

Modelling the Interactive Influence of Intellectual Capital Indicators

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Abstract: Knowledge generation, in contemporary times, has dictated the economic strength and national and regional competitive advantage. The advent of the open innovation model has driven firms to collaborate and engage in external interactions to incite their innovation spark to become even more competitive globally and nationally. There have been a wealth of success in creating intellectual capital in the European Union. In line with that, subsequent funding have been provided for small and medium sized firms (SMEs) with the view of assisting them to individually or cooperatively generate intellectual capital. However, even as human resources, cooperation and other environmental factors have been acclaimed to influence regional intellectual capital capacity, we question whether these factors offer an interactively significant influence on themselves in creating intellectual capital. This will enable identification of catalytic indicators to expertly position regional activities that generate regional competitive advantage. Using the Structural equation modelling (SEM) and data from European Innovation Survey (2018), research aims to test the interactive influence of the selected indicators of intellectual capital and their significance in generation intellectual capital represented by patents, trademarks and design applications. The results revealed that whilst research system attractiveness and firm-to-firm or academia linkages were very significant in generating intellectual capital, human capital were not significant in generating intellectual capital contrary to mass of literature. Attractiveness of research systems were strongly significant in affecting the human resource structure and innovation friendliness of member states and generation of intellectual capital. Private, public and venture capital were found to have been strongly influenced by labour structure and friendliness of a geography whilst it also strongly affected the cooperation tendencies of firms and academia. Policies that aligned regional strengths to these findings were further recommended.

Keywords: intellectual capital, human capital, public and private funds, cooperation, innovation

1. Introduction

In recent times, open Innovation (OI) as a newly-adopted concept and strategy for innovation has been the hailed as the ideal model for innovation in recent years. As an advancement beyond the black box innovation model, the linear and the systemic model of innovation, open innovation has moved firms to exist beyond a self-centred innovation mentality to a more integrative innovation-oriented structure. Chesbrough (2003a) coined this term and referred to it as *“combining internal and external ideas as well as internal and external paths to market to advance the development of new technologies”*. This model admonishes firms to endorse and actively engage in the knowledge sharing, interaction and cooperate with external entities without fear of imitation but rather with the objective of learning, acquisition of knowledge, being opened to new technological processes and consequently improving and expediting innovation processes. In a quest to boost industrial innovation efforts, a range of research has been conducted by various authors (Dahlander & Gann, 2010; Chesbrough & Bogers, 2014; West & Bogers, 2014) which has entrenched the popularity in adoption of this model for innovation. Clubs and associations have been created to provide a valuable platform for industrial managers to share experiences and practices that may have been crucial in spurring the wider adoption of the term by other firms. These industrial clubs have been supported by academics, helping to promote dialog and debate between open innovation scholars and practitioners. Alongside these academic and practitioner communities, the concept has been taken up by all levels of governments, whether local, regional, national or supra-national West, Salter, Vanhaverbeke, Chesbrough 2014). Overtime, open innovation has come to be redefined in newer contexts to capture the changes in the views of firms in this engagement. Chesbrough and Bogers (2006) now interpret open innovation as *“a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization’s business mode”*.

Small companies are believed to gain more from open innovation as both their resources and market reach are limited and their innovation efforts already have an external focus making them more prepared for a more open innovation interactions (Lee, Park, Yoon and Park, 2010). However, process was feared to be defied by large incorporations owing to their financial prowess and ability to engage multiple personnel with diverse background.

Cooperation in the European Union is valued as a salient feature that assists in accelerating and reaping the results of innovation creation and even knowledge dissemination (European Commission 2014). Community Innovation Survey (2014) assesses the innovativeness of firms by verifying open innovative efforts of firms (Cricelli, Greco and Grimaldo 2015). Public and private funding to most firms also have begun to endorse the open innovation efforts of SMEs such that funds can be specifically set aside for such innovative orientations.

Research of Cricelli, Greco and Grimaldo (2015) showed that the portion of firms adopting the OI concept has risen, both in terms of inbound and coupled activities. They also revealed that even as firms have intensified the use of the inbound OI mode, the use of collaborations had been rarely used. This effectively understates the interactive skill, knowledge extraction and sharing capacities of organisations' inherent human capital in creating generating intellectual capital. Rahman and Ramos (2013) also researched on the limitation of OI and found that high wage level is creating scarcity of skilled manpower effectively creating a dearth of skilled resources and also inhibiting the firm's ability to employ more diverse persons. There is also a high cost of innovation including an insufficiency in knowledge about OI strategies. Having known the funding efforts exerted by public and private entities for open innovation scheme and the limitations firms face in their efforts to openly innovate, we aim to assess the interactive influence of selected indicators of intellectual capital on themselves and their significance in the generation intellectual capital represented by patents, trademarks and design applications. In the effort to protect and generate further intellectual capital, within the European Union, this paper will be of such essence that it will reveal the sub variables that not only affects intellectual capital but also shows the degree to which such indicators respond to each other in a catalytic and synergistic effort to enable policy makers carefully position resources to reap the best results from structural and social variables for innovation. This could mitigate the pressure of funding and further funding for innovation activities especially newly introduced funding schemes of the European Union such as the Horizon 2020.

2. Literature review

As shown in figure 1, the study tests the model that indicators of intellectual capital have a systemic effect on intellectual capital such that they interact to influence themselves to effectively create both synergetic and individual effects on patents, trademarks and design applications. This model hinges on theoretical propositions of Lundvall (2010), Kwiek (2015), Audretsch and Feldman (2004) who found that human capital of organisations and public and private expenditure as relevant inputs of intellectual capital. Furthermore, there is a debatable use of indicators to measure intellectual capital.

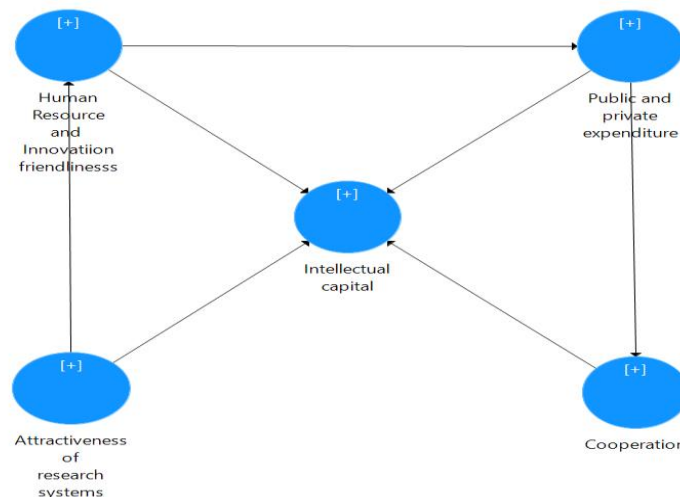


Figure 1: SEM Model structure of variables analysed

The definition of intellectual capital introduced by Bontis (2004) is the one most frequently quoted by scientists in research in that field: "The intellectual capital of a nation includes the hidden values of individuals, enterprises, institutions, communities and regions that are the current and potential sources for wealth creation". According to Jurczak (2008), Luthy (1998) and Bukowitz & Williams (2000), measuring intellectual capital can be one of the four methods: Direct Intellectual capital methods (DICM), Market Capitalisation Methods (MCM), Return On Assets Methods (ROA) and Scoreboard Methods (SC). However, as used by Bontis (1996), we opted for the citation based measure of DICM which uses the valuation of the number and cost of patents. For comprehensiveness and diversity, we also incorporated design application and trademarks also provided by the

European Innovation Scoreboard (EIS). It is worth to note that even though intellectual property generally may consist of patents, copyrights, licensing and trademarks, the usage of Citation-weighted patents- enables a measure intellectual capital resources from the bottom up and can therefore be faster and more accurate than ROA and MCM measures with respect to resources. Since they do not need to be measured in financial terms, they are very useful for not-for-profit organizations, business units, government agencies, and for environmental and social purposes.

2.1 Research attractiveness, human resource and intellectual capital

In recent times, intellectual capital has been highly revered as a very significant source if not a measure of economic performance (Malhotra 2000). Traditionally, most countries had focused on the impact of land, labour, capital and entrepreneurship as factors determining the economic output, i.e. Gross domestic product (GDP). In this era of knowledge economy, large multinationals corporations such as Facebook and Microsoft strongly pride their marginal returns on additional knowledge and interaction created. Research attractiveness have been lauded as a catalyst for expediting technological innovation and a crucial facilitator of the creation of a stronger knowledge network. Research has shown that firms need to protect their knowledge when they engage in formal external collaboration (Cassiman and Veugelers, 2002, Heiman and Nickerson, 2004) as this is a means that firms accesses skills and knowledge unavailable within the boundaries of their organizations. Kwiek (2015) researched on 11 European Union member states to reveal the impact research collaboration on productivity of research. He found that European Union member states research productivity in Europe had a direct correlation with international research collaboration. Lee and Bozeman (2005) also researched to find out the impact of research collaboration on scientific productivity. They found contrasting results that revealed that when scientific productivity was measured by 'normal count' (a scientist's total number of publications), collaboration was a strong predictor of publishing productivity. When publishing productivity was measured by 'fractional count' (dividing credit by the number of co-authors), collaboration and publishing productivity were found not to be significantly related when they controlled for moderating variables. However, in a practical sense, not all persons are moved by attractive structures as most are rather attracted by sumptuous compensation packages. Due to the development of innovation beyond the systemic model to even the open innovation structure, it is believed that an attractive research structure could be a bait for attracting highly qualified personnel and also reducing attrition rate of currently existing research persons inadvertently determining the quality and diversity of human resources research personnel. Hence, we hypothesise that *“attractiveness of research systems has an impact on human capital and innovation friendliness”*-H1.

2.2 Human capital, firm funding and intellectual capital

Existing research on human capital and performance has unanimously demonstrated that effective human capital management is a significant contributor to organizational performance (Macduffie, 1995; Delaney & Huselid, 1996; Combs, Liu, Hall, & Ketchen, 2006; Jiang, Lepak, Hu, & Baer, 2012;) irrespective of whether it is assessed from the universalistic perspective (the so-called best practice approach) or the configurational perspective (the application of bundles of interrelated HRM practices) (Boxall & Purcell, 2003; Delery & Doty, 1996). There is the assumption that organization's capacity to innovate dwells in its employees' capacities, their intrinsic and extrinsic motivation owing to the undeniable need of human capital in the development and implementation of innovations (Jiménez-Jiménez & Sanz-Valle, 2008).

According to Seeck and Diehl (2016), this assumption above reflect two dimensions of the effect of human capital on innovation- the best practice approach which asserts that firms will improve their innovative performance if they implement certain best practices- and the bundled approach which concerns supporting employee commitment to affect firm innovative efforts. In this vein, Zhou, Hong and Liu (2013) assessed 179 organizations in China to examine the interaction effects of two HRM systems on affecting firm innovation and performance. They found that both systems assessed, the commitment-oriented system and the collaboration-oriented system. Using structural equations modelling, Jimenez and Valle (2008) assessed one hundred and seventy-three (173) Spanish manufacturing firms to analyse human capital effect on innovation. The findings showed that innovation contributes positively to business performance and that human resource management enhances firm's patents generated for innovation. Liu (2013) also researched on the influence of human capital of inventors on the decision to keep or discard a patent. The results showed that having star inventors on the team of inventors, having more coinventors, and having inventors from multiple locations significantly raised the

chances of renewal of patent. Additionally, having more coinventors positively moderates the effects of star inventors on patent renewal.

However, Pérez and Diaz (2010) in an empirical study assessed 157 firms in Canary Island and arrived at the conclusion that high commitment to an effective human resource management (HRM) had a positive influence on process innovation in firms. Their results also showed that the structural formalisation of firm's human resource policy and job stability also raised firms' level of patent generation (Seeck and Diehl 2016); however, regarding the role of human capital as a determinant of public and private expenditure, there hasn't been a clear-cut direction between the diversity or quality of human capital and public or private expenditure. It could be explained that the impact assessment has taken a different direction such that Knowledge as an asset is assumed to dwell in the firms' human capital and the output of these persons is what generates firms' productivity, patents and competitive advantage. Most researches have rather focused on the quality of human capital affecting foreign direct investment (Agbola 2013; Thangavelu and Narjoko 2014; Kottaridi and Stengos 2010). Foreign-direct investment (FDI) inflows are considered to be more strongly and positively related to improvement in human development when FDI policy restricts foreign investors from entering some economic sectors and when it discriminates against foreign investors (Reiter and Steenma 2010). In addition, they also found that the relationship between FDI and improvement in human development is also more strongly positive when corruption is low. Nevertheless, thorough research has established the relevance of public and private funding on firm's innovation input which is largely embodied in human capital; the research will test the connection of human capital on private and public expenditure in determining intellectual capital. Having revealed this, we also hypothesise that *"Human capital and innovation friendliness has a significant impact on the public and private expenditure invested"* - H2.

2.3 Public and private funding, cooperation and intellectual capital

Extensive literature have affirmed the recurring essence of public and private funding schemes on creation and generation of intellectual capital and cooperation. Henry Junior and Odei (2018) researched on Slovak countries and found a positive significance of National and European Union funding on the cooperation levels of Czech Republic, Slovakia and Hungary even though the impact differed based on the type of funding. This could also explained by the result of Teirlinck and Spithoven (2012) who found that public funding provided by the EU framework programme did not exert an impact on the creation or facilitation of industry-science cooperation, neither with universities nor with public research centres. He explained that this could occur due to the fact that EU funding is oriented at firms that are already cooperating and does not favour the cooperation of start-ups. Venture capital levels are already in the red zone in the European Union compared with China, Canada and United States and this is not even helped by the low mergers and acquisitions rate and consequently poor foreign-direct investment levels (European Commission 2018). Having known these we finally hypothesise that *"Public and private expenditures has a significant effect on the cooperation centric activities of countries"*-H3. The objective of the research thereof is to show the catalytic effect of intellectual capital indicators on themselves in the creation of intellectual capital to enable expert positioning of available national resources in creation and generating of intellectual capital.

3. Data and methodology

The research is of exploratory nature and employs the purposive sampling technique in selecting the unit of analysis. As the research is of quantitative nature and largely revolves around the innovation status, we employed the data from European Innovation Survey (2018). The data consist of innovation activities of all the twenty-eight (28) European Union (EU) member states as of 2018 and carefully scores the framework conditions of member states, the investments injected, the innovation activities involved and their impacts. This survey collects data about the innovation status of all European Union member states and relatively ranks them based on their scores. Member states are ranked as innovation leaders, strong innovators, moderate innovators and modest innovators relative to their performance with the European Union average score. This provides the platform for an active comparison of member states with one another for healthy competition and effective benchmarking of performances. We chose to research on the European Union due their renewed ambition of the Union to propel their innovation efforts to move far ahead of nearest competitors evidenced by the implementation of the Horizon 2020 funding scheme and other multiple funding schemes enacted to propel the wheels of innovation. This was also chosen because of the efforts to catch up financially in terms of research and expenditure invested and venture capital invested. This research will reveal the collective effects of indicators on intellectual capital and how they could be harnessed to expedite innovation processes without

extensive recourse to merely funding schemes. As the research hinged on the intellectual capital generation, we selected indicators from framework conditions, investments and linkages from the investment activities as shown in table 1 below.

Table 1: Variables selected for SEM analysis

Variables	Abbreviation	Category	Variable type	Resources
New doctorate graduates	NDG	Human capital and Innovation friendliness	Input/Output	Servage (2009), EIS (2018)
Population completed tertiary education	TERP	Human capital and Innovation friendliness	Input/Output	
Lifelong learning	LL	Human Capital	Input/Output	
International scientific co-publications	SCICOP	Attractiveness of Research systems	Input	EIS (2018)
Foreign doctorate students	FDS	Attractiveness of Research systems	Input	EIS (2018)
Broadband penetration	BBPEN	Human capital and Innovation friendliness	Input/Output	Ghosh (2017), EIS (2018)
Opportunity-driven entrepreneurship	ODE	Human capital and Innovation friendliness	Input/Output	EIS (2018)
R&D expenditure in the public sector	PUEXP	Public and private expenditure	Input/Output	Henry Junior and Odei (2018), EIS (2018)
Venture capital investments	VCI	Public and private expenditure	Input/Output	Botazzi and Da Rin (2002) Colombo, Adda and Pirelli (2016), EIS (2018)
R&D expenditure in the business sector	PREXP	Public and private expenditure	Input/Output	Hashi and Stojcic (2013) Anderson and Stejskal (2019) EIS (2018)
Non-R&D innovation expenditure	NIE	Attractiveness of Research systems	Input	Anderson and Stejska (2019), EIS (2018)
Enterprises providing ICT training	EICT	Attractiveness of Research systems	Input	EIS (2018)
Innovative SMEs collaborating with others	SMECOLLAB	Cooperation	Input/Output	Natario (2018), EIS (2018)
Public-private co-publications	PPCP	Cooperation	Input/Output	EIS (2018)
Private co-funding of public R&D expenditures	PRCOFUND	Cooperation	Input/Output	EIS (2018)
PCT patent applications	PAT	Intellectual capital	Output	Bontis (1996), Crema, C Verbano (2016)
Trademark applications	TRDMK	Intellectual capital	Output	Forte and Matonti (2017), Abdullah and Othman (2019) EIS (2018)

Variables	Abbreviation	Category	Variable type	Resources
Design applications	DESAPP	Intellectual capital	Output	Forte and Matonti (2017), EIS (2018)

Source: Authors' selection from EIS (2018)

In analysing the data, we employed the Structural Equation Model (SEM) analysis to compute the collective and interactive impact of sub variables of Research attractiveness, Human Capital and Innovation friendliness, Public and private expenditure and Cooperation on intellectual capital generation. This tool was used to develop a model to analyse, test and confirm the above-stated hypothesis in the literature. It was selected due to its assumption of free distribution, its analytical capability of revealing moderating and mediatory roles and its compound of analytical tools that enable analysis of multiple latent variables with sub variables (Kock & Hadaya, 2018) as well as its capacity to generally compute models in a multiple regression context. In using this model, as shown in table 2, reliability tests had to be constructed to verify the fitness and reliability of the model. Reliability tests for Cronbach's alpha, rho's A, composite reliability and average variance extracted (AVE) all satisfied the conditions set by Hair et al. (2012). Additionally, cross loadings computed also showed all variables mapped to the latent variables created was significant.

Table 2: Results of construct reliability and composite reliability tests.

Construct reliability	Cronbach's Alpha	Rho_A	Composite Reliability (CR)	Average Variance Extracted (AVE)
Attractiveness of Research systems	0.857	0.893	0.912	0.777
Human Resources & Innovation friendliness	0.805	0.879	0.868	0.579
Linkages	0.720	0.863	0.838	0.643
Public and private funding	0.650	0.821	0.816	0.625
Intellectual Capital	0.670	0.664	0.819	0.602

Source: Authors' own computation

We also conducted a test of the variance inflation factor (V(F) to verify the multi-collinearity level of the data used. According to Hair et al. (2012), there is a low multi-collinearity level if the variance inflation score ranks below 5.0. According to the results in Table 3, there was no strong multi-collinearity issues found.

Table 3: Variance Inflation factor (VIF)

Variable	NDG	TERP	LL	SCICOP	FDS	BBPEN	ODE	PUEXP	VCI
Score	1.465	1.179	4.584	2.671	2.092	1.590	3.670	3.099	1.064
Variable	PREXP	NIE	EICT	SMECOLLAB	PPCP	PRCOFUND	PAT	TRDMK	DESAPP
Score	2.990	1.337	2.543	2.005	1.937	1.170	1.147	1.912	2.108

4. Results and analysis

Results of the analysis presented below shows the SEM results conducted to test the hypothesis created.

Table 4: Results of test of Hypothesis.

Hypothesis	Significance	SD	F square	P Values	Status
H1	Attractiveness of Research systems -> Human Resources & Innovation friendliness	0.07	1.358	0.000 ***	Accepted
	Attractiveness of Research systems -> Intellectual capital	0.31	0.479	0.045 ***	
H2	Human Resources & Innovation friendliness -> Public and private funding	0.05	2.106	0.000 ***	Accepted
	Human Resources & Innovation friendliness -> Intellectual capital	0.30	0.002	0.879	

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Hypothesis	Significance	SD	F square	P Values	Status
	Linkages -> Intellectual capital_	0.32	0.432	0.017 ***	
H3	Public and private funding -> Linkages	0.03	3.223	0.000 ***	Accepted
	Public and private funding -> Techno innovation_	0.42	0.336	0.054 *	

Significance levels are appraised such that “***”- p value is less than 0.00; “*”- p value is less than 0.05; “**” when p value is less than 0.05

A quick look at table above shows the latent variables created all have a significant impact on the creation of intellectual capital excluding the Human capital and Innovation friendliness. This is contrary to most research such that it is recognised that knowledge and information resides in individual and the sharing, interaction, . Regarding the actual hypothesis created, the results showed that attractiveness of research systems has a strong significance to Human resources and innovation friendliness. The f squared test also shows a very strong effect on the output variable. This implies that research structures created has a high tendency to attract and determine the quantity and quality of human resource personnel attracted to a region. With that being revealed, countries can conveniently invest in highly attractive research structures with the confidence of replication of efforts in quality human capital and subsequent acceptable environment for even further quality personnel. Positive image created works in attracting new residents, tourists, potential employees and actively raises the interest on the part of the media and consequently the goodwill of city as well (Kotler, Keller, Brady, Goodman, Hansen, 2009). This can also be said to enhance promotional activities and strengthen the bargaining hand of regional authorities. The research supports the finding of Insch (2011) and Raszkowski (2012) and effectively accepts H1.

Furthermore, Human resource and innovation friendliness was found to have strong significance to the public private and venture capital invested in member states in the European Union. It is worth noting that already the venture capital level in the European Union is the lowest compared to United States, Canada and China as well and public expenditure levels have sought to be raised with the inception of the Cohesion policy aiming for 3% of Gross Domestic Product of EU member states to be invested into research and development. However, these results reveal that the human capital and friendliness of a regions does determine the public funding efforts and even investors interest in investing in the block and degree of public or private or even venture capital funding. This could be reasonably be explained that the quality or diversity of personnel does impact the funds committed to research and development of provided to a member state or a region even though it does have a strong influence on the intellectual capital via cooperation, knowledge sharing and other interactions. It could also be implied that if the human capital and innovation friendliness of a region significantly determines funds invested basically for research purposes, and we currently have a low R&D investment and relatively poor venture capital investment levels, this could be interpreted as a failing workforce loss of trust in the human capital potential of the Union, a poor human capital management by organisations (Noe, Hollenbeck, Gerhart and Wright 2017) or even a poor organisational culture (Gully, Phillips, Castellano, Han, & Kim, 2013) that operates harnessing of the potential and talents of human capital. Headey and Hodge (2009) revealed that working age population could affect economic growth since population dominated by the old and children use most of their resources to cater for young and old which may depress economic growth as EU’s working population has been decried to be “greying” as working population keeps reducing (European Commission 2018), this could be a reason as well. Nevertheless, this effectively accepts H2.

Lastly, the public and private and venture capital levels revealed a strong significance on the level of cooperation of firms, institutions and academic bodies even as they both had a significant influence on creating intellectual capital. This effectively confirms H2 and implies that expenditures from all sectors invested in the cooperation centred activities has a strong bearing on collaborative activities. This is imperative as innovation in contemporary times have been largely information-based and centres on the interactive capacities of human resources to share and exchange information. Hence, it is comprehensible that private and public bodies have thrown their financial weight around cooperation centric initiatives to creating regional competitive advantage. This effectively confirms H3 and affirms the research of Henry-Junior and Odei (2018), Acosta, Coronado and Romero (2015) and Maietta (2015). However, Prokop and Stejskal (2018) presented another side of cooperation

revealing that firms prefer to cooperate on process innovation and innovation results are reaped in cooperation when firms engage with cooperation with too much partners.

5. Conclusion

The paper set out to reveal the interactive influence of intellectual capital indicators and the synergistic significance on intellectual capital creation. We focused on the European Union as a bloc and assessed the variables of research and innovation attractiveness, human capital and innovation friendliness, public and private research funding, cooperation and intellectual capital represented by patents, design application and trademarks. We conducted this multi-analysis using Structural Equation Model (SEM).

H1 which supposed that the attractiveness of research and innovation systems did determine the quality and quantity of human capital attracted to the region as well the friendliness of the region was accepted. This reveals that in as much as human capital is attracted by attractive package compensation, regions could, also invest in rich regional structures and education programs that improves the quality and value of human capital thereby rendering them more valuable to themselves, the region and the firms involved. As stated by Raszkowski (2012), this places the region in a brighter light in terms of global recognition and employee popularity. This could be resorted to rather than attempts to provide more financial packages that could easily be misappropriated and embezzled or even inefficiently used.

H2 was also accepted. This hypothesis also supposed that human capital and friendliness of innovation is a significant determinant of the funding appropriated for research and development as well as venture capital levels. However, even though this hypothesis was fulfilled, it could be inferred that human capital management and possibly organisation structures in the European Union were not efficient enough in harnessing the potential of current human capital. It could be connected to the ageing population according to the 2018 Ageing Report by the European Commission, poor organisational cultural structure and also poor strategic and supervisory management of human capital resources. It is recommended that firms actively engage in open practices that instils confidence, belief and trust in the intra-organisational connections and even other inter-organisational networking to facilitate knowledge sharing and confident exploration and utilisation of human resource potential. Healthy competitions and science workshops can also be organised and hinged more on friendly competitions and collaborative accomplishments.

Finally, H3 which presupposed that public and private funding including venture capitals had significant influence on linkages, representing SMEs openly collaborating with other SMEs, public and private and even academia interactions, was also accepted. This finding had the highest effect of significance amongst all the statistically significant hypotheses found and strongly entrenches the need for adequate financial structures. Most authors have revealed that cooperation efforts lie at the forefront of open innovation efforts both with firms and regions. Countries are therefore recommended to instigate policies that actively support cooperation-endowed sessions and correspondingly motivate the not-so open firms to engage in open innovation to move in line and engage in a meaningful information interchange for the mutual growth of firms and regions considered.

Limitation of this research was such that the data considered did not have selective figures for individual member state analysis hence we couldn't point out the member states experiencing the poorest connection of input indicators to output indicators combined. We further recommended that any further analysis is conducted on a panel level to assess decade changes in pattern of preferences for open innovation and changes in significance overtime.

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