End-user collaboration for process innovation in services: The role of internal resources

UNU-MERIT Working Paper Series

#2014-019

End-user collaboration for process innovation in services: The role of internal resources

Mona Ashok, Rajneesh Narula and Andrea Martinez-Noya

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: info@merit.unu.edu | website: http://www.merit.unu.edu

Maastricht Graduate School of Governance (MGSoG)
email: info-governance@maastrichtuniversity.nl | website: http://mgsog.merit.unu.edu

Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499

UNU-MERIT Working Papers

ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology, UNU-MERIT

Maastricht Graduate School of Governance MGSoG

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at UNU-MERIT and MGSoG to stimulate discussion on the issues raised.

End-user collaboration for process innovation in services: The role of internal resources

Mona Ashok, Rajneesh Narula and Andrea Martinez-Noya

Abstract

This paper focuses on how to improve process innovation in service sectors. To do so, we analyse how the interplay of external knowledge sources (specifically, the intensity of end-user collaboration and the breadth of external collaboration) and the firm's internal resources impact process innovation at the firm level. Survey data from 166 Information Technology Services firms provide the empirical data, which is tested using the partial least squares structural equation model. Our results demonstrate that benefits from collaboration are not automatic, as the firm's commitment of internal resources fully mediates the impact of the intensity of end-user collaboration and breadth of external collaboration on process innovation. Thus, internal resources become critical to make effective use of the knowledge residing both internally and externally, and key managerial practices that enable a firm to extract benefits from external collaboration are identified.

Keywords: end-user collaboration, external knowledge sources, internal resources, process innovation, service industry

JEL: O32, M15, F230

End-user collaboration for process innovation in services: The role of internal resources

1 INTRODUCTION

Previous studies have highlighted the importance of innovation in the service sector (Howells and Tether, 2004; OECD, 2005; Oliveira and von Hippel, 2011), and that process innovation is a much neglected aspect of innovation studies (Davenport, 1993; Keupp et al., 2012; Reichstein and Salter, 2006). Indeed, prior research has identified a need for better understanding of firm-level factors that impact process innovation (Frishammar et al., 2012), specifically in the services context (Gopalakrishnan et al., 1999). In response to these research gaps, we analyse the impact (and interplay) of external knowledge sources and internal resources on process innovation in the services sector. In particular, we examine external knowledge sources as the *intensity* of end-user collaboration and the *breadth* of external collaboration. We argue that the *intensity* of end-user collaboration plays a fundamental role for innovation in the services context particularly when service firms are not supplier dominated. Users are integral to the provision of a service and are key collaborative partners (Howells and Tether, 2004). End-users are known to collaborate with firms to commercialise their innovations (von Hippel, 2005), both in the services (Oliveira and von Hippel, 2011), and the process context (de Jong and von Hippel, 2009). Further, *breadth* of external collaboration is also expected to be important for process innovation. This is because firm-level innovations are more likely to be collaborative and interactive, where the firm works with various external partners (OECD, 2005; Tether, 2002).

However, firms are not expected to benefit from external knowledge sources just by being exposed to them. Instead, they must develop the ability to recognise the value of new external knowledge, to assimilate it, and to utilise it for commercial ends (Cohen and

Levinthal, 1990). Thus, firms need to commit internal resources to build competences, and to generate economic gains from innovation (Hamel, 1991; Teece et al., 1997). Internal resources are also necessary to support learning, encourage collaboration with partners, and translate valuable external knowledge into competitive advantage for the firm. In this study, we provide a better understanding of harnessing external knowledge sources and committing internal resources in order to implement process innovation (Dahlander and Gann, 2010).

Based on this, we consider the research questions: 'How do the external knowledge sources and internal resources impact process innovation in the services context?' and 'What role do the internal resources play in extracting value from external knowledge sources for the benefit of process innovation?' To address these questions we apply rigorous testing procedures; we followed the guidelines provided by Govindarajan and Kopalle (2006) on reporting valid and reliable measures for innovation studies. Using the advanced technique of partial least squares-structural equation modelling (PLS-SEM) for model testing (Hair et al., 2012; Hulland, 1999), our study shows that end-user collaboration is important for process innovation in the service sector. However, external knowledge sources only contribute optimally to process innovation when the firm has committed internal resources. That means the firm's commitment of internal resources fully mediates the impact of the intensity of end-user collaboration and breadth of external collaboration on process innovation. We also contribute to management practice by discussing the relative importance of external knowledge sources and internal resources in improving process innovation; thus reducing the inherent uncertainty associated with business process change (Hall et al., 1993; O'Neill and Sohal, 1999). Finally, our results provide guidance that should enable managers to better control the factors that benefit process innovation in the service sector.

2 THEORY AND HYPOTHESES

2.1 Process innovation and the strategic link to competitive advantage

Although it is well known that the introduction of a new product, service, or organisational change is often dependent on innovation in the underlying processes, the study of process innovation has received less academic attention (Davenport, 1993), particularly in the services industry (Gopalakrishnan et al., 1999). In response, we focus on process innovation in this study, and analyse the firm-level factors of external knowledge sources and internal resources that maximise the prediction of process innovation.

The term *process* is defined as the transformation of inputs through a structured set of tasks, done manually or automatically, with a view to create an output that is of some value to the users (Harrington, 1991). The term *process innovation* is defined as the implementation of a new or significantly improved production or delivery method that is of value to the user, where process innovation includes significant changes in techniques, equipment and/or software. The focus on 'value to user' is added to the definition given by OECD (2005) because the users have to be willing to pay for the improved or new process, and end-user value provides a source of competitive advantage (Woodruff, 1997). We adopt Vargo and Lusch's (2004, p. 2) definition of *services,* "as the application of specialised competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself ."

A key challenge in undertaking process innovation is the high level of uncertainty. The wider process change literature reports ambiguity of long-term results of process change, and failure of a large proportion of process innovation projects to deliver their full potential (Baer and Frese, 2003). Despite these challenges, process innovation enables generation of economic rents and development of organisational capabilities (Huang and Rice, 2012; Pisano and Wheelwright, 1995). When properly implemented, process innovation can deliver improved efficiency, effectiveness, quality and reliability (Bauer and Leker, 2013; Davenport, 1993; Frishammar et al., 2012), which helps the firm to deliver value internally and to its customers. Finally, process innovation can lead to a systemic change, which cannot be easily imitated by competitors; this provides a source of advantage to the service firms (Gopalakrishnan et al., 1999). Thus, the study of factors that maximise the predictive power of process innovation is beneficial for the service sector.

2.2 The firm-level factors impacting process innovation

We investigate the intensity and breadth of knowledge sources, where intensity is studied in relation to end-user collaboration and we analyse the diversity or breadth of external collaboration. Taking the service context, end-user collaboration is fundamental as they co-produce value (Vargo and Lusch, 2004). The breadth of external collaboration with partners like competitors, consultants, customers, government, group companies, suppliers, and universities will also benefit process innovation (Huang and Rice, 2012; Narula, 2001; OECD, 2005). This is because the firm is unlikely to possess all the skills or capabilities to innovate, and sources of novel ideas are not restricted to the boundaries of the firm (Arundel and Kanerva, 2010; Powell et al., 1996).

In this study, *end-user* is defined as the individual who is the consumer and co-producer of value, and expects benefit from using a product or service (Vargo and Lusch, 2004). The firm is the producer of the product or service offerings to meet end-user or customer needs. The term c*ollaboration* is defined as the joint creation of value by the firm and its partners, and involves exchange, sharing and co-development (Gulati, 1995; Prahalad and Ramaswamy, 2004). Thus, "pure contracting out work, where there is no active participation is not regarded as [collaboration] (Tether, 2002, p. 949)."

We also study the role of internal resources on process innovation, as reflected by of the degree of executive management engagement, the firm's continuous investment in resources, and its process benchmarking practices. Firms need to commit internal resources to build competences, and deliver competitive advantage through process innovation. We argue that commitment of internal resources mediates the benefit of collaboration on process innovation. To our knowledge, this is the first attempt to study the interplay of collaboration and internal resources on process innovation in the services context. The research model is captured in Figure 1, and we derive the hypotheses in the following sections.

----Figure 1 about here----

2.3 End-user collaboration

End-users are substantial contributors of innovations in services (Oliveira and von Hippel, 2011), and are an integral part of the service firm's operations (Vargo et al., 2008). The end-user's contribution in the process context is far from negligible. A large scale survey concluded that over half of the end-user firms modified or developed new process equipment or software, and a quarter of these innovations were later commercialised (de Jong and von Hippel, 2009). We propose that higher end-user collaboration will provide the focal firm greater opportunities for knowledge creation, testing the application of innovation, and reducing process innovation uncertainty (von Hippel, 2005). This is because firms benefit by co-ordinating and learning from end-users (Vargo and Lusch, 2004).We analyse end-user collaboration through the dimensions of end-user integration, end-user innovation drivers, and end-user influence (Figure 1).

2.3.1 End-user integration

We argue that end-user integration is a critical aspect of end-user collaboration, because internal team and end-user cohesiveness will positively influence process innovation (Davenport, 1993). Previous studies have demonstrated that joint innovation with end-users provides opportunities for differentiation, customisation and competitive advantage (Xie et al., 2008). The integration of leading-edge end-users contributes towards the generation of innovative ideas, alignment of innovation activities to user needs, improvement of cross-functional team working, and reduction of risk of failure of innovation projects (Lüthje and Herstatt, 2004). For these reasons, end-user integration reflects end-user collaboration.

2.3.2 End-user innovation drivers that support collaborative behaviour

Current academic thinking enumerates the benefits of collaborating with leading-edge end-users, because they are highly innovative and show specific traits (Schreier and Prügl, 2008; von Hippel and Riggs, 1997).These end-users are highly motivated, have prior process experience, and see benefits of participation in process innovation; we call these traits end-user innovation drivers. The understanding of these traits is important, because end-users are more effective than producer employees in the context of innovations developed (Hienerth et al., 2014). End-users are willing to collaborate with firms because they gain access to competences and resources. Thus, we posit that these traits are a critical aspect of the end-user collaboration.

2.3.3 End-users influence on the diffusion and adoption of process innovation

Investments in innovation are plagued with uncertainty and poor results, and process innovation is no exception (Baer and Frese, 2003; O'Neill and Sohal, 1999). We argue that end-user influence is a critical dimension of end-user collaboration. This is because innovative end-users are able to diffuse innovation through a variety of means (Füller et al., 2013). The integration of end-users as problem solvers improves the market acceptability of innovation (Bilgram et al., 2008). Indeed, the survival of innovation is often dependent on end-users, who are willing to experiment the new product (service or process) (Malerba et al., 2007). Thus, we posit that end-user influence on the diffusion and adoption of process innovation is a critical aspect of end-user collaboration for process innovation.

Therefore, based on the previous arguments, we propose that end-user collaboration — as reflected by end-user integration in process innovation, end-user innovation drivers that support collaborative behaviour, and end-user influence on the diffusion and adoption of process innovation—will be beneficial for the undertaking of process innovation in the service sector (Figure 1).

Hypothesis 1: End-user collaboration will positively influence process innovation results.

2.4 Breadth of external collaboration

The interaction between a firm and its environment is known to be important for the firm to exploit external sources of knowledge for innovation. Large scale surveys conducted by the European Union's Community Innovation Survey (EU CIS) and UKIS (2012) have shown that firms undertaking innovation benefit by collaborating with partners like competitors, consultants, customers, government, group companies, suppliers, and universities. Thus, collaborative partners are not limited to end-users. We argue that the exploitation of diverse partners' knowledge will benefit process innovation in the service sector. Indeed, openness to external knowledge is more evident in process innovation than product innovation (Robertson et al., 2012).

The ability to use external sources of knowledge may also provide a differentiating capability for the innovating firm (Frishammar et al., 2012). Firms undertaking process innovation are faced with high levels of investment costs, uncertainty, and resource constraints.We argue that one of the ways firms can combat these challenges is to access knowledge across diverse partners. Thus, we posit that the breadth of external collaboration will be beneficial for the undertaking of process innovation in the service sector (Figure 1).

Hypothesis 2: Breadth of external collaboration will positively influence process innovation results.

2.5 Internal resources as reflected by management practices

Commitment of internal resources is necessary to manage the friction between old and new knowledge, therefore aiding process innovation in the service sector. Dedicated internal resources and underlying management practices will enable capability development, resource adjustment, and the undertaking of process change. We build upon Foss et al.'s (2011) work and identify a mix of inward and outward-looking management practices. The first practice studied is the executive management engagement in process innovation (Kotter, 1995; Frishammar et al., 2012). The second practice examined is continuous investment, which has been a key subject of innovation studies (Zairi and Sinclair, 1995), and is an enabler of innovation (UKIS, 2012). Finally, the outward-looking practice of process benchmarking investigates the firm’s strategy to compare process performance (Anderson and McAdam, 2004; Camp, 1989). Thus, we examine the dimensions of internal resources through the management practices of executive management engagement, continuous investment, and process benchmarking (Figure 1).

2.5.1 Executive management engagement

There is broad consensus that executive management governance is a precursor to the success of process innovation (Frishammar et al., 2012). We argue that executive management engagement reflects commitment of internal resources, because management roles are known to be key initiators, leaders, and participants in business-wide process reengineering projects (Zairi and Sinclair, 1995). Executives are responsible for propagating good practices, encouraging communication, and enabling transformation to undertake innovation. In particular, executive management involvement is expected to be crucial for process innovation, because executives are able to guide internal teams and make the process innovation project attractive (Scott, 1997). They are critical in creating collaborative behaviour internally and shared belief with external partners (Frishammar et al., 2012), and challenging status-quo (Hall et al., 1993). Executives are responsible for driving organisational vision for process change, addressing conflicts, governing multi-function process change, motivating stakeholders, and exploiting value from external contact (Kotter, 1995). Therefore, we posit that executive management engagement practice is intrinsic to the commitment of internal resources.

2.5.2 Continuous investment practice

Investment strategies are at the heart of innovation literature. In general, poor investment practices leads to firm-level inertia, and an inability to learn from new knowledge and technology (Narula, 2002). Similarly, poor investment strategies compromise the firm's agility and responsiveness (Kogut and Zander, 1992), and a firm's refusal to invest in updating its capabilities creates what Leonard-Barton (1992) calls 'core rigidity'. Thus, we argue that continuous investment reflects internal resources committed by the firm because a firm's historical investment into learning, skills, and capability building shapes the paths it can take in the future (David, 1985; Teece and Pisano, 1994). We posit that firms will benefit by investing in new process thinking that breaks away from the old way of working. Continuous investment practices have the potential to enhance capabilities, to increase interaction with the environment, and to improve responsiveness to fluid conditions. We examine the firm's investment practices in relation to factors that enable process innovation, and argue that continuous investment is intrinsic to the commitment of internal resources (Hall et al., 1993).

2.5.3 Process benchmarking practice

The term *benchmarking* is defined as a continuous process of assessing a firm's product (service), practices, work processes, and core competency position against competitors and industry leaders, for the purpose of organisational improvement (Anderson and McAdam, 2004; Camp, 1989). Thus, benchmarking assesses the firm's process maturity and performance through internal and external surveillance (Potter, 2012; Tidd and Bessant, 2011). The practice of process benchmarking challenges status-quo, responds to a business problem through diligent enquiry, and helps long-term process corrections. Benchmarking is used as a continuous improvement strategy in the service sector (Dattakumar and Jagadeesh, 2003). Thus, process benchmarking is an integral part of the service firm's commitment of internal resources that enables process innovation.

Therefore, taking all the previous arguments into account, we propose that internal resources — as reflected by the management practices of executive management engagement, continuous investment, and process benchmarking— are expected to benefit process innovation (Figure 1).

Hypothesis 3: Internal resources will positively influence process innovation results.

2.6 Extracting value from collaboration: the mediating role of internal resources

The benefits of external knowledge sources on process innovation are not expected to be automatic, but dependent on the commitment of internal resources to extract value. Firms have to take a strategic decision to systematically organise their management practices to benefit from collaborative arrangements. Internal resources supported by good management practices minimise risks, improve industry positioning, and support collaboration for innovation (Teece, 1986). Kogut and Zander (1992) argue that only a firm that learns to create and translate knowledge efficiently within its organisational context can differentiate itself from its competitors. Thus, the benefits of end-user collaboration and breadth of external collaboration are expected to be dependent on the commitment of internal resources; where the internal resources help to make effective use of the knowledge residing internally and externally to maximise the economic effect of process innovation (Cohen and Levinthal, 1990).

In relation to this, we have discussed that end-users are substantial contributors of innovations in the service sectors, and are an integral part of the service firm's operations. However, a large scale study that analysed the impact of customer collaboration on product innovation performance concluded that this impact was mediated through organisational practices (Foss et al., 2011). Further, we know that the management practice of process benchmarking is a key mechanism to capture end-user needs and translate the needs into process innovation targets (Davenport, 1993). Innovative end-users can choose which firm to co-operate with; and they are more likely to collaborate with a firm with high management commitment, eagerness to continually investment, and inclination to benchmark process performance. Thus, we argue that the impact of end-user collaboration on process innovation will be mediated through the internal resources committed by the firm (Figure 1).

Hypothesis 4: End-user collaboration will positively influence internal resources committed by the firm, and in turn internal resources will positively influence process innovation.

In a similar vein, we argue that breadth of external collaboration will impact process innovation as mediated through internal resources. This is because collaborative arrangements with multiple partners require organisational intent and commitment. Joint working with partners entails an organisational atmosphere of continuous dialogue, transparency, and trust (Prahalad and Ramaswamy, 2004). Further, under dynamic environments and changing market conditions, the firm's management is responsible to maximise the value of knowledge to improve the firm's innovativeness (Esterhuizen et al., 2012). Thus, we argue that the impact of breadth of external collaboration on process innovation will be mediated through the internal resources committed by the firm (Figure 1).

Hypothesis 5: Breadth of external collaboration will positively influence internal resources committed by the firm, and in turn internal resources will positively influence process innovation.

3 RESEARCH DESIGN

3.1 The sample

The data used for analyses came from 166 firm-level responses to a web-based survey. We chose to test the hypotheses in a specific service industry – the Information Technology Services (ITS), because it provides the perfect setting for the factors analysed. The ITS industry plays a key role in the economy; although it continually faces volatile end-user needs and technological advances (Blackmore and Hale, 2012b; Hale and Blackmore, 2012). Additionally, firms from other industries depend on ITS firms to achieve transformation, undergo structural change and deliver efficiency (Pavitt, 1984). We adopted Gartner's taxonomy to identify firms operating in the ITS industry; these firms are involved in Consulting, Implementation, IT Outsourcing, Business Process Outsourcing, and Software Support and Hardware Support (Blackmore and Hale, 2012a). Finally, although previous studies already show that end-user integration is especially important for ITS firms because these firms are knowledge-intensive and business services oriented (Hertog, 2000), as well as high-technology services oriented (Tether, 2002); we also spoke to numerous ITS business leaders to validate the importance of research in the area of process innovation for the industry.

A web-based questionnaire design was used to collect the data, and Campbell's (1955) guidelines were followed to confirm the informant's competence. The informant's role was evaluated using an online profile, and only functional heads and top management were chosen to respond to the survey on behalf of their firms. We took various steps to improve the accuracy of the responses. The questionnaires were sent out in three waves in May, July, and October 2012, and the informants were asked to reflect upon the survey questions (on behalf of their organisation) for the last one year, and to complete the survey at the Business Unit level if respondents performed various roles.

The sample for this study was obtained from two sources, a professional networking site and from experienced network members. The choice of these sources was relevant for the industry of our study for the following reasons. Social networks and communication channels are fundamental in the ITS industry to attract skilled workforce, prepare the organisation's social media practices, connect with its online-active end-users, and exploit valuable knowledge exchanged on such networks (Ridder, 2013; Ridder and Cohen, 2013). Given the sampling method, we tested for bias using accepted procedures. We compared responses based on the time taken to complete the survey, the wave when the surveys were sent out, and the early and late responses across the waves (Armstrong and Overton, 1977). No evidence of difference was found in these three tests.

After cleaning[1] the responses, a total of 166 usable responses were obtained from the 612 requests for participation. We got a response rate of 27 percent, which is comparable to other studies using web-based survey design (Baruch and Holtom, 2008; Foss et al., 2011; Sauermann and Roach, 2013). A sample size of 166 is adequate to conduct the analysis in this study because of the following reasons. Sample size as a determination of alpha level 0.05, for a seven point scale, and acceptable margin of error of 0.03 is 118 (Bartlett et al., 2001, p. 46). The criteria of sample size to indicator variables ratio of 5:1 was also met (Hair et al., 2013a). Sample size requirements using Tabachnick and Fidell's (2001) guidelines for multiple correlation and testing individual predictors were also met. In addition, we undertook numerous steps to improve response quality. We contacted the respondents via email to explain the context and potential business implications of the survey, assured confidentiality, and promised a copy of the summary results. Some criticisms of online surveys are that respondents may lack online experience, or may be excluded because they have no internet access (Evans and Mathur, 2005); these issues do not apply to our research context. Descriptive analysis of the sample was undertaken; the sample showed that small firms represented six percent of the sample with less than equal to 50 employees, 17 percent of medium firms with greater than 50, but less than equal to 1000 employees, and 77 percent of large firms with greater than 1000 employees. The respondents indicated the country pertaining to the process innovation experience, where 13 percent came from Europe, 19 percent from North America, 28 percent from India, 29 percent from UK, and 11 percent from other countries. An analysis of external partners collaborated with showed that 41 percent of respondents reported collaboration with Competitors, 42 percent with Universities, 45 percent

[1]Responses of 'Not Applicable' and 'Don't Know' treated as system-defined missing data. Responses with less than 25% missing data are used, outliers are deleted, and special attention is given to missing data analysis (Enders, 2001; Rubin, 1976). This is because missing data creates an issue for further analysis using structural equation modelling (Allison, 2003). We conclude that the data is missing completely at random because Little's MCAR test shows $p>0.05$. EM algorithm is used to replace missing data (Dempster et al., 1977), which is an accepted practice for latent variable models and factor analysis (Schafer and Graham, 2002).

with Government, 66 percent with Consultants, 73 percent with Group businesses, 75 percent with Suppliers, and 86 percent (highest) with Clients or customers.

3.2 Variables and measures

The research instrument contained 31 reflective scale indicators, of which 6 indicators measure the dependent construct process innovation, and the remaining 25 indicators measure independent constructs, see Appendix A for a list of indicators. A seven point scale was used, because it allows the study of greater variation of responses as compared to a five point scale (Lietz, 2010). Only the extremities were labelled; scale one was labelled as 'Strongly Agree' and scale seven as 'Strongly Disagree'. Further, based on the instrument testing feedback, options of 'Not Applicable' and 'Don't Know' were also added[2]. New scales for all these constructs were developed in line with Churchill (1979) and Rossiter's (2002) guidelines, as appropriate existing scales were not found. We validated the measures through discussions with ITS executives, and further pilot-tested the survey. We present a reflective model; we argue that the direction of causality is from the construct to measured indicators, as indicated by face validity of the measured indicators. Further, the instructions used on the questionnaire would lead respondents to perceive these questions as reflections or perceptions of the construct. The construct and measurement development is captured in Table 1.

3.2.1 Second-order constructs

The constructs of end-user collaboration and internal resources are studied as second-order constructs (Figure 1). The second-order construct design is driven by the objectives of theoretical parsimony, which assists the construction of the hypotheses, and future research (Edwards, 2001). We study the commonality of first-order constructs through the second-

[2]Studies show that when 'Don't Know' choice is offered, the probability of its use increases (Lietz, 2010).

order constructs, which reduces model complexity. It is important that the second-order constructs are examined through their relationship with other constructs in the model (Law et al., 1998). In this study, the higher-order constructs are not designed in vacuum but used in the model as predictors of the dependent variable process innovation, additionally end-user collaboration is a predictor of internal resources (Chin, 1998a).

The first order constructs do not show any cause-and-effect relationship with the second order factor. However, the causal flow is from the second-order construct to the first-order construct. The repeated indicators approach was taken, therefore items reflecting the first-order constructs were repeated at the second-order construct level in order to run PLS-SEM (Hair et al., 2013a).

3.3 Method of Analysis

We analysed the data in SmartPLS (Ringle et al., 2005), which uses PLS-SEM. We inferred that PLS, as against covariance based (CB)–SEM, was more suitable for our study based on the discussion on the topic by Wold (1982), Hair et al. (2013a), and Hair et al. (2013b). A key difference between the SEM models is that PLS trades in optimality for consistency in the statistical inference. PLS-SEM is a preferred method for our study for the following reasons. Our research is aimed at maximising prediction of the endogenous factor, and analysing theory in its early stage of development. PLS is distribution-free, and achieves higher statistical power with smaller samples (Henseler et al., 2009). However, as discussed in Section 3.1 (The sample), our study met with the sample requirement, and the indicators met with the skewness and kurtosis conditions with the exception of CI4 that showed kurtosis value of -1.0827 (indicators are described in Appendix A). In addition, PLS estimates remain consistent for large number of indicators per latent variable, PLS supports a complex model design, and is therefore relevant for our study (Ringle et al., 2012). We started the analysis using Cronbach's (1951) discussion on redundancy issues among indicators[3]. We evaluated the indicator outer loadings, first to ascertain indicators that poorly reflect the construct. Next, we checked for high inter-item correlation for indicators at a construct level; we maintained only one indicator and deleted other highly correlated indicators to address the redundancy issue (see Appendix A for indicator loadings). Then we evaluated the PLS path coefficients of the indicators for their first and second-order constructs as applicable.

3.4 Potential sources of bias in the analyses

The results should be viewed in light of potential sources of bias in the study. Our sample shows high (over three-quarters) representation of large ITS firms. All respondents are senior management ITS executives; hence corroboration of firm-level responses (as perceived by the management) through the study of additional factors will benefit future research. Factors like ITS firm's geographic spread, cultural differences, process innovation team composition, approach to unsuccessful versus successful projects, and level of diversity promoted will be beneficial. We took a cross-sectional view for the research; application of the model in a longitudinal research setting will enable the understanding of how firm-level factors impact process innovation over time.

4 RESULTS

We adopted the guidelines set in literature to test a reflective outer and inner model using PLS-SEM.

4.1 Outer (measurement) model

[3]Cronbach (1951, p. 330) summarises this issues as, "A set of redundant items can carry much less information than a set of independent items."

Reflective measurement model was evaluated through the assessment of reliability and validity of the constructs. Reflective relationship between the construct and its indicators is called Model A (Wold, 1982). The traditional Cronbach's alpha is said to underestimate the internal consistency reliability and assumes equal reliability of all construct indicators, therefore the composite reliability measure was used for the assessment (Chin, 1998b). All constructs in our model reported greater than 0.9 composite reliability values, so exceeding the 0.7 criterion (Henseler et al., 2009). Next, the construct's convergent validity was assessed through the average variance extracted (AVE) scores. AVE scores of greater than 0.5 is preferable so that the construct explains at least 50 percent of each of its indicator's variance, and all constructs in our model met this criterion (Henseler et al., 2009). Finally, discriminant validity was tested; by qualitative assessment of face validity, by checking indicator construct cross–loadings (Appendix B), and by examining that the square root of construct's AVE was greater than the correlation with the other constructs (for the inner model, and the first-order constructs in the study, see Appendix C) (Henseler et al., 2009). Bootstrapping analysis was undertaken to ascertain cross-loadings, using 5000 sub-samples as prescribed by Hair et al. (2013a).

4.2 Inner (structural) model

The inner model's path assessment was undertaken after evaluation of the outer measurement model. First, the second-order reflective constructs were analysed, and the results provide theoretical confirmation. All path coefficients are significant. Two of the three paths for end-user collaboration and all three paths for internal resources shows greater than 0.7 path coefficients, thereby meeting Chin (1998a) guideline for using second-order constructs. The path assessment, t-statistic and significance levels are captured in Figure 2. The control variables of firm size and country pertaining to the process innovation experience show non-significant impact on process innovation, the path coefficients for both control variables are 0.00 (Figure 2). In a literature review, Damanpour (2010) found that the impact of firm size on process innovation was inconsistent across studies.

----Figure 2 about here----

Next, the hypotheses were assessed using one-tailed tests, because the path coefficients are hypothesised to be positive. The linkage signs were assessed first for the direct effects. H1, H2, and H3 show partial empirical validation with the correct signs (Henseler et al., 2009). H4 results indicated that the previously significant and positive linkage from end-user collaboration to process innovation had a sign change and was insignificant when mediated through internal resources. Similarly, H5 results concluded that the previously significant and positive linkage from breadth of external collaboration to process innovation was insignificant when mediated through internal resources. Sobel's (1982) test for indirect effect was undertaken using the path assessment results. The z-values for indirect effects of breadth of external collaboration and end-user collaboration on process innovation through internal resources were 3.75 and 6.23 respectively[4]; we conclude that the indirect effect in both cases was not equal to zero. Further, using Baron and Kenny's (1986) three step guidelines to test mediation, we concluded that internal resources fully mediates the effect of breadth of external collaboration and end-user collaboration on process innovation. PLS-SEM does not have a global goodness-of-fit index therefore various tests were undertaken (Table 2). We tested for multi-collinearity of the predictor constructs and all VIF values are <5, therefore do not present any concerns (Hair et al., 2013b). The explanatory power or R^2 of the endogenous variables internal resources and process innovation are 0.37 and 0.54 respectively[5]. Using Cohen's (1992) guidelines for effect size, we conclude that both breadth of external

[4]z-value computation is not included here, but available on request.
[5]It is difficult to compare our study's R^2 value with previous studies due to the differences in measures and factors used, however we have comparable results.

collaboration and end-user collaboration show small and medium effect on internal resources respectively, while only internal resources shows a large effect on process innovation. We further undertook blindfolding and set distance at 5, the Q^2 greater than 0 for both endogenous variables indicating predictive relevance (Wold, 1982). In order to investigate the effect sizes, we ran a one-way ANOVA to compare mean values of all the constructs with a dummy variable factor. The dummy variable was coded to show if the Process innovation PLS latent variable unstandardized score was within the top, middle or bottom third percentile of the sample. All constructs showed mean differences (significant at 0.05 level, two-tailed) between the bottom third and top third, as well between the bottom third and middle third responses. This indicates that firms experiencing the least economic effect of process innovation performed poorly on all predictor variables, when compared to the organisations experiencing average or high economic effect of process innovation.

5 DISCUSSION

It is well-known that accessing external knowledge from a variety of agents is critical for firms to innovate products (services) and processes. This study aims to contribute to the innovation literature by developing and testing a conceptual model on the interplay of external knowledge sources and internal resources to optimise process innovation in the services context, specifically in the ITS industry. We show that the benefit of external knowledge sources on process innovation is dependent on the firm's commitment of internal resources. In addition, we also identify the key managerial practices that underlie the commitment of internal resources. This study addresses some of the research gaps identified by prior studies. We have provided a better understanding of firm-level factors impacting process innovation, of indirect effect of collaboration on innovation, and of the process of harnessing external knowledge for innovation. We discuss the findings of the study, and the implications for researchers and business executives in the following paragraphs.

5.1 Theoretical contributions

This study makes two contributions to our understanding of the firm-level factors of process innovation. To our knowledge this is the first attempt to provide a linkage between collaboration and internal resources, with a view to maximise the prediction of process innovation in the service industry. The commitment of internal resources is expected to support learning, encourage collaboration, and create competitive advantage from valuable knowledge. The analysis of the interplay of external knowledge sources and internal resources on process innovation allowed us to respond to the research questions. Specifically, our study concludes that internal resources fully mediate the impact of the end-user collaboration and breadth of external collaboration on process innovation, although a partial mediation effect was hypothesised. This result is similar to the indirect effect of end-user collaboration on product innovation performance, as mediated by organisational practices as reported by Foss et al. (2011). Thus, our study shows that a firm differentiates itself by demonstrating the ability to use external knowledge sources by efficiently building firm-specific capabilities through the commitment of internal resources.

Second, a new research instrument was created and tested, and it adds to the body of knowledge on firm-level factors influencing process innovation (Frishammar et al., 2012). We also contribute towards the rigorous testing of strategic management studies by using PLS-SEM to empirically analyse the data (Hair et al., 2013b). Our choice of model was a response to the need for researchers to use advanced techniques for model testing, to adopt consistent reporting, and to disseminate the use of PLS–SEM where appropriate (Hair et al., 2012; Hulland, 1999).

5.2 Managerial implications

Over half of our survey respondents reported abandoned process innovation activities, and 75 percent reported incomplete process innovation activities, highlighting the discussion of uncertainty in process innovation (Baer and Frese, 2003). The inferences drawn here empower ITS executives to focus on the firm-level factors of collaboration and internal resources, in order to enhance process innovation results. This study helps ITS organisations to perceive process innovation in light of the economic effects of process change. It reiterates the importance of implementing a process innovation initiative, and emphasises the need for firms to undertake a broader view of process innovation, which in turn requires linking the success of process change to firm-level targets. This provides a framework to track process innovation initiatives, and set accountability for the results (Potter, 2012).

Second, results indicate that ITS organisations should select end-users for collaboration in process innovation by evaluating end-users' innovation integration, drivers, and influence as supported by previous studies (Malerba et al., 2007; Schreier and Prügl, 2008). The key finding of this study is that intensity of end-user collaboration impacts process innovation only indirectly, through internal resources. We find that end-user collaboration shows a medium-to-large effect on the internal resources. Thus, the intension to collaborate with end-users is likely to be followed through by internal resources in ITS firms.

Third, ITS executives need to look at collaboration with external partners as an intrinsic part of knowledge acquisition strategy. Our study respondents reported higher engagement with clients or consumers, suppliers, group companies, and consultants, and lower engagement with government, universities, and competitors. Thus, ITS providers will benefit by working jointly with a wide spread of partners on process innovation, a result consistent with prior studies on process innovation (Huang and Rice, 2012; Reichstein and

Salter, 2006). However, the benefit of external collaboration is also indirect, and dependent upon the organisational preparedness to extract value from collaboration. Therefore, the ability to collaborate is subject to the ITS firm's internal resources.

Fourth, the commitment of internal resources is the most important factor, as reflected by its large effect on process innovation. We find that the executive management engagement is the most important of the underlying management practices of the internal resources. Further, ITS firms will benefit by continually investing in process innovation enablers, and we suggest that process benchmarking should be formalised. This is because benchmarking organisational processes at the front-end of process innovation is beneficial; where outward and inward looking benchmarking measures are necessary to define process innovation targets.

6 CONCLUSIONS

This study emphasises the need for consistent organisational commitment towards process innovation. It suggests that collaborative attitude is more beneficial than innovating in isolation, because co-creating value with end-users and other partners necessitates a structured, rigorous, and open approach. Similar to new product development, process innovation can translate into hard benefits. However, the success of process innovation is contingent upon service firms seeking to deliver deep and broad changes, through end-user collaboration, multi-partner engagement, and commitment of internal resources.

This study did not address the potential issues of sharing end-users and other collaborative partners with competitors, and the dangers of end-users becoming a competitor in a different business engagement. These issues form part of the deliberation on why and how to innovate. Nevertheless, we believe that process innovation continues to be a critical differentiator for organisations; hence dedicated effort is needed to assess the extent of waste in process innovation projects. High proportions of our sample reported abandoned and incomplete projects; this might be a reflection of the organisational rigidity towards change and organisational tendency to revert to old practices and competencies. Alternatively, discarding of process innovation projects might be a mechanism for firms to identify the most beneficial investment. Therefore, further research in this area will be beneficial. We believe that continued effort to standardise measures in process innovation remains vital; for this reason, we expect that consistent reporting of the measurement model and standardised reporting of structural model results to assist research and business.

REFERENCES

Allison, P. D. 2003. Missing Data Techniques for Structural Equation Modeling. Journal of Abnormal Psychology, 112, 545-557.

Anderson, K., McAdam, R. 2004. A critique of benchmarking and performance measurement: Lead or lag? Benchmarking: An International Journal, 11**,** 465-483.

Armstrong, J. S., Overton, T. 1977. Estimating non response bias in mail surveys. Journal of Marketing Research, 14**,** 396-402.

Arundel, A., Kanerva, M. 2010. Neglected innovators –non-R&D performers: What do they do and does it matter? Working Paper at Australian Innovation Research Centre, University of Tasmania and UNU-Merit.

Baer, M., Frese, M. 2003. Innovation is not enough: climates for initiative and psychological safety, process innovations, and firm performance. Journal of Organizational Behavior, 24**,** 45-68.

Baron, R. M., Kenny, D. A. 1986. The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. Journal of Personality and Social Psychology, 51**,** 1173-1182.

Bartlett, J. E., Kotrlik, J. W., Higgins, C. C. 2001. Organizational research: Determining appropriate sample size in survey research. Information Technology, Learning, and Performance Journal, 19**,** 43.

Baruch, Y., Holtom, B. C. 2008. Survey response rate levels and trends in organizational research. Human Relations, 61**,** 1139-1160.

Bauer, M., Leker, J. 2013. Exploration and exploitation in product and process innovation in the chemical industry. R&D Management, 43**,** 196-212.

Bilgram, V., Brem, A., Voigt, K.-I. 2008. User-Centric Innovations in New Product Development — Systematic Identification of Lead Users Harnessing Interactive and Collaborative Online-Tools. International Journal of Innovation Management, 12, 419-458.

Blackmore, D., Hale, K. 2012a. Market Definitions and Methodology: IT Services. Gartner, ID:G00230808, 1-51.

Blackmore, D., Hale, K. 2012b. Market Share Analysis: IT Services, Worldwide, 2011. Gartner, G00228769.

Camp, R. C. 1989. Benchmarking: the search for industry best practices that lead to superior performance. ASQC/Quality Resources.

Campbell, D. T. 1955. The Informant in Quantitative Research. American Journal of Sociology, 60, 339-342.

Chin, W. W. 1998a. Issues and Opinion on Structural Equation Modeling. MIS Quarterly.

Chin, W. W. 1998b. The partial least squares approach for structural equation modeling (Chapter Ten). In: Marcoulides, G. A. (ed.) Modern methods for business research. Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Churchill, G. A., Jr. 1979. A Paradigm for Developing Better Measures of Marketing Constructs. Journal of Marketing Research, 16, 64-73.

Cohen, J. 1992. Quantitative methods in psychology: A power primer. Psychological Bulletin, 112, 155-159.

Cohen, W. M., Levinthal, D. A. 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly, 35, 128-152.

Cronbach, L. 1951. Coefficient alpha and the internal structure of tests. Psychometrika, 16, 297-334.

Dahlander, L., Gann, D. M. 2010. How open is innovation? Research Policy, 39, 699-709.

Damanpour, F. 2010. An Integration of Research Findings of Effects of Firm Size and Market Competition on Product and Process Innovations. British Journal of Management, 21, 996-1010.

Dattakumar, R., Jagadeesh, R. 2003. A review of literature on benchmarking. Benchmarking: An International Journal, 10, 176-209.

Davenport, T. H. 1993. Process Innovation: Reengineering Work Through Information Technology. Harvard Business School Press Books.

David, P. A. 1985. Clio and the Economics of QWERTY. The American Economic Review, 75, 332-337.

de Jong, J. P. J., von Hippel, E. 2009. Transfers of user process innovations to process equipment producers: A study of Dutch high-tech firms. Research Policy, 38, 1181-1191.

Dempster, A. P., Laird, N. M., Rubin, D. B. 1977. Maximum Likelihood from Incomplete Data via the EM Algorithm. Journal of the Royal Statistical Society. Series B (Methodological), 39, 1-38.

Edwards, J. R. 2001. Multidimensional Constructs in Organizational Behavior Research: An Integrative Analytical Framework. Organizational Research Methods, 4, 144-192.

Enders, C. K. 2001. A Primer on Maximum Likelihood Algorithms Available for Use With Missing Data. Structural Equation Modeling: A Multidisciplinary Journal, 8, 128-141.

Esterhuizen, D., Schutte, C. S. L., du Toit, A. S. A. 2012. Knowledge creation processes as critical enablers for innovation. International Journal of Information Management, 32, 354-364.

Evans, J. R., Mathur, A. 2005. The value of online surveys. Internet Research, 15, 195-219.

Foss, N. J., Laursen, K., Pedersen, T. 2011. Linking Customer Interaction and Innovation: The Mediating Role of New Organizational Practices. Organization Science, 22, 980-999.

Frishammar, J., Kurkkio, M., Abrahamsson, L., Lichtenthaler, U. 2012. Antecedents and Consequences of Firms' Process Innovation Capability: A Literature Review and a Conceptual Framework. IEEE Transactions on Engineering Management, 59, 519-529.

Füller, J., Schroll, R., von Hippel, E. 2013. User generated brands and their contribution to the diffusion of user innovations. Research Policy, 42, 1197-1209.

Gopalakrishnan, S., Bierly, P., Kessler, E. H. 1999. A reexamination of product and process innovations using a knowledge-based view. The Journal of High Technology Management Research, 10, 147-166.

Govindarajan, V., Kopalle, P. K. 2006. Disruptiveness of innovations: measurement and an assessment of reliability and validity. Strategic Management Journal, 27, 189-199.

Gulati, R. 1995. Does Familiarity Breed Trust? The Implications of Repeated Ties for Contractual Choice in Alliances. The Academy of Management Journal, 38, 85-112.

Hair, J. F., Hult, G. T. M., Ringle, C., Sarstedt, M. 2013a. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). SAGE Publications, Inc.

Hair, J. F., Ringle, C. M., Sarstedt, M. 2013b. Partial Least Squares Structural Equation Modeling: Rigorous Applications, Better Results and Higher Acceptance. Long Range Planning, 46, 1-12.

Hair, J. F., Sarstedt, M., Pieper, T. M., Ringle, C. M. 2012. The Use of Partial Least Squares Structural Equation Modeling in Strategic Management Research: A Review of Past Practices and Recommendations for Future Applications. Long Range Planning, 45, 320-340.

Hale, K., Blackmore, D. 2012. Forecast Overview: IT Services, 2008-2015, 4Q11 Update. Gartner, ID:G00227960, 1-17.

Hall, G., Rosenthal, J., Wade, J. 1993. How to Make Reengineering Really Work. Harvard Business Review, 71, 119-131.

Hamel, G. 1991. Competition for competence and interpartner learning within international strategic alliances. Strategic Management Journal, 12, 83-103.

Harrington, H. J. 1991. Business process improvement: The breakthrough strategy for total quality, productivity, and competitiveness, McGraw-Hill New York.

Henseler, J., Ringle, C., Sinkovics, R. R. 2009. The use of partial least squares path modeling in international marketing. New Challenges to International Marketing. Emerald Group Publishing Limited.

Hertog, P. D. 2000. Knowledge-Intensive Business Services as Co-Producers of Innovation. International Journal of Innovation Management, 04, 491-528.

Hienerth, C., von Hippel, E., Jensen, M. B. 2014. User community vs. producer innovation development efficiency: A first empirical study. Research Policy, 43, 190-201.

Howells, J., Tether, B. S. 2004. Innovation in Services: Issues at Stake and Trends (Final Report) [Online]. Commission of the European Communities, Brussels - Luxembourg, 2004: Centre for Research on Innovation and Competition, the University of Manchester.

Huang, F., Rice, J. 2012. Openness in Product and Process Innovation. International Journal of Innovation Management, 16, 1250020.

Hulland, J. 1999. Use of partial least squares (PLS) in strategic management research: a review of four recent studies. Strategic Management Journal, 20, 195-204.

Keupp, M. M., Palmié, M., Gassmann, O. 2012. The Strategic Management of Innovation: A Systematic Review and Paths for Future Research. International Journal of Management Reviews, 14, 367-390.

Kogut, B., Zander, U. 1992. Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. Organization Science, 3, 383-397.

Kotter, J. P. 1995. Leading Change: Why Transformation Efforts Fail. Harvard Business Review, 73, 59-67.

Law, K. S., Wong, C.-S., Mobley, W. H. 1998. Toward a Taxonomy of Multidimensional Constructs. The Academy of Management Review, 23, 741-755.

Leonard-Barton, D. 1992. Core capabilities and core rigidities: A paradox in managing new product development. Strategic Management Journal, 13, 111-125.

Lietz, P. 2010. Research into questionnaire design. International Journal of Market Research, 52, 249-272.

Lüthje, C., Herstatt, C. 2004. The Lead User method: an outline of empirical findings and issues for future research. R&D Management, 34, 553-568.

Malerba, F., Nelson, R., Orsenigo, L., Winter, S. 2007. Demand, innovation, and the dynamics of market structure: The role of experimental users and diverse preferences. Journal of Evolutionary Economics, 17, 371-399.

Narula, R. 2001. Choosing Between Internal and Non-internal R&D Activities: Some Technological and Economic Factors. Technology Analysis and Strategic Management, 13, 365-387.

Narula, R. 2002. Innovation systems and 'inertia' in R&D location: Norwegian firms and the role of systemic lock-in. Research Policy, 31, 795-816.

O'Neill, P., Sohal, A. S. 1999. Business Process Reengineering A review of recent literature. Technovation, 19, 571-581.

OECD 2005. Oslo manual: Guidelines for collecting and interpreting innovation data, Organisation for Economic Co-operation Development publishing.

Oliveira, P., von Hippel, E. 2011. Users as service innovators: The case of banking services. Research Policy, 40, 806-818.

Pavitt, K. 1984. Sectoral patterns of technical change: Towards a taxonomy and a theory. Research Policy, 13, 343-373.

Pisano, G. P., Wheelwright, S. C. 1995. The New Logic of High-Tech R&D. Harvard Business Review, 73, 93-105.

Potter, K. 2012. IT Metrics: Intervention to Avoid Strategic Missteps With IT Benchmarking and IT Cost Transparency. Gartner, ID:G00235258, 1-19.

Powell, W. W., Koput, K. W., Smith-Doerr, L. 1996. Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. Administrative Science Quarterly, 41, 116-145.

Prahalad, C. K., Ramaswamy, V. 2004. Co-creation experiences: The next practice in value creation. Journal of Interactive Marketing, 18, 5-14.

Reichstein, T., Salter, A. 2006. Investigating the sources of process innovation among UK manufacturing firms. Industrial and Corporate Change, 15, 653-682.

Ridder, F. 2013. Generation Y Will Reinvent Outsourcing. Gartner, ID:G00250544, 1-9.

Ridder, F., Cohen, L. R. 2013. Outsourcing Trends 2013: The Impact of Social, Information, Mobile and Cloud on Your Sourcing Strategies. Gartner, ID: G00239102, 1-13.

Ringle, C. M., Sarstedt, M., Straub, D. W. 2012. A Critical Look at the Use of PLS-SEM in MIS Quarterly. MIS Quarterly, 36, iii-xiv.

Ringle, C. M., Wende, S., Will, A. 2005. SmartPLS 2.0. www.smartpls.de.

Robertson, P. L., Casali, G. L., Jacobson, D. 2012. Managing open incremental process innovation: Absorptive Capacity and distributed learning. Research Policy, 41, 822-832.

Rossiter, J. R. 2002. The C-OAR-SE procedure for scale development in marketing. International Journal of Research in Marketing, 19, 305-335.

Rubin, D. B. 1976. Inference and missing data. Biometrika, 63, 581-592.

Sauermann, H., Roach, M. 2013. Increasing web survey response rates in innovation research: An experimental study of static and dynamic contact design features. Research Policy, 42**,** 273-286.

Schafer, J. L., Graham, J. W. 2002. Missing data: our view of the state of the art. Psychological Methods, 7**,** 147-177.

Schreier, M., Prügl, R. 2008. Extending Lead-User Theory: Antecedents and Consequences of Consumers' Lead Userness. Journal of Product Innovation Management, 25**,** 331-346.

Scott, S. G. 1997. Social identification effects in product and process development teams. Journal of Engineering and Technology Management, 14**,** 97-127.

Sobel, M. E. 1982. Asymptotic confidence intervals for indirect effects in structural equation models. Sociological methodology, 13**,** 290-312.

Tabachnick, B. G., Fidell, L. S. 2001. Using multivariate statistics (4th edition). In: Pascal, R. (ed.). Allyn and Bacon.

Teece, D. J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy, 15**,** 285-305.

Teece, D., Pisano, G. 1994. The Dynamic Capabilities of Firms: an Introduction. Industrial and Corporate Change, 3**,** 537-556.

Teece, D. J., Pisano, G., Shuen, A. 1997. Dynamic Capabilities and Strategic Management. Strategic Management Journal, 18**,** 509-533.

Tether, B. S. 2002. Who co-operates for innovation, and why: An empirical analysis. Research Policy, 31**,** 947-967.

Tidd, J., Bessant, J. 2011. Managing innovation: integrating technological, market and organizational change. Wiley.

UKIS 2012. First Findings from the UK Innovation Survey 2011: Science and Innovation Analysis [Online]. UK BIS – Department for Business Innovation and Skills.

Vargo, S. L., Lusch, R. F. 2004. Evolving to a New Dominant Logic for Marketing. Journal of Marketing, 68**,** 1-17.

Vargo, S. L., Maglio, P. P., Akaka, M. A. 2008. On value and value co-creation: A service systems and service logic perspective. European Management Journal, 26**,** 145-152.

von Hippel, E. 2005. Democratizing Innovation [Online], The MIT Press.

von Hippel, E., Riggs, W. 1997. A lead user study of electronic home banking services : lessons from the learning curve. Working Paper. Sloan School of Management, MIT**,** 19.

Wold, H. 1982. Soft modeling: The basic design and some extensions. In: Jöreskog, K. G., Wold, H. (eds.) Systems under indirect observation: causality, structure, prediction. North-Holland Publishing Company.

Woodruff, R. B. 1997. Customer value: The next source for competitive advantage. Journal of the Academy of Marketing Science, 25**,** 139-153.

Xie, C., Bagozzi, R. P., Troye, S. V. 2008. Trying to prosume: toward a theory of consumers as co-creators of value. Journal of the Academy of Marketing Science, 36**,** 109-122.

Zairi, M., Sinclair, D. 1995. Business process re-engineering and process management: A survey of current practice and future trends in integrated management. Business Process Re-engineering & Management Journal, 1**,** 8-30.

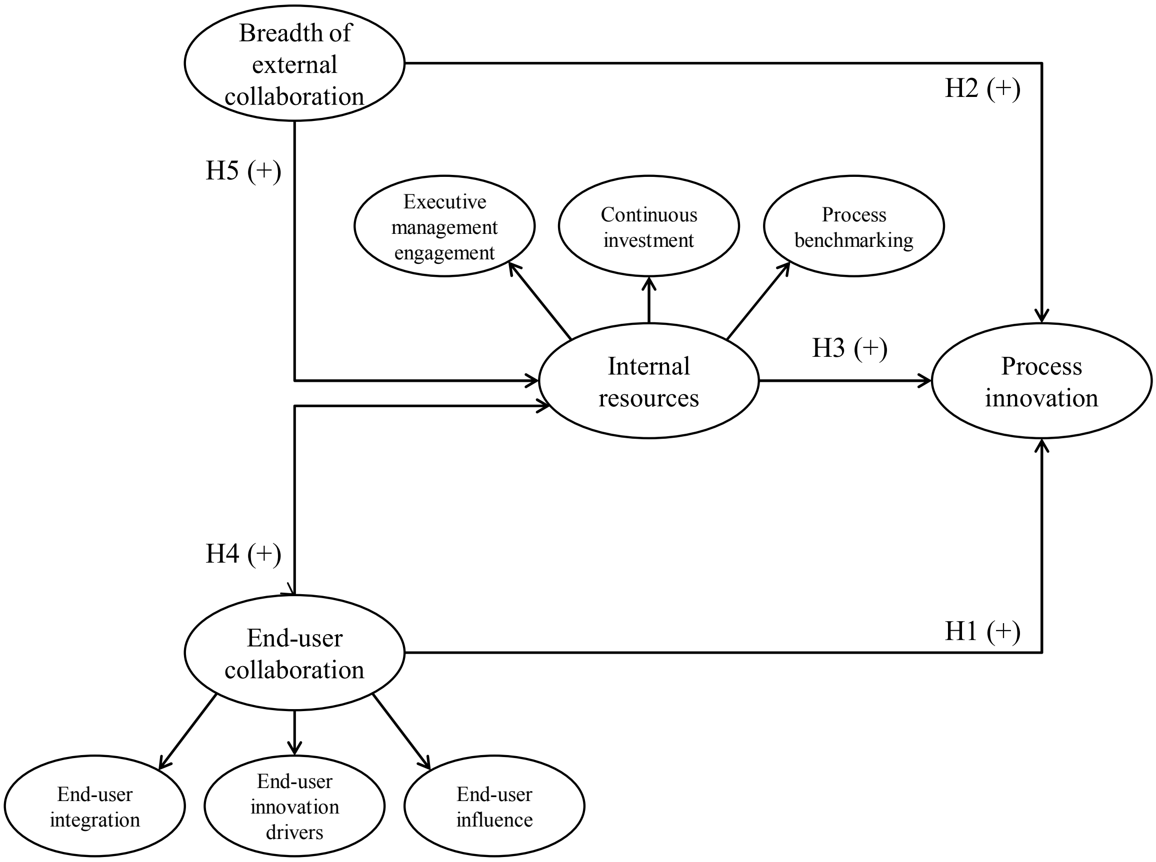
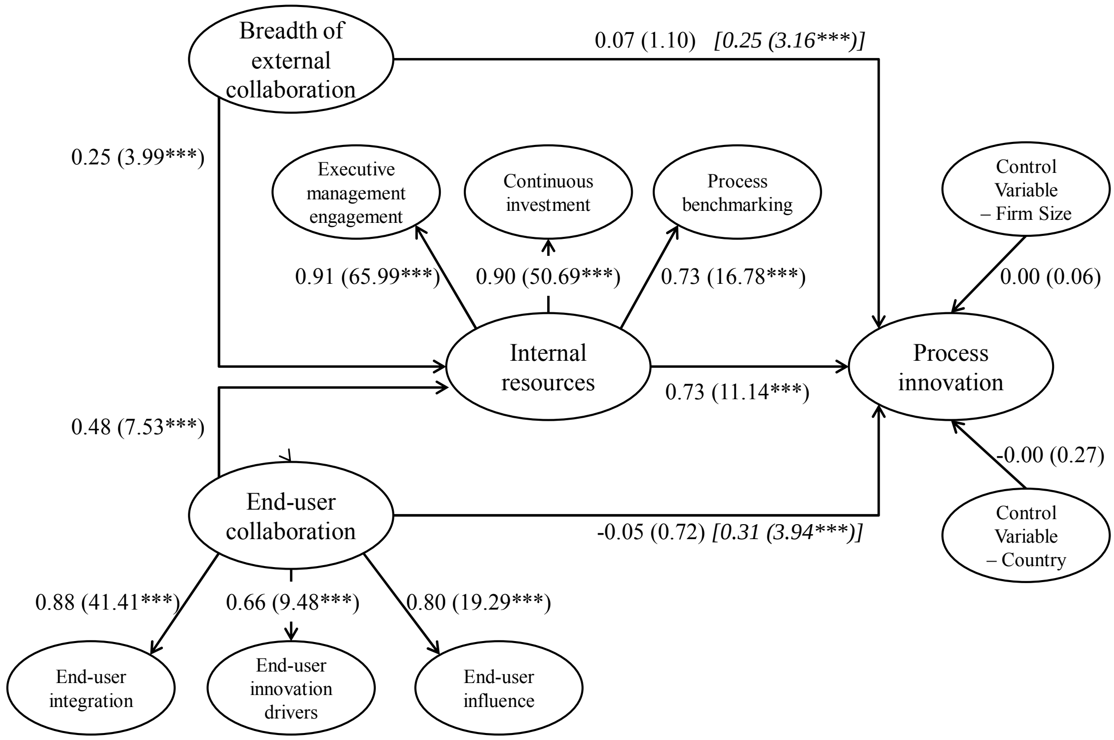


Figure 1: Research model of process innovation and its firm-level factors



<u>Note:</u>
numbers represent standardised path coefficients (t-statistic), *** significant at 0.001 (one-tailed)
numbers *in italics and in [ ]* are standardised path coefficients (t-statistic) for direct effect
both the direct effect in the absence of mediator, and the indirect effect through the mediator are studied

Figure 2: Path assessment, standardised path coefficient (t-statistic)

Table 1: Construct and measurement development

Construct	Indicators	Measurement development
Dependent variable		
Process innovation	Six reflective indicators on a one-seven scale	Studied as the depth and breadth of change. Measures created from Davenport (1993), Hall et al. (1993), and UKIS (2012).
Independent variables		
Breadth of external collaboration	Seven types of partner co-operations captured, see Appendix A. The responses were binary coded, '1' for presence of co-operation and '0' for absence.	Calculated as a percentage of partners co-operated for process innovation. Indicators adapted from the EU CIS and UKIS (2012). This construct was reversed for analysis.
End-user collaboration	Second-order construct using 13 repeated indicators of three first-order constructs	Analysed the determinants of end-users' innovativeness (von Hippel and Riggs, 1997), and studied end-user capabilities that provide source of knowledge for innovation.
End-user integration	Six reflective indicators on a one-seven scale	Indicators created based on the co-creation of value and business process change literatures (Davenport, 1993; Prahalad and Ramaswamy, 2004).
End-user innovation drivers	Three reflective indicators on a one-seven scale	Indicators based on stimuli for end-users to innovate for self-use and to coordinate for innovation (Schreier and Prügl, 2008; Oliveira and von Hippel, 2011).
End-user influence	Four reflective indicators on a one-seven scale	Indicators drawn from the studies on the impact of end-user collaboration on the adoption and diffusion of innovation (Bilgram et al., 2008; Lüthje and Herstatt, 2004; Malerba et al., 2007).
Internal resources	Second-order construct using 12 repeated indicators of three first-order constructs	Management practices impacting process innovation identified.
Executive management engagement	Five reflective indicators on a one-seven scale	Indicators derived from studies on impact of top management support on process change teams, and on process innovation (Frishammar et al., 2012; Scott, 1997).
Continuous investment	Four reflective indicators on a one-seven scale	Indicators created from factors impacting process reengineering (Hall et al., 1993) measures of innovation enablers (UKIS, 2012), and OECD's (2005) guidelines for investment. We did not use input measures to reflect investment because this study took a cross-sectional view, and previous studies show lack of correlation between capital investment (Reichstein and Salter, 2006), R&D expenditure (Huang and Rice, 2012) and process innovation.
Process benchmarking	Three reflective indicators on a one-seven scale	Indicators based on the accepted types of benchmarking – internal, competitive, and world class (Camp, 1989). The indicators measure forward-looking benchmarking practices, because this approach is more beneficial than backward-looking benchmarking at the output stage (Anderson and McAdam, 2004).
Control variables		
Firm size	Dummy variables: '1' Small<=50 employees, '2' Medium<=1000 employees, and '3' Large>1000 employees	Firm size as represented by number of employees has been studied in numerous innovation studies (Damanpour, 2010)
Country pertaining to the process innovation experience	Dummy variables: '1' Europe, '2' India, '3' North America, '4' Others, and '5' UK	Large-scale surveys like the EU CIS use innovation data across countries to compare trends and set benchmarks.

Table 2: Structural model assessment and goodness-of-fit indices

Endogenous constructs	**VIF Values**	**R^2**	**Adjusted R^2 [a]**	**ΔR^2**	**f^2**	**Q^2**
Process innovation		*0.54*	*0.53*			*0.37*
Breadth of external collaboration	1.18			0.54	0.01	
End-user collaboration	1.45			0.54	0.00	
Internal resources	1.58			0.22	0.69	
Internal resources		*0.37*	*0.36*			*0.20*
Breadth of external collaboration	1.08			0.31	0.09	
End-user collaboration	1.08			0.15	0.34	

[a] Adjusted $R^2 = 1-(1-R^2)*(n-1)/(n-v-1)$, where n=sample size and v=number of predictor variables for the endogenous construct

APPENDIX A

The measurement scale and model loadings

Construct-Indicators		1st order outer loading	2nd order outer loading	AVE	Composite Reliability
Process innovation				**0.69**	**0.93**
	Our organisation has delivered a new or significantly improved process:				
PI1	across the business unit	0.82			
PI2	across group companies	0.80			
	Our organisation delivered ‘process innovation’ that:				
PI3	increased profit margin on sales	0.85			
PI4	led to growth in sales/turnover	0.83			
PI5	impacted multiple systems	0.82			
PI6	provided competitive advantage	0.88			
Internal resources is a second-order construct, reflected by CI, PB and EME below				**0.54**	**0.93**
Continuous investment (CI)				*0.71*	*0.91*
	In comparison to the past, in the last year our organisations strategy towards ‘process innovation’ has changed and our organisation now:				
CI1	invests more skilled resources	0.90	0.75		
CI2	invests more management time	0.87	0.76		
CI3	invests more in training	0.84	0.80		
CI4	publishes more case studies, articles, papers and sections in a book	0.77	0.72		
Process benchmarking (PB)				*0.77*	*0.91*
	At the beginning of ‘process innovation’, our organisation benchmarked the process against best practices:				
PB1	within the organisation	0.83	0.64		
PB2	with direct competitors	0.87	0.63		
PB3	with market leading companies	0.93	0.66		
Executive management engagement (EME)				*0.71*	*0.92*
	Executive management in our organisation were involved in these ‘process innovation’ activities:				
EME1	enable training	0.82	0.77		
EME2	provide resources	0.88	0.80		
EME3	review progress	0.87	0.82		
EME4	communicate success	0.75	0.66		
EME5	assist in addressing challenges faced	0.88	0.78		
End-user collaboration is a second-order construct, reflected by EUI, EUD and EUF below				**0.50**	**0.93**
End-user integration (EUI)				*0.75*	*0.95*
	The end users involved in these ‘process innovation’ activities:				
EUI1	define objectives	0.85	0.76		
EUI2	plan	0.89	0.77		
EUI3	review progress	0.92	0.80		
EUI4	review outcomes/results	0.84	0.75		
EUI5	assist in addressing challenges faced	0.87	0.78		
EUI6	provide resources	0.82	0.71		
End-user innovation drivers (EUD)				*0.75*	*0.90*

Construct-Indicators		1st order outer loading	2nd order outer loading	AVE	Composite Reliability
	The end users involved in 'process innovation' with our organisation:				
EUD1	had high motivation to work on 'process innovation'	0.87	0.55		
EUD2	had prior process change experience	0.86	0.56		
EUD3	wanted to participate throughout the 'process innovation' journey	0.87	0.60		
End-user influence (EUF)				*0.82*	*0.95*
	The end users involved in 'process innovation' with our organisation:				
EUF1	showed potential to influence market demand after 'process innovation'	0.89	0.71		
EUF2	showed potential to open up new markets after 'process innovation'	0.92	0.72		
EUF3	are respected in the market for opinion leadership	0.92	0.76		
EUF4	were well connected	0.88	0.68		
Breadth of external collaboration				**1**	**1**
	Our organisation co-operated with the following for 'process innovation':				
	other businesses within our group companies				
	suppliers of equipment, materials, services, or software				
	clients or customers				
	competitors or other businesses in our industry				
	consultants, commercial labs, or private R&D institutes				
	universities or other higher education institutions				
	government or public research institutes				
Firm size - control variable (see Table 1 for details)				**1**	**1**
Country pertaining to the process innovation experience - control variable (see Table 1 for details)				**1**	**1**

APPENDIX B

Discriminant validity – cross loading test

Indicators	*Firm size - control*	*Continuous investment*	*Country - control*	*End-user integration*	*End-user collaboration*	*End-user innovation drivers*	*End-user influence*	*Executive management engagement*	*Extent of external collaboration*	*Internal resources*	*Process benchmarking*	*Process innovation*
Firm size - control	**1.00**	-0.09	0.11	-0.07	-0.10	0.00	-0.14	-0.08	-0.05	-0.11	-0.12	-0.08
Extent of external collaboration	-0.05	0.35	-0.05	0.25	0.28	0.21	0.20	0.32	**1.00**	0.39	0.33	0.34
PI1	-0.10	0.54	-0.14	0.19	0.23	0.20	0.17	0.53	0.27	0.59	0.42	**0.82**
PI2	-0.12	0.58	-0.12	0.28	0.31	0.18	0.25	0.49	0.35	0.61	0.52	**0.80**
PI3	-0.00	0.48	-0.08	0.27	0.30	0.22	0.22	0.53	0.23	0.57	0.44	**0.85**
PI4	0.02	0.57	-0.10	0.24	0.28	0.26	0.20	0.58	0.23	0.63	0.43	**0.83**
PI5	-0.08	0.49	-0.14	0.36	0.38	0.24	0.26	0.51	0.35	0.58	0.50	**0.82**
PI6	-0.09	0.54	-0.16	0.35	0.37	0.29	0.23	0.64	0.26	0.67	0.55	**0.88**
CI1	-0.11	**0.90**	-0.15	0.35	0.36	0.17	0.28	0.58	0.28	0.75	0.41	0.51
CI2	-0.06	**0.87**	-0.17	0.34	0.38	0.27	0.28	0.61	0.24	0.76	0.42	0.54
CI3	-0.03	**0.84**	-0.11	0.33	0.41	0.29	0.36	0.69	0.34	0.80	0.48	0.64
CI4	-0.10	**0.77**	-0.16	0.32	0.37	0.27	0.29	0.57	0.33	0.72	0.49	0.46
EME1	-0.01	0.63	-0.08	0.46	0.46	0.30	0.30	**0.82**	0.32	0.77	0.44	0.49
EME2	-0.07	0.64	-0.14	0.43	0.44	0.26	0.33	**0.88**	0.28	0.80	0.44	0.57
EME3	-0.09	0.69	-0.19	0.42	0.46	0.33	0.32	**0.87**	0.30	0.82	0.44	0.64
EME4	-0.09	0.52	-0.20	0.33	0.39	0.25	0.33	**0.75**	0.13	0.66	0.34	0.50
EME5	-0.09	0.57	-0.18	0.53	0.53	0.29	0.37	**0.88**	0.31	0.78	0.45	0.57
EUI1	-0.02	0.32	-0.07	**0.85**	0.76	0.34	0.44	0.46	0.26	0.46	0.38	0.35
EUI2	-0.11	0.38	-0.07	**0.89**	0.77	0.37	0.40	0.45	0.23	0.47	0.36	0.31
EUI3	-0.06	0.32	-0.06	**0.92**	0.80	0.37	0.43	0.43	0.22	0.41	0.29	0.26
EUI4	-0.01	0.33	-0.03	**0.84**	0.75	0.34	0.44	0.48	0.27	0.45	0.31	0.34
EUI5	-0.10	0.38	-0.07	**0.87**	0.78	0.35	0.47	0.46	0.16	0.47	0.34	0.27

Indicators	*Firm size - control*	*Continuous investment*	*Country - control*	*End-user integration*	*End-user collaboration*	*End-user innovation drivers*	*End-user influence*	*Executive management engagement*	*Extent of external collaboration*	*Internal resources*	*Process benchmarking*	*Process innovation*
EUI6	-0.07	0.32	0.01	**0.82**	0.71	0.33	0.37	0.42	0.19	0.40	0.26	0.24
EUD1	-0.06	0.21	-0.04	0.30	0.55	**0.87**	0.39	0.26	0.16	0.27	0.24	0.22
EUD2	-0.00	0.25	-0.03	0.34	0.56	**0.86**	0.37	0.28	0.22	0.32	0.28	0.25
EUD3	0.06	0.31	-0.11	0.40	0.60	**0.87**	0.37	0.34	0.17	0.34	0.20	0.26
EUF1	-0.07	0.36	-0.05	0.46	0.71	0.35	**0.89**	0.37	0.13	0.39	0.26	0.25
EUF2	-0.15	0.29	-0.03	0.43	0.72	0.44	**0.92**	0.35	0.16	0.35	0.23	0.19
EUF3	-0.15	0.35	-0.00	0.48	0.76	0.42	**0.92**	0.38	0.20	0.40	0.29	0.26
EUF4	-0.12	0.29	-0.02	0.40	0.68	0.36	**0.88**	0.33	0.23	0.34	0.25	0.27
PB1	-0.10	0.45	-0.12	0.31	0.40	0.38	0.29	0.47	0.29	0.64	**0.83**	0.55
PB2	-0.08	0.48	-0.04	0.29	0.26	0.13	0.16	0.41	0.27	0.63	**0.87**	0.46
PB3	-0.14	0.48	-0.08	0.37	0.39	0.23	0.29	0.45	0.32	0.66	**0.93**	0.50
Country- control	0.11	-0.17	**1.00**	-0.06	-0.06	-0.07	-0.03	-0.19	-0.05	-0.19	-0.09	-0.15

Note: the numbers in **bold** are the highest outer loadings for the indicators. All indicators show higher correlation with their construct, as compared to other constructs.

APPENDIX C

Discriminant validity – correlations of constructs and √AVE

Discriminant Validity - First-Order Constructs	1	2	3	4	5	6	7	8	9	10
1. Company size-control	***n/a***									
2. Continuous investment	-0.09	***0.85***								
3. Country-control	0.11	-0.17	***n/a***							
4. End-user integration	-0.07	0.39	-0.06	***0.87***						
5. End-user innovation drivers	0.00	0.30	-0.07	0.40	***0.87***					
6. End-user influence	-0.14	0.36	-0.03	0.49	0.43	***0.90***				
7. Executive management engagement	-0.08	0.73	-0.19	0.52	0.34	0.39	***0.84***			
8. Breadth of external collaboration	-0.05	0.35	-0.05	0.25	0.21	0.20	0.32	***n/a***		
9. Process benchmarking	-0.12	0.53	-0.09	0.37	0.28	0.28	0.50	0.33	***0.88***	
10. Process innovation	-0.08	0.64	-0.15	0.34	0.28	0.27	0.66	0.34	0.57	***0.88***

Discriminant Validity - Inner Model	A	B	C	D	E	F
A. Company size-control	***n/a***					
B. Country-control	0.11	***n/a***				
C. End-user collaboration	-0.10	-0.06	***0.71***			
D. Breadth of external collaboration	-0.05	-0.05	0.28	***n/a***		
E. Internal resources	-0.11	-0.19	0.55	0.39	***0.73***	
F. Process innovation	-0.08	-0.15	0.38	0.34	0.73	***0.88***

Note: The **bold and indented numbers along the diagonal** are square root of AVE
n/a entered for a single-item construct

The UNU-MERIT WORKING Paper Series

2014-01 *The medium-term effect of R&D on firm growth* by Marco Capasso, Tania Treibich and Bart Verspagen

2014-02 *Diverse and uneven pathways towards transition to low carbon development: The case of diffusion of solar PV technology in China* Michiko Iizuka

2014-03 *User innovators and their influence on innovation activities of firms in Finland* by Jari Kuusisto, Mervi Niemi and Fred Gault

2014-04 *Migration, remittances and household welfare in Ethiopia* by Lisa Andersson

2014-05 *Path-breaking directions of nanotechnology-based chemotherapy and molecular cancer therapy* by Mario Coccia and Lili Wang

2014-06 *Poor trends - The pace of poverty reduction after the Millennium Development Agenda* Richard Bluhm, Denis de Crombrugghe, Adam Szirmai

2014-07 *Firms' adoption of international standards: Evidence from the Ethiopian floriculture sector* by Mulu Gebreeyesu

2014-08 *School choice, segregation, and forced school closure* by Cheng Boon Ong and Kristof De Witte

2014-09 *Gender difference in support for democracy in Sub-Saharan Africa: Do social institutions matter?* by Maty Konte

2014-10 *Why are women less democratic than men? Evidence from Sub-Saharan African countries* by Cecilia García-Peñalosa and Maty Konte

2014-11 *Tipping points? Ethnic composition change in Dutch big city neighbourhoods* by Cheng Boon Ong

2014-12 *Technology life cycle and specialization patterns of latecomer countries. The case of the semiconductor industry* by Giorgio Triulzi

2014-13 *Patents as quality signals? The implications for financing constraints on R&D* by Dirk Czarnitzki, Bronwyn H. Hall and Hanna Hottenrott

2014-14 *Assessment of effectiveness of Chinese aid in competence building and financing development in Sudan* by Samia Satti Osman Mohamed Nour

2014-15 *Education, training and skill development policies in Arab Gulf countries: Macro-micro overview* by Samia Satti Osman Mohamed Nour

2014-16 *Structure of labour market and unemployment in Sudan* by Samia Satti Osman Mohamed Nour

2014-17 *Overview of knowledge transfer in MENA countries - The case of Egypt* by Samia Satti Osman Mohamed Nour

2014-18 *The impact of ICT in public and private universities in Sudan* by Samia Satti Osman Mohamed Nour

2014-19 *End-user collaboration for process innovation in services: The role of internal resources* by Mona Ashok, Rajneesh Narula and Andrea Martinez-Noya