THE IMPACT OF IT TOOL USAGE ON PREDEVELOPMENT PERFORMANCE

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ABSTRACT

The predevelopment stage of the New Product Development (NPD) process is complex and risky. Firms are increasingly looking towards information technology (IT) tools to improve this process; yet, there is still little empirical evidence to understand how these IT tools influence NPD outcomes. Using a sample of 152 Australian managers, we test a conceptual model for IT tool usage in the predevelopment stage of the NPD process. We find that firms who seek to incorporate new IT tools into their NPD process have improved performance outcomes including the number of concepts generated and tested, more efficient NPD team collaboration, and faster management approval.

INTRODUCTION

The new product development (NPD) process and its management have become complex and time critical. Firms have increasingly sought to adopt information technology (IT) tools to improve the NPD process (Song et al., 2007) moving from basic communication (email), desktop applications (word processing), and computer-aided-design packages (CAD) to include more advanced tools like cloud-based collaboration software and product-lifecycle management (PLM) suites (Marion et al., 2012a; Ozer, 2003; Pavlou et al., 2003).

The predevelopment stage, or the "front-end of innovation" as it is often known (Koen et al., 2001), has been acknowledged as a critical stage in the NPD process, and has been linked strongly to the market performance of new products (Evanschitzky et al., 2012). The need to improve communication and coordination in the predevelopment stage has led to an increased impetus to evaluate and consider new IT tools to supplement and support traditional tools (Ordanini and Rubera, 2010). For example, Carlson (2012) found that firms are increasingly evaluating various automated and commercially

available NPD software tools and solutions as a way to improve NPD performance. These new applications are designed to allow users both inside and outside an organization to easily communicate and collaboratively ideate, design, manage, and launch new products and services. Examples of such new IT tools include project wikis, comment/blog sections within software packages, cloud-based tools such as Google Docs and social networking applications like Facebook. In addition, the move to incorporate open-innovation projects that span multiple firms and external partners has provided a further impetus to embrace advanced IT tools and services (Akgun et al., 2008; Chau and Tam, 2000; Tsou and Chen, 2012) including those with social networking features. For instance, Kenly and Poston (2010) found in a survey of 90 products and services that companies are using social media tools such as Weblogs, wikis, shared workspaces, micro-blogging, and social media sites throughout the NPD process.

IT tools used in NPD are designed to promote timely communication, knowledge flow and knowledge management both inside and outside the corporation. Nonetheless, empirical evidence on the effectiveness of IT usage in the NPD process is limited and somewhat mixed. For example, Durmusoglu et al. (2006) found no relationship between IT tool usage and NPD outcomes such as speed, cost, and flexibility. In contrast, Barczak et al. (2007) found that IT usage had an impact on the market performance of new products but not on speed-to-market. In the most recent CPAS study by the Product Development & Management Association (PDMA), the best performing firms used a variety of IT tools to speed the time-to-market of their new products (Markham and Lee, 2012). Finally, Marion et al. (2012b) found that both traditional and new IT tools positively influenced a range of NPD development stage outcomes but they also found that social networking tools had a negative effect on development performance.

The present research builds on the study by Marion et al. (2012b) by examining the predevelopment stage of the NPD process, and the influence that traditional and new IT tools have on the successfulness of this phase. The research aims to make three contributions to the extant literature. First, by emphasizing the usage of IT tools for NPD, this research adds to the emerging literature stream on this topic (Barczak, Sultan and Hultink, 2007; Barczak, Hultink, and Sultan, 2008; Terwiesch et al., 2002;), and will provide more guidance to firms as to the significance of such IT tools in the important predevelopment stage of the NPD process. Second, investigating the effect of IT tools on various predevelopment stage outcomes will provide a deeper understanding of which tools act as levers that can be managed to promote NPD project success (Barczak, Sultan and Hultink, 2007; Kohli and Grover, 2008; Marion et al., 2012b; Sun et al., 2009). Specifically, this study investigates whether utilizing particular IT tools in the predevelopment stage can lead to more efficient NPD team collaboration, more concepts/prototypes generated, and faster management evaluation. These outcomes were selected based on previous research (Cooper, 2001; Hultink et al., 2006; Kahn et al., 2012; Krishnan and Ulrich, 2001; Ulrich and Eppinger, 2011), which indicates that they are appropriate performance metrics for the predevelopment phase. Third, from a theoretical perspective, this research will show the importance of building IT resources and assets to develop a firm's NPD and knowledge management capabilities.

THEORETICAL BACKGROUND

Resource-Based Theory

The resource-based theory (RBT) of the firm suggests that firms have different resources (i.e., knowledge and assets) and that firm performance depends on those resources and how they are used (Wade and Hulland, 2004; Wernerfelt, 1984). Moreover, higher performance is maintained when resources are relatively scarce and cannot be imitated or substituted (Rumelt, 1987). Capabilities are processes, or embedded routines that deploy or transform the firm's resources into desired outcomes (Morgan et al., 2009). As Ngo and O'Cass (2008) suggest, firms will (or should) have as many capabilities as are necessary to transform their resources into valuable outputs. For this current study, a firm's resources can include IT (Barney, 1991) whereas the NPD process is a capability supported by IT resources (Madhavaram and Hunt, 2008). In fact, the IT literature argues that assets include such things as physical IT assets, technical platforms, databases, architectures and standards (Ross et al., 1996) helping firms to create a competitive advantage (Wade and Hulland, 2004).

Prior research supports the successful use of IT for knowledge gathering, dissemination, analysis, and implementation in NPD (Akgun et al, 2008; Boutellier et al., 1998; Chau and Tam, 2000; Ozer, 2000, 2003; Song et al., 2007; Tsou and Chen, 2012). Further, the usage of IT tools enhances the quality of NPD decision-making (Ozer, 2000; Teo and Choo, 2001) resulting in improved NPD capabilities and potentially, in more successful new products. Thus, the resource-based theory of the firm provides a fundamental theoretical explanation as to why the usage of IT tools in the NPD process may increase performance (Ordanini and Rubera, 2010).

Focus on the Pre-Development Phase

The current study focuses on the predevelopment stage of the NPD process, where initial product ideas are conceived, product concept definitions are formulated and evaluated, and projects are tentatively planned (Bertels et al., 2011; Koen et al., 2001; Langerak, Hultink and Robben, 2004; Reid and de Brentani, 2004; Verworn, Herstatt, and Nagahira, 2008). Decisions made during the predevelopment stage affect the firm's options regarding which products can be developed and commercialized, and often affect the success of these outcomes (Bertels et al., 2001; Cohen and Levinthal, 1990; Evanschitzky et al., 2012). The failure to communicate, collaborate and formulate appropriate ideas in the predevelopment stage can result in a significant waste of scare resources and market failures (Koen et al., 2001). Moreover, the front-end of innovation is fundamentally different from the latter phases of the innovation process, which are relatively well-structured and well-researched (Brown and Eisenhardt, 1995; Cooper, 2001; Montoya-Weiss and Calantone, 1994). Investigating the usage of IT tools and their impact on the successfulness of the predevelopment stage is therefore warranted (Barczak, Hultink, and Sultan, 2008; Durmusoglu and Barczak, 2011; Marion et al., 2012b).

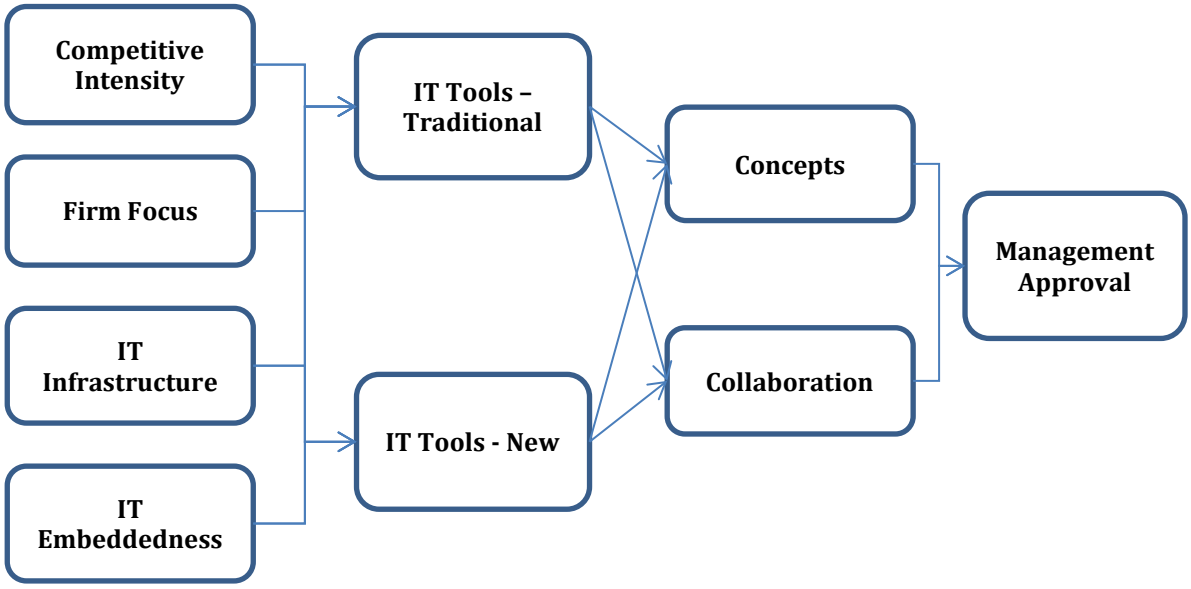
The extant research shows that different IT tools are useful in each phase, and tools may have different effects on NPD outcomes across stages (Boutellier et al., 1998; Durmusoglu and Barczak, 2011; Malhotra and Majchrzak, 2004). Moreover, there has been a call for research on understanding the role of IT tools across distinct phases of the

NPD process (Banker, Bardhan and Asdemir, 2006). The predevelopment stage is often messy and iterative (Koen et al., 2001) with project team members requiring constant communication and feedback on ideas and concepts and often needing to collaborate across functions in order to shape ideas and concepts for further development (Verworn, 2009). Diverse functional areas such as marketing, manufacturing, design and engineering work cooperatively, share information, and jointly determine the specifications for the product to be developed. Moreover, the predevelopment stage may also involve communication and collaboration with external partners such as suppliers, distributors, and customers (Ozer, 2000). Thus, the use of diverse types of IT tools that facilitate information sharing and problem-solving among core and extended team members are likely to be useful.

RESEARCH MODEL AND HYPOTHESES

Figure 1 shows our research model that highlights in an integrated fashion the role of antecedents shaping the usage of traditional and new IT tools in the predevelopment stage of the NPD process. The model also shows the subsequent influence of IT tool usage on predevelopment performance, including efficient NPD team collaboration, concepts generated and tested, and finally management feedback and approval.

Figure 1: Conceptual Model



Antecedents

Competitive Intensity is defined as a situation where competition is fierce due to the number of competitors in the market and the lack of potential opportunities for further growth. Kearns and Lederer (2004) found a positive and significant impact of environmental factors such as competition and growth on IT usage. In this research, we focus on competitive intensity, which is one of the factors contributing to environmental hostility (Dess and Beard, 1984; Zahra and Covin, 1995). The literature on corporate

entrepreneurship suggests that firms need to engage in a greater level of entrepreneurial activities, such as innovation, as competiveness intensifies (Zahra and Covin, 1995). It can be expected that firms facing competitive environments will utilise a wider range of IT tools in order to effectively and efficiently communicate within the firm and with customers and other stakeholders to enable rapid responses to competitor actions. Thus:
H1: Competitive intensity will result in a higher level of usage of a) traditional IT tools and, b) new IT tools in the predevelopment phase of the NPD process.

Firm outward focus is an open innovation concept referring to the degree to which a firm sources and employs information from customers, develops a strategy that will meet customer needs, and implements that strategy by being responsive to customer needs and wants (Patterson et al., 2005). A number of studies found that an outward focus on customers and the utilisation of knowledge gained from customers allows a firm to employ information more effectively in product ideation and design (Brown and Eisenhardt, 1995; Feng et al., 2012). Reid and Brady (2012) in a study of 173 Australian firms, found that market orientation, including a customer orientation, had a significant influence on the predevelopment stage of the NPD process. In addition to customer information, innovative ideas may result from engagement with customers through customer partnerships or through interaction using both new and traditional IT tools. It is expected that firms with an outward focus will use a greater range of both new and traditional IT tools to communicate with customers, to facilitate customer insights, product ideation and concept development and evaluation (Remneland-Wikhamn and Wikhamn, 2011). Firms with an outward focus will likely use these tools to share this information amongst team members and project stakeholders in order to make better decisions about which concepts to progress. Thus:
H2: Firm outward focus will result in a higher level of usage of a) traditional IT tools and, b) new IT tool in the predevelopment phase of the NPD process.

IT Infrastructure refers to the extent to which a firm has computer hardware, software, and human resources necessary to support the use of IT tools (Barczak, Sultan and Hultink, 2007; Bhatt et al., 2010; Sethi, Pant, and Sethi, 2003). Whilst some recent research (Barczak, Sultan and Hultink, 2007; Barczak, Hultink, and Sultan, 2008) found that IT infrastructure had no impact on IT usage, this finding was considered surprising as the IT literature suggests that lack of an IT infrastructure impedes diffusion (Goodman et al.,1994). IT infrastructure is considered as a resource (Keen, 1991; McKenney, 1995) that facilitates cross-functional process capabilities such as NPD by enhancing connectivity across various functional groups (Bhatt et al., 2010; Keen, 1991). A proficient IT infrastructure supports NPD project teams and provides them with access to a range of IT tools. Access to systems and tools allows NPD team members to more easily and quickly share necessary project-related information. These benefits drive IT tool usage as project teams learn the advantages of using the infrastructure to accomplish their work (Barczak, Sultan and Hultink, 2007; Barczak, Hultink, and Sultan, 2008)
H3: IT infrastructure will result in a higher level of usage of a) traditional IT tools and, b) new IT tools in the predevelopment phase of the NPD process.

IT Embeddedness refers to the extent to which IT has been assimilated into specific business activities and its effectiveness in enabling those activities (Barczak, Sultan and Hultink, 2007;Neirotti and Paolucci, 2011). Firms with a high level of IT embeddedness will likely have integrated IT tools into their NPD process (Barczak, Sultan and Hultink, 2007; Sethi, Pant, and Sethi, 2003). Recent research has shown that IT embeddedness has a positive and direct influence on IT tool usage (Barczak, Sultan and Hultink, 2007; Barczak, Hultink, and Sultan, 2008). The key difference between IT embeddedness and IT usage relates to whether or not the IT tools are routinized into the NPD process (Barczak, Sultan and Hultink, 2007). Usage of a particular tool may be due to an individual team member and their drive to improve efficiency and effectiveness of a project they are working on. This can be independent of what the organization requires in terms of the formal NPD process. In firms that have embedded specific IT tools into their NPD process, project team members will be familiar with those tools and know which tools are appropriate for particular activities (Barczak, Sultan and Hultink, 2007). High levels of embeddedness may also result in projects using a suite of IT tools. Thus, the degree of IT embeddedness in the firm is likely to influence IT usage.
H4: IT embeddedness will result in a higher level of usage of a) traditional IT tools and, b) new IT tools in the predevelopment phase of the NPD process.

IT Tools

One way to potentially improve predevelopment stage outcomes is to utilize IT tools (Durmuşoğlu and Barczak, 2011). Computer-mediated communication technologies are IT tools that facilitate communication and interaction between NPD team members and other stakeholders during an NPD project (Song et al., 2007). Email and web meetings are the most frequently used tools allowing for more increased collaboration and communication, and enhanced information sharing and dissemination (Pavlou and El Sawy, 2006). Shared drives similarly provide access to project documentation and shared databases of work plans, schedules, product designs, engineering and marketing data, project planning documents, and project histories that support knowledge integration (Durmuşoğlu and Barczak, 2011; Pavlou and El Sawy, 2006). Hence, shared drives and virtual project rooms enable access to all project information from a single entry point, and can aid NPD teams to achieve knowledge accumulation and transfer (Pavlou and El Sawy, 2006; Sethi 2000). More advanced virtual prototyping and product design tools enable computer simulation of potential new products and enable quicker and more realistic market testing (Durmuşoğlu and Barczak, 2011). Research has also begun to show the increased use of social media tools in the NPD process (Kenly and Poston, 2010). Kaplan and Haenlein (2010) define social media as a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0 and that allow the creation and exchange of user generated content. These tools may include wikis, weblogs, social networking sites, and file-sharing sites.

Overall, firms with a desire to improve their NPD process will leverage those tools that best suit their circumstances. In the predevelopment stage, those tools that support idea generation will have a powerful influence on the ability of employees to collaborate efficiently and generate innovative concepts with more customer appeal, thereby promoting higher quality and market performance (Ulrich and Eppinger, 2011).

H5: Firms that use a wider array of traditional IT tools in the predevelopment phase of the NPD process will a) generate a larger number of new product concepts, and b) have a greater level of resource efficient collaboration.

H6: Firms that use a wider array of new IT tools in the predevelopment phase of the NPD process will a) generate a larger number of new product concepts, and b) have a greater level of resource efficient collaboration

Performance Outcomes

Concepts Generated: One of the critical outcomes of the predevelopment stage of the NPD process relates to the number and quality of the ideas and concepts generated (Martinsuo and Poskela, 2011). Successful generation of concepts ultimately results from iterations of the idea for the new product and the proposed design concept and solution. Since IT tools facilitate collecting and developing ideas from a multitude of sources and enable efficient collaboration, the diversity of ideas generated should increase, resulting in more innovative new product concepts (Ancona and Caldwell, 1992; Cooper 2001). Thus, the degree to which ideas and concepts are generated is a suitable outcome measure for the predevelopment phase.

Efficient Team Collaboration is defined as an affective process in which two or more individuals or units work together, have mutual understanding, share resources, and achieve collective goals (Appley and Winder, 1977; Kahn, 1996; Schrage, 1990). The predevelopment stage requires efficient cross-functional collaboration as parallel actions are occurring that involve engineering, design, marketing and operations/ manufacturing. In addition, this stage requires information acquisition and dissemination that necessitates team collaboration (Cooper, 2001; Martinsuo and Poskela, 2011). Souder (1977, 1987) found that harmony between departments (i.e., greater collaboration) led to more successful NPD projects. Similarly, Kahn (1996) indicated that collaboration rather than simply interaction is a primary factor for NPD success. More recently, Nakata and Im (2010) provided evidence that cross-functional integration of NPD team members has a positive impact on new product performance. In other words, combining the skills, knowledge, and efforts of various functional team members leads to more successful new products. Thus, the literature suggests that NPD team collaboration is an appropriate outcome measure in the predevelopment stage because of the interdependent and multiple activities going on and the evidence that collaboration leads to NPD success.

Management Evaluation: Both horizontal and vertical knowledge flow and management within a firm is a conduit for learning and sharing (Meyer and Zack, 1996; Zack, 1999). Vertical knowledge sharing is particularly important in the NPD process as management needs to make decisions about such issues as the NPD portfolio, allocation of resources (financial, human, equipment/materials), the technology platforms for development and manufacturing, and the product road map (Kester et al., 2011). Additionally, after each stage of the NPD process, management should engage in a gate review of each project and make a decision as to whether or not the project moves forward (Cooper 2001, 2009). Research has indicated that progressive companies are automating their NPD processes,

including the gate reviews, to ensure that management has the information they need to make quality decisions (Cooper 2006, 2009). Thus, management evaluation is an appropriate outcome metric for the predevelopment stage of the NPD process. As a result, this study investigates the effect of traditional and new IT tools on management evaluation.

H7: Project teams generating a higher number of concepts will have an increased likelihood of stage management approval.

H8: Project teams with a higher level of efficient team collaboration will have an increased likelihood of stage management approval.

METHODOLOGY

Sample and Data

Data collection for this research utilized an online business management panel procured from an Australian research field house (Latitude Insights Ltd). A sample of 152 managers was obtained in order to derive data amenable to multivariate analysis. Two qualifying questions were employed to screen the pool of participants. First, respondents had to be involved in the NPD process of the organization, and secondly they needed to have an understanding of how IT tools were used in the firm to manage the NPD process. The main advantages of this form of online panel data collection are the speed of data collection (1 week) and the ability to carefully screen those individuals to complete the questionnaire.

Table 1 presents the sample characteristics. The industries represented include aerospace systems, automobiles, computers, consumer electronics, agricultural manufacturing, mining, and chemicals. The firms in our sample are predominantly established, and Australian rather than multinational. Firms are predominantly small to medium in size, which is consistent with the nature of Australian business (DSIR, 2011). The respondents are primarily from engineering and manufacturing backgrounds with some representation from marketing, sales, and R&D. There are a number of 'other' classified respondents, representing general management and business owner positions.

A project-level analysis is adopted for this research as the focus for the study is on the IT tools used to manage the predevelopment stage of the NPD process. The project-level analysis is preferred for determining the impact of IT tools (Barczak et al., 2007; Devaraj and Kohli, 2003) as most IT tools used for NPD occurs at the project-level (McGrath and Iansiti, 1998).

Measures

The design of the survey is based on recent work undertaken by Marion et al. (2012b). Measures for the study were based on existing scales and adapted where necessary.

To measure predevelopment stage outcomes, respondents were asked to indicate on a three-point scale, whether the IT tools influenced eight specific outcomes (fewer, average, or greater than average) relative to projects that did not use these tools. The scales were developed based on previous research (Cooper, 2001; Krishnan and Ulrich, 2001; Perks et al., 2005; Ulrich and Eppinger, 2011), which suggested that these items represented appropriate metrics for the predevelopment phase. Principal components

analysis on the eight outcome items yielded three predevelopment outcome measures – efficient NPD team collaboration, concepts generated, and management stage approval.

Table 1: Sample Characteristics

Firm Type	%	Firm Size	%	Firm Age	%	Function	%
Australia Only	57.9	Fewer than 100	49.3	Less than 5 years old	5.9	Sales	12.5
Multinational	42.1	100 - 500	17.8	5 to 10 years old	20.4	Marketing	5.3
		500 - 1,000	11.2	10 to 20 years old	26.3	Engineering	30.9
		1,000 - 5,000	9.9	20 to 50 years old	27.6	Manufacturing	21.1
		5,000 - 10,000	6.6	Greater than 50 years old	19.7	R&D	8.6
		Greater than 10,000	5.3			Other	21.7

To measure the impact of project-level IT tool usage on the outcomes of the predevelopment stage, a set of 18 IT tools was developed (Barczak et al., 2007; Durmusoglu and Barczak, 2011; Marion et al., 2012b). Respondents were asked to indicate the extent of use of these tools within the predevelopment stage using a 6-point Likert-type scale (0 = Not used, 5 = Used to a Great Extent). Previous research suggests that self-reported usage measures correlate well with actual usage (Barczak et al., 2007; Taylor and Todd, 1995). Principal components analysis on the identified IT tools yielded two distinct IT tool categories: 1) new media tools (e.g., project wikis and cloud-based file sharing, weblogs and Twitter) and 2) traditional IT tools (e.g., email, file sharing sites).

For the antecedent measures, competitive intensity was based on Jaworski and Kohli (1993) and Langerak (2003). Firm outward focus was based on Remneland-Wikhamn and Wikhamn (2011). The measures for IT infrastructure and IT embeddedness were based on the work by Barczak, Sultan, and Hultink, (2007) who first proposed and confirmed these measures.

Measurement Model Validation

Scale reliability and validity were assessed following the suggestions of Anderson and Gerbing (1991). First, item correlations were evaluated one scale at a time. Principal components analysis was subsequently conducted on the independent and dependent variables separately and the reliability of each scale was assessed, eliminating items that decreased scale reliability below 0.70. During this purification process, five items were removed: an item for competitive intensity, an item for firm outward focus and three of the IT tools.

Confirmatory factor analysis was conducted on the independent measures and on the IT tools and outcomes measures. Analysis of the revised scales showed corresponding measures having acceptable factor loadings, ranging from 0.65 to 0.89. One item related to email as a traditional IT tool demonstrated a lower than expected factor loading but was retained as it often underlies a significant degree of inter and intra firm communications. The average variance extracted for the variable retaining the email item is still higher than the correlation between it and other factors. As such, discriminate validity is deemed to be sufficient. For the independent variables, the final CFA model showed an adequate fit to the data (X^2= 364.84; df = 180, NFI = 0.85; and CFI = 0.91, RMSEA =.08). Similarly the final dependent variable CFA model also showed an adequate fit to the data (X^2= 519.04, df = 263, p=0.000; CFI = 0.89; NFI = 0.85; and RMSEA = .08). Table 2 presents the means, standard deviations, average variance extracted (AVE) estimates, correlation coefficients and their associated p-values for all variables.

Table 2: Correlation matrix and Descriptive Statistics

	1	2	3	4	5	6	7	8	9
1. Management approval									
2. Efficient NPD Team Collaboration	0.34**								
3. Concepts Generated	0.36**	0.65**							
4. IT Tools - Traditional	0.08	0.20*	0.35**						
5. IT Tools - New	0.19*	0.27**	0.36**	0.45**					
6. Competitive Intensity	-0.18*	0.15	0.23**	0.27**	0.23**				
7. Firm Outward Focus	0.08	-0.06	-0.14	0.06	-0.32**	0.22**			
8. IT Infrastructure	0.20*	0.25**	0.25**	0.45**	0.41**	0.19*	-0.01		
9. IT Embeddedness	0.11	0.31**	0.31**	0.52**	0.39**	0.26**	-0.16	0.16	
Mean	2.10	2.06	2.01	3.76	2.35	3.52	3.50	3.45	3.34
StdDev	0.52	0.46	0.50	1.02	1.39	0.86	1.11	0.89	1.04
Cronbach Alpha	0.83	0.84	0.87	0.67	0.94	0.85	0.90	0.93	0.90
CR	0.83	0.84	0.88	0.71	0.94	0.85	0.90	0.93	0.90
AVE	0.84	0.72	0.79	0.65	0.77	0.72	0.81	0.79	0.87
No. of Items	2	5	4	3	11	5	5	8	3

RESULTS

To test the hypotheses, the proposed direct effects were estimated using a structural path analysis. The results of the AMOS v.20 estimation and the associated hypotheses are reported below.

In this analysis, competitive intensity, firm outward focus, IT infrastructure and IT embeddedness are the exogenous variables, with traditional and new IT tools as mediator

variables and efficient NPD team collaboration, concepts generated and management stage approval as the endogenous outcomes. Overall, the data fit the conceptual model well (X^2 19.32, df =13, p=0.000; CFI .98; TLI .95; Cmin/df 1.49; RMSEA 0.6).

The results (Table 3) demonstrate that the use of traditional IT tools to facilitate NPD is positively and significantly influenced by the firm's IT embeddedness (H4a: B=0.39, p<0.01) and by both the firm's outward focus, (H2a: B=0.18, p<0.05) and the competitive intensity of the environment (H1a: B=0.15, p<0.05). IT infrastructure (H3a) appears to have no significant influence on the use of traditional IT tools in the NPD process.

The results also demonstrate that in contrast to traditional tools, the use of new IT tools to facilitate NPD is positively influenced by the firm's IT Infrastructure (H3b: B=0.32, p<0.01). The use of new IT tools to facilitate NPD is however, negatively influenced by the firm's outward focus (H2b: B=-0.30, p<0.01). Both competitive intensity (H1b) and IT embeddedness (H4b) appear to have no significant influence on the use of new IT tools.

Table 3: Path Analysis Results – Direct Effects

Path (hypotheses)			**Std Estimate**	**T-values**
H1a: IT Tools - Traditional	<---	IT Infrastructure	0.12	1.43ns
H1b: IT Tools - New	<---	IT Infrastructure	0.32	.3.66**
H2a: IT Tools - Traditional	<---	IT Embeddedness	0.39	4.45**
H2b: IT Tools - New	<---	IT Embeddedness	0.14	1.67ns
H3a: IT Tools - Traditional	<---	Firm Focus - Outward	0.18	2.48*
H3b: IT Tools - New	<---	Firm Focus - Outward	-0.30	-4.27**
H4a: IT Tools - Traditional	<---	Competitive Intensity	0.15	2.06*
H4b: IT Tools - New	<---	Competitive Intensity	0.06	0.74
H5a: Concepts Generated	<---	IT Tools -	0.16	2.01*

		Traditional		
H5b: Efficient NPD Team Collaboration	<---	IT Tools - Traditional	0.04	0.50
H6a: Concepts Generated	<---	IT Tools - New	0.29	3.54**
H6b: Efficient NPD Team Collaboration	<---	IT Tools - New	0.26	3.01**
H7: Management approval	<---	Concepts Generated	0.27	2.91**
H8: Management approval	<---	Efficient NPD Team Collaboration	0.18	1.94*

Model fit. X^2 19.32 (df 13), p=0.000; CFI .98; TLI .95; Cmin/df 1.49 ; RMSEA 0.6

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

For the outcome and performance measures, concepts generated in the predevelopment stage was significantly influenced by both traditional (H5a: B= 0.16, p<0.05) and new (H6a: B=0.29, p<0.01) IT tools. Efficient collaboration between individuals involved in the NPD process is significantly influenced by the use of new IT tools (H6b: B=0.26, p<0.01) but not by the use of traditional IT tools (H5b: B=0.04, ns). Finally, stage management approval for progression of concepts to development is significantly influenced by both the number of concepts developed (B=.27, p<0.01) and by efficient NPD team collaboration (B=0.18, p<0.05) amongst NPD team members. Overall, nine of the fourteen stated hypotheses can be accepted whilst one (firm focus) is rejected as it has a negative rather than positive influence on new IT Tool use. Three of the hypotheses were found to be non-significant.

Overall, the results highlight the importance of using both traditional and new IT tools in the predevelopment stage of the NPD process. Using such tools promotes better concept generation and more efficient team collaboration. The usage of IT tools is influenced by the nature of the IT systems and their infrastructure and IT embeddedness. Usage of traditional IT tools is also influenced by the competitive intensity in the market and by the firm having an inward rather than an outward focus.

DISCUSSION

This paper addresses a highly pertinent and timely issue associated with the role of IT in improving the predevelopment stage of the NPD process. Product innovation is at the heart of business growth strategies and the need to communicate and collaborate with multiple internal and external stakeholders is central to a successful product innovation process. Drawing on the resource based view of the firm, the approach developed through this paper highlights several antecedents to IT tool use in the predevelopment stage of the

NPD process and subsequently examines how IT tool use influences several measures of success at the front end of innovation. Specifically we find the following:

- IT infrastructure influences the use of new IT tools but does not directly influence the degree to which traditional tools are used in the predevelopment stage of the NPD process.

Little infrastructure is required to use communication tools such as email or traditional desktop tools such as spreadsheets and shared drives and files. Firms seeking more advanced collaboration and communications through new IT tools need to have a much more developed and advanced IT infrastructure. They will need to ensure their external collaborators can also link into these tools.

- IT embeddedness directly influences the use of traditional IT tools but does not influence the degree to which new tools are used in the predevelopment stage of the NPD process.

Traditional tools such as email and desktop tools are a basic platform for the management of NPD projects and NPD stakeholder communication generally. Since these tools are ubiquitous, NPD team members know how to use these tools effectively and efficiently to ensure appropriate project communication throughout the predevelopment phase. However, as noted earlier, new IT tools such as social media tools are not used to a large extent yet for NPD. This lack of usage suggests that such tools are not embedded yet into the NPD process because project teams are unsure as to how, when, and why to use these tools. As well, embeddedness may be a double edged sword. On one level it may be that firms have traditional tools so ingrained in their NPD processes that it is hard to redevelop an infrastructure and workflow process that enables the implementation use of potentially powerful new IT tools, including social media tools.

- The firm's outward focus on customers positively influences the use of traditional IT tools and has a direct but negative influence on the degree to which new IT tools are used in the predevelopment stage of the NPD process.

The NPD process often requires teams to collaborate with other firms and entities like market research agencies, packaging development firms, marketing communication consultants, and retailers. Firms may also deal directly with end users and suppliers, especially in developing new business and industrial products. Such communication can be constrained by the IT infrastructure of external stakeholders and be restricted to more traditional tools such as email or simple file sharing arrangements. Firms with a more inward focus may have the opportunity to develop more advanced tools and infrastructure but run the risk of incompatibility with their collaborators. Thus, for firms to work in partnership with external stakeholders, they need to build joint infrastructure that supports effective and efficient systems and tools around NPD projects. Firms that have adopted customer orientated development processes have developed extensive custom IT capabilities to manage these relationships. These include established firms like IBM and newer firms like Local Motors based in the United States.

- The competitive intensity present in the firm's market environment directly influences the degree to which a firm use more traditional IT tools in the NPD process, but has no influence on the use of new IT tools.

Firms facing competitively intense environments are often faced with a dilemma about whether to invest in new systems and processes, such as IT, or to use available funds to drive sales and marketing communications. This research suggests that, in the predevelopment phase, firms "stick to their knitting" (Peters and Waterman, 1994) employing traditional tools and avoiding perceived risks and costs associated with building a newer infrastructure incorporating new IT tools. However, as noted above, without an IT infrastructure that provides and supports the use of new IT tools, these tools will likely not be used in the predevelopment phase and thus the benefits of such tools will not be realized.

- The use of traditional IT tools by the firm has a direct positive influence on the number of concepts generated but does not appear to influence the degree to which the firm experiences resource efficient collaboration.

- The use of new IT tools directly influences the number of concepts generated and also directly influences the degree to which the firm experiences resource efficient collaboration.

Traditional tools such as email and shared files appear to be critical in the predevelopment stage of the NPD process in that they promote communication and practices essential in concept generation. Prior research shows that improved collaboration is required to facilitate successful projects (Kahn, 1996; Nakata and Im, 2010; Souder, 1977, 1987). The current research suggests that the use of new IT tools, including social media tools, has a direct influence on both concepts generated and on resource efficient collaboration. Firms seeking to improve collaboration and communication and overall efficiency in their NPD process will need to consider new tools.

- Management feedback and stage approval was directly influenced by the number of the concepts generated and tested and by the resource efficient collaboration of team members.

Although the speed of management feedback and stage approval was about average (mean = 2.10), our results show that the number of concepts generated and the resource efficient collaboration of the team affects both. Thus, it appears that in the predevelopment phase, when uncertainty about the market and product exists, management evaluation is influenced by the ability of the team to work together effectively and efficiently in developing new concepts.

THEORETICAL IMPLICATIONS

This research adds to the emerging literature on the impact of IT tools on new product performance. Through an examination of the predevelopment phase of the NPD process,

our findings show the importance of building IT resources and assets to develop a firm's NPD and knowledge management capabilities. Specifically, this study indicates that the use of both traditional and new IT tools in the predevelopment phase enable NPD project teams to generate new product concepts and prototypes. The creation of new product concepts is critical to the entire NPD process as decisions will be made regarding which of these concepts goes through the remainder of the NPD process and ultimately, gets launched into the market. Thus, the IT tools act as resources enabling the NPD process to be implemented, thereby enhancing the firm's NPD capability. Similarly, new IT tools facilitate the efficient collaboration of project team members. Cross-functional teams that share knowledge, work together throughout the NPD process, and collaborate effectively and efficiently are critical elements of NPD success (Kahn, 1996; Nakata and Im, 2010; Souder, 1977, 1987), and thus, of building an NPD capability.

MANAGERIAL IMPLICATIONS

This research provides several implications for managers. First, if firms wish their NPD teams to utilize new IT tools such as social networking, project wikis, weblogs, microblogs, etc. than they need to put into place an IT infrastructure that trains and supports NPD teams in using such tools. An IT infrastructure is a major resource for a firm. Thus, expanding a firm's current IT infrastructure to include new IT tools should facilitate usage of those tools for NPD. This in turn, based on our findings, will help increase the number of concepts generated in the predevelopment phase and lead to more efficient team collaboration. Second, firms who wish to be actively engaged in open innovation, need to develop an IT infrastructure in partnership with the external entities with whom they wish to collaborate. This is necessary to ensure that these external partners can get access to and link into the system thereby enabling knowledge sharing and dissemination. Third, firms who want to ensure active use of new IT tools will have to embed those tools into their NPD process. Currently, firms seem unsure as to which tools to use, for what purpose, or how to best use particular tools in the context of NPD. As firms gain more experience and knowledge about what works best, when, and how, certain new IT tools may be able to be embedded into and routinized for particular activities and phases of the NPD process.

LIMITATIONS

As with all studies, this research has several limitations worth noting. First, the study examines the constructs of interest at one point in time, across industries. Thus, the results cannot be generalized to particular industries or businesses. Future research could examine the conceptual framework in specific industries to determine if the relationships in the model hold. Second, the study uses single respondents. However, the use of screening questions to select respondents provides assurance that the informants were well-qualified to report on the variables in the study. Third, the sample is restricted to Australian companies, limiting the generalizability to other countries and continents. Future research should explore the research questions by using firms in other countries.

REFERENCES

Ancona, Deborah and Caldwell, David. 1992. Demography and design: Predictors of new product team performance. Organization science. 3(3), 321-341.

Anderson, J.C. and Gerbing, D.W. 1991. Predicting the performance of measures in a confirmatory factor analysis with a pretest assessment of their substantive validities. Journal of applied psychology. 76(5), 732-740.

Akgun, Ali., Dayan, M., and Di Benedetto, C. Anthony. (2008). New product development team intelligence: Antecedents and consequences. Information & management. 45, 221–226.

Appley, D.G. and Winder. A.E. 1977. An evolving definition of collaboration and someimplications for the world of work. Journal of applied behavioral science. 13, 279–291.

Banker, R., Bardhan, I. and Asdemir, O. 2006. Understanding the impact of collaboration software on product design and development. Information systems research, 17(4), 352-373.

Barczak, G., Sultan, F., & Hultink, E. 2007.Determinants of IT usage and new product performance. Journal of product innovation management, 24, 600-613.

Barczak, Gloria, Hultink, Erik Jan and Sultan, Fareena. 2008. Antecedents and consequences of information technology usage in NPD: A comparison of Dutch and U.S. companies. Journal of product innovation management, 25, 620-631.

Barney, J.1991. Firm resources and sustained competitive advantage. Journal of management. 17(1), 99−120.

Bertels, H., Kleinschmidt, E. and Koen, P. 2011. Communities of practice versus organizational climate: which one matters more to dispersed collaboration in the front end of innovation? Journal of product innovation management. 28(5), 757-772.

Bhatt, Ganesh, Emdad, A., Roberts, N., and Grover, V. (2010). Building and leveraging information in dynamic environments: The role of IT infrastructure flexibility as enabler of organizational responsiveness and competitive advantage. Information & management. 47, 341–349.

Boutellier, R,,Gassman, O., Macho, H., and Roux, M. 1998. Management of dispersed product development teams: The role of information technologies. R&D management. 28(1), 13-25.

Brown, S. and Eisenhardt, K. 1995. Product development: Past research, present findings, and future directions. Academy of management review. 20(2), 243-278.

Carlson, M. 2012. Powering the Next Generation. PDMA Visions. (3), 27-29.
Chau, P.Y.K., and Tam, K.Y. (2000). Organizational adoption of open systems: a `technology-push, need-pull' perspective. Information & management. 37, 229-239.

Cohen, Wesley and Levinthal, Daniel. 1990. Absorptive capacity: A new perspective on learning and innovation. Administrative science quarterly. 35(1), 128-152.

Cooper, R.D. (2009). Effective Gating: Make product innovation more productive by using gates with teeth. Marketing management. March/April, 12-17.

Cooper, R.G. 2001. *Winning at New Products*. New York: Perseus Publishing.

Cooper, R. G. 2006. Formula for success. Marketing management, 18-24.

Dess, Gregory and Beard, Donald. 1984. Dimensions of organizational task environments. Administrative science quarterly. 29(1), 52-73.

Devaraj, S. and Kohli, R. 2003. Performance impacts of information technology: Is actual usage the missing link? Management Science. 49(3), 273-289.

Durmusoglu, Serdar, Calantone, Roger and Sambamurthy, V. 2006. Is more information technology better for new product development? Journal of product & brand management. 15(7), 435-441.

Durmusoglu, S.. and Barczak, G. 2011. The use of information technology tools in new product development phases: Analysis of effects on new product innovativeness, quality, and market performance. Industrial marketing management. 40, 321-330.

Evanschitzky, H., Eisend, M., Calantone, R. and Jiang, Y. 2012. Success factors of product innovation: An updated meta-analysis. Journal of product innovation management. 29(S1), 21-37.

Feng, T.W., Sun, L.Y., Zhu, C.Y., and Sohal, A.S (2012). Customer orientation for decreasing time-to-market of new products: IT implementation as a complementary asset. Industrial marketing management, 41, 929–939.

Jaworski, B. J., and Kohli, A. K. 1993. Market orientation: antecedents and consequences. Journal of marketing. 57(3), 53-70.

Kahn, K.B. 1996. Interdepartmental integration: A definition with implications for product development performance. Journal of product innovation management. 13(2), 137-151.

Kahn, K.B., Barczak, G., Nicholas, J., Edwith, A., and Perks, H. (2012). An Examination of New Product Development Best Practice. Journal of product innovation management. 29(2), 180–192.

Kaplan, A. and M. Haenlein. 2010. Users of the world unite! The challenges and opportunities of social media. Business horizons. 53,59-68.

Kearns,G.S., and Lederer, A.L. (2004). The impact of industry contextual factors on IT focusand the use of IT for competitive advantage. Information & management. 41, 899–919.

Keen, G.W. (1991). *Shaping the Future: Business Redesign through Information Technology*. Boston: Harvard Business School Press.

Kenly, A. and B. Poston. 2010. Social media and product innovation. Kalypso White Paper. www.kalypso.com.

Kester, L., Griffin, A., Hultink, E.J. and Lauche, K. 2011. Exploring portfolio decision-making processes. Journal of product innovation management. 28(5), 641-661.

Koen, P., Ajamian, G., Clamen, A., et al. (2001) Providing Clarity and a Common Language to the "Fuzzy Front End". Research-technology management. 44(2), 46-55.

Kohli, R. and Grover, V. 2008. Business value of IT: An essay on expanding research directions to keep up with the times. Journal of the association for information systems. 9(1), 23-39.

Krishnan, V.and K. Ulrich. 2001. Product development decisions: A review of the literature. Management science. 47(1), 1-21.

Langerak, F. 2003. An appraisal of research on the predictive power of market orientation. European Management Journal. 21(4), 447-464.

Langerak, Fred, Hultink, Erik Jan, and Robben, Henry. 2004. The Impact of Market Orientation, Product Advantage, and Launch Proficiency on New Product Performance and Organizational Performance. Journal of product innovation management. 21(2), 79-94.

Madhavaram, S., Hunt, S. D. (2008). The Service Dominant Logic and a Hierarchy of Operant Resources: Developing Masterful Operant Resources and Implications for Marketing Strategy. Journal of the academy of marketing science. 36(1), 67-82.

Malhotra, A., and Majchrzak, A. 2004. Enabling knowledge creation in far-flung teams: Best practices for IT support and knowledge sharing. Journal of knowledge Management. 8(4), 75−89.

Marion, T.J., Fixson, S.K., and Meyer, M.H. 2012a. The problem with digital design, Sloan management review. Summer Issue.

Marion, Tucker, Barczak, Gloria and Hultink, Erik Jan. 2012b. Do social media tools impact the development phase? An exploratory study. Working Paper.

Markham, S. and H. Lee. 2012. Winning at NPD: Success drivers from the 2012 CPAS study. Presentation at the 2012 Product Innovation Management Conference, Orlando, FL.

Martinsuo, M. and Poskela, J. 2011. Use of evaluation criteria and innovation performance in the front end of innovation. Journal of product innovation management. 28(6), 896-914.

McGrath, M. and Iansiti, M. 1998. Envisioning IT—Enabled Product Development. PRTM Insight Magazine. Fall-Winter, 1-12.

McKenney, J.L. (1995). *Waves of Change: Business Evolution through Information Technology*. Cambridge, MA: Harvard Business School Press.

Meyer, M. H. & Zack, M.H. 1996. The design of information products. Sloan management review. 37(3), 43-59.

Montoya-Weiss, Mitzi and Calantone, Roger. 1994. Determinants of New Product Performance: A Review and Meta-Analysis. Journal of product innovation management. 11(5), 397–417.

Nakata, C. and Im, S. 2010. Spurring cross-functional integration for higher new product performance: A group effectiveness perspective. Journal of product innovation management. 27, 554-571.

Neirotti, P. and Paolucci, E. 2011. Assessing the importance of industry in the adoption and assimilation of IT: Evidence from Italian enterprises. Information & management. 48(7), 249-259.

Ordanini, A., and Rubera, G. (2010). How does the application of an IT service innovation affect firm performance? A theoretical framework and empirical analysis on e-commerce. Information & management. 47, 60–67.

Ozer, M. 2000. Information technology and new product development. Industrial marketing management. 29(5), 387−396.

Ozer, M. 2003. Process implications of the use of the Internet in new product development: A conceptual analysis. Industrial marketing management. 32(6), 517−530.

Pavlou, P., and El Sawy, O. 2006. From IT leveraging competence to competitive advantage in turbulent environments: The case of new product development. Information systems research. 17(3), 198−227.

Perks, H., Cooper, R. and Jones, C. 2005. Characterizing the role of design in new product development: An empirically derived taxonomy. Journal of product innovation management. 22, 111-127.

Peters , T. J., and Waterman, R.H. (1994) In Search of Excellence: Lessons from America's Best-Run Companies. Collins Business Essentials.

Reid, Michael and Brady, Erica. 2012. Improving firm performance through NPD: The role of market orientation, NPD orientation and the NPD process. Australasian marketing journal. 20(4), 235-241.

Reid, Susan and De Brentani, Ulrike. 2004. The fuzzy front end of new product development for discontinuous innovations: A theoretical model. Journal of product innovation management. 21(3), 170-184.

Remneland Wikhamn, B. and Wikhamn, W. (2011). Open Innovation Climate Measure: The introduction of a validated scale. Creativity and innovation management. 20(4), 284-295.

Ross, J. W., C. M. Beath, and D. L.Goodhue. 1996. Develop long-term competitiveness through IT Assets. Sloan management review. 38(1), 31-42.

Rumelt, R. P. 1987. Theory, strategy and entrepreneurship in *The Competitive Challenge*, D. Teece (ed.), Ballinger, Cambridge, MA 137-158.

Schrage, M. 1990. *Shared minds: The new technologies of collaboration*. New York: Random House.

Sethi, Rajesh. 2000. Superordinate identity in cross-functional product development teams: Its effect on new product performance and its antecedents. Journal of the academy of marketing science. 28, 330-344.

Sethi, Rajesh, Pant, Somendra, and Sethi, Anju. 2003. Web-based product development systems integration and new product outcomes: A conceptual framework. Journal of product innovation management. 20(1), 37-56.

Song, M.X., Berends, H., Van der Bij, H., & Weggemen, M. 2007. The effect of IT and co-location on knowledge dissemination.Journal of product innovation management. 24(1), 52−68.

Souder, W.E. 1977. Effectiveness of nominal and interacting group decision processes for integrating R&D and marketing. Management science. 23(6), 595-605.

Souder, W.E. 1987. *Managing New Product Innovations*. Lexington, MA: Lexington Books.

Sun, Y., A. Bhattacherjee, and Q.Ma, 2009. Extending technology usage to work settings: The role of perceived work compatibility in ERP implementation, Information & management. 46, 351-356.

Taylor, S. and P. Todd. 1995. Understanding information technology usage: A test of competing models. Information systems research. 6(2),144–76.

Teo, Thompson S. H., and Choo, W.Y. 2001. Assessing the impact of using theInternet for competitive intelligence. Information & management. 39(1), 67−83.

Terwiesch, T., C. Loch, and Meyer, A.E.. 2002. Exchanging preliminary information in concurrent engineering. Organization science. 13(4), 402–419.

Tsou, H.T., and Chen,J.S. (2012). The influence of interfirmcodevelopment competencyon e-service innovation. Information & management. 49, 177–189.

Ulrich, K. and Eppinger, S. 2011. *Product Design and Development,* 5th edition. Irwim/McGraw-Hill.

Verworn, Birgit. 2009. A structural equation model of the impact of the “fuzzy front end” on the success of new product development. Research policy. 38(10), 1571-1581.

Verworn, Birgit, Herstatt, Cornelius, and Nagahira, Akio. 2008. The fuzzy front end of Japanese new product development projects: impact on success and differences between incremental and radical projects. R&D management. 38(1), 1-19.

Wade, M. and J. Hulland 2004. The resource-based view and information systems research: Review, extension and suggestions for future research. MIS quarterly. 28(1), 107-42.

Wernerfelt, B. 1984.A resource-based view of the firm. Strategic management journal. 5(2),171−180.

Zack, M. (1999). Developing a knowledge strategy. California management review 41(3), 125-145.

Zahra, S., & Covin, J. (1995). Contextual influences on the corporate entrepreneurship-performance relationship: A longitudinal analysis. Journal of business venturing. 10, 43-58.

Appendix

Traditional Tools – discovery (Marion, Barczak and Hultink, 2012b)	Traditional Desktop Tools (e.g. Microsoft Excel, etc.) (6)	.70	3.93 / 1.30
	Email (2)	.32	4.10 / 1.29
	Shared files and drives (8)	.93	3.59 / 1.67
New Tools – discovery (Marion, Barczak and Hultink, 2013)	Twitter (16)	.89	1.91 / 1.77
	Social Networking Tools (e.g. Google Plus, Facebook) (14)	.79	2.27 / 1.84
	Dedicated Intranet sites (13)	.74	2.59 / 1.81
	Product Lifecycle Management (PLM) Tools (12)	.78	2.36 / 1.84
	Virtual Simulation Tools (11)	.74	2.37 / 1.81
	Weblogs (15)	.86	2.03 / 1.78
	Requirements Management Software (9)	.70	2.64 / 1.78
	Cloud-based file sharing (e.g. Google Docs) (7)	.65	2.49 / 1.83
	Project Wikis (4)	.78	2.30 / 1.83
	Video conferencing (e.g., Skype) (1)	.67	2.55 / 1.75
	Dedicated Open Innovation Tools (17)	.84	2.17 / 1.79