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OPEN INNOVATION: SYSTEMATISATION OF KNOWLEDGE EXPLORATION AND EXPLOITATION FOR COMMERCIALISATION

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This paper explores the intricacies of various determinants that can be used to systematise open innovation processes as the functional streaming of knowledge, both inbound and outbound, to expedite internal innovation and extricate the market for external use of innovation. Drawing on extant open innovation literature and data collected from organisations on the list of Thomas Reuters Derwent World Patents Index covering North America, Europe, Asia, Sub-Saharan Africa, the Middle East and North African for their open innovation practices, a model was developed that conceptualises the systematisation of open innovation processes toward commercial activities. The results show that the systematisation of open innovation requires a balancing act of knowledge exploration (KET) and exploitation (KEL) ambidexterity for commercialisation of the firm, and that a relationship exists between these variables. Using the contingency-based approach to organisational development, the paper adds to the understanding of the role of open innovation processes, systematisation, content and context as well as the research and development aspect of open innovation.

Keywords: Ambidexterity; commercialisation; knowledge exploration; knowledge exploitation; open innovation; systematisation.

Introduction

The concept of open innovation has attracted much attention from management researchers from a variety of theoretical perspectives. However, open innovation has

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been mostly investigated from the organisational level, while the antecedents, processes and outcomes on the other levels remain relatively unexplored. Traditionally, industrial firms depend on internal knowledge (closed innovation) to develop and nurture ideas inside the company until they are launched as new products or businesses. Open innovation allows ideas to flow in and out of an organisation through what can be described as porous boundaries (Vanhaverbeke, 2005; Chesbrough, 2003). Used first by Chesbrough (2003, p. 24), the term open innovation suggests that "firms can and should use external as well as internal ideas and paths to market as they look to advance their technology". The concept is used to describe innovation processes in which firms interact extensively with their environment, leading to a significant amount of external knowledge (EK) exploration (KET) and exploitation (KEL). To link open innovation framework to related literature, Lichtenthaler (2011, p. 77) proposes an expanded definition of open innovation, as "systematically performing KET, retention and exploitation inside and outside an organization's boundaries throughout the innovation process".

Historically, this interchange of knowledge with organisations or individuals that are not employed by the focal firm has been at the core of open innovation. Chesbrough (2006a) and Gaule (2006) posit that there is a general demand for companies to adopt this new way of thinking in order to exploit trends such as the increasing availability and mobility of skilled workers, the growth of venture capital and the rising quality of suppliers together with trends that erode the advantages of closed innovation.

In recent times, the strategy of open innovation has been used across industries with firms increasingly acquiring external technologies to complement their internal knowledge bases (for example, by means of strategic alliances or in-licensing, which involves acquiring the right to use EK (Beamish and Lupton, 2009; Cassiman and Veugelers, 2006; Teece, 1986; von Hippel, 1998). Similar developments have been observed in KET and KEL, whereby firms across industries actively commercialise their technological knowledge, either exclusively or in addition to using it internally for their own products by means of out-licensing or strategic alliances, thereby allowing external partners the use of their technology.

Despite its growing importance, many firms experience severe challenges in actively managing the processes of open innovation (Lichtenthaler, 2008a; van de Vrande *et al.*, 2009), although there is evidence to show that pioneering companies, such as Procter & Gamble, Cisco, DuPont, Philips, Apple, Samsung, Motorola, Hewlett Packard, Xerox, Unisys and Eli Lilly have achieved great benefits from the open innovation construct (Hacievliyagil *et al.*, 2007; Huston and Sakkab, 2006; Schwartz and Huff, 2010; Schumpeter, 2002).

Additionally, the most successful firms had to overcome major challenges at the beginning of their open innovation initiatives (Chesbrough, 2007; Laursen and

Salter, 2006), and there are major inter-firm differences in how open innovation is successfully managed. However, there has not been much research to systematise the open innovation process across organisations by adding value to the existing work of exploring knowledge for organisational development. Thus, practitioners and academics alike need a better understanding of open innovation processes in order to grasp the benefits while avoiding potential pitfalls rather than a trial and error approach (Gassmann and Enkel, 2004). Gassmann *et al.* (2010), for example, have suggested the need for researchers to develop a multilevel conceptual framework for organising open innovation in firms. Similarly, many of the studies on open innovation provide general prescriptions and do not take into consideration many contexts and contingencies that influence the innovation process (Tidd, 2014a).

Accordingly, this study contributes to the literature by exploring the determinants for systematising the open innovation process. The objective is to examine how systematisation of a firm's external KET and KEL processes influence the firm's commercialisation activities and overall performance. Although exploration and exploitation may compete for resources and that there are trade-offs between the two (Lavie *et al.*, 2010), we follow prior research and argue that exploratory and exploitative innovation can be pursued simultaneously at the organisational level (Bierly and Daly, 2007; Cao *et al.*, 2009; Gupta *et al.*, 2006).

The systematisation of the commercialisation process provides an appropriate means of integrating the exploration and exploitation process and consequently, helping to achieve the right balance between the two as it relates to the sector, firm structure and strategy (Lichtenthaler, 2011). To do this effectively, the study employs the structural equation model (SEM) that takes in to account measurement problems, especially, as they relate to latent variables. In the sections that follow, a brief overview of the open innovation literature is given after which the methodology is described, the results are discussed, implications and conclusions given and directions for future research offered.

Literature Review

In this section, we present a brief overview of the open innovation paradigm and the hypotheses for the study.

Open innovation paradigm

In recent times, firms have been encouraged to employ open innovation to overcome challenges associated with increased competition and shorter product life cycles (Chesbrough, 2003). As firms become more permeable to the external environment, they gain benefits in terms of their ability to use the technology developed by others and vice versa (Cassiman and Valentini, 2009). Chesbrough (2003, pp. 36–37) puts it succinctly when he states that "open innovation allows firms to commercialize external ideas by deploying outside pathways to the market". The importance of the external source in open innovation is based on the assumption that the innovator for a particular product does not need to be the manufacturer of the product. In other words, any agent that derives benefits from an innovative product can also be a source of innovation (Hacievliyagil *et al.*, 2007). Accordingly, firms who embrace open innovation are able to scale down internal research and development resources, while expanding the scope of their innovation activities to improve organisational performance.

Ozman (2011) claims that firms that employ open innovation strategies have the potential to increase their market share directly by increasing the number of participants in the market. Even more important is the opportunity for network externalities, especially in multi-layered markets. In light of the many benefits of open innovation, Roijakkers *et al.* (2014) assert that open innovation projects and strategies provide strong incentives for organisational growth and development. By opening their doors and integrating EK bearers (Kang and Kang, 2009) companies' can cope with shorter innovation cycles, rising R&D costs and inadequate resources (Gassmann and Enkel, 2004; Piller and Hilgers, 2008).

Empirically, Mention and Asikainen (2012) examine the effects of open innovation on performance at the firm level and find that simultaneous cooperation and information sourcing from and to competitors reduce innovation expenditures and shorten the time to market for novelties. Similarly, Scott and Chaston (2013) investigate the effect of Peruvian firms engaged in open innovation and report that firms that employed open innovation systems enjoyed higher sales growth. Mowery (2009) and Trott and Hartmann (2009), however, argue that there is nothing new about the open innovation concept, and consequently, describe open innovation as old wine in new bottle. Trott and Hartmann (2009), in particular, assert that the open innovation concept is merely a repackaging and representation of what is already known in management and innovation literature. Indeed, more than three decades ago, Allen (1983) described the collaborative process between rival firms or market participants in sharing information and the development of new technologies as collective invention. Tidd (2014b) alludes to the popularity of the open innovation concept but criticised it for being too vague and prescriptive. In view of the limitations of the open innovation concept, Dabrowska *et al.* (2013) argue that it should be seen as a corporate philosophy rather than an activity performed by an organisation.

Further, Trott and Hartmann (2009) claim that Chesbrough (2003) creates a false dichotomy in the argument that open innovation is the only alternative to closed innovation. The authors examine the six principles of open innovation to show that the paradigm creates a partial perception of what is true in itself but false in conveying the wrong impression that firms follow these ideas in recent times.

Empirical findings by Hacievliyagil *et al.* (2007) show that though in many instances firms may open up the flow of knowledge, the internal boundaries are tightened. Cassiman and Valentini (2009) also examine the argument that firms that employ open innovative systems are active in both the buying and selling market for technology and did not find support for this hypothesis for Belgian firms. Cassiman and Valentini (2009) find that the research and development productivity for firms active in selling, buying technology or doing both is not significantly different. This gives credence to the idea that open innovation paradigm overlooks the importance of research and technology transfer and absorptive capacity (Trott and Hartmann, 2009). These findings support the view that open innovation discussion should not just focus on accessing technology (Bigliardi *et al.*, 2012) but also on research and development to deepen our understanding of how firms can maximise the benefits of technology acquired externally (Cohen and Levinthal, 1990).

Hypotheses development

Open innovation systematisation allows firms to clearly define, capture and document key learning and experiences with the purpose of transferring and adapting knowledge for commercialisation (UNDP, 2013). In this regard, systematisation helps to facilitate institutional review and learning resulting from projects to contribute to institutional decisions and changes encouraging more open and insightful organisational development. Accordingly, systematisation that helps to establish what is to be achieved, who is to do it and how to do it could reduce substantially the variance associated with the task (Gilson *et al.*, 2005; March, 1991). Additionally, systematic processes and structures create a climate of goodwill that promotes creativity and knowledge (Koskinen *et al.*, 2003; Madhavan and Grover, 1998). Lichtenthaler (2011), for example, has argued that managers may try to build on a firm's existing organisational processes and structures rather than implementing entirely new open innovation processes to avoid excessive initial learning periods. In an earlier study, Lichtenthaler (2008b) claims that the quality of the KET and KEL process drive the commercialisation and therefore performance of the open innovation activity. Obviously, being systematic enhances predictability and certainty in decision making. According to

Lichtenthaler (2011), the increased predictability promotes trust within and outside the organisation and particularly among the project and product development teams. Thus, the systematisation of knowledge is critical for both exploration and exploitative activities of the firm. In a related study, Tidd *et al.* (2001) assert that the degree of systematic management routines is a key determinant of the commercialisation activity. Further, Frishammar *et al.* (2012) argue that the key to successful firm performance is contingent to commercialisation of firms' control processes. Prior literature adduce the fact that process innovation focuses on reaping efficiency gains by means of cost reductions and increased production volumes (Frishammar *et al.*, 2012) and, in the process, contributes extensively to the reduction in development times for products (Chesbrough, 2006a; Pisano, 1994, 1996).

Although, we acknowledge that exploration and exploitation may compete for resources and that there may be trade-offs between the two (Lavie *et al.*, 2010), we follow prior research and argue that exploratory and exploitative innovation can be pursued simultaneously at the organisational level (Cohen and Levinthal, 1990; Cao *et al.*, 2009; Gupta *et al.*, 2006).

Accordingly, it is hypothesised that:

H1: The systematisation of a firm's KET processes is positively related to the firm's commercialisation activities.

H2: The systematisation of a firm's KEL process is positively related to the firm's commercialisation activities.

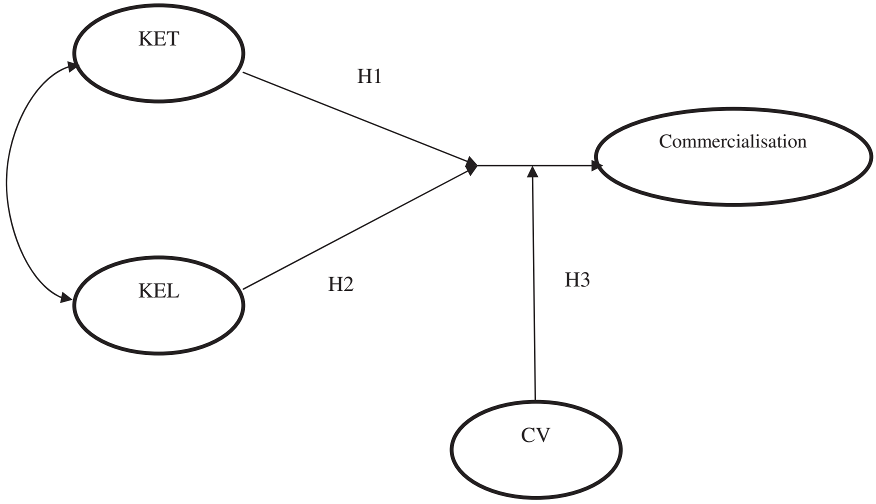

Fig. 1. Structural model for open innovation in a path diagram.

H3: The commercialisation of a firm's control processes in knowledge systematisation affects firm's performance.

Figure 1 provides the structural model for open innovation in a path diagram based on the literature review taking in to account structural equation modelling.

The model is based on a contingency-based approach to organisational development (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Miller and Friesen, 1983) with the assumption that open innovation is used to tap EK and technology and putting it to use internally within firm. It is simultaneously aimed at commercialising internal knowledge and technology by finding new pathways to the external domain. Further, the main driver for switching between exploration and exploitation as alternative modes of learning is for the purposes of commercialisation. A concrete model with a concise framework addressing intellectual property issues, value capture, organisational culture and knowledge management would help organisations on a global scale to exploit ideas that are otherwise shelved due to uninformed markets (Meyer, 2009). Table 1 provides the variables and observed variables for the initial model.

Table 1. Latent variables and observed variables for initial model.

Latent variables/ constructs	Observed variable/indicators	Abbreviations	References
KET	Customer involvement	KET1	van de Vrande *et al.* (2009); Thomke and von Hippel (2002).
	Technology solution	KET2	Gassman (2006).
	External networking	KET3	Chesbrough and Crowther (2006).
	External participation	KET4	Chesbrough (2006) Van de Vrande *et al.* (2009)
	Outsourcing R&D	KET5	Gassman (2006); Prencipe (2000); Chesbrough (2006a).
	Intellectual property	KET6	Chesbrough (2006b).
	Seeking opportunity	KET7	Fetterhoff and Voelkel (2006).
	Evaluating potential markets	KET8	
	Recruiting potential partners	KET9	
	Value capture	KET10	
	Extending innovation offer	KET11	
KEL	Customer utility	KEL1	Fetterhoff and Voelkel (2006).
	Competition	KEL2	

Table 1. (*Continued*)

Latent variables/ constructs	Observed variable/indicators	Abbreviations	References
	Commerce	KEL3	
	Capital	KEL4	
	Copyright	KEL5	
	Company fit	KEL6	
Commercialisation (COM)	Licensing sales and revenue	COM1	Chesbrough (2003); Kline (2003).
	Successful relationship with client and competitors	COM2	
	Planning	COM3	Reid *et al.* (2001); Escher (2003).
	Intellectual property	COM4	
	Negligence	COM5	
	Realisation	COM6	
Control (CV)	Venture capital	CV1	Dyer *et al.* (2001); Hoffmann (2005).
	R&D	CV2	Hacievliyagil *et al.* (2007); Pisano (1994, 1996).
	Commercialisation	CV3	Frishammar and Horte (2005); Frishammar *et al.* (2012).
	Information need	CV4	Lichtenthaler (2005).
	Information generation	CV5	Makhija and Ganesh (1997); Hoffmann (2005).
	Information evaluation	CV6	
	Information control	CV7	

Methodology

Data collection

Data was collected employing survey questionnaire methodology in order to resolve, refine and adjust the model described and shown in Fig. 2. The questionnaire was designed using guidelines outlined by Dillman (1991). The questions were based on the theoretical framework as indicated in Table 1. The questionnaire consisted of two sections, the first was devoted to demographic characteristics and the second, a brief and straight to-the-point questions addressing the factors measured by multiple questions.

The documents was set out in-line with the four sections and sub-sections, namely, KET, KEL, commercialisation and the controls. A five-point Likert scale was administered with "1" corresponding to strongly disagree and "5" being strongly agreed.

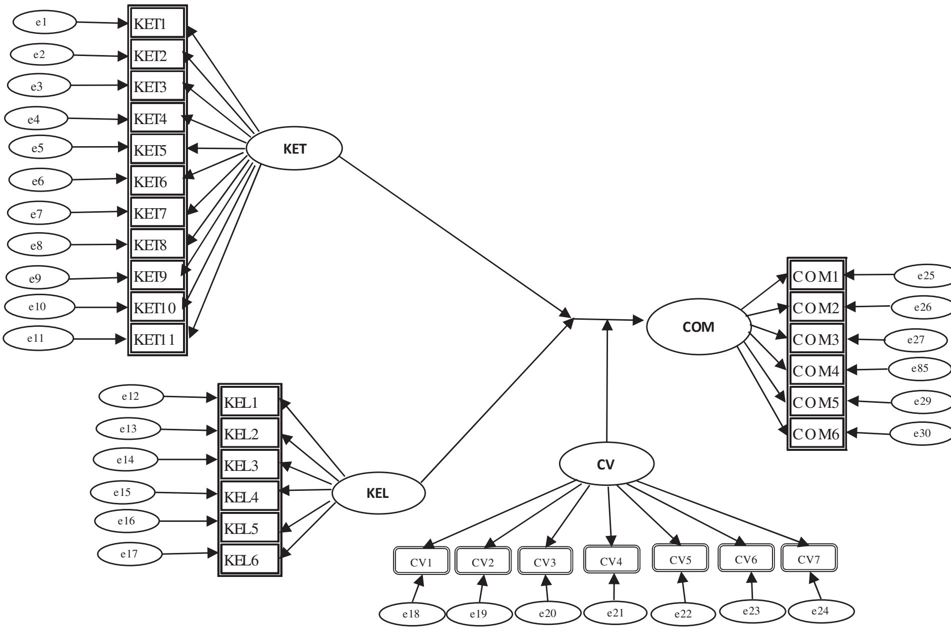

Fig. 2. Initial SEM for open innovation.

Prior to formal administration of the survey, a panel of five experts comprising of two senior academicians and three experienced practitioners from industry were used to solicit their opinions and assess the contents of the questionnaire. Some questions were rephrased for respondents to gain better understanding and to eliminate (or minimise as much as possible) the response bias. Revisions were then made to further refine the survey instrument. Thereafter, the refined questionnaire was considered an adequate instrument for the survey and was administered as such. The questionnaire was crafted in English and only those who were well versed in English were asked to respond to avoid misinterpretation of the questions.

The control stage refers to the evaluation and control processes of KET and KEL. Prior research in to alliances has shown that there are many interdependencies between the control stage and the other process stages, particularly planning and intelligence (Dyer *et al.*, 2001; Hoffmann, 2005). Similar to intelligence, proficient control processes comprise the identification of information needs, information generation, information evaluation and information communication (Frishammar and Hörte, 2005; Lichtenthaler, 2005). The identification of information needs is directed at delimiting the needs to facilitate successful control (Gerybadze, 1994).

Besides controlling the activities of the firm, attention has to be paid to the technology customer's contribution (Yan and Gray, 1994; Bozeman, 2000). After generating information (Makhija and Ganesh, 1997; Hoffmann, 2005), its relevance has to be determined. Apart from evaluating the information, this assessment leads to organisational learning (Lichtenthaler, 2003). Finally, the results are communicated, and a decision is taken whether the activities will be continued or whether particular technology transactions should be redirected or finished (Doz and Hamel, 1998; Hoffmann, 2005). As defined by Chesbough (2006a), open innovation occurs through exploitation of knowledge diffusion outside corporate R&D. Hence, several key factors drive the diffusion of technology-based knowledge as well as customer insight. In many cases, there are surrogate indicators that demonstrate the dynamics of knowledge diffusion. The total amount of venture capital spent in a given market sector reflects the investment industry's belief in the business health within that sector.

The SEM was used due to its advantage of modelling open innovation dependencies and latent variables (Nachtigall *et al.*, 2003). SEM assists in the estimation of multiple and interrelated dependence relationships, possess the ability to represent unobserved concepts in these relationships and account for measurement error (Hair *et al.*, 2009). The interdependencies between factors of KET and KEL may be assessed by other methods like analytic network process (ANP). Nevertheless, one of the drawbacks of ANP is that complexity increases exponentially with the number of indicators and their interdependencies due to the numbers of pairwise comparisons while SEM does not have limitation on the number of variables. There is no difficulty in hypothesis testing in SEM because it takes the confirmatory approach rather than the exploratory approach. The point that needs attention is that with the analyses employing SEM, like the present study, statistical correlation or association does not prove causation or influence, but simply supports the logical or intuitive belief in their presence (Xiong *et al.*, 2014).

Sampling procedure and biases

Participants were drawn from five geographical locations (North America, Europe, Asia, Sub-Saharan Africa, the Middle East and North African). Base on Thomas Reuters Derwent World Patents Index, seven industrial categories that is; aerospace and defence, ITC, automotive, home appliances, medical devices pharmaceutical/ biochemistry and semi-conductors were sourced and used for the study. The details of the demographic characteristics is shown in Table 2.

The objective of the study was to collect data on open innovation, bearing this requisite in mind, the respondents were selected on the basis of relevant field

Table 2. Demographic characteristics of respondents.

Characteristics	Category	Frequency (N=164)	Percentage (%)
Geographical location	North America	44	27
	Europe	36	22
	Asia	39	24
	Sub-Sahara Africa	24	15
	Middle East and North African region	21	13
Age group	>45	54	33
	35–44	62	38
	25–34	44	27
	<24	4	2
Gender	Male	137	84
	Female	27	16
Educational background	PhD	45	27
	MSc	66	40
	BSc	53	33
Work experience	>10 year	99	60
	5–10 years	65	40
Designation	Operations manager	42	26
	Innovations manager	70	43
	R&D manager	23	14
	Project manager	29	18
Industry (*Thomas Reuters Derwent World Patents Index*)	Aerospace and defence	20	12
	ITC	14	9
	Automotive	40	24
	Home appliances	32	20
	Medical devices	12	7
	Pharmaceutical/biochemistry	31	19
	Semi-conductors	15	9

experience (at least five years), current designation (must at least be working at managerial level or as a full-time practitioner) as well as educational background (must hold at least a Bachelor's degree).

From Table 2, participation from practitioners having experience of more than 10 years is evident. Since we required a sound educational background, 67% of the respondents were post-graduates whereas 43% of the total were managers involved in innovation management.

The automotive sector had the dominant role in the survey followed by the home appliance and pharmaceutical/biochemistry sectors. Although it is believed that managers provide reliable and objective data by relying on their own self-reports (Aronson *et al.*, 2006; Lukas and Ferrell, 2000; Podsakoff and Organ, 1986), we take in to account related biases. Self-report data are most problematic for subjects which generate strong sentiments such as attitudes (Aronson *et al.*, 2006; Cote and Buckley, 1987). Open innovation is a lesser emotional topic and thus less probable to be distorted by self-reports. Another issue is the social desirability bias that mostly leads to distorted results (Podsakoff and Organ, 1986). The nature of the present study shows no evidence of having been affected by social desirability.

Results and Analysis

Sample size and response rate

Out of 267, 196 forms were returned and 164 responses were considered valid for the analysis resulting in a response rate of 61.4%. This response rate is deemed reasonable on the basis of the previously published similar studies (Chen *et al.*, 2011; Dvir and Lechler, 2004; Xiong *et al.*, 2014). As SEM is a large sample technique (Mainul *et al.*, 2005), a sample of at least 200 is recommended for normally distributed data (Hox and Bechger, 1998). Notwithstanding, this study with a sample size of 164 subjects is in line with previously-published SEM studies that used sample sizes of less than 200. For example, Mainul *et al.* (2005) used 52 cases, Eybpoosh *et al.* (2011) used 166 cases, Chen *et al.* (2011) used 124 cases, Doloi *et al.* (2011) used 97 cases and Xiong *et al.* (2014) used 125 cases, while exceeding the minimum of 100 cases recommended by Bagozzi and Yi (2012). Additionally, the present study does not lack adequate statistical power according to the framework developed by MacCallum *et al.* (1996) who determined the minimum sample sizes to achieve sufficient statistical power for SEM analyses.

Construct reliability

Cronbach's reliability test was performed to assess the strength and adequacy of measurement model (Jin *et al.*, 2007). A cut-off value of 0.70 was used for Cronbach's alpha coefficient to indicate the acceptable level of internal consistency. Table 3 shows the items measuring four finally obtained latent constructs of the final SEM and their corresponding indicators. As shown, the constructs were found to have values above 0.70 resulting in a high degree of reliability and were proved to be sufficiently reliable for analysis. Latent variables and observed variables were used for initial model.

Table 3. Reliability test for the final model.

Latent variables/ constructs	Observed variable/indicators	Abbreviations	Cronbach's alpha value (α)
KET	Customer involvement,	KET1	0.8792
	Technology solution	KET2	
	External networking,	KET3	
	External participation,	KET4	
	Outsourcing R&D	KET5	
	Intellectual property	KET6	
	Seeking opportunity	KET7	
	Evaluating potential markets	KET8	
	Recruiting potential partners	KET9	
	Value capture	KET10	
	Extending innovation offer	KET11	
KEL	Customer utility	KEL1	0.801
	Competition	KEL2	
	Commerce	KEL3	
	Capital	KEL4	
	Copyright	KEL5	
	Company fit	KEL6	
Commercialisation (COM)	Licensing sales and revenue	COM1	0.762
	Successful relationship with client and competitors	COM2	
	Planning	COM3	
	Intellectual property	COM4	
	Negligence	COM5	
	Realization	COM6	
Control (CV)	Venture capital	CV1	0.892
	R&D	CV2	
	Commercialisation	CV3	
	Information need	CV4	
	Information generation	CV5	
	Information evaluation	CV6	
	Information control	CV7	

The SEM as shown in Fig. 2 was analysed using the statistical computer program AMOS version 21. The questionnaire contained 30 variables as mentioned in detail in Table 1 representing five latent variables. In order to achieve a reliable final model and be compatible with the SEM framework, appropriate variables have to be selected from this list. Pearson product–moment coefficient of correlation analysis was performed to analyse variable correlations in the model.

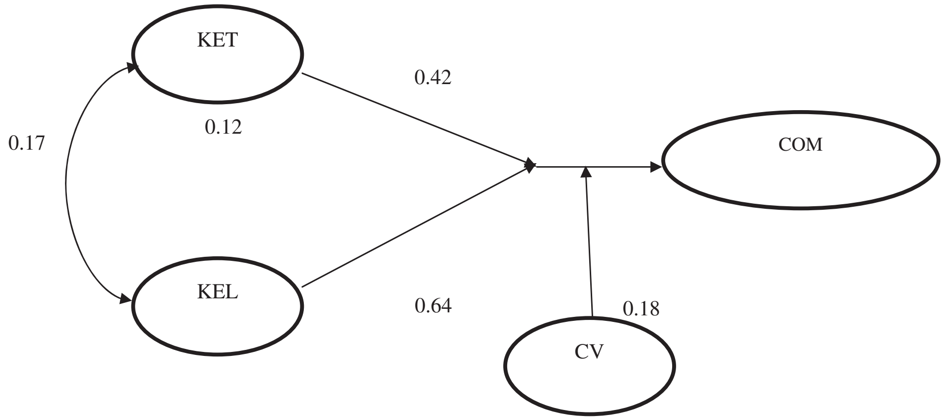

Fig. 3. Final structural model showing the insignificant paths.

At 95% confidence interval, variables showing insignificant associations with other variables within a latent construct and with other variables across the entire initial SEM were finally excluded from the model (Doloi *et al.*, 2011; Mainul *et al.*, 2005). Figure 3 illustrates the final structural model showing the paths.

The process was essential for the maturity of the model because the initial model that was based on theoretical expectations and past empirical findings was found to be premature without meeting the standard indices of model fit (Molenaar *et al.*, 2000). Table 4 indicates the comparison of goodness-of-fit (GOF) indices of the initial and final SEM. After undergoing several iterations, the final model attains the recommended level of fitness and thus considered feasible for the analysis.

As displayed, the final model for commercialisation based on the necessary GOF measures is appropriately supported. The χ^2/degree of freedom ratio, giving

Table 4. Comparison of GOF measures of initial and final models.

GOF	Recommended levels of GOF measures Source: Molenaar *et al.* (2000) and Ong and Musa (2012)	Initial model	Final model
x^2 degree of freedom	<5	6.12	2.5
Absolute fit RMSEA	<0.1	0.10	0.078
Incremental fit			
CFI	0 (no fit) to 1 (perfect fit)	0.51	0.81
TLI	0 (no fit) to 1 (perfect fit)	0.44	0.80
Parsimonious fit			
PFGI	>0.5	0.45	0.51
PNFI	>0.5	0.42	0.59

a value of 2.5, indicates acceptable fit to the data. The value of the absolute fit parameter, root mean square error of approximation (RMSEA), is 0.078 which is below the recommended cutoff level of 0.10. The two incremental fit parameters, namely, comparative fit index (CFI) and Tucker–Lewis index (TLI) give values of 0.81 and 0.80, respectively, which also makes obvious the acceptable model fit. Parsimonious GOD index (PGFI) and parsimonious normal-fit index (PNFI) values above 0.5 provide sufficient evidence that the fit between measurement model and data is acceptable.

Pearson correlation analysis was used to validate the interrelationships among the constructs of project complexity in the final model achieved (Fornell and Larcker, 1981). These correlations are presented in Table 5. Significant correlations among the factors of commercialisation supported the convergent validity of the conceptual model.

Final SEM results and discussion

The two-stage method was used to develop the SEM as followed by Xiong *et al.* (2014). Confirmatory Factor Analysis (CFA) provides the first step and demonstrates a satisfactory GOF. This leads to the next (post-CFA) stage in which correlations between the latent variables are replaced with the hypothesised causal relationships as shown in Fig. 3.

Table 5. Construct correlations.

Constructs	Correlations
KET ⟷ KEL	0.173
KET ⟷ CV	0.41*
KET ⟷ COM	0.41*
KEL ⟷ KET	0.41
KEL ⟷ CV	−0.04[a]
KEL ⟷ COM	0.17
COM ⟷ KET	0.18
COM ⟷ KEL	0.47**
COM ⟷ CV	0.27
CV ⟷ KET	0.008***
CV ⟷ KEL	0.67
CV ⟷ COM	−0.2[a]

Notes: Correlation of significant at: *0.1 level, **0.05 level, ***0.001 level, [a]Insignificant.

The measurement component

Table 6 shows measurement model estimates. The standardized regression weights are the measures of association of each observed variable to its corresponding latent variable.

Recruiting potential partners, value capture and extending innovation offer hierarchical levels and intellectual property have the most influence while EK,

Table 6. Measurement model estimates: standardized regression weights and SE.

Item	Standardized regression weights				SE	t-value
	KET	KEL	COM	CV		
KET1	0.890				0.15	2.882
KET2	0.785				0.14	3.587
KET3	0.424				0.13	3.541
KET4	0.540				0.014	5.423
KET5	0.705				0.16	5.410
KET6	0.734				0.16	5.900
KET7	0.872				0.16	5.680
KET8	0.786				0.16	4.075
KET9	0.956				0.15	16.620
KET10	0.964				0.15	9.450
KET11	0.652				0.05	8.320
KEL1		0.880			0.05	18.600
KEL2		0.416			0.06	11.966
KEL3		0.930			0.05	10.243
KEL4		0.718			0.06	9.756
KEL5		0.874			0.07	13.429
KEL6		0.810			0.06	12.563
COM1			0.780		0.05	10.666
COM2			0.881		0.04	11.450
COM3			0.416		0.14	6.890
COM4			0.930		0.13	7.540
COM5			0.718		0.14	8.790
COM6			0.850		0.06	4.670
CV1				0.780	0.08	3.542
CV2				0.842	0.06	11.680
CV3				0.786	0.06	12.492
CV4				0.940	0.11	4.943
CV5				0.640	0.06	5.354
CV6				0.760	0.12	5.642
CV7				0.870	0.14	4.670

Note: All factors are significant at $p < 0.001$.

technology solution and customer involvement have the least influence on KET. Similarly, KEL is greatly influenced by customer utility, copy right and competition whereas capital has the least influence. Successful relationship with clients and competitors show the most influence in commercialisation followed by licensing sales and revenue. Research and development show higher influence on the control side followed by information valuation with venture capital having the least influence.

The structural component

Discussing the hypotheses as proposed in Sec. 4 of this paper, the main research finding is that all three hypotheses are supported based on the information derived from the data collected from practitioners. Table 6 illustrates the measurement model estimates showing the standard regression weights and standard error (SE).

Figure 4 depicts the final model of the paths. As seen, all of the path coefficients are positive and significant at $p < 0.001$ except one, illustrated in Table 7. The final SEM results suggest that knowledge exploitation has a strong positive effect on commercialisation.

Besides this effect, it is evident that the control elements directly influence commercialisation with almost the same strength. Since literature did not provide sufficient evidence to establish a causal hypothesis between venture capital and

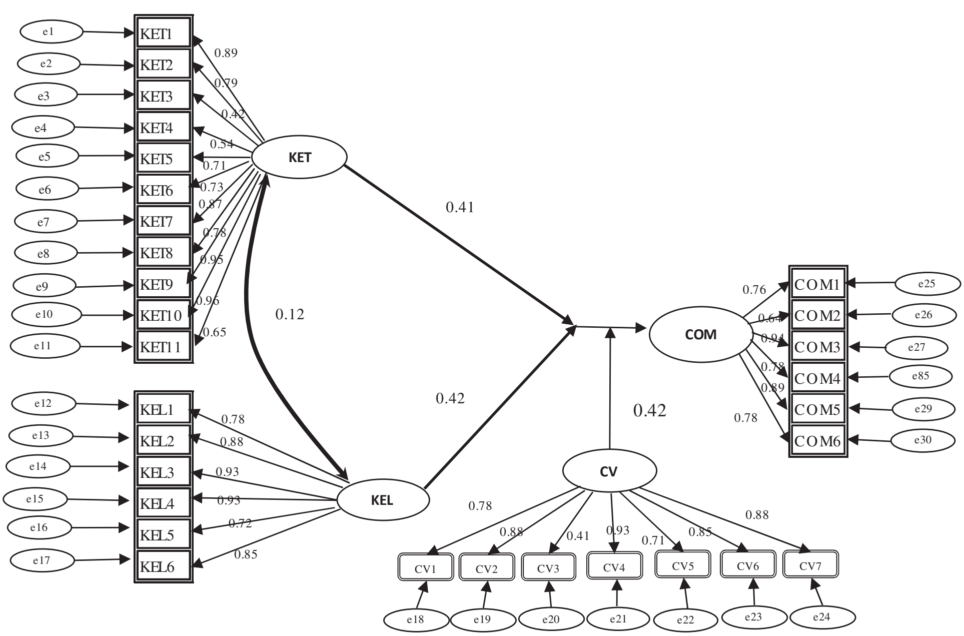

Fig. 4. Final SEM with all coefficient values.

Table 7. Direct and indirect effects of structural model.

Path	Direct effect	Indirect effect	SE	t-value
KET → KEL	0.12[a]	—	0.15	0.600
KET → COM	0.40	—	0.15	9.522
CV → COM	0.62	—	0.06	2.468
CV → KET	0.42	—	0.05	8.200
CV → KEL	−0.14[a]	—	0.17	−1.018
KET → CV → KEL	—	0.24		

Notes: All values are significant at $p < 0.001$. [a] Insignificant.

value creation, the results in Table 7 indicate that knowledge exploitation and commercialisation are positively correlated with a standardized coefficient of 0.67 significant at $p < 0.10$.

Conclusions

By crafting a model that systematises KET and KEL in open innovation, this paper adds to the understanding of the role of open innovation, process, systematisation, content and context as well as the research and development side of open innovation.

The study has numerous contributions to make to open innovation discourse. First, we extend discussions on open innovation and argue that systematisation of open innovation requires the balancing act of KET ambidexterity and exploitation for commercialisation of the firm, and that there is a mediated relationship between these variables. Second, by identifying the gap which mitigates the knowledge transfer through an organised medium in commercialising new ideas and technology thereby integrating the exploration and exploitation process, we provide a new threshold of insight that will help organisations widen the horizons of their technological arena. Third, the outcome of this study provides an understanding of the need for a business model which further streamlines the acceptance and institutionalising of open innovation process in organisations regardless of the size of the organisation. Fourth, the research helps explore the possibilities to minimise the issues of value capturing and intellectual rights. Fifth, the research sheds light on the importance of systematisation, values and attitudes on an individual-level, group-level and the organisation-level in adapting and implementing the open innovation process (de Jong *et al.*, 2010).

Finally, the study provides insight in to how process innovation may add value directly to customers through improved product quality and reliability

(Gopalakrishnan *et al*., 1999) and thus, lead to gains in effectiveness, advance a firm's competitive position and performance.

Implications

Our conclusions have several practical ramifications. Open innovation should not only be considered as a tool for absorbing useful input but integrating it in to the innovation process. Value capturing, knowledge management and protecting the intellectual property rights in an unbiased fashion, specifically focusing on integrating the various factors at an organisational level (including individual level and group level as propositions) in exploring and exploiting the EK.

By developing a business model to commercialise the external ideas as articulated by Majoor (2009), firms can investigate and substantiate the systematisation of the codification and sustaining the acquired EK to empower value capturing and intellectual property rights in implementing the open innovation process in their organisation.

Prior research has shown the importance of establishing a reputation as a knowledge provider in order to increase the monetary and strategic benefits of technology out-licensing (Lichtenthaler and Ernst, 2007). A third practice to benefit from internal knowledge is to capitalise on the initiatives and knowledge of current employees, including those who are not employed at the internal R&D department. Several case studies illustrate that in formalities of employees with employees of other organisations are crucial to understand how new products are created and commercialised (Chesbrough and Crowther, 2006). Many practitioners and scientists, also outside the field of open innovation, endorse the view that innovation by individual employees is a means to foster organisational success (van de Ven, 1986). Work has also become more knowledge-based and is less rigidly-defined. In this context, employees can be involved in innovation processes in multiple ways, for example, by taking up their suggestions, exempting them to take initiatives beyond organisational boundaries, or introducing suggestion schemes such as idea boxes and internal competitions (van Dijk and van Den Ende, 2002).

Porter (1990) earlier justifiably posited that innovation is the bedrock of achieving competitive advantage, as such, the business environment has become more volatile, competitive and dynamic. As a result, increasingly more organisations are continuously looking for new ways of achieving innovation. Innovation speculates the replacement of an old concordance with a new paradigm within the bounds through a medium which establishes new horizons for exploring and exploiting technology and knowledge available both inside and outside the organisations.

Limitations and future research

Many of the open innovation studies offer insights and propose various frameworks to support managerial decision making. Nevertheless, Gassmann *et al.* (2010) recently noted that the internal process by which companies manage open innovation is still more trial and error than a professionally-managed process. What is missing is a decent cookbook, an integrated framework that helps managers to decide when and how to deploy open innovation practices. Managers need to decide in what stage of the innovation process is collaboration most effective, and with which parties to collaborate, and how to find and select them. Decisions to be made also include selecting the best way to capture value in collaborative networks, especially when formal protection methods are less feasible, for example, with service innovations or small firms. These and many other issues require more systematic research.

Further research can also be carried out with a larger sample across more organisations from different industries and regions in order to obtain more validated information that can be analysed to draw conclusions on the various aspects and determinants of the open innovation process. Future research could also aim at testing the hypothesis: Accumulation of EK and its dissimilation positively impacts on the systematising of innovativeness in organisations. Once the determinants are succinctly established, the analytical hierarchy process can be used to determine further the critical success factors for systematisation and areas that organisations need to pay attention the most.

Finally, it is expected that this paper will spark a fruitful discourse on open innovation as well as related fields of organisational development and serve as stimulus for further research.

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