Innovation, intellectual capital, supply chain leveraging and its impact on firm's performance

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Abstract

Antecedences of innovation have been largely studied in the literature; however their effect on business performance still does not give a definitive answer. The purpose of this work is to study relationships how innovation investments, supply chain leveraging and intellectual capital affect innovation and consequently business results. The study derived a measurement model from three streams of literature (absorptive capability, intellectual capital and dynamic capabilities). The proposed model is proven robust and on grounds of that model it was possible to evaluate exact contributions of innovation investments, supply chain leveraging and intellectual capital on innovation performance and business results.

Keywords: innovation, business performance, GMRG 2012 survey

Introduction

Innovation is still under researched in terms how to foster it. Many researchers either take innovation input (investment into R&D, training and into technology) and look how it affects innovation output measured either by revenues from new products or perceptual measures that look at innovation in comparison to competitors. Other stream of literature goes from the different angle, that is, – measuring innovation output, they determine the level of antecedences of innovation. So, how innovation happens, is little studied, and presents a black box. This black box is maybe best described by the IDEO case (Thomke and Nimgade, 2007), which encompasses stages such as understanding customer needs, visualisation through brainstorming, selecting ideas for further development, iterative process of correcting and problem solving to make the new product and finally commercial exploitation.

This ability to innovate, and by that means staying competitive, is researched in several different streams of literature. Macher and Mowery (2009); Ellonen et al (2011) and Pavlou and El Sawy (2011) this ability to innovate call dynamic capability. Other streams of literature explaining innovation are the Absorptive capability stream that

started with work of Cohen and Levinthal (1990) and Intellectual capital literature that started with work of Bontis (1998). However, our literature research showed great overlapping of measurement instruments in all three streams of literature. So, our first research goal is to provide a sound and tested measurement instrument that could measure this ability to innovate, which we will call Intellectual capital, because in all three streams of literature the work of Subramaniam and Youndt (2005) is mentioned, and they termed that ability to stay competitive – intellectual capital.

Not all innovation investments will lead to innovation. Also, if one looks only at innovation output, one does not see all the new product efforts that ended up as failures. In line with IDEO case and (Dyer and Hatch, 2004; Flint et al., 2008; Hult et al., 2003) learning with and from supply chain partners is a key determinant of innovation and ultimately performance. Thus, we also analyse the role of supply chain partners in innovation.
Our research question is how innovation investment and supply chain leveraging influence intellectual capital, and how all three variables affect innovation performance and then business performance.

The large database from Global Manufacturing Research Group (GMRG) V is used. The data was collected in 2012. The database consists of 1008 companies from 16 countries. Structural equation modelling for analysis is used in order to assess complex relationships among constructs. Even though we performed all the standard tests and obtained a good model fit, the majority of the paper is concentrated around explaining the variables that entered the model, that is, to contribute to calls of Pisano (2015), Knoppen et al. (2015), and Mariano and Walter (2015) and Aribi and Dupouët (2015) to empirically test a measurement instrument that is derived from components of these three different streams of literature, yet showing significant overlapping.

This work tries to reconcile divergent literature streams in a concise, testable measurement model and as such represents a contribution to the existing theory on the subject. That is possible because GMRG research instrument is extensive and covers data from demographic data, innovation, organizational culture, supply chain management and sustainability.
Second contribution is in the fact that large GMRG database is used, comprised of developed and developing countries, in fast and slow industries that could contribute to more generalizable results. So far, the majority of research is conducted in hyper competitive environments, lacking insights from the majority of manufacturing that is not in such hyper space. The results present a very good model fit explaining the role of innovation investment, supply chain leveraging and intellectual capital and its effects on innovation performance and business results.

Literature research

Innovation investment

According to Stadler et al. (2013) companies always perform cost benefit analyses to determine investment into capabilities (sunk costs). If a company perceives that the investment will yield lower cost or add new value, the company is likely to invest into capabilities. Those investments will not always give predictable results, depending on the circumstances the firm operates. Helfat and Winter (2011) use the example of Intel. Intel's ability to continuously innovate is a dynamic capability but it entails investments

into R&D, education of their highly skilled workforce and development of routines for even faster innovation. Any company with large enough resources can invest into R&D, education and equipment but not all will get benefits from it. Classical example is IBM versus Apple. IBM invested significantly more but, Apple outperformed IBM by far. So investment into innovation is important but it is not enough for staying competitive. We measure competitiveness by increase of business performance through tree items (see Table 1). Therefore we pose our first hypothesis:
H1. Innovation investment will influence more positively innovation output, then business performance.

Intellectual capital

Absorptive capital by Cohen and Levinthal (1990, p. 128) "is an ability to recognize the value of new information, to assimilate it, and apply it to commercial ends". This is in line with Teece's (2014) definition of dynamic capabilities. Teece (2014) divided dynamic capabilities into: (1) sensing opportunities from the market, (2) seizing, that is, mobilizing resources to address opportunities (asset orchestration) and (3) continued renewal – transforming (learning and reconfiguration). These dynamic capabilities Simon (2010) calls organizational culture, but many of the variables for measuring organizational culture are from Subramaniam and Youndt (2005). Subramaniam and Youndt (2005), however, call their constructs Intellectual capital and show that this intellectual capital presents a competitive advantage.
Until Aribi and Dupouët (2015) there was no work that compared innovation from absorptive capability (AC) and intellectual capital (IC) approaches. Both approaches (AC and IC) suffer from lack of unified measurement instrument. For example, Knoppen et al. (2015), and Mariano and Walter (2015) on grounds of thorough literature research, explicitly show that there is still no measurement model for absorptive capacity. Our literature research showed great inconsistency in intellectual capital research, both in terms of naming components as well as the number of components.
Aribi and Dupouët (2015), being the most recent authors investigating IC define IC as: "the sum of all knowledge firms utilize for competitive advantage" (Subramaniam and Youndt, 2005, p. 450) and includes three distinct dimensions:
1. the human capital, that is, the knowledge possessed at the individual level;
2. the organizational capital that lies in the structure and formal rules of firms, knowledge databases, patents..; and
3. social capital that represents informal networks of interrelationships and the knowledge that can be accessed through these (Subramaniam and Youndt, 2005; Youndt et al., 2004).
Since, new knowledge can be built only on already possessed knowledge by means practice and communication, Aribi and Dupouët (2015), as in the AC field, define IC as a dynamic capability. They do not provide a measurement model rather they use three case studies to show overlapping of AC and IC.
Since intellectual capital is considered as a dynamic capability that should contribute to competitiveness, we pose our second hypothesis:
H2a. Intellectual capital will more positively influence business performance than innovation output

Supply chain leveraging

Supply chain leveraging can contribute to competitiveness of the company, and Vanpoucke et al. (2014) and Kleinbaum and Stuart (2014) show that this connection

with supply chain partners can be considered as a dynamic capability. Learning with and from supply chain partners is a key determinant of innovation and ultimately performance (Dyer and Hatch, 2004; Flint et al., 2008; Hult et al., 2003). Knoppen et al. (2015) prove a positive relationship between information sharing and exploration (learning) and the outcome (innovation). Supply chain leveraging is described in our model by 12 statements, 6 concerning key suppliers and 6 concerning key buyers. Statements dominantly ask about knowledge exchange (see Table 1 for exact questions). Therefore our third hypothesis is:
H3a. Supply chain leveraging will more positively influence innovation output than business performance

Methodology

Data collection

In Table 1 we present results from confirmatory factor analysis showing that indeed our model is reliable. The analysis is conducted using SPSS and AMOS. SPSS was used for descriptive analysis and assessing the Cronbach Alpha reliability measures, and post hoc Harman one-factor analysis. AMOS is used for confirmatory factor analysis and evaluating the structural equation model. Table 1 presents Constructs, Measurements and factor loadings for the model.
In order to asses such a complex issue as dynamic capabilities, a large database from Global Manufacturing Research Group (GMRG) V is used. The data is a sub-sample of the round V GMRG data collection effort taken place in 2012. The Global Manufacturing Research Group (GMRG) (www.gmrg.org) is an international community of researchers studying the improvement of manufacturing supply chains worldwide. The GMRG consists of leading international academic researchers from over 20 countries. These researchers developed the GMRG survey instrument to understand manufacturing practices around the world. This survey instrument facilitates a global comparison of the effectiveness of manufacturing practices (Whybark, et al., 2009). Where possible, existing constructs and measures were used to ensure their validity. Since 1985, the GMRG has completed five rounds of the worldwide survey. When translating the questionnaire into the language of the respective country, particular attention is paid to translation equivalence of the questionnaire versions by rigorous translating and back-translating rounds by language and subject matter experts (Douglas and Craig, 1983). The unit of analysis for the survey is the manufacturing site or plant, and all data are collected from plant managers as key informants within that site. These managers are targeted since they are deemed to possess a comprehensive knowledge of the plant's operations, in addition to having insight into related functions. The managers are advised to solicit input from other functions, such as marketing and finance, when appropriate. Data is collected by individual members of the GMRG, who are requested to apply the most appropriate approach and the most suitable population frame depending on the country-specific circumstances (Whybark, 1997). This flexibility is afforded to the researchers owing to the complexity and length of the questionnaire, often requiring the key respondent to consult with other individuals within the firm, or the compilation of historical data and the calculation of indices. As such, most questionnaires are completed during an on-site visit (43%) by the researcher, followed by Internet (29%) and mail surveys (23%) (Schoenherr and Narasimhan, 2012). GMRG survey is tested for common method bias in accordance with Conway and Lance (2010); Ota, et al. (2013).

A $\chi 2$ analysis is conducted against early and late respondents to validate for non-response bias in each country (Armstrong and Overton, 1977). As no significant differences are revealed, non-response bias is not evident. The survey instrument uses observable and perceptual measures. Past studies have demonstrated that perceptual measures are useful for empirical research that is related to managerial evaluations (Vickery et al., 1993; Klassen and Whybark, 1999).

The questionnaire has five modules, of which the Core module is obligatory and contains demographic data of the company. Other modules are elective, and the researcher that collects the data is obtaining only the data from other gatherers on modules he/she collects. The core module in round V answered 1008 companies.

Table 1: Variables and results from confirmatory factor analysis

		Factor loading*	S.E.	Critical ratio (t-value)
	Internal social capital Moenaert and Souder (1996), Subramaniam and Youndt (2005), Lee et al. (2011)			
Intellectual capital (CR=0,924, AVE=0,510, Cronbach's Alpha=0,934)	1. There is ample opportunity for informal conversations among employees in the plant.	0,75		
	2. Employees from different departments feel comfortable calling each other when need arises.	0,75	0,044	29,353
	3. People are quite accessible to each other in the plant.	0,724	0,047	29,692
	4. We are able to discuss problems and tough issues openly.	0,737		
	Structural capital Subramaniam and Youndt (2005)			
	5. Standard operating procedures are in place.	0,746	0,035	27,886
	6. Much of this plant's knowledge is contained in manuals, archives, or databases.	0,566	0,043	24,23
	7. We usually follow the sequence of written procedures and rules.	0,662	0,042	23,252
	8. Processes in our plant are well defined.	0,616	0,04	23,432
	Human capital (Snell and Dean (1992), Subramaniam and Youndt (2005),Lee et al. (2011))			
	9. Employees in this plant are highly skilled in their respective jobs.	0,604	0,043	17,202
	10. Employees in this plant are considered among the best people in the organization.	0,655	0,042	20,244
	11. Employees in this plant are experts in their particular jobs and functions.	0,575	0,044	19,019
	12. Every employee in this plant has useful experience.	0,551	0,042	18,14
	External social capital Subramaniam and Youndt (2005)			
	13. This plant and its major external partners have common understanding about what activities are best for our relationship.	0,613	0,047	20,076
	14. This plant and its major external partners have shared objectives and visions.	0,631	0,049	17,498
	15. This plant and major external partners share common language and codes (e.g. special vocabulary, abbreviation, and technical terms).	0,58	0,052	16,757
	16. This plant and its major external partners have common understanding about the same concepts (e.g. good, fast, cost, quality).	0,538	0,047	17,969
	17. This plant and its major external partners have similar behavioral rules and norms.	0,367	0,048	19,056
	18. This plant and its major external partners have common values and culture.	0,728	0,044	17,403
	Innovation investment (Hsu and Wang, 2012)			

Innovation investment (CR=0,735, AVE=0,581, Cronbach's Alpha=0,720)	At the plant level, what was your average research and development (R&D) budget as a percentage of total plant sales? (Scale 1 =<0,25% of sales, 7= more than 4% of sales)	0,729	0,046	16,183
	What was your plant's average training budget for education of employees as a percentage of total plant sales? (Scale 1 =<0,25% of sales, 7= more than 4% of sales)	0,687	0,048	11
	At the plant level, what was your average investment in new process technologies and equipment as a percentage of total plant sales? (Scale 1 =<0,25% of sales, 7= more than 20% of sales)	0,663	0,035	29,601
	Innovation output (Prajogo and Ahmed (2006) and Koufteros et al. (2007)) (7 point Likert scale in comparison to competitors) 1-Much worst, 7- far better			
Innovation output (CR=0,735, AVE= 0,581, Cronbach's Alpha=0,935)	Percentage of total sales stemming from new products.	0,817		
	Percentage of market share stemming from new products.	0,762	0,032	25,656
	Number of new products.	0,826	0,038	24,026
	Speed of introducing new products.	0,714	0,035	23,919
	Frequency of new products introduction.	0,64	0,036	20,221
	Business performance (Measured on 7-point Likert scale as a change in the last fiscal year, 1 – decreased by 25%, 7 increased more than 25%), Knoppen et al. (2015)			
Business performance (CR=0,885, AVE=0,719, Cronbach's Alpha=0,880)	Total sales of goods and services	0,801		
	Profitability	0,86	0,044	29,353
	Market share	0,881	0,047	29,692
	Supply chain leveraging (Modified Stewart et al. (2012)			
Supplier chain leveraging (CR=0,905, AVE=0,546, Cronbach's Alpha=0,920)	1. We are able to obtain a tremendous amount of technical know-how from our suppliers.	0,573		
	2. We rapidly respond to technological changes in our industry by applying what we know from our supplier.	0,553	0,045	22,168
	3. As soon as we acquire new knowledge from our supplier, we try to find applications for it.	0,568	0,046	22,401
	4. Our key supplier's technological knowledge enriched the basic understanding of our innovation activities.	0,671	0,068	16,03
	5. Our key supplier's technological knowledge reduced the uncertainty of our innovation activities.	0,61	0,056	18,227
	6. Our key supplier's technological knowledge helps us to identify new aspects of innovation activities that would otherwise have gone unnoticed.	0,528	0,057	16,556
	7. We are able to obtain a tremendous amount of our product knowledge from our customers.	0,715	0,074	17,255
	8. We rapidly respond to technological changes in our industry by applying what we know from our customer.	0,728	0,073	17,004
	9. As soon as we acquire new knowledge from our customer, we try to find applications for it.	0,745	0,079	17,006
	10. Our key customer's technological knowledge enriched the basic understanding of our innovation activities.	0,754	0,081	16,815
	11. Our key customer's technological knowledge reduced the uncertainty of our innovation activities.	0,781	0,08	16,895
	12. Our key customer's technological knowledge identified new aspects of innovation activities that would otherwise have gone unnoticed.	0,719	0,084	16,396
X^2/df=3,308, GFI=0,903, NFI=0,927, IFI=0,948, CFI=0,947, REMSA=0,048, PCLOSE=0,942				

As it can be seen in Table 1, all threshold values are all in acceptable range ($\chi 2/df<5$), IFI and CFI>0,8, REMSA<0,1 (Hu and Bentler, 1999). Composite reliability (CR) statistics indicates strong construct reliability in each case; all values are well above 0.7 (Fornell and Larcker 1981). The results established convergent validity and unidimensionality for each construct, as all item loadings (lambdas) are highly significant (all t-values are >2.0). The results also indicated acceptable discriminant validity for the measures at both the construct and item levels. The average variance extracted (AVE) for each construct variable is greater than the squared correlation of the construct with any other construct, indicating acceptable construct discrimination (Fornell and Larcker 1981). All AVE (convergent validity) are greater >0,5 in line with Hair et al. (2010).

All item loadings are above 0.5 and significant at the 1-per cent significance level which indicate convergent validity (Bagozzi et al., 1991). Even though some values of factor loadings are less than 0,7 we did not need to exclude any single variable from our proposed model. The main difference of our model and Subramaniam and Youndt (2005) is in the fact that they had one component for both internal and external social relationship.

Common method variance is a crucial question when both the dependent and focal explanatory variables are perceptual measures derived from the same respondent. Four approaches are recommended in the literature as methods that researchers should use to avoid or correct CMV (Chang et al., 2010; Podsakoff et al., 2003). In this work all four preconditions are fulfilled.

1. Using different sources for independent and dependent variables (in this research increase in revenues, market share and profits are an objective value generated by the bookkeeping unit of the company, so are investments into R&D, training and technology, whereas other perceptual measures are self-rated on seven point Likert scales).

2. In the design phase of the questionnaire the questions are in different sections, and different scales are used, so this prescription is also fulfilled. The core part of the questionnaire gathers financial data, whereas innovation module gathers perceptual measures on intellectual capital.

3. Complicated specifications of regression models reduce the likelihood of CMV. Specifically, respondents are unlikely to be guided by a cognitive map that includes difficult-to-visualize interaction and non-linear effects. This is less likely the more complicated the model. Intellectual capital and dynamic capabilities and the performance outcomes of a company are not a linear effect (Eisenhardt and Schoonhoven, 1996) and it is hard to visualize, so this prescription is also fulfilled.

4. A post hoc Harman one-factor analysis is often used to check whether variance in the data can be largely attributed to a single factor. The post hoc Harman one-factor analysis is performed and the results indicated presence of loading to more factors.

Findings

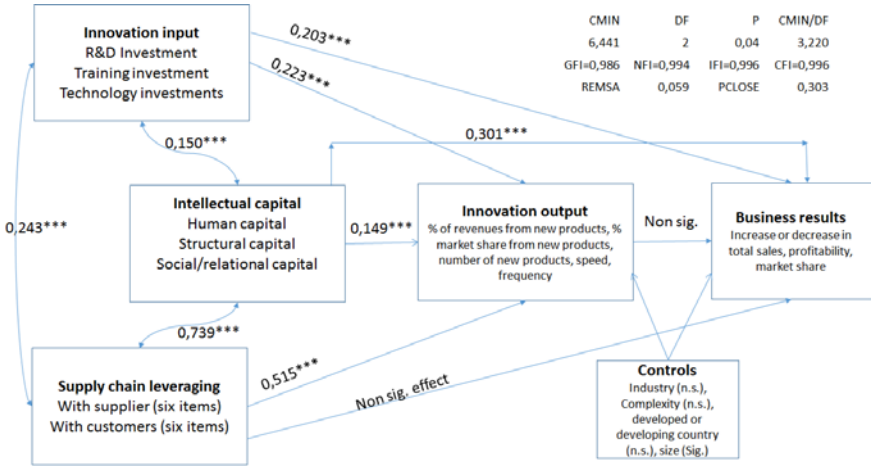

Figure 1. Tested model

There is a strong correlation between Supply chain leveraging and Intellectual capital (0,739***), but a smaller correlation between innovation inputs and Intellectual capital (0,150***). Supply chain leveraging and Innovation investments are also significantly correlated (0,243***). However, Innovation investment (0,223***) and Supply chain leveraging (0,515***) have higher direct effects on innovation output. Maybe the most interesting finding is that innovation performance does not significantly increase business performance, which would be expected from the literature, rather we find a very significant and strong relationship between intellectual capital and business performance (0,301***). This might mean that innovation output is increased by innovation input and good relations to customers and suppliers, but it is actually intellectual capital that increases the ability to change to external environment and as such increases business performance. Therefore, all our three hypotheses are confirmed.

Discussion

In order to innovate, our results show that investment into R&D, education and equipment is necessary and contributes to innovation outcome. Also, investments into better supply chain relationships significantly build intellectual capital and innovation. Intellectual capital has a significant positive relationship to innovation output, but higher effect is found on business results. That is in line with current literature on dynamic capabilities that Intellectual capital is a dynamic capability and hence increases competitiveness which, in our case is measured through increased business results. The originality of our contribution is the large effect that supply chain leveraging has on intellectual capital and innovation. This actually proves that in today's competitive landscape no company can work on its own rather choose supply chain partners carefully and invest into those relationships, as they are important for their innovation. Even though innovation investment or sunk cost may not always lead to desired innovation outcome, it is vital for innovating but also for generating positive business results.

Conclusion:

There is not enough research connecting companies' capabilities and business performance (Braunscheidel and Suresh (2009) and Tavani et al. (2014)). In this regard, this study contributes to the literature showing which capabilities (innovation

investment, intellectual capital and supply chain leveraging) enhance innovation output and business results. Innovation investment, supply chain leveraging and intellectual capital are not static variables and could be easily considered as dynamic capabilities. Such studies are rare (Pisano, 2015).

We show that innovation input and supply chain leveraging influence innovation performance directly, more than through the construct of intellectual capital. However, intellectual capital on the other hand has strong positive impact on business performance. The contribution of this work is a proposed measurement instrument that enabled to evaluate exact influences of innovation investment, supply chain leveraging and intellectual capital on innovation output and business results.

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