INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD • INDIA

Degree of Openness and Project Performance: A Multi-Country Empirical Assessment of Information Technology (IT) Innovation Projects

Sudeep K. Krishnan
Rekha Jain
Rakesh Basant

W.P. No. 2013-06-03
June 2013

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380 015
INDIA

Degree of Openness and Project Performance: A Multi-Country Empirical Assessment of Information Technology (IT) Innovation Projects

Sudeep K. Krishnan
Indian Institute of Management, Ahmedabad, India
Email: sudeepk@iimahd.ernet.in

Rekha Jain
Professor, Indian Institute of Management Ahmedabad
Email: rekha@iimahd.ernet.in

Rakesh Basant
Professor, Indian Institute of Management Ahmedabad
Email: rakesh@iimahd.ernet.in

Abstract

Open innovation is a paradigm that is based on the concept of availability of abundant knowledge outside the boundaries of organizations. This study identified the influence of degree of openness, strength of appropriability regime, and project management maturity on the performance of open innovation projects. Performance was measured based on reduction of technology transfer time from research labs to business units, time to market innovations from the business units, and degree of innovativeness of the outcome. Data from 92 open innovation IT projects across India and Europe were used to test the proposed hypotheses using multiple linear regression and binary logistic regression. We developed an index termed Partner Collaboration Intensity (PCI) to measure degree of openness based on number of partners, intensity of collaboration, and innovation funnel openness. Results showed that specialized research or market partners reduced technology transfer time from research labs to business units. Results also indicated higher values of PCI index, higher strength of appropriability regime, and higher levels of project management maturity positively influenced reduction of technology transfer time from research labs to business units. Results of the logistic regression model showed that all parameters except higher strength of appropriability regime had a positive correlation with the occurrence of breakthrough innovations compared with incremental innovations.

Keywords: Open innovation, Collaboration, Information Systems Strategy, Performance

Degree of Openness and Project Performance: A Multi-Country Empirical Assessment of Information Technology (IT) Innovation Projects

Introduction

Open innovation is a paradigm that is based on the concept of availability of abundant knowledge outside the boundaries of organizations. Open innovation asserts that firms can and should use external as well as internal ideas, and internal and external paths to market, as they look to advance their technology. Open Innovation strategies enable organizations to access external technology base outside its boundaries and also enable the firms to share internal technologies when outside agencies have higher busienss prospects (Chesbrough, 2003). By licensing-in, by buying Intellectual Property (IP) or by engaging in co-development technology in-sourcing is made possible. The in-sourced technologies can create new markets for the organization or can effectively address the needs of its existing markets. A developed idea/technology not aligning with the current strategies or for which current capabilities of the organization do not support commercialization prospects can be licensed out to an outside agency. The IP owned can be licensed out or sold to an external partner, which will address the needs of the external partners' current market. A spin-off organization can also develop a new market. Thus, open innovation strategies aim at maximizing utility of developed technologies aiming at commercial success.

This study identified the influence of degree of openness, strength of appropriability regime – which refers to the resource owners' ability to receive a return corresponding to the value created by the resource, and project management maturity of the focal firm on the performance of open innovation projects.

This manuscript is structured as follows: next section describes current literature which provides theoretical support and need for the current study. The research questions, hypotheses and research methodology for the study are described in the following sections. Results and contributions are described in the later sections.

Literature Review

Open innovation is defined as a *"paradigm that assumes that firms can and should use external as well as internal ideas, and internal and external paths to market, as they look to advance their technology"*(Chesbrough, 2003). *Closed Innovation* is the model of innovation management that assumes - to generate ideas for successful innovation companies should develop, build, market, distribute and support the ideas, and this paradigm calls for self reliant organizations having all the capabilities in-house (Chesbrough, 2004). Under the concept of open innovation research results are able to traverse the firm's boundaries rather than being held within the firm's boundaries.

Majority of studies on open innovation, including Chesbrough's work, have built considerable conceptual knowledge in this emerging area. Current studies on open innovation have looked at the principles of open innovation, individual drivers, and benefits of open

innovation. This section outlines the studies that have attempted to measure degree of openness and performance parameters.

Measuring Degree of Openness

Existing studies have asserted that adoption of open innovation principles reduces the time and cost to develop and launch innovations, and improves the innovativeness of the end solution and inter-organizational transfer of knowledge (Chesbrough, Vanhaverbeke, & West, 2006; Gassmann & Enkel, 2006; Van de Vrande, Vanhaverbeke, & Gassmann, 2010). The measures of openness across current studies are based on parameters such as partner characteristics, permeability of boundaries, and extent of usage of external sources of knowledge (extent of exploitation of external sources by acquisitions and extent of internal technology licensing) (Gianiodis, Ellis, & Secchi, 2010). Most of the studies have considered presence or absence of open innovation strategies as a binary categorical variable while performing the analysis.

Lazzarotti, Manzini and Pellegrini (2010) use two variables for representing the degree of openness: the number and type of partners (partner variety), and the number and type of phases of the innovation process open to external contributions (innovation phase variety). Laursen and Salter (2006) use an additional measure - intensity of collaboration to measure openness. Intensity of collaboration is defined as the extent of usage of an external knowledge source by the focal firm and is measured in terms of the contributions provided by that external source. They measure the 'depth' of the collaboration intensity as perceived by the focal firms.

Van der Meer (2007) explains adoption of different openness mechanisms across the conceptualization, development, and commercialization stages of projects. This classification of project phases is in line with the study of Boscherini, Chiaroni, Chiesa, and Frattini (2010) which categorizes the stages of innovation projects as conceptualization, realization, and transfer of results. The openness of the stages is termed 'innovation funnel openness' in their study. It can be seen that the other ways of categorizing stages of open innovation include acquisition of knowledge, transfer of knowledge, and firm acquisition (Chesbrough, 2003;2006). The studies show it is essential to identify openness across the different stages of project execution.

It is at the project level that firms identify, assimilate, and integrate external knowledge. In order to measure openness of firms, firm level analysis should be complemented with project level analysis to measure the extent of external knowledge invloved. However, none of the existing studies measure openness at a project level within a firm. It is essential to incorporate partner variety, number of partners, collaboration intensity, and phase openness to measure openness at the project level because the extent of contribution by an external source can only be measured at project level. It is also essential to understand contributions by all of the partners through out the different stages of innovation process.

Impact of Openness on Innovation Performance

We study the influence of degree of openness on two innovation performance measures at project level: the technology transfer time and the type of innovation outcome. We used the project level measures from New Product Development (NPD) and conceptual frameworks developed in open innovation domain as no prior research at project level exists in the open innovation research.

Technology Transfer Time

There are studies on innovation speed in the NPD literature which have demonstrated that the existence of accelerator firms consistently improved innovation speed and thus generated early profits (Stalk Jr, 1988). Kesseler and Chakrabarti (1996) studied innovation speed across initial development phase and commercialization. However, these studies do not distinguish between the influence of internal or external sources of knowledge. NPD literature details specific strategic, project, process, and environmental characteristics that lead to acceleration of technology transfer time. For example, Droge, Jayaram and Vickery (2004) show external strategic design integration and internal process integration with suppliers and customers improves the innovation time. The conceptual frameworks developed in open innovation literature (Chesbrough, 2006; Gassmann et al 2006) also mention acceleration of technology transfer as one of the main innovation performance characteristics for open innovation. This study contributes by linking the concept of innovation speed to open innovation, by empirically verifying the influence of openness on technology transfer time.

We disentagle technology transfer across two stages for analysis in this study

1. Time from the conceptualization of the project in the research lab to transfer to the business unit
2. Time from the transfer to the business unit to the first entry to the market

Degree of Innovativeness

Existing open innovation literature considers the improved innovativeness of the outcome of collaboration as another performance characteristic of open innovation adoption. According to Christensen (1997), innovations may be classified as disruptive, evolutionary, and revolutionary. The classification is based on changes in technology and markets that these innovations create. Disruptive or breakthrough innovations changes current technology and in most of the cases creates a whole new market. Existing solutions may also exit from the markets due to disruptive innovation. Evolutionary or incremental innovations are normally modifications in current offerings and create products and services with slight modifications in features. Revolutionary or platform innovations create new ways for providing same products or services for existing markets and this may result in new markets. Gatignon, Tushman, Smith and Anderson (2002), also classifies innovation outcomes as breakthrough and incremental. The current study adopts two extreme cases of innovation outcomes as

breakthrough and incremental innovations as the measures for degree of innovativeness of the developed solution to study how open innovation adoption influences the diverse outcomes.

Strength of Appropriability Regime

Since new knowledge and know-how could be a source of competitive advantage, protecting it from the competitors is important. New knowledge and know-how may spill over to competitors when the markets are deregulated, complex networks are created, and/or with improved channels for communication, creating an appropriability problem (Hurmelinna-Laukkanen & Puumalainen, 2007). Innovators are not always vulnerable as companies have various means of protection against the loss of knowledge assets, and by taking advantage of these protection mechanisms, innovators can make intangibles non-transferable, and consequently profit from their knowledge assets. They may also be able to earn rents for their assets. Hurmelinna-Laukkanen & Puumalainen, (2007) define appropriability regime as the means by which the resource owners are guaranteed value for their resources.

In the case of open innovation, use of internal and external paths to market and emphasis on moving people from one organization to other may create complex networks that have access to organizational knowledge (Chesbrough, 2003). At the same time, these networks and knowledge transfer processes are critical for open innovation management. Moreover, it is found that protection of IP may hinder the collaboration process (Vonortas & Okamura, 2009). Therefore, rather than the maximization of protection, the major goal in an open innovation network should be maximization of expected net profit from the knowledge assets (Shapiro & Varian, 1999). This objective is aligned with maximizing efficiency of appropriability regime to benefit from their knowledge assets.

However the role of appropriability regime, which may be an important attribute at the project level, is not explored in the context of open innovation. While doing a project level analysis, the measurement of strength of appropriability regime can be done based on scale developed by Hurmelinna-Laukkanen and Puumalainen (2007), and Hurmelinna-Laukkanen, Sainio, and Jauhiainen, (2008) in the context of multiple sectors in Finland. The scale incorporates measures for mechanisms such as Intellectual Property Rights (IPRs), contracts, tacit nature of knowledge, Human Resource Management (HRM), lead time (ability to be the first on market), and practical or technological means of concealment (restricting usage through passwords).

Project Management Maturity of Focal Firms

Proficient project management could avoid unnecessary staggers in the innovation processes. Some empirical findings show that increasing the project management maturity is positively correlated to the innovation levels (Chen et al., 2010). The proficiency of launch activities (Henard & Szymanski, 2001) and project monitoring and review (Chen et al, 2010) positively influence the outcomes. However, when the complexity of the project management processes increases, the increased task of co-ordination between partners may cause delays and challenges (Das et al, 2006). Depending on the type of proposed innovation outcomes, the

management activities in a project are likely to vary. Incremental innovations require fewer changes in technology and are easier to manage as compared to breakthrough innovations (Cooper & Klienschmidt, 1994). However, in the current stream of studies, conducted in the open innovation area, the role of project management maturity by the focal firm is unexplored. While performing a project level analysis of openness, project management maturity is an antecedent that may affect the innovation performance in open innovation projects, and therefore its influence on innovation performance needs to be analysed.

Market Knowledge Strategies

Exploration and exploitation are the two market knowledge search strategies. March (1991) introduced the concepts of exploration and exploitation as: '*Exploration includes things captured by terms such as search, variation, risk taking, experimentation, flexibility, discovery, and innovation while Exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, and execution'*. While exploration is experimentation oriented, exploitation is variety-reducing and efficiency oriented (March, 1991). These two strategies require different structures, processes, strategies, capabilities and cultures, and may have different impacts on an organization's performance. Therefore, it is necessary to understand which strategy has been adopted by focal firms in the open innovation projects and study the processes accordingly.

Li, Vanhaverbeke, and Schoenmakers (2008) build on March (1991) and other studies on categorization of projects and define exploitation and exploration in terms of technological innovation projects. According to the study, exploitation and exploratory strategies are knowledge search strategies that enable technological innovations to be translated to new and commercially viable business models. The strategies however differ in ways of building ties and network configuration, and in risk taking categorization of organizations. Exploitation is characterized by stronger ties by which firms try to broaden their existing technological capabilities (Dittrich and Duysters, 2009).

Li, Vanhaverbeke, and Schoenmakers (2008) reconcile existing studies and show a positive relationship between exploration strategy and outcome being breakthrough innovation, and exploitation strategy leading to incremental innovation. However, exploration and exploitation are ex-ante strategies of firms while pursuing innovations while breakthrough and incremental innovations are outcomes of the processes. Hence the relationship need not hold in every innovation process. The relationship and influence in the context of open innovation projects needs further investigation.

Literature Gaps

Studies on open innovation, including Chesbrough's work, have built considerable conceptual knowledge in this emerging area. They have looked at the principles of open innovation, individual drivers, and particular benefits. Lazzarotti & Manzini (2009) have developed a conceptual framework to analyze the principles of open innovation while Boscherini, Chiaroni, Chiesa, & Frattini (2010) and Hwang, Kim, & Kim (2009) have studied

a particular aspect of open innovation such as factors influencing adoption of open innovation principles in pilot projects and open source technology projects respectively.

No constructs have been developed to measure the degree of openness of projects, open innovation project performance, and to identify the influence of various factors on the performance of open innovation projects. There exists a need to evaluate degree of openness and analyse how factors such as type of networks, strength of appropriability regime, and project management maturity in open innovation initiatives influence the performance of projects. From the current studies we may also see how collaboration with different types of partners helps firms differently. However, no specific research on benefits of specific external sources of knowledge has been developed yet.

Firms adopt open innovation practices to accelerate innovation activities and enhance efficiency of innovations; however limited scholarly research has explored underlying facilitating factors (Chesbrough et al, 2006; Gassmann & Enkel, 2004). No research has empirically tested whether open innovation can accelerate innovation process (Chesbrough, Vanhaverbeke, & West, 2006). Kessler and Bierly (2002) suggests if open innovation can accelerate transfer of technology, firms may gain inimitable competitive advantage over competitors. However, empirical evidence on the impact of open innovation on technology transfer time is to yet to be developed.

Current studies show conflicting findings on partner characteristics and open innovation performance. Based on samples from ten US based firms operating in advanced scientific and chemical materials, industrial equipments, and consumer goods, Kessler, Bierly and Gopalakrishnan (2000) found collaboration with external partners can delay projects. However, studies like that of Droge, Jayaram and Vickery (2004) and Langerak and Hultink (2005) found that transfer time reduces with improved collaboration. Droge, Jayaram and Vickery (2004) were looking at firm performance and influence of technology transfer time in automotive sector while Langerak and Hultink (2005) looked at how supplier involvement influenced firm performance in the manufacturing sector. These studies however did not differentiate contributions of internal and external sources of knowledge and assumed the focal firm takes the solution to market. Moreover, in the study of project phases were limited to research and commercialization stages. A granular analysis on the type of partners, phases of projects, and classification of contributions should address this conflicting finding.

Research has not explored what specific factors influence inter-organizational transfer of knowledge across different stages of the project. It is also important to analyse partner influence on technology transfer time as open innovation aims at commercial success of projects. The influence of appropriability regime and its effect on knowledge sharing and the related factors that lead to better collaboration, and the direct influence on open innovation project performance also need to be explored.

Existing open innovation studies have been mainly conducted in the Manufacturing, Pharmaceutical, and Electronics sector. Studies in the Information Technology (IT) sector, an area which has high scope for open innovation and cross-sector performance influence, are

inadequate. Moreover, most of the empirical studies are limited to single cases of firms or a small aspect of open innovation such as licensing-in or details of spin-off organizations. The unit of analysis has remained at the firm level in all the existing empirical studies.

This study tries to address some of these gaps identified in the current studies by careful disaggregation of data and analysis at multiple levels.

Research Objectives

This study explored how openness of projects influences the innovation performance. Innovation performance was measured based on reduction of technology transfer time from research labs to business units and from business units to market, and degree of innovativeness of the end result.

Specific objectives of the study in the quantitative phase were to identify the influence of the following factors on open innovation project performance measured in terms of technology transfer time reduction and degree of innovativeness of the outcome:

- partner variety – differentiated as collaboration with research (research labs, government run institutions, and academic partners) and market partners (customers, suppliers, start-ups, strategic alliances, and other value chain partners)
- number of partners – number of research and market partners
- the phases of the project at which the project goes open (innovation funnel openness)
- intensity of collaboration with the partners as perceived by the focal firm
- strength of appropriability regime – strength of measures that guarantee value for resource owners in each of the project
- project management maturity by the focal firm

This study refined the dependent variables: technology transfer time and degree of innovativeness as described below in order to identify specific influence of these independent factors.

Technology transfer time was measured as:

1. Time from the conceptualization of the project in the research lab to transfer to the business unit
2. Time from the transfer to the business unit to first entry to the market

Degree of innovativeness was classified as:

1. Incremental
2. Breakthrough

The developed hypotheses are:

1. *Increasing the partner variety in an open innovation network accelerates the speed of the innovation process*

2. *Increasing the number of partners in the open innovation network will increase the time of the innovation process*
3. *Increasing the openness of project phases accelerates the speed of the innovation process*
4. *Increasing the intensity of collaboration with the partners in an open innovation network accelerates the speed of the innovation process*
5. *Increasing the openness of projects increases the degree of innovativeness of the technology solutions*
6. *Making the appropriability regime stronger improves the success rate of open innovation projects*
7. *Effective project management (control) improves the success rate of open innovation projects.*

The overall conceptual framework and predicted relationships are shown in Figure 1.

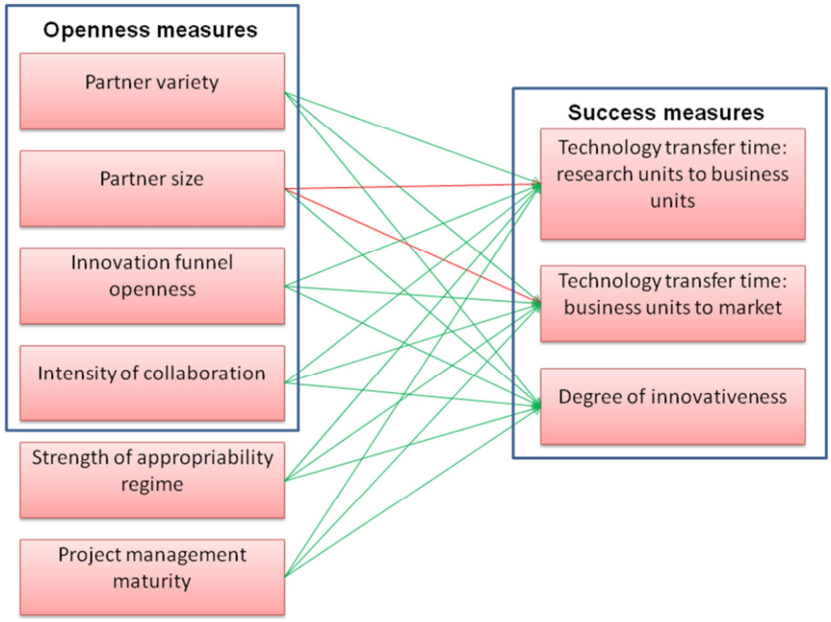

Figure 1: Conceptual model for the study (green lines show possible positive relations and red lines show possible negative relations)

Qualitative Analysis

Even though the quantitative empirical assessment in this study looks at projects as the unit of analysis, it was difficult to separate the firm level context from the projects while studying the process aspect;2s of implementing open innovation. Moreover, the existing body of literature was not extensive enough to pose causal research problems. Hence, we conducted qualitative phase prior to the survey based analysis. Twenty four semi-structured interviews were conducted to develop and validate the scales adopted. Two case studies at SAP Co-Innovation Labs (COIL) and IBM India Research Labs were used to explain how open innovation principles were practiced in the industry by documenting and analysing open

innovation projects across their complete life cycle. The cases were also used to augment the quantitaive analysis.

Details of Data and Methodology

To test the developed hypotheses, we used a dataset created from project data collected from firms across India and Europe. The studied firms include both specialized IT firms and organizations that had executed IT projects. The dataset used for analysis consists of 92 research projects that were executed in these firms during the time period 2006-2012. 57 of the projects were collected from the firms based out of India and 35 from Europe. Even though the independent data set size across India and Europe was inadequate to perform a differential analysis, we controlled for the region factor throughout our analysis in all the developed models.

Three of the observations were found to be outliers from the analysis and was removed from the sample for further analysis. 89 projects were used for the final analysis of which 56 are from India and 33 from Europe. Details were collected based on responses from multiple sources including the top management and managers in charge of the projects. The statistical methods used in the current study were Ordinary Least Squared (OLS) Multiple Regression and Logistic Regression. Multiple Regression was used to identify the influence of multiple independent variables on the Technology Transfer Time while Logistic Regression was used to predict the Degree of Innovativeness of the outcome.

Findings

The model fit is provided in Table 1 for multiple regression models for technology transfer time stage 1 and stage 2 and for the logistic regression model to predict outcome as breakthrough innovations.
The results of the analysis are given below in Table 2, 3 and 4.

Table 1: Model Fit

Regression Model	Adjusted R-Square	Regression Fit (F Value)
Technology Transfer Time Stage 1	0.629	15.931
Technology Transfer Time Stage 2	0.315	5.038
Degree of Innovativeness (Logistic Regression)	0.626 (Nagelkerke R-square)	93.3% (Prediction)

Table 2: Results for Technology Transfer Time Stage 1

Technology Transfer Time Stage 1			
Variable	**Beta**	**Significance**	**VIF**
Number of Academic Partners * Average Intensity of Collaboration	-0.469	0.031	2.872
Number of Market Partners * Average Intensity of Collaboration	-0.368	0.033	2.042
Partner Variety Dummy	2.482	0.256	2.591
Strength of Appropriation Regime	-1.864	0.031	1.283
Project Management Maturity	-1.692	0.076	1.518
Project Complexity	-0.799	0.348	1.701
Region	-3.627	0.016	1.797
Innovation Type	16.383	0.000	1.561
Prior Experience – Dummy 1	-2.142	0.091	1.328
Prior Experience – Dummy 2	-4.508	0.033	1.258

Table 3: Results for Technology Transfer Time Stage 2

Technology Transfer Time Stage 2			
Variable	**Beta**	**Significance**	**VIF**
Number of Academic Partners * Average Intensity of Collaboration	0.959	0.032	2.790
Number of Market Partners * Average Intensity of Collaboration	-0.009	0.951	1.466
Partner Variety Dummy	-7.157	0.008	2.887
Strength of Appropriation Regime	-2.555	0.007	1.259
Project Management Maturity	1.433	0.145	1.346
Project Complexity	1.985	0.032	1.620
Region	2.503	0.113	1.681
Innovation Type	4.896	0.014	1.636
Prior Experience – Dummy 1	1.007	0.464	1.322
Prior Experience – Dummy 2	-1.234	0.586	1.233

Table 4: Results for Degree of Innovativeness

Degree of Innovativeness – Logistic Regression			
Variable	**B**	**Exp(B)**	**Significance**
Partner Variety - Dummy	-2.699	0.067	0.140
Number of Academic Partners * Average Intensity of Collaboration	0.143	1.153	0.364
Number of Market Partners * Average Intensity of Collaboration	0.316	1.371	0.030
Strength of Appropriation Regime	-1.336	0.263	0.036
Project Management Maturity	2.104	8.196	0.021
Project Complexity	2.248	9.466	0.001
Region	3.287	26.759	0.056
Prior Experience – Dummy 1	1.872	6.499	0.124
Prior Experience – Dummy 2	2.014	7.491	0.235

Discussion

In the initials models developed for analysis we can see the two dummy variables created to analyse partner variety (dummy 1 corresponding to academic/research or market collaboration and dummy 2 corresponding to only academic/research collaboration or both types of collaboration) had high correlation and was also correlated to the number of partners and intensity of collaboration. Hence, for the final model developed for analysis, the variety aspect was studied from the single dummy variable corresponding to having one form of partnership, either with market partners or research partners (value 0) and having both types of partnership (value 1).

Partner Variety Dummy for Stage 1 has a co-efficient of 2.482 (with significance level 0.256) showing Technology Transfer Time increases in Stage 1 when both the types of partners are present, even though significance level is not high. Results show having both the type of partners has no significant influence on the reduction of technology transfer time from research labs to business units. Thus, it is better to have either Academic Partners or Market Partners as specialized partners according to the innovation objective.

In the similar model developed for Technology Transfer Time Stage 2, we can see Partner Variety Dummy has significant influence on the Transfer Time in Stage 2 (-7.157 with significance level $p < 0.008$) showing having both types partners in the commercialization phase reduce the time to market innovations from the business units.

The insights gained from the qualitative stage highlight the importance to analyse the extent of contributions from external sources to determine the degree of openness at the project level. The cases also show increasing number of partners, phase openness, or intensity of

collaboration independent of other factors need not increase the openness of the projects. When we statistically analyse Number of Research Partners in Stage 1 and Average Intensity of Collaboration with Research Partners across the Ideation and Development stages it was found to be significantly correlated (0.752) and so were Number of Market Partners in Stage 1 and Average Intensity of Collaboration with Market Partners across the Ideation and Development stages (0.613). Hence, for the analysis in this study to measure degree of openness, we used the composite index termed the Partner Collaboration Intensity (PCI index) measured as follows:

Research PCI Index Stage 1: Average number of research partners across ideation and development stages * average intensity of collaboration with research partners across ideation and development stages

Research PCI Index Stage 2: Number of research partners in the commercialization stage * average intensity of collaboration with research partners in the commercialization stage

Market PCI Index Stage 1: Average number of market partners across ideation and development stages * average intensity of collaboration with market partners across ideation and development stages

Market PCI Index Stage 2: Number of market partners in the commercialization stage * average intensity of collaboration with market partners in the commercialization stage

We analyse Hypotheses 2, 3 and 4 together as we are using this composite index. For the analysis for Hypotheses 2, 3 and 4 we modified the hypotheses into a single hypothesis (and sub-problems) as given below:

Improving the PCI index of project reduce the technology transfer time from research labs to market.

In Stage 1, we can see from the results Research PCI Index Stage 1 and Market PCI Index Stage 1 both have significant negative correlation with Technology Transfer Time (-0.469 with $p<0.031$ and -0.368 with $p<0.033$). While in Stage 2, we see can the variable Research PCI Index Stage 2 has a positive correlation with Technology Transfer Time (0.959 with $p<0.032$) and Market PCI Index Stage 2 has no significant influence.

Hypothesis 5 was developed to test the influence of number of partners, intensity of collaboration, and openness of project phases on the degree of innovativeness of the outcome. The model for analysis used the PCI index developed and hence the hypothesis was modified accordingly as given below.

Increasing the openness of projects increases the degree of innovativeness of the technology solutions

Hypothesis 5 was tested using the binary logistic regression model. The classification model predicts overall 93.3% of the observed values. Details of the model are given above in the binary logistic regression model outputs. In the prediction model all variables apart from the

Strength of Appropriability Regime and Partner Variety Dummy have a positive influence on breakthrough innovations.

Hypothesis 6 was developed to test Strength of Appropriability Regime – Reduction of Technology Transfer Time and Degree of Innovativeness relationship. From the binary logistic model we can see Degree of Innovativeness relationship is not supported and contrary to our assumption stricter policies on IP, secrecy control etc show negative relationship with outcomes resulting as breakthrough innovations. The result shows that freedom in operations may actually improve the Degree of Innovativeness of the outcomes. From Model 4 developed for Stage 1, we can see Strength of Appropriability Regime has a negative correlation with the Technology Transfer Time Stage 1 with high level of significance (-1.864 with $p<0.031$). Similarly for Technology Transfer Time Stage 2, the negative correlation is stronger (-2.555 with $p<0.007$).

Hypothesis 7 explores the relationship between project management maturity of the focal firm and innovation performance of the projects. In Stage 1, Project Management Maturity has a negative correlation with the technology transfer time (-1.692 with $p<0.076$). However, in Stage 2, the opposite relationship is exhibited, but with a weaker support. Project Management Maturity has a positive correlation +1.433 with $p<0.145$ which was moderately significant, showing the transfer time processes are taking more time, when the focal firm's influence on partners is stronger and when the network has more formal processes for activities like closure and reviews. Hence, we may generalize stricter and formal control processes may create additional overhead on the transfer time (However, with very weak support $p<0.145$). The binary logistic model also shows positive influence of project management maturity on the innovation outcome.

Comparative Analysis across the Regions

In the models shown for the Transfer Time in stage 1 and stage 2, and for the Degree of Innovativeness, we had controlled for the region factor. 56 projects in the final analysis were from focal firms based out of India and the remaining 33 were from Europe (from the final sample after outlier analysis).

For Technology Transfer Time Stage 1, Region factor has a distinct negative correlation (-3.627 with significance 0.016), showing clear reduction in technology transfer time in the European projects. In Stage 2, the Region factor has a positive correlation with the Transfer Time (commercialization stage) as shown in the results for stage 2 (2.503 with $p<0.113$), a moderately significant relationship. This shows that the Indian projects had lower commercialization time as compared to the European projects. The region factor also shows a positive influence on breakthrough innovation in the binary logistic regression analysis (Exp(B) = 26.579), showing that the European open innovation projects resulted more in breakthrough outputs. The results show that the conceptualization and development in the research phase are quicker in the European open innovation projects while Indian projects aimed at faster commercialization with improved openness. Further, the degree of innovativeness of the end results is found to be better for European projects.

Influence of Prior Partner Experience

We formulated two dummy variables to analyse the influence of prior partner experience on transfer time and degree of innovativeness of the outcome. Prior partner experience was mentioned as a significant success factor during the qualitative stage of analysis and this factor was controlled during the quantitative analysis. The first dummy variable had value 0 when there were no prior experience and value 1 when only one of the partners had prior experience showing moderate level of prior partner experience. The second dummy variable had value 0 when there were no prior experience and value 1 when all of the partners had prior experience in the network showing complete level of previous experience.

Both the prior experience dummy variables show moderately significant influence on the reduction of technology transfer time in stage 1 (-2.142 and -4.508 with $p<0.091$ and $p<0.033$), showing prior experience of anyone of the partners itself will reduce the technology transfer time from research labs to business units (Ideation and Development stages) and innovation performance improves when all partners has prior experience. However, in stage 2 the relationship is not significant for both the scenarios, a single partner having prior experience or even all partners having prior experiences, showing the commercialization phase involves a set of processes and activities that cannot be influenced even by the partners who have prior experience. The innovation outcome is also positively influenced by the prior experience factor. Exp(B) for single partner having prior experience is 6.499 favouring breakthrough innovations and multiple partners' prior experience have positive influence of 7.491, showing previous collaboration, when repeated will actually lead to more effective collaborations resulting in more innovative outcomes.

Contributions

Firms need to accelerate the innovation process keep up with competition and make sure the research results reach market in a faster pace. The different components of opening up the boundaries and its influence on transfer time were identified from the project data. Results suggest organizations may decide on how to develop their open innovation strategies based on the expected outcomes. However, we have not measured how open innovation will impact the possibility of generating revenue or how faster rate in revenue generation can be achieved. Results show adopting open innovation strategies decreases the time to market of R&D projects.

All previous attempts to analyse partner contribution and influence of external collaboration considered all types of partners together and in open innovation studies adoption of the strategies by a focal firm to open up boundaries were considered as indicators for openness. However, we analysed the phenomenon in a more granular way and differentiated the influence of openness based on each of the parameters. Degree of openness may be defined from our analysis as cumulative effect of all the variables analysed.

Degree of openness = F(partner variety, PCI index(number of partners, phase openness, intensity of collaboration))

The results show how to structure the open innovation networks according to the innovation objectives. The granular analysis across different stages for technology transfer shows the need to structure the network differently across the different stages. In stage 1, partner variety was not preferred. However, increasing the number of partners, phase openness and intensity of collaboration with specialized partners showed improved technology transfer time across the ideation and development phases. In stage 2, even though PCI index was not showing significant influence, improving the variety was showing significant influence. The measures for strength of appropriability regime and project management maturity were also found to improve technology transfer time across both the stages.

All measures of openness and project management maturity had positive influence on the degree of innovativeness of the outcome while strength of appropriation regime was hindering breakthrough innovation. The results of the study will help in understanding how to modify different aspects of open innovation when the innovation objective is to develop breakthrough innovations. In case the objectives include both reduction of technology transfer time and degree of innovativeness, strength of appropriability regime should be minimized. However, other factors will contribute positively to both the innovation objectives. The results also show how granular analysis of different aspects of openness influences performance and why earlier studies had found conflicting results. Earlier studies had considered open innovation as a single process or studied one aspect of partnering such as taking adoption of one open innovation strategy as a proxy for openness and considering number of external partners as a measure of openness. This study was successful in addressing such gaps.

Limitations

One of the limitations of this study is the sample size. The study attempted to study open innovation at project level and required completed instances of open innovation IT projects. Most of the IT firms are yet to adopt open principles and the projects for which data can be provided from the studied firms were limited. The overall sample size was good enough for analysis but was not sufficient for a region wise differential analysis. Even though data collected was cross checked using project reports and whenever possible with multiple respondents who had handled the same project, there may be response bias for variables such as intensity of collaboration and project complexity. By using additional questions to all respondents the scale was made clearer in the attempt to reduce responses biases across different firms.

References

Almirall, E., & Casadesus-Masanell, R. (2010). Open Versus Closed Innovation: A Model of Discovery and Divergence. *Academy of Management Review* , 27-47.

Boscherini, L., Chiaroni, D., Chiesa, V., & Frattini, F. (2010). How to use pilot projects to implement Open Innovation. *International Journal of Innovation Management* , 1065-1097.

Belderbos, R., Carrie, M. & Lokshin, B. (2004). Cooperative R&D and firm performance. *Research Policy*, 1477-1492.

Carbonell, P., & Rodriguez, A. I. (2006). Designing teams for speedy product development: The moderating effect of technological complexity. *Journal of Business Research*, 225-232.

Chen, J. Y., Damanpour, F., & Reilly, R. R. (2010). Understanding antecedents of new product development speed: A meta-analysis. *Journal of Operations Management*, 17-33.

Chesbrough, H., & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change* , 529–555.

Chesbrough, H. (2003). A better way to innovate. *Harvard Business Review* , 12-13.

Chesbrough, H. (2003). Open platform innovation: Creating value from internal and external innovation. *Intel Technology Journal* , 5-9.

Chesbrough, H. (2003). The era of open innovation. *Sloan Management Review* , 35-41.

Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

Chesbrough, H. (2004). Managing Open Innovation. *Research Technology Management* , 23-26.

Chesbrough, H., Vanhaverbeke, W., & West, J. (2006). *Open Innovation: Researching a New Paradigm*. Oxford: Oxford University Press.

Chesbrough, H., & Crowther, A. K. (2006). Beyond high tech: Early adopters of open innovation in other industries. *R&D Management* , 229–236.

Christensen, C. M. (1997). *The innovator's dilemma: when new technologies cause great firms to fail.* Boston: Harvard Business School Press.

Christensen, J. F., Olesen, M. H., & Kjær, J. S. (2005). The industrial dynamics of Open Innovation—Evidence from the transformation of consumer electronics. *Research Policy* , 1533–1549.

Das, A., Narasimhan, R. and Talluri, S. (2006). Supplier Integration-Finding an Optimal Configuration, *Journal of Operations Management*, 563-582.

Dittrich, K., & Duysters, G. (2007). Networking as a means to Strategy Change: The Case of Open Innovation in Mobile Telephony. *The Journal of Product Innovation Management* , 510-521.

Droge, C., Jayaram, J., & Vickery, S. K. (2004). The effects of internal versus external integration practices on time-based performance and overall firm performance. *Journal of Operations Management*, 557-573.

Gassmann, O and Enkel, E (2004). Towards a theory of open innovation: Three core process archetypes. *Proceedings of the R&D Management Conference*. Sesimbra,Portugal.

Gassmann, O., Enkel, E., & Chesbrough, H. (2010). The future of open innovation. *R&D Management* , 213-221.

Gianiodis, P. T., Ellis, S. C., & Secchi, E. (2010). Advancing a typology of open innovation. *International Journal of Innovation Management* , 531-572.

Hienerth, C. (2006). The commercialization of user innovations: the development of the rodeo kayak industry. *R&D Management*, 273–294.

Hurmelinna-Laukkanen, P., & Puumalainen, K. (2007). Formation of the appropriability regime: Strategic and practical considerations. *Innovation: management, policy & practice* , 2-13.

Hurmelinna-Laukkanen, P., Sainio, L.-M., & Jauhiainen, T. (2008). Appropriability regime for radical and incremental innovations. *R&D Management* , 278-289.

Hwang, J., Kim, E., & Kim, S. (2009). Factors affecting open technological innovation in open source software companies in Korea. *Innovation: management, policy & practice* , 279–290.

Kessler, E. H., Bierly, P. E., & Gopalakrishnan, S. (2000). Internal vs. external learning in new product development: effects on speed, costs and competitive advantage. *R&D Management*, 213-224.

Kleinknecht, A. & Mohnen, P. (2002). *Innovation and Firm Performance*. New York: Palgrave.

Kirschbaum, R. (2005). Open innovation in practice. *Research and Development Technology Management* , 24–28.

Langerak, F., & Hultink, E. J. (2005). The impact of new product development acceleration approaches on speed and profitability: Lessons for pioneers and fast followers. *IEEE Transactions on Engineering Management*, 30-42.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal* , 131–150.

Lazzarotti, V., & Manzini, R. (2009). Different Modes of Open Innovation: A theoretical Framework and an Empirical Study. *International Journal of Innovation Management* , 615-636.

Lazzarotti, V., Manzini, R., & Pellegrini, L. (2010). Open innovation models adopted in practice: an extensive study in Italy. *Measuring Business Excellence* , 11-23.

Lokshin, B., Belderbos, R., & Carree, M. (2008). The productivity effects of internal and external R&D: Evidence from a dynamic panel data model. *Oxford Bulletin of Economics and Statistics*, 399-413.

Li, Y., Vanhaverbeke, W., & Schoenmakers, W. (2008). Exploration and exploitation in innovation: Reframing the interpretation.*Creativity and Innovation Management*, 107–126.

March, J.G. (1991). Exploration and Exploitation in Organizational Learning. *Organization Science*, 71–87.

Shapiro, C &Varian, H. R. (1999). *Information Rules. A Strategic Guide to the Network Economy*. Harvard Business School Press.

van der Meer, H. (2007). Open Innovation – The Dutch Treat: Challenges in Thinking in Business Models. *Creativity and Innovation Management* , 192-202.