surveys etc.	0.864
analysis tools)	(3) Online communities, net ethnography, virtual shopping, semiotics	0.875
IT2[a]	(4) Groupware (software which allows group interaction)	0.818
(Communication and	(5) Software system to connect technology specialist within firm	0.847
collaboration tools)	(6) Video-conferencing	0.702
IT3[a]	(7) Product data management systems	0.880
(Knowledge/project	(8) Product portfolio management software	0.821
management tools)	(9) Project management systems	0.770
IT4[a]	(10) Rapid prototyping systems,	0.681
(Product design/	(11) Performance modelling & simulation systems	0.803
development tools)	(12) Virtual reality/ virtual design/ cave technology	0.805
	(13) Remote collaborative design systems	0.819
NPD collaboration (COLL[b])		
COLL1	Have performance indicators to assess results of co-development projects and the quality of relationships that exist with our partners	0.873
COLL2	Shared risk, reward, and performance contract structures	0.853
COLL3	Interlocking concurrent development processes	0.883
Financial performance (FIN)		
FIN1	Percent of new product profits from more innovative projects	1.000
Product development time (TIME)		
TIME1[c]	How long it typically takes to develop a new product from concept to formal market introduction (for more innovative projects)	1.000

[[a]Usage of the IT tools were measured on a 5-point Likert scale (1=Never used, 2=25% of time, 3=50% of time, 4=75% of time, 5=virtually always). [b]Items were measured on a 5-point Likert scale. [c] Measured in weeks.]

Measurement Validity and Reliability

In PLS-SEM, examining the reliability and validity of measures involves outer model assessment (the term outer model refers to constructs and their associated measures). The procedures described by Hair et al. (2011) were used for evaluating validity (convergent and discriminant) and reliability of the measurement models. Financial performance and product development time were considered as single-item constructs, based on data availability. Table 2 presents the results obtained from the tests to confirm convergent validity, internal consistency and reliability of the measures. Composite reliability values were used to test the internal consistency and reliability.

Measures that do not relate strongly with their underlying constructs (factor loadings < 0.7) are candidates for elimination as these imply low convergent validity. The same can be said about measures that contribute towards low scale reliability or internal consistency (composite reliability < 0.7) (Hair et al. 2011). Therefore, three items were selected from the 15 questionnaire items used to evaluate the collaboration in NPD programmes. This elimination significantly improved convergent validity (average variance extracted (AVE) was changed from 0.3859 to 0.7564). In addition, the three items selected (COLL1, COLL2, and COLL3) had factor loadings higher than 0.8 and delivered maximum composite reliability value 0.903. However, one indicator (rapid prototyping systems) with a loading slightly below 0.7 (0.681) was retained because of its importance/contribution towards providing substantive meaning to the corresponding IT usage construct IT4 (product design and development tools). Consequently, composite reliability values of all the model constructs were above 0.7, which confirms internal consistency and reliability (Nunally 1978). Since all the factor loadings were higher than the recommended threshold value of 0.7 (except rapid prototyping systems with loading 0.681), no considerable indication of lack of indicator reliability was reported.

Table 2: Reliability and Convergent Validity Assessment

	AVE	Composite Reliability
IT1	0.696	0.873
IT2	0.626	0.833
IT3	0.681	0.864
IT4	0.607	0.860
NPD collaboration	0.756	0.903

(Note: Single-item constructs are excluded)

Since all the measurement models are reflective, their convergent validity and discriminant validity must be confirmed. AVE values higher than 0.5 indicate the adequate level of convergent validity of all the constructs. This suggests that each latent variable explains more than half of the variance in its indicators, on average. The Fornell and Larcker criterion (1981) was used to test the discriminant validity. According to this criterion, the square root of AVE of each latent construct must be larger than the construct's highest correlation with any other latent construct. Table 3 presents these results which are satisfactory for the path model considered. In addition, indicator loadings were compared with its cross-loadings to test the discriminant validity. Since all the indicator loadings were higher than its cross-loadings, no violation of discriminant validity was evident.

Table 3. Discriminant Validity Assessment

Construct	IT1	IT2	IT3	IT4	COLL	TIME	FIN
IT1	**0.834**						
IT2	0.585	**0.791**					
IT3	0.582	0.539	**0.825**				
IT4	0.577	0.551	0.602	**0.779**			
COLL	0.553	0.476	0.454	0.492	**0.870**		
TIME	0.060	0.165	0.148	0.105	0.006	**1.000**	
FIN	0.063	0.039	0.064	0.055	0.177	0.072	**1.000**

(Diagonal values – square root of the AVE for each construct, cell values – latent variable correlations)

RESULTS AND DISCUSSION

This section describes and discusses the results obtained in the path analysis performed to test the five main hypotheses that examine direct and indirect effects of IT usage on financial performance and new product development time. Table 4 presents the test results including the path coefficients and corresponding t-values obtained. According to these results, no IT type shows a significant direct positive impact on financial performance or time performance of NPD projects and thus, H1 and H2 are not supported. However, the significant positive path coefficient of 0.204 between IT2 (communication and collaboration tools) and product

development time indicates a direct positive impact of these tools on product development time. This result supports Oke et al. (2010) who also found a similar impact of these IT tools on new product development time. Oke's study highlights that the difficulties in coordination and personal attitudes of participants may cause longer development times in NPD projects when companies largely rely on media rich communication and collaboration IT tools. However, if the present study included simple tools such as e-mail and voice mail which have been proven as efficient in collaborative NPD contexts (Boutellier et al. 1998; Thomas 2013), the observed result related to IT2 category is likely to be different. For example in a study examining the impact of overall usage of various IT tools in NPD projects, Barczak et al. (2007) found no significant impact of IT usage on speed to market. According to the results, IT3 have no significant direct effect on NPD collaboration. Therefore, IT3 do not have a significant indirect impact on financial and time performance of NPD projects. This result is consistent with a recent research which found no significant effect of product data and knowledge management tools and a marginal positive effect of project management software on NPD collaboration (Peng et al. 2014). However, Vaccaro et al. (2010) who found a positive effect of these tools on NPD projects' financial and time performance has focused specifically on automotive industry which represent only 7% of the current sample. Also, the present study does not include advanced IT tools such as PLM software that have been previously proven as having positive impact on NPD performance (Banker et al. 2006).

Table 4. Results of the Path Analysis

Path	Path Coefficient	t-Value	Outcome of the hypothesis test
IT1 -> FIN	-0.024	0.262	H1a not supported *(p > 0.05)*
IT2 -> FIN	-0.074	1.150	H1b not supported *(p > 0.05)*
IT3 -> FIN	-0.018	0.188	H1c not supported *(p > 0.05)*
IT4 -> FIN	-0.020	0.191	H1d not supported *(p > 0.05)*
IT1 -> TIME	-0.052	0.491	H2a not supported *(p > 0.05)*
IT2 -> TIME	0.204***	2.616	H2b not supported (positive coef.)
IT3 -> TIME	0.120	1.639	H2c not supported *(p > 0.05)*
IT4 -> TIME	0.027	0.277	H2d not supported *(p > 0.05)*
IT1 -> COLL	0.316***	4.688	**H3a supported**
IT2 -> COLL	0.150**	2.470	**H3b supported**
IT3 -> COLL	0.081	1.234	H3c not supported *(p > 0.05)*
IT4 -> COLL	0.166**	2.508	**H3d supported**
COLL -> FIN	0.233***	3.246	**H4 supported**
COLL -> TIME	-0.114*	1.898	**H5 supported**
R^2 (COLL – NPD collaboration)	0.370		
R^2 (FIN – Financial performance)	0.035		
R^2 (TIME – Development time)	0.046		

(*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$)

Significant positive path coefficients corresponding to the effects of IT1, IT2, and IT4 on NPD collaboration support the hypotheses: H3a, H3b, and H3d. In addition, collaboration has a positive effect on financial performance (indicated by the positive path coefficient 0.233) and time performance (indicated by the negative path coefficient, -0.114 between collaboration and product development time) of NPD projects. Consequently, both H5, and H6 are supported. This result indicates that IT1, IT2, and IT4 help increasing NPD collaboration which in turn improves financial and time performance of NPD projects. This suggests that, market research/ analysis tools (IT1), communication/collaboration tools (IT2) as well as product design/development tools (IT4) indirectly contribute to increasing the NPD project performance. Therefore, collaboration is identified as a useful mediating variable that enables firms to achieve better NPD performance (financial performance and product development speed) through intensive use of IT tools. These findings extend current literature on the positive indirect effect of tools in IT1 and IT2 categories on new product's innovativeness, through cooperation between partners (Vilaseca-Requena et al. 2007). The indirect impact of product design and development IT tools on financial and time performance confirm and advance the findings of Tan et al. (2006) who found a direct positive effect of computer aided design (CAD) usage on cost performance of NPD. Relatively higher path coefficient of market research/analysis tools (0.316) indicates that the positive effect of these tools (IT1) on collaboration is comparatively higher than that of communication/collaboration tools (0.150) and product design/development tools (0.166). Kawakami et al. (2011) states that use of market research IT tools such as online surveys facilitates fast, low cost evaluations of new product ideas and concepts within large customer

communities. The present finding confirms this and indicates the significance of these tools for achieving higher NPD performance.

CONCLUSIONS AND IMPLICATIONS

Using data collected in PDMA's 2012 comparative performance assessment study, this study attempts to examine the direct and indirect impact of IT usage on performance of collaborative NPD projects. The results obtained offer significant implications for NPD practitioners and researchers. Through a partial least squares path analysis, the study finds that market research/analysis tools, communication/collaboration tools, and product design/development tools have significant indirect positive impact (mediated by NPD collaboration) on financial and time performance of NPD projects. However, there is no significant direct effect of three (IT1, IT3, and IT4) of four IT types considered, on NPD performance. In conclusion, higher usage of IT tools is more likely to be effective in NPD projects where products are developed through collaborations with internal and external partners.

Findings reveal that the market research and analysis tools are likely to have a relatively higher contribution towards increasing financial and time performance of NPD projects by improving collaboration. Therefore, these are the most significant IT tools that enable firms collect, analyse, and share information related to customer requirements, which are highly important for the success of collaborative NPD projects. Although findings suggest that frequent and intensive communication through higher use of communication/collaboration IT tools may increase product development cycle times, the knowledge transferred helps in improving collaboration between partners, which may add value to future NPD projects in improving product quality and innovativeness (Hoegl 2005). A significant positive impact of product design and development IT tools on NPD collaboration is also evident in this study. IT tools in this category include the tools that can be accessed by geographically dispersed NPD teams for joint development (e.g., virtual design, remote collaborative design systems). Use of these tools facilitates greater integration and contribution of internal and external NPD partners in the product design and development stages, ensuring intensive collaboration in these stages. According to the results of the study, simply making knowledge/project management IT tools available may be less important to confirm higher levels of collaboration between NPD partners. However, if organizations are able to overcome contextual, social, and human-related dependencies in use of these tools, the resulting benefits may be substantially increased (Shankar et al. 2013). Use of advanced knowledge/project management IT tools that overcome above dependencies (Banker et al. 2006) and long-term experience with existing tools and collaborative partners would provide the means to improve knowledge transfer which is necessary to increase NPD collaboration.

This study has significant contributions to extend existing literature about the impact of IT usage on NPD performance. Observed direct and indirect impact of the four IT types in this study confirm and extend current literature related to the direct impact of overall IT usage or use of specific IT tools on financial and time performance of NPD (e.g., Barczak et al. 2007; Durmuşoğlu et al. 2011). In a study focusing on some IT tools in IT1 (Market research and analysis IT) and IT2 (communication and collaboration IT) categories Vilaseca-Requena et al. (2007) found direct and indirect positive effects on new product's innovativeness. Advancing this knowledge, the present study provides empirical evidences for similar indirect effects on financial and time performance of NPD projects. Supporting Oke et al. (2010) the present study suggests that higher reliance on communication and collaboration IT tools is likely to increase development times of new products. The observed direct effects of IT types on NPD collaboration confirm and extend recent research findings on these effects (Peng et al. 2014). This knowledge is further explored by the mediator role of collaboration investigated in this study in relation to the four IT types and NPD performance dimensions considered. The study confirms the findings of Barczak et al. (2007) who claims that the impact of IT usage on NPD performance is not as strong as managers expect. Further, this study suggests use of IT tools as important means of improving NPD collaboration rather than those of increasing final project outcomes. Higher levels of this collaboration lead to increase in financial and time performance of NPD projects. The findings will be useful to organizations involved in collaborative NPD projects to justify IT investments and contribution of IT tools towards reducing product development cycle times and increasing financial returns of these projects.

LIMITATIONS AND FUTURE RESEARCH

While this study derives several important implications for researchers and practitioners, it has some limitations that could be overcome in future research. Since the present path model is based on data related to more innovative projects, generalising the results on the direct and indirect impact of IT usage on financial and time performance to other types of NPD projects (radical and incremental) would not be possible. Therefore, future studies would be worthwhile to address the use of IT in collaborative NPD projects with varied levels of radicalness. The identified relationships between IT usage and collaborative NPD performance are possible to vary for different organizational contexts such as type of industry, organization size, and technology base. The

moderating effects of such contextual factors could be examined in a future study using relevant variables. Use of single-item constructs for the financial performance and time performance is another limitation in the present study. The results obtained concerning these performance indicators could be further improved by using more informative multi-item scales. However, the present study suggests that, in a collaborative context, the impact of IT usage on financial and time performance of NPD programmes is indirect rather than direct. Future research can focus on different aspects of NPD performance (e.g., quality, innovativeness) to provide a more comprehensive view of the indirect impact of IT usage on collaborative project performance.

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