Four-Component Model of Intellectual Capital and Its Impact on Process and Product Innovations

Jasna Prester, Najla Podrug, Maja Daraboš
University of Zagreb, Faculty of Economics and Business, Kennedyev trg 6, 10000 Zagreb, Croatia
jprester@efzg.hr
npodrug@efzg.hr
mdarabos@efzg.hr

Abstract:
Today in an extremely fierce and global competition, companies need to innovate to survive and create at least a temporary competitive advantage. This work researches literature on creativity, innovation management and intellectual capital literature and by doing so proposes a robust model of intellectual capital (IC) with four components that can possibly explain constituents on innovation and give prescriptions on how to enhance innovation. Apart from current literature that researches intellectual capital as an internal driver, our model includes external social relationships. The article empirically tests four-component model of Intellectual capital. The model is tested using Structural equation modelling on a large sample of 890 companies. The variables in the survey are drawn from previous literature therefore ensuring content validity. The results show a robust confirmation of the model. This proves the necessity of the fourth component – External social capital as an important component in Intellectual capital and its influence on innovation. The research also clearly shows how each component of intellectual capital affects product and process innovations. This works adds value to the work of Subramaniam and Youndt (2005), but who tested only a three-component IC model.

Keywords: Intellectual capital, innovation, product and process innovations, GMRG survey

1. Introduction

Nahapiet and Ghoshal, (1998) were the first to talk about intellectual capital. They did not get into details how to measure it, but defined it as knowledge and knowledge capability of a social collectivism. Although the importance of IC in pursuing performance is known, the specific means through which IC influences organizational performance is still under researched.

Many influential papers followed Nahapiet and Ghoshal, (1998) path, defining Intellectual capital from RBV theoretical lens (Stewart, 1997; Subramaniam and Yundt, 2005; Reed et al., 2006; Dean and Krestchmer, 2007). Martín-de Castro (2014) presented a table showing the discrepancy in terminology of IC components. This poses a serious problem for advancement in researching intellectual capital. Most authors did not follow the Nahapiet and Ghoshal (1998) advice that social capital should be divided into internal and external networks. The Martín-de Castro (2014) table shows that current research dominantly looks at IC as a three component model. Human capital (HC), Structural/Organisational capital (SC, OC), Social/Relational (SOC/REL). The most problematic is actually the last component that does not differentiate between internal and external social/relational capital. This is important because there is a different motivational driver for engaging in internal and external relationships.

The second problem is absolutely no consensus on measuring components of IC. Our literature review shows that different authors use different measuring instruments. Dominantly Bontis (1998) measurement model that has three components (HC, SC, and Customer capital) is used. The next widely cited measurement model is that of Subramaniam and Youndt (2005). They also have only three components (HC, OC, SOC). However, their SOC component includes both internal and external social capital. The problem is that, internal and external social capital cannot be put into same component. Kalkan et al. (2014); Alegrea and Chiva (2008); Halim (2010) used other sources for questionnaire's questions generation. Only three researches show a four IC component model: Asiaei and Jusoh (2015) tested on Teheran companies on a small sample of only 103 manfacturing and 23 service companies. Elsetouhi et al. (2015) tested their model on banks services. The methodology is also questionable because it was conducted through interviews with bank managers. Wu et al. (2008) tested their model on 159 Taiwanese companies. Their external IC component is Customer capital and that suggest a large part of service organizations. Chen and Wang (2014) also tested outside relationships, but

the problem in their work is that they merely replicated internal intellectual capital components with outside partners (making it a six component model of Intellectual capital).
Our literature review shows that there is no uniformity in researched companies. Some are services, some are manufacturing, some are knowledge intensive while others pure traditional industries. In this research we propose to use a homogenous set of whole manufacturing sector from 16 countries, of which some are developed and some developing. We start from the universalistic point of view, that the findings can be generalised for the whole industry (Martín-De Castro et al. 2013). We test the model on a large-scale GMRG V database comprising 890 manufacturing companies conducted in 2012.

2. Componets of intellectual capital

2.1.Human capital

Human creativity is an important driver of innovation (Si and Wei, 2012). Epstein et al. (2013) reinforce how knowledge is important to innovation but they also state that different types of knowledge are necessary. Human capital is rooted in a certain way in the talent of employees. Human capital consists of components such as knowledge, expertise, skills, experience and competence (Sydler et al., 2014). According to Snell and Dean (1992); Subramaniam and Youndt (2005) and Lee et al. (2011) human capital will be greater if:

- there are highly skilled employees,
- employees have great knowledge and are considered as best people in the organization,
- employees are experts in their particular jobs and functions,
- employees have useful experience.

2.2. Structural capital

Sometimes employees leave. Companies invest into knowledge management systems to retain knowledge of the employees that leave. But, these investments have also another positive effect, that is, knowledge is readily available and easy to share. The existence of knowledge databases, manuals and the like will enhance information and knowledge sharing which is important (Subramaniam and Youndt, 2005). But, in order to systemize knowledge it is necessary to have detailed work procedures in place. Therefore, a company with high structural capital will have knowledge stored in databases as well as standard operating procedures. Brown and Eisenhardt (1997) explain this benefit of structure, because organized knowledge and procedures make work easier and more effective. Employees are privileged by not having to “reinvent the wheel” each time. Therefore, according to Subramaniam and Youndt (2005), a company possesses high level of structural capital if:

- standard operating procedures are in place,
- much of this plant’s knowledge is contained in manuals, archives, or databases,
- the employees usually follow the sequence of written procedures and rules and
- processes in the company are well defined.

2.3. Internal social capital

According to Çokpekin and Knudsen (2012) in order to enhance creativity there has to be balance between freedom of employees and the level of easiness of debating ideas. As a consequence of supportive management’s attitude towards problem solving, employees will gather in informal conversation, be it for discussing innovative ideas, discussing possible solutions to a problem or for a simple social talk. These talks should not be limited to only one department as it is known that successful product launch or some problem’s solution, needs collaboration from different departments (e.g. engineering, marketing, R&D) (Rese et al. (2013). This ability to talk freely and openly across organization, backed by management support is called internal social capital in line with intellectual capital literature. Therefore it is assumed that if:

- employees engage in informal conversation,
- there is high cross-functional cooperation,
- employees are accessible to each other and
- the open discussion on hard topics is possible,

then the employees will be able to solve even the most complex problems coming from the environment.

2.4. External social capital

Unlike internal connections between employees who don't usually choose their peers, external ties are usually on a voluntary base. An employee will engage in such a voluntary action only if there are mutual interest and high levels of trust and reciprocity. Although trust and reciprocity is also important for internal relations among employees, but employees being in the same company, will have similar goals so the trust and reciprocity is somewhat assumed. For external social ties trust and reciprocity is a precondition. The exchange of knowledge will start only after shared norms are established usually through a longer period of negotiation and probing the potential partner (Dhanaraj and Parkhe, 2006; Fichter, 2009). Taking into account trust, norms, willingness to cooperate with outside partners Subramaniam and Youndt (2005) believe that this external connection will be beneficial if there is:

- common understanding with outside partners,
- shared objectives and visions,
- shared common language,
- common understanding of concepts (e.g. quality, cost,…)
- similar behavioral rules and norms and
- common values and culture.

3. Linking intellectual capital to innovation

Subramaniam and Youndt (2005) state that it is now widely accepted that organization's capability to innovate is closely related to its intellectual capital. The essence of a firm resides than in its ability to create, transfer, assemble, integrate and exploit knowledge assets. All four components of intellectual capital will foster innovation. However not all components of intellectual capital will have the same effect on innovation.

Product innovations are defined as new products or services introduced to meet an external user need, and process innovations are defined as new elements introduced into a firm's production or service operation to produce a product or render a service. Therefore, while product innovations are embodied in the outputs of an organization and may result in product differentiation or an increase in product quality, process innovations are oriented toward the efficiency or effectiveness of production and may result in a decrease in the costs of production. According to Damanpour (2010) they will have the same antecedents, that is - intellectual capital. In line with Kraft (1990) and Menor et al. (2007) it is expected to find a strong interrelation between product and process innovations. So, the first hypothesis is:

Hypothesis 1: There is a strong interrelation between products and process innovations.

According to Lee et al. (2011) process innovations are all activities necessary to design and implement a new manufacturing process, or to change an existing process. Since by this definition it is highly likely that a company that invests into process change will hire external consultants it is believed that external social capital has a high impact. However, external consultants cannot do the work so structural and internal social capital also plays an important role. New procedures have to be put in place changing the structural capital of the company but also workers among them need to cooperate more in order to put changes in place. Product innovations are grounded on knowledge of the workers (human capital) and external social capital as sources of ideas for new products. Of course, internal social capital and structural capital play a role in innovation, but it is supposed that their effect is lower.

Therefore hypotheses how each component of intellectual capital influences product and process innovation can be stated as follows:

Hypothesis 2 Human capital has a significant positive effect on product innovation.
Hypothesis 3 External social capital has a significant positive effect on product innovation.
Hypothesis 4 Structural capital has a significant positive effect on process innovations.
Hypothesis 5 Internal social capital has a significant positive effect on process innovations.
Hypothesis 6 External social capital has a significant positive effect on process innovation.

4. Methodology

4.1. Data collection

In order to asses such a complex issue as innovation and intellectual capital, a large database from Global Manufacturing Research Group (GMRG) V is used.

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). The survey questionnaires for all countries are translated and back-translated by several academic researchers (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. 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). A $\chi 2$ analysis is conducted against early and late respondents to validate for non-response bias in each country (Armstrong and Overton, 1977). Non-response bias is not evident. The survey instrument uses observable and perceptual measures. 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 890 companies.

4.2. The sample

The sample consists 890 manufacturing companies out of which 25,9% are small companies up to 50 employees. 47% of companies are middle sized companies (50 till 250 employees) and 27,1% of companies are large with over 250 employees. Countries in the sample are presented in Table 1.

Tables:

Table 1. Descriptive statistics

Country	Count	Percent	Profit margin	Revenues from new products as % of total sales
Australia	66	7,4%	21,71	19,68
Canada	4	0,4%	24,50	13,75
China	97	10,9%	12,49	38,09
Croatia	110	12,4%	18,05	25,21
Czech Republic	1	0,1%		20,00
Germany	44	4,9%	16,33	29,55
Hungary	36	4,0%	7,72	20,60
India	57	6,4%	23,77	22,63
Ireland	30	3,4%	25,05	23,67
Netherlands	2	0,2%	24,00	12,50
Nigeria	46	5,2%	13,06	27,02
Poland	76	8,5%	-4,14	26,84
Taiwan	40	4,5%	18,28	29,85
Ukraine	48	5,4%	21,10	21,20
USA	166	18,7%	16,10	21,14
Vietnam	67	7,5%	18,14	71,62
Total	890	100,0%	14,99	28,89

Country origin is not subject of the analysis, even though it is important to stress the that developed and developing countries participated in the research. Also, some countries have above average profit margins yet they have average revenues from new products as for example companies from Canada and Netherlands. It simply shows that that some companies put bigger emphasis or innovations, while others on for example quality. The overall average of innovations revenues is 28,89% of total revenues.

4.3. Measures

This study investigated relationships among four elements of intellectual capital and innovation. Structural equation modeling for analysis is used in order to assess complex relationships among constructs. Latent constructs are operationalized using seven-point Likert type multi item scales (strongly disagree=1; strongly

agree=7). Measures for each construct are developed from previous literature to assure content validity. Measures are presented in Table 2.

Table 2. Items for each construct measured on 7 point Likert scale (strongly disagree, strongly agree) and the related literature

	Internal social capital	Moenaert and Souder (1996), Subramaniam and Youndt (2005), Lee et al. (2011)
ISC1	There is ample opportunity for informal conversations among employees in the plant.	
ISC2	Employees from different departments feel comfortable calling each other when need arises.	
ISC3	People are quite accessible to each other in the plant.	
ISC4	We are able to discuss problems and tough issues openly.	
	Structural capital	Subramaniam and Youndt (2005)
STRUC1	Standard operating procedures are in place.	
STRUC2	Much of this plant's knowledge is contained in manuals, archives, or databases.	
STRUC3	We usually follow the sequence of written procedures and rules.	
STRUC4	Processes in our plant are well defined.	
	Human capital	Snell and Dean (1992), Subramaniam and Youndt (2005), Lee et al. (2011)
HC1	Employees in this plant are highly skilled in their respective jobs.	
HC2	Employees in this plant are considered among the best people in the organization.	
HC3	Employees in this plant are experts in their particular jobs and functions.	
HC4	Every employee in this plant has useful experience.	
	External social capital	Subramaniam and Youndt (2005)
ESC1	This plant and its major external partners have common understanding about what activities are best for our relationship.	
ESC2	This plant and its major external partners have shared objectives and visions.	
ESC3	This plant and major external partners share common language and codes (e.g. special vocabulary, abbreviation, and technical terms).	
ESC4	This plant and its major external partners have common understanding about the same concepts (e.g. good, fast, cost, quality).	
ESC5	This plant and its major external partners have similar behavioural rules and norms.	
ESC6	This plant and its major external partners have common values and culture.	
	Process Innovation in comparison to competitors	Modified Jansen et al. (2006), Burgelman et al. (2004)
PROC1	We are learning more about the newest processes than our competitors.	
PROC2	We are the first within the industry to deploy new processes.	
PROC3	We keep up with the latest process developments.	
PROC4	Process innovation is important to this plant.	
PROC5	We frequently introduce processes that are radically different from existing processes in the industry.	
PROC6	We have no difficulty in introducing processes that are radically different from existing processes in the industry.	
	Product Innovation in comparison to competitors	Modified Jansen et al. (2006), Burgelman et al. (2004)
PROD1	We are the first within the industry to introduce new products.	
PROD2	We keep up with the latest product developments.	
PROD3	Product innovation is important to this plant.	
PROD4	We frequently introduce products that are radically different from established products in the industry.	
PROD5	We have no difficulty in developing products that are radically different from existing products in the industry.	

The latent variables constructs are in line with proposed definitions of components of intellectual capital. All constructs have at least four variables in order to catch the complexity of the construct, that is, component of intellectual capital.

5. Results

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 3 presents Constructs, Measurements and factor loadings for the model.

Table 3. Constructs, Measurements and factor loadings for the model

		Factor loadings*	Standard error	Critical ratio (t value)
Internal social capital: CR=0.881, AVE=0.654	ISC1	0,584		
	ISC2	0,851	0,10	14,1
	ISC3	0,899	0,10	14,3
	ISC4	0,862	0,11	13,9
Structural (organizational) capital CR=0.883, AVE=0.656	STRUCT1	0,705		
	STRUCT2	0,745	0,08	15,9
	STRUCT3	0,887	0,08	17,8
	STRUCT4	0,886	0,07	18,0
Human Capital CR=0.889, AVE=0.668	HC1	0,826		
	HC2	0,793	0,05	20,3
	HC3	0,878	0,05	22,9
	HC4	0,767	0,05	19,0
External social capital CR=0.901, AVE=0.603	ESC1	0,755		
	ESC2	0,806	0,06	18,9
	ESC3	0,743	0,07	16,5
	ESC4	0,761	0,06	17,2
	ESC5	0,83	0,06	18,4
	ESC6	0,76	0,07	16,7
PROC CR=0.889, AVE=0.573	PROC1	0,756		
	PROC2	0,815	0,06	19,0
	PROC3	0,861	0,06	19,7
	PROC4	0,732	0,06	16,5
	PROC5	0,728	0,07	16,5
	PROC6	0,629	0,06	14,1
PROD CR=0.848, AVE=0.528	PROD1	0,757		
	PROD2	0,788	0,05	17,2
	PROD3	0,735	0,06	15,5
	PROD4	0,708	0,06	15,6
	PROD5	0,637	0,06	14,0
$\chi 2$=1513,203, $\chi 2$/df=4,18, p=0, IFI =0,882, CFI =0,881, RMSEA =0,065				

We first performed an exploratory factor analysis to find how many factors are in the IC construct. The analysis revealed four distinct factors. Secondly, we performed a confirmatory factor analysis. As it can be seen in Table 3, 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).

Common method variance (CMV) 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 (Chang et al., 2010; Podsakoff et al., 2003) and in this work all four preconditions are fulfilled.

Table 4. Interrelations among constructs

	Human capital	Structural capital	Internal social capital	External social capital	Process innovations	Product innovations

Human capital	1					
Structural capital	0,598	1				
Internal social capital	0,599	0,541	1			
External social capital	0,633	0,604	0,539	1		
Process innovations	0,436	0,375	0,299	0,426	1	
Product innovations	0,415	0,374	0,36	0,469	0,772	1

**Correlations are all significant at p=0.001 level*

As can be seen from Table 4. all components of intellectual capital have a significant positive effect on innovation. Specifically external social/relational capital has a positive and significant impact (0,469) on product innovations. This can be explained as the companies with higher contacts with outside partners especially customers get the information and idea for new product launch. However, in order to achieve a successful launch of a product human capital expressed in knowledge and skills of employees is very important (0,415). Structural capital (0,374) and internal relations among co-workers (0,360) also enhance a probability of a successful new product launch but in a lesser amount than external social capital and human capital.

Hypothesis 1- 6 are confirmed. The correlation between products and process innovations is 0.772***. Human capital has a significant positive effect on product innovation (0.415***). External social capital has a significant positive effect on product innovation (0.469***). Structural capital has a significant positive effect on process innovations (0.375***). Internal social capital has a significant positive effect on process innovations (0.299***). External social capital has a significant positive effect on process innovation (0.426***)

6. Conclusion

The model depicted in Table 4. shows that external social capital has highest impact on product innovations. This is understandable because links with primarily customers are a significant source of ideas for new products. But human capital is important too. Without the knowledge and expertise of employees it would be impossible to create and launch new products. However, it should be noted that internal social capital and structural capital are of no less importance. The knowledge has to be codified in order to be useful throughout the company, and internal social capital is important for launching new products because the launches of a new product will necessities expertise from different departments from the company like marketing, engineering, production and R&D.

For process innovations the dominant effects are again human capital (the knowledge of employees) that will use the technology, external social capital which will transfer the knowledge how to use the new equipment, and structural capital which means that the knowledge of usage of machines is probably codified into manuals that can then be easily accessed and used. Lesser effect on process innovation is internal social capital which is probably due to the fact that employees are experts in usage of part of process technology and do not spend time explaining how to use machines when it is all in manuals.

Product and process innovations are highly correlated, so it proves Kraft (1990) and Menor et al. (2007) thesis that those two aspects of production should be investigated in parallel.

Finally, it can be concluded from the results that absolutely all four components are important but have different function in process and product innovations.

7. Managerial implications

Table 1 shows, that on the average only 28,89% of revenues are generated by new products. That means that the rest of revenues are generated by old products or accompanied services. Also, Prester (2013) showed that to best performing manufacturing companies', quality rather than innovation is first priority. The next priority to best performers is cost, and innovation is the forth priority out of six researched manufacturing priorities.

Therefore, management of a company should first decide what their priorities are. If quality and efficiency are the first priorities than process innovation, rather than product innovations will be important to the company. In that case, the order of importance of IC components is: External social capital (0.426***), Structural capital (0.375***), Internal social capital (0.299***). That means that in order to increase these IC components managers must balance between giving the freedom to employees in boundary spinning roles such as

purchasing, and strict procedural practices for codifying externally acquired knowledge. This is by no means an easy managerial task to create such work climate. It means that employees should be trusted and that they will work in the best interest of the company by choosing external partners with similar values and norms. Also they must be motivated to share their externally acquired knowledge to other employees by imputing it into company's knowledge management system. First steps may be rewarding employees or group of employees that behaved in that manner. With time, this rewarding scheme will turn into company's culture and all employees will start to behave in this way (see Table 2 for components of external social and structural capital for operative details on what to reward). Imposed external partners by managers that employees do not feel comfortable to work with will lower the benefits of collaborating, and lower the external social capital component. Then, as a vicious circle, codifying knowledge will seem to employees as a burden, and internal social capital will turn into complaining among employees.

If innovation is top priority, than, orders of importance of IC components are: external social capital (0.469***) and human capital (0.415***). In case of new product design again freedom must be given to employees to collaborate, brainstorm or any other possibility to interact with external partners to get new ideas. If this freedom is not given, than innovation will rely only on internal knowledge and that may not be enough for fast changing customers' needs and competition. Innovation is usually a recombination of existing knowledge, so that explains why human capital is also important for innovation. To increase human capital and enhance exchanges of ideas with external partners, a proven method is to invest into continuous education of employees.

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