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EVALUATION OF THE ROLE OF CRUCIAL IMPACTS ON NETWORKS FOR TECHNOLOGICAL INNOVATION

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In Pardubice on May 13, 2020 Ing. Henry Junior Anderson

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DEDICATION

I dedicate the entire content of this thesis to my parents and I'm honoured and blessed to have them see this completed successfully with light still in their eyes.

ANNOTATION

Technological innovation, in recent times, has been pivoted as the foundation of regional competitive advantage. Its generation has grown to a multi- interactive structure involving multiple elements ranging from human capital, financial capital, social capital and structural capital and knowledge interactions. In effect, some regions have pivoted their funding acquisitions on the best innovating firms whilst others focus more on creation of structures to assist Small and Medium Scale Enterprises (SMEs) to nurture their innovation base appreciably for a higher regional competitive advantage. In light of competition from other states, the European Union have initiated funding schemes like Horizon 2020, aside regional targets of for research and development expenditure, to strongly propel the innovation status of the bloc. Other framework conditions such as human, social and structural capital have been focused on as well, however, there have been arguments about their actual role played. Literature have portrayed them to have varying and contrasting effect in the eco-system for creation of technological innovation in various contexts ranging from regional need to partners involved and even to the location as well whilst there are also arguments against their actual role in supporting technological innovation. In that regard, this research intends assess the contributory role of financial, interactive, institutional and structural factors in the network of technological innovation generation in the European Union.

Keywords: Technological innovation, Human capital, Cooperation, Funding, Innovators

ANOTACE

Technologické inovace se v poslední době staly základem regionální konkurenční výhody. Jeho generace se rozrostla na multi- interaktivní strukturu zahrnující více prvků, od lidského kapitálu, finančního kapitálu, sociálního kapitálu a strukturálního kapitálu a vzájemných znalostí. Některé regiony ve skutečnosti zaměřily své akvizice na financování na nejlepší inovativní firmy, zatímco jiné se více zaměřují na vytváření struktur, které malým a středním podnikům pomáhají významně rozvíjet jejich inovační základnu pro vyšší regionální konkurenční výhodu. S ohledem na hospodářskou soutěž zahájila Evropská unie programy financování, jako je Horizont 2020, s výjimkou regionálních cílů výdajů na výzkum a vývoj, které výrazně podporují inovační status bloku. Zaměřeny byly i další rámcové podmínky, jako je lidský, sociální a strukturální kapitál, nicméně existují argumenty o jejich skutečné roli. Literatura je vylíčila, že mají v ekosystému různý a kontrastní účinek na vytváření technologických inovací v různých kontextech od firemních typů po zapojené partnery, přičemž existují i argumenty proti jejich skutečnému dopadu na inovační činnosti. V tomto ohledu má tento výzkum v úmyslu prozkoumat podstatu regionálních inonvativních prvků zapojených do prostředí technologických inovací v Evropské unii.

Klíčová slova: Technologické inovace, Lidský kapitál, Spolupráce, Financování, Inovátoři

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
AT&T	American Telephone and Telegraph Company
AVE	Average Variance Extracted
CA	Cronbach Alpha
CB	Covariance Based
CEE	Central and Eastern European Countries
CIS	Community Innovation Survey
CR	Composite Reliability
EPO	European Patents Office
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GRETL	Gnu Regression, Series Library Econometrics and Time
HC	Human Capital
HRM	Human Resource Management
HTMT	Heterotrait – Monotrait Ratio of Correlations
NOP	New Organisational Practices
NPD	New Product Development
NPI	New Product Innovation
OECD	Organisation for Economic Cooperation and Development
OI	Organisational Innovation
PhD	Doctor of Philosophy
PITEC	Spanish Technological Innovation Panel
PLS	Partial Least Squares
PTD	Patents, Trademarks and Design Applications
R&D	Research and Development
SEM	Structural Equation Modelling
SMEs	Small and Medium Scale enterprises
STDEV	Standard Deviation
TI	Technological Innovation
TIS	Technological Innovation System
VIF	Variance Inflation Factor

INTRODUCTION

Competitive advantage, the brand of innovation driver in an industry and country and regional progress has driven a deeper need for technological innovation in this modern era. Various theoretical concepts have grown to support this quest for firm and regional technologically innovative growth ranging from various growth theories as well as other interactive regional models that have developed from the then linear model (Marinova and Philimore, 2003) in the 1950's to the interactive and open system of innovation (West and Bogers, 2017). These efforts at creation of technological innovation was primarily meant solve societal upheavals and besetting socio-economic and technological conundrums (Carlsson and Stankiewicz, 1991). Technological Innovation System (TIS) is largely enhanced by the meshed and nested network of actors ranging from employee cooperation, firm-to-firm or firm-to-government cooperation and even a more nested connections among these stakeholders (Bergek, Hekkert and Jacobsson, 2015). As a framework, technological innovation system was developed typically as a tool to comprehend the emergence of technological innovations and also capture the shortcomings of technological innovation policies to enable provision of solutions to policies oriented to it. However, in its efforts to capture the relevance and suitability of innovated technologies, multiple context structures need to be actively present and interact to create and end-product suitable as a solution to technology needs.

However, there are currently held reservations against the operation ability of these framework conditions and even and mediating variables in the creation of technological innovation. Some researchers argue that framework conditions, which are direct result of the regional characteristics have no effect on such innovators such as product, process or even marketing innovation (Seeck and Diehl, 2016). As a mix of socio-economic, political, and technological aspects contribute to the viability of a regional research system, it is undeniably, a very sensitive factor and irreplaceable context structure (Bergerk et al., 2015) for technological innovation and even for internal and external investors as well (Raszkowski, 2013) of which Sweden performs best among all of the 28 considered EU member states. Regarding the cooperation of firms with their stakeholders like consultants and suppliers or even research institutes, higher level educational institutions, and other academic entities, this has been largely entrenched as being positively significant to creation of technological innovation (Siedschlag et al., 2012) and technological innovations (Carvalho, Madeira, Carvalho, Moura and Duarte, 2018). Additionally, funding support has widely been reasonably entrenched as a relevant and largely unarguable pillar of facilitating innovation. However, in the analysis of these aforementioned variables' relevance to the technological innovation creation which we mainly measure by patents, trademarks and design innovation, there has not been a differentiated analysis undertaken considering the innovation classification of the Union assessing the variables' relevance to technological innovation.

The author believes that, in as much as regions are endowed with their exceptional strengths and weaknesses, such as Sweden being the strongest in Human capital, innovation friendliness and research systems, Germany in firm investments and intellectual assets, the effect of the innovation inputs may be markedly different for some class of countries compared to others. This revelation will offer a more ground level impact of technological innovation support provided and force reconsideration of blanket type of support for member states and regions in their efforts at creating technological innovation. Hence, we intend to assess the significance of these framework conditions as a bloc on the entire European Union as well as deeply probe the innovative level relevance of funding and the other aforementioned variables to the cause of technological innovation-patents trademarks and design application- in light of the taxonomy of innovation levels- innovation leaders, strong innovators, modest and moderate innovators. Therefore, the purpose of this research is to assess the contributory role of financial, interactive, institutional and structural factors in the network of technological innovation generation in the European Union.

1. CONCEPTUAL FRAMEWORK

1.1. Innovation Systems: Technological Innovation Systems

The concept of systems of innovation have garnered widespread appeal in the research arena on processes of innovation and policy crafting (Sharif, 2006). Approaches from the system concept have been proved to be a viable contributor in notifying a wide range of imminent public policy issues, economic competitiveness of firms, regions and global industrial economy. The concept of Technological Innovation System was first mentioned by Thomas Hughes in his writing on "Networks of Power". A technological innovation system is defined as a set of elements, including technologies, actors, networks and institutions, which actively contribute to the development of a technology field (Bergek et al., 2015). The TIS perspective highlights systemic inter-dependencies between these elements, essentially creating synergies which actors could not otherwise produce in isolation**.** This system is posited to solve problems identified in the market.

With this concept, problem identification usually begins with a thorough assessment of the demand status and the resources available to fulfil this request. This is because inventions can be hinged on identifications on outdated systems of existing technology, lessons of current technologies or even on inventions that failed to translate to innovations (Negro, Hekkert and Smits. 2007). However, it is imperative to remind that elements of TIS framework do not chiefly operate to only promote technology. This misconception had led to the wrongful interpretation of the framework as being akin to "functionalism". Nevertheless, this has been duly clarified in latest TIS oriented studies (Jacobsson and Jacobsson, 2014).

In an effort for TIS to solve problems via innovation and even facilitate incremental and radical innovation diffusions there is a **need for a strong coupling** to the currently functioning context structures it could conveniently assist creation of new technologies (Onufrey, 2014). Considering this, the preliminary type of context structure is defined to incorporate all connected and surrounding TISs. Even to an extent, these functional relations is deemed as direct result of the definition of geographical and technological system boundaries. Practically, different technologies are pitted against one another in the market, similar firms compete for the similar products and different branding strategies and in some remote ways some products are produced to complement other existing market offers, which points to the potential of TIS to exhibit interactive influence on other dynamics (Sandén and Hillman, 2011). In this regard, it could be briefly concluded that each TIS exists as a potentially crucial context for others.

Furthermore, one other form of context structure can be connected to infrastructures and other currently existing institutions (Bergek et al., 2015). As firms and countries consistently develop incremental innovations or radically different technologies, they are consciously run on the pillars of other old and strong structures which may have long tenure of development to acquire much broader technology range and more innovation public policy objectives. Essentially it could be termed as larger technological structures giving birth or morphing into to other much needed structures. Case in point can be picked up from Germany's Biogas sector which pioneered as agricultural technology but later metamorphosed into a typical energy technology as detailed by Markard, Wirth and Truffer (2016). Lastly, there could also be some context structures that are not primarily meant for but related to the providing peculiar system level assets such as inciting political support for some technology-oriented policies, the primary need to have higher level of trained personnel or even specific type of funding like venture capital. In each instance, these TIS is expected to interact with other system like the political field, educational or possibly financial sphere as well in as much as they may all exhibit different constraints and dynamics to the cause of TIS.

Final context structure is those related to the **delivery of definite system-level assets**. This can be interpreted as the support provided at the political level for technological innovation policies, provision of capital to support specifically new ventures and support for training personnel in some specific technologies or with some tools. Each of these cases calls for, there a intense interaction with the political sector, educational and/or financial as well. Influencers as they are may each reveal different heckles and dynamics, which could potentially change the developmental trend of TI.

1.1.1. Functional Processes of Technological Innovation System

At the structural level, TIS is composed of the four above-named components, namely: *technology, actors, institutions and network* (Bergek, Jacobsson and Sanden, 2008). Actors in a TIS system are the chess-piece that embodies that physical structure of the network as they symbolise firms along the entire value chain of the technology. This ranges from the production of primary materials to dissemination of end-products or even supply of complimentary services. Regarding networks, they can be described as the formal and informal relationships connecting actors engaged to in a task. Institutions could be perceived as the culture, the rules, the norms, the mental pattern and routine ingrained in the minds of actors including the legal regulations (Bergek et al., 2008). The component of technology is recognised as both an output of the system and a component of the innovation (Hellsmark and Jacobsson, 2009) system largely because technology stems from knowledge that resides in objects, designs, applications and software as well as in persons in institutions (Lundvall, 2017).

In this structural context, in an effort of TIS processes to develop, diffuse and utilize technology, some functions are produced (Bergek et al., 2008). These have been segregated and discussed below in line with their various functional connections with technological innovation system.

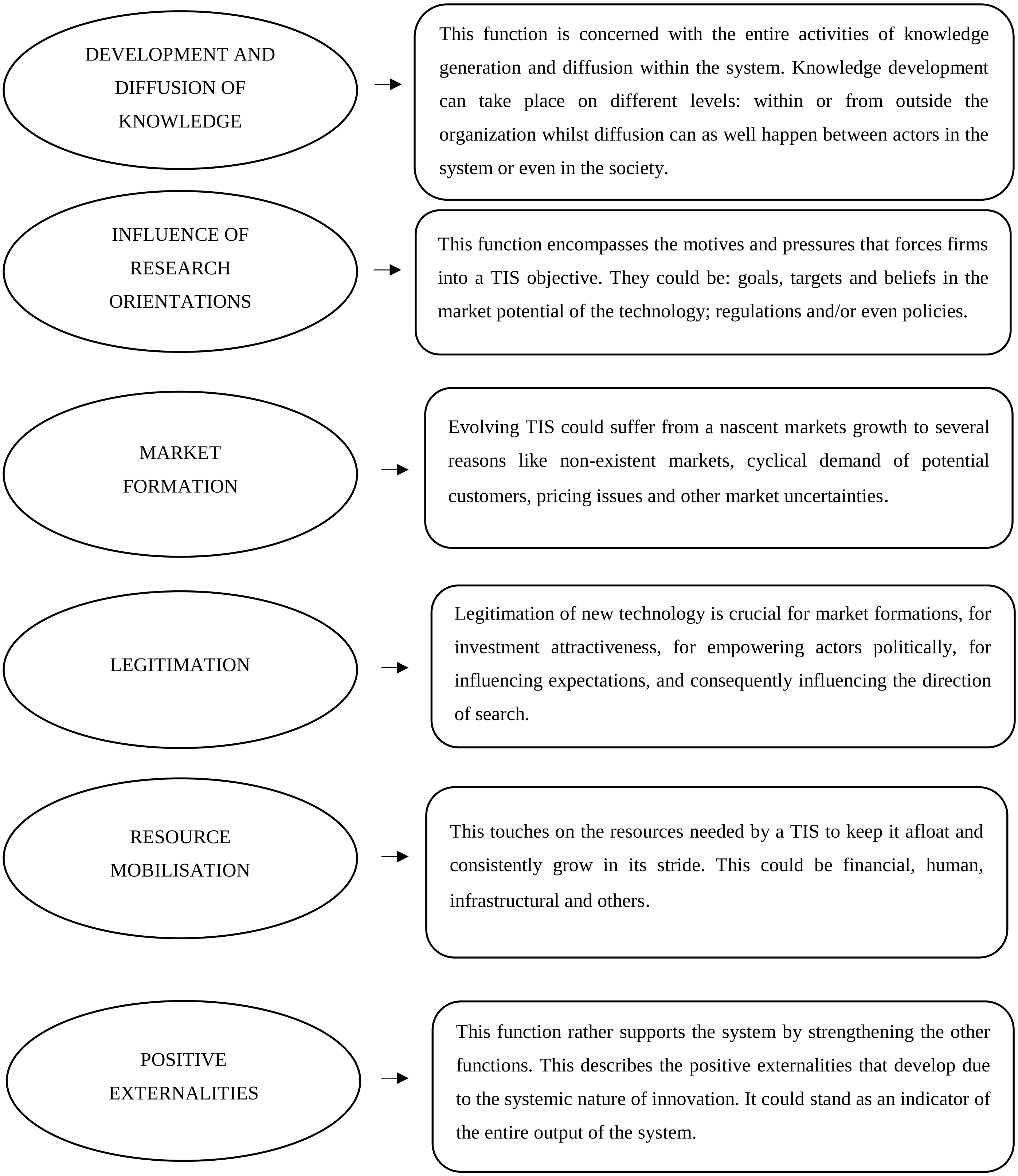


Figure 1: Functional Processes of a Technological Innovation System.

Source: Modified from the work of Bergek et al. (2008), Tigabu, Berkhout, and Beukering (2015) and Fartash and Davoudi (2012)

According to the work of Markard and Truffer (2008), the structure and functional processes of TIS are not distinct from each other but rather two inter-related dimensions of TIS. Such that, in as much the functions may appear as interactions between actors purely at the structural level, the functional processes including external factors could all affect the structural components of TIS. Designed below is the visual presentation of the TIS structure.

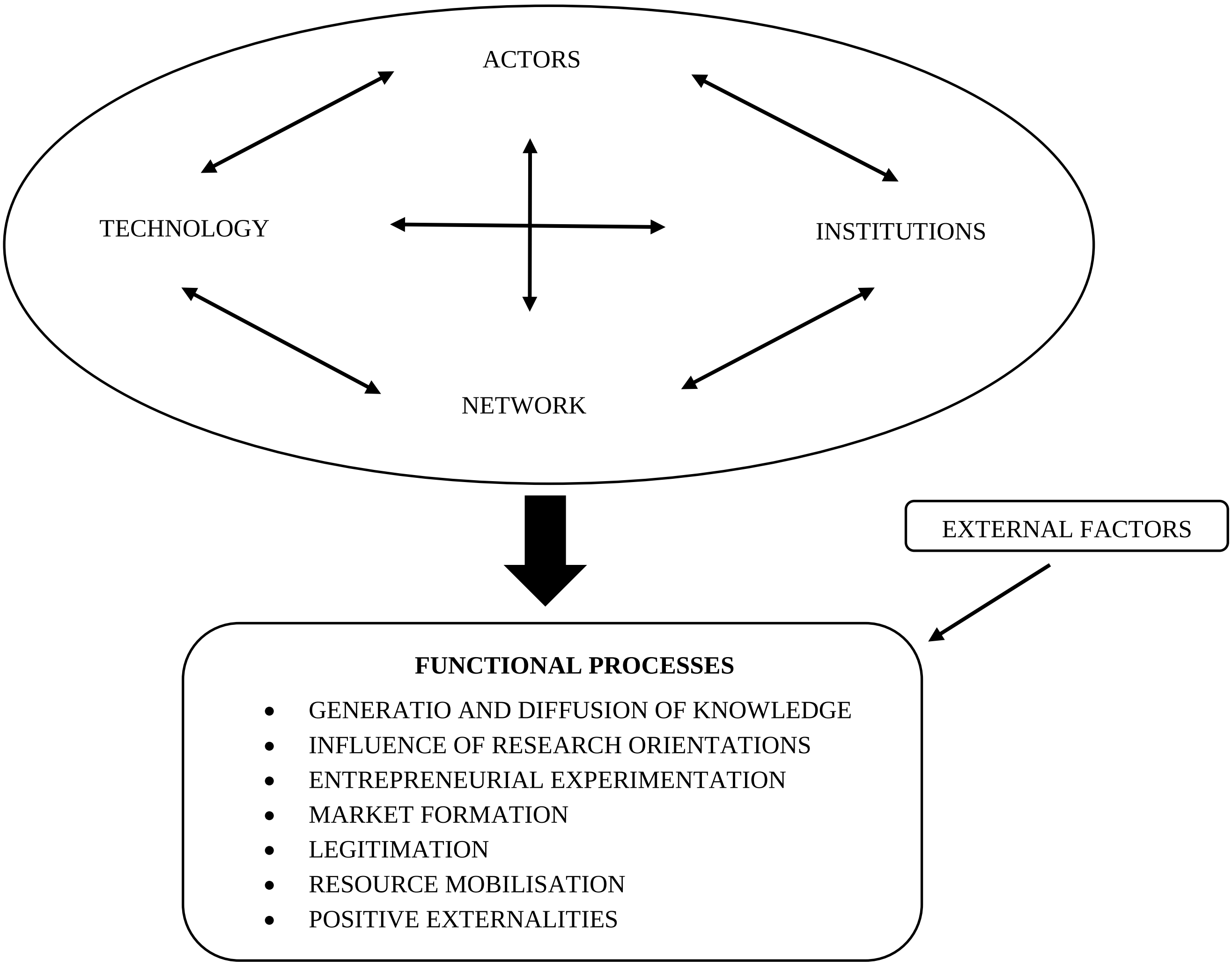


Figure 2: Structure of a Technological Innovation System

Source: Modified from the work of Hellman and Jacobsson (2009)

1.1.2. Emergence and Renewed Direction of Technological Innovation System

The **framework** of **technological innovation systems** was gradually developed as an analytical tool for analysing the emanation of technological innovation problem and to comprehend the dynamics of the systemic innovation structure, focus on specific technologies and to reveal the shortcomings, recommendations and crafted policies in support of such specific technologies. Since the introduction of TIS by Carlsson and Stankiewicz (1991), it has been argued that it needs to develop a more definitive and connective structure that could make explicit conceptual opening to the systemic connections of TIS and its other context (Makkard, Hekkert and Jacobsson, 2015). Such a framework will endow the innovation system with very substantive benefits (Bergek et al., 2015). This framework was endorsed by Makkart, Hekkert and Jacobsson (2015) also as a new area of touch of TIS whilst also re-iterating that introduction of public policies could play a vital role in the creation and recreation of new technological fields. This affirms the need for a maintained focus on legitimised support of new technologies, proper policies oriented to such, as well as progressive regulatory changes.

Such **effort to develop a definitive and connective structure** will cause an improved framework of contextual comprehension of TIS will permeate and facilitate the search for interactions between the TIS as a context and the TIS as a system (Bergek et al., 2015). They also argued that this will raise the awareness among analysts and policymakers about different variation among context and development of technology. A more explicit consideration of contexts would open up the comprehension Overt analysis of contexts would afford us a deepr understanding of the specificities of case findings whilst also providing us with a valid foundation for classifying, simplifying and conveying findings which is central to TIS-oriented policies.
Moreover, by acknowledgement that context structures are dynamic over time, affords analysts to the opportunity to identify particularly desired (or undesired) opportunities for progress of new technologies. Finally, a consistent framework that incorporates the context structures would allow for a deepened analytical work with stricter eye on the fundamnental impacts of different contexts discussed (or set of TISs) smears on related contexts. In this regard, a supplementary benefit may be to facilitate progress of a TIS-based framework which essentially assists in analysing significant changes and formation that involves growth and recession of inventios and innovations and their related transformations (Bergek et al., 2015).

In another line of thought by Makkard, Hekkert and Jacobsson (2015), the other penetrative area of TIS is the attention directed to the numerous subtle processes that defines TIS formation, such as creation of networks and coalitions, organisation of resources, (re)defining of targets and markets (Dewald and Truffer, 2011; Kukk et al., 2015; Musiolik and Markard, 2011; Musiolik et al., 2012**). This line of research has drawn multiple knowledge** from concepts in the strategic management literature as well as other actor-centred concepts in the field of policy analysis to name a few.

Finally, in one final dimension revealed, researchers have begun working towards **adapting and applying the TIS framework** to the study of socio-technological transitions (Markard and Truffer, 2008; Markard and Hekkert, 2013). Comparably, this is a nascent development area with the potential to handle setbacks like interaction of multiple TIS features and even the system decline, in the TIS lifecycle. Even though there has been identified overlaps with the literature (Makkard et al., 2012) on sustainable transitions and lifecycles of industries (Anita, Nicolas and Joel 2004) there is the strong expectation that with the systemic foundations and multiple context structures involved in TIS framework, it can entrench itself as key framework for analysis and study of innovation system.

Having also known the systems and actors and contexts that drives technological innovation system to creating technologies to solving societal problems, it is imperative to **identify and assess** the modern factors and how they contribute to the generation of these.

1.2. Contemporary Indicators of Modern Technological Innovation

The concept of technological innovation system (TIS) has developed as variety of stakeholders had be continuously consulted and the range of beneficiaries equally widened across the sphere. With time, the relevance of these structures has been almost difficult to ignore and hence, regional stakeholders have had to align these diverse structures integrate to cohesively work together to contribute to the generation and effective dissemination technological innovation. These structures are discussed and presented below.

1.2.1. Research Systems

In recent times, intellectual capital has been highly revered as a very significant source if not a measure of economic performance (Dženopoljac, Janoševic, and Bontis, 2016; Cleary and Quinn 2016; Sharma and Dharni, 2017). Traditionally, most countries had been looking at the impact of land, labour, capital and entrepreneurship as factors determining the economic performance, 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 systems have been lauded as a **catalyst for expediting technological innovation** and a crucial facilitator of the creation of a stronger knowledge network. The European Union focuses on this as a key indicator of researcher's international openness and the attractiveness of the research arena to externally interested and relevant stakeholders. According the European Innovation Survey (2019), research systems includes three indicators which measures the international competitiveness of the scientific activities by analysing International scientific co-publications with other authors, the most cited publications, and also international students all of which are key to knowledge contribution of the scientific research society, diversity of views and international acceptability of research reports as well.

In terms of knowledge and research publications, several research have tended towards the need for firms **to protect their knowledge** when they decide to adopt open innovation (Cassiman and Veugelers, 2002, Heiman and Nickerson, 2004) as this is a means that both competitors and external parties gains access to relevant firm information which would otherwise be only accessible within the firm's intranet. Kwiek (2015) researched on 11 European Union member states to reveal the influence of collaborative research on research productivity. 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 how collaborative research affects scientific productivity. They found contrasting results that revealed that collaboration was a strong predictor of publishing productivity. When the measure of publication productivity was switched to 'fractional count' considering the number of co-authors, collaboration and productivity of publishing were found not to be significantly related when they controlled for moderating variables. However**, in a practical sense,** not all persons are moved by strength of the research 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 a **strong research system** 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 capital research personnel.

1.2.2. Financial Cradles

Financing schemes have largely proven to be a strong initiator and/or catalyst in the creation of innovators- product, process, marketing or organisational innovation- (Seiffert and Chattaraman, 2017) and extensively, in the creation and generation of technological innovation- patents, trademarks, sales and design applications (Kerr and Nanda, 2015).

Efforts at the generating innovators has largely been proven to affirm the recurring essence of public and private funding schemes on creation and generation of intellectual capital and cooperation. Research on Slovak countries show 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 (Henry Junior and Odei, 2018). This could also be explained by the result of Teirlinck and Spithoven (2012) who found that financial support provided by the EU did not have an impact on the creation or facilitation of industry-science cooperation. They explained that may happen because EU funding is oriented at firms that are already engaged in cooperation and it is not supportive to 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). Furthermore, in Central and Eastern European countries (CEE) public funding of research and **regional innovation attempts** have largely contributed to the national and subnational innovation-oriented schemes. Their financial and regulating capacity have allowed them to ensure transparency, accountability in the innovation cycle has consequently eased off acquisition of public and private funds as well.

Impact of funding for regional players have also garnered different perceptions from multiple researchers. Lundvall (2010) keenly pressed on the essence of direct funding to this as it is the foundational point of international competitiveness. Dodgson, Hughes, Foster and Metcalfe (2011), in his research, also talked of the public sector as financial contributor to private firms and concurred with Fehr, Rosenborg and Wiegard (2012) on the need for capital funding that are tailored for small and medium sized enterprises. This, he believed, will allow innovative new firms to introduce socially useful products to their market niches.

On the aspect of innovation support on firms in a region, Kang and Park (2012) both direct and indirect connection of financial support on the innovation output of SME's in biotechnology when they biotechnology enterprises. On the other hand, **in Finland,** funding from the public sector raised efforts oriented at innovation in private firms that received the funding (Cnarztitki and Ebersberger, 2013). He also found funding, on average, increasing the innovation output of firms, however, this sort of support was rather at its peak of efficiency when meant to stimulate collaborative innovators via collaboration. In the academia however, Funding efforts in the education system in Bulgaria for instance, was found to be largely inefficient when public schools were compared with private schools (Tochkov and Nenovsky, 2011) prompting questions of control and adequate accountability enforcements.

1.2.3. Human Capital

Most research on human capital and performance has arguably shown that **effective human capital management** is an influential factor to organizational innovative performance and productivity (Combs, Liu, Hall, and Ketchen, 2006; Jiang, Lepak, Hu, and Baer, 2012;) notwithstanding the direction of its assessment whether from a universalistic perspective or from a configurational perspective (Boxall and Purcell, 2003). 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 and Sanz-Valle, 2016).

According to Seeck and Diehl (2016), this assumption above reflects two dimensions of the influence of human capital on innovation- the best practice approach which asserts that firms will improve their innovative output if they incorporate certain preferred 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-Jimenez and Valle (2008) assessed one hundred and seventy-three (173) Spanish manufacturing firms to analyse human capital effect on innovation. The findings rev4ealed that innovation positively contributes to productivity measure of businesses and that HRM enhances firm's patents generated for innovation. Liu (2014) also researched on the influence of human capital of inventors on the decision to keep or discard a patent. The results showed that having high class inventors or more coinventors and having inventors from diverse locations significantly improved the possibilities of renewal of patent. Additionally, the more co-inventors one has the more it moderates the influence of star inventors on renewal of patent.

Saa Pérez and Diaz Diaz (2010) in an empirical study assessed 157 firms in Canary Island and concluded that extreme commitment to an effective human resource management (HRM) had a direct 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 is 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 directly connected to improvement in human development when investors from external sources are prevented from ventring into some economic sectors by FDI policies and when it acussed to discriminate against external investors (Reiter and Steenma, 2010). In addition, it was also found that low level of corruption also strengthens the relationship between FDI and human development. This has **left little knowledge** about how the diverse human capital or even excess of it is a propels regional technological innovation objectives.

1.2.4. Cooperation

Strategic management literature affirmed that knowledge acquisition and cooperation from various stakeholders are valuable resources of the firm this competitive era chiefly for innovative reasons (De-faria, Lima and Santos, 2010). The concept of open innovation has admonished firms to create and maintain networks and enduring relationships among agents such as customers, Universities, research institutions to support internal capacities for innovation (Laursen and Salter 2006; Dachs, Ebersberger and Loof, 2008). Sanchez-Gonzalez and Herrera (2014) assessed how innovation tendencies are affected by customer-oriented cooperation and found that customers pushed these firms to raise investments levels oriented to expanding the base of technological knowledge. This consequently also revealed that cooperation positively affected the economic returns from marketing innovations essentially ramping up their competitive edge (Franke, Keinz, and Schreier, 2008; Von Hippel, 2009).

Based on the above discussed literature, the endorsement of funding supports posits it as a significant mediator to the contribution of cooperation to creation of innovators even as there are some held rejections (Bozeman and Gaughan, 2007), the author is of the notion cooperation of firms and persons should effectively support the technological innovation environment, however, we also hold **strong reservation** on the grounds that extreme differences in social and cultural background could be strong impediment to the technological innovation network. This seems to be very much the case in the European Union with twenty-eight (28) different nationalities and almost different language and social background for every other member state.

1.3. Regional Attractiveness for Innovation and Foreign Direct Investments

Extant literature have revealed the **varying degree** of foreign direct investment (FDI) in this globalized economy (Wang, Ning, Li, Prevezer, 2016; Ascani and Gagliardi, 2015) the preferred location choice of foreign direct investment (FDI) (Nielsen and Asmussen, 2017) and regional conditions (Smith and Thomas, 2017). Most researchers consider foreign direct investment (FDI) important element in their quest for economic development due to its obvious representation of capital consolidation, marketing, and management and technology (Kokkinou, Aikaterini, Psycharis, Ioannis, 2004). The Innovation Systems approach portrays economic milieus in geographically constrained territories in which regional stakeholders are supposedly positioned in a dynamic way to influence regional innovation capacity. In this regard, FDI must can be hardly argued as a crucial agent of interaction and integration even between open innovation systems. FDI has been realised as an enduring and sensitive player to achieving national growth, technological progress and also facilitate knowledge transfer. The chief drivers of these resources have been multinational companies not only as initiators, but rather as recipients of many kinds of technological and knowledge spill-overs. In as much as it presents transforming benefits to firms and regional competitive advantage, it has equally drawn strong competition in terms of regional assets and structures to attract these investments.

According to Shatz and Venables (2000) firms would like to invest in foreign ventures for two main reasons: first is to be well equipped to serve the local market. This usually happens in "horizontal" foreign direct investment and it usually involves duplication of market productions plants to occupy market share potentials untapped, to economise on national tariffs and transport costs. **Secondly, to gain access to lower costs inputs, firms tends to engage in "vertical" or production cost-reducing** FDI to maximize the profits accrued in selected production area (Popescu, 2014). A case in point is the introduction of foreign companies like AT&T Global Network and Services and Oracle in Czech Republic as well other call centres in the Central part of Europe. These centres largely occupy the customers handling procedures which would cost relatively much higher to finance in the home countries. Openness of an economy represented by exports in GDP showed an outstandingly strong influence on the final FDI inflows.

In the CEE e, the markedly **different socio-economic and cultural conditions** is also another attractive factor for FDIs (Popescu, 2014). FDI flows from the developed Western and transition economies is largely initiated by unit labour costs, national economic conditions and locality in question. The accession process of the European Union morphs member states into the generally preferred social conditions, economic performance and preparedness status declaration about calendars for admission to the EU enhances degrees of FDI to the possible members. The attractiveness of the CEE economies for FDI is vindicated by the macroeconomic position of these host nations and by the macroeconomic changes in the Eurozone. Reasonably, if external firms are too similar to domestic firms, it would produce an economically unattractive venture for the investing country and hence irrational decision. Despite this, for the CEE countries, it is believed that their potential accession or accession to the European Union is a good confidence spike of investors in these regions. However, this was even exacerbated after the credit crunch in 2007 allowing a larger room for potential growth for member states. This can partly be credited for the observed quick growth rate of the newly acceded EU countries like Czech Republic, Poland, Croatia. Not taking away the role played by spill-overs from the Western and highly innovative member states. Additionally, gains forecasted will be more relevant if invested expenditures are less sensitive in the host economy than in the source country (Bevan and Estrin, 2004).

However, FDI have had positive but quite unstable when assessed with 2013 as the base year in the European Union. Back in 2006, a European Commission report captioned ‘How is the internal market integration performing?’ showed a low level of foreign direct investment (FDI) into the service sector. Even more sensitive is that fact that it formed the largest part of EU’s gross domestic product (Eurostat 2018). Even though it was set to, the performance levels have not improved in terms of stability and absolute terms from Figure 3 below. This can be understood as a low interest in mergers and acquisitions, or possibly too similar and hence unattractive for potential mergers or perhaps not so bright growth potential. This could really be a useful revelation particularly in light of the generally and relatively low venture capital investments.

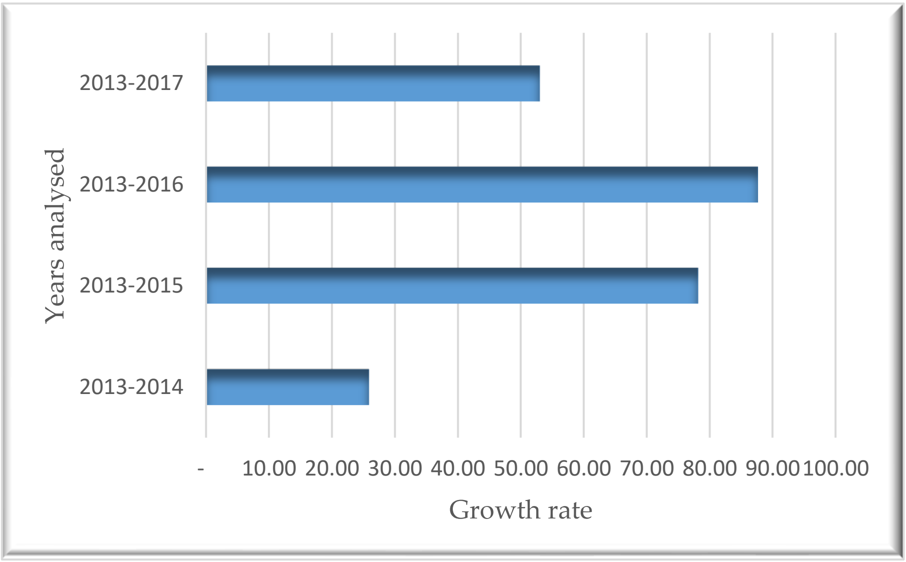


Figure 3: Inward Foreign-Direct Investment Flow into The EU as A Percentage Of GDP Compared with Base Year 2013

Source: Author's own calculation using data from Eurostat

Notwithstanding this, the 2019 innovation performance report shows the European Union recorded an increased innovation performance in 25 countries with Sweden at its helm and has also surpassed the United States in terms of innovation performance for the first time whilst also entrenching a considerable lead over Brazil, India, Russia, and South Africa. Nevertheless, this presses for a keener assessment of the innovation initiators in the Union to harness the potential the market with almost 500million persons and to keep pace ahead of Chinese innovation growth which is statistically three times faster than that of the European Union.

1.4. Innovation Indicators' Contribution to Regional Innovators

Several discussions in the recent times has portrayed innovation as a significant variable in the growth of regions (Buesa, Heijs and Baumert, 2010). As most authors from different study backgrounds such as social sciences, economics and even geography have assessed the influence of innovation tendencies and innovation itself on economic growth. Various authors from diverse studying backgrounds, such as economics, geography and others have examined the effects of innovation on economic growth, the potential factors that spurs the production of innovations, as well as its geographic distribution and knowledge spillovers (Audretsch and Feldman, 2004; Tavassoli and Carbonara, 2014). Most of these studies showed a direct influence of firm innovation activities and entrepreneurial opporutnies on, growth of regions (Rosenthal and Strange, 2003) whilst some studies also added how diverse and complementary economic activities supports innovation in a spatial economy (Audretsch and Feldman, 2004). Innovation can be demonstrated in various forms depending on the output of the firm -whether they are service oriented or product oriented (Lopez, 2008). The variation in these innovation forms also presents several measurement methods such as patent counts, research and development intensity and sales of new output (Acs, Anselin and Varga, 2002; Buesa et al., 2010). To select the driver of innovation, some researchers resorted to the creation and diffusion of knowledge as an end product (Franco and Oliveira, 2017). They also posited human capital, level of business sophistication, research output and specialization of market as real drivers to innovation. Other researchers also looked at the direction of expenditure (Lundvall, 2017)

As part of a national developmental efforts to develop, such developmental inputs are provided to firms (Cassiman and Veugelers, 2006). **Non-material inputs** have been mentioned as **important** requirements for facilitating innovation. They range from learning activities, knowledge transfer, interaction among firms and proximity. Prompting research on regional proximity have also showed the need for support for creation of clusters and the reliance on regional proximity to expedite information dissemination and spatial knowledge diffusion (Oinas, 2017). However, Boschma (2005), **on the contrary**, expressed concerns about creating and extensively relying on geographical proximity among firms. He insisted this could results in “lock in” consequently affecting knowledge processes and interactive learning thereby rendering investments in clusters and cooperation largely unproductive. Regarding the use of material inputs, firm management of these investments was deemed a sensitive factor for appropriating outputs from such inputs (Darroch, 2005). Some authors also rendered organizational culture as significant to affecting the density of connections among innovation-oriented cooperating firms (Laursen and Salter, 2006). Potentially, depending on the management of these factors, this could adversely influence learning outcomes and innovative tendencies of firms, their competitive advantage and technological innovation (Calantone, Cavusgil and Zhao, 2002).

1.4.1. Product and Process Innovation

According to CIS (2014), product and process innovation is used to represent any new or significant change to products or processes of a firm. Owing to their different output objectives, different factors may oppress or spur their occurrence tendencies and it is imperative to reveal which factors affects these innovative potentials. Using a panel data from (2004-2012) from

PITEC about Spanish Knowledge intensive firms, the determinants of innovation for the technology-oriented innovation, i.e. product and process innovation and non-technology-oriented innovation, i.e. organizational and marketing innovation were assessed. It was found that cooperation, research and development, intramural expenditure and size as the **main determinants** of innovation among the Spanish firms (Alarcon, Aguilar and Galan 2019). Their findings revealed that for knowledge-intensive firms that cooperate, increases their chances of creating technological innovation more than four times (4) times. In the case of non-technological oriented firms, their chances raised more than double after they initiated cooperation. Edquist (2011) the relationship between R&D and innovation is highly complex and is potentially even moderated by public investment in R&D.

Furthermore, Pegkas, Staikouras and Tsamadias (2019) researched on the research and development expenditure investment in the European Union from (1995-2014). Their findings revealed a direct and significant influence of finance and support for R&D on innovation; however, business R&D sector was found to have the much higher effect on technological innovation. These results offer strong reasons for the need to strengthen cooperation among public, private and businesses and also ramp up partnerships even between competitors. Even more imperative is collaboration with various external factors such as research institutions, suppliers and customers. According to literature, this is expected to improve knowledge sharing from various knowledge sources, widen the firm's knowledge base and consequently advance firms' technological innovation potential (Clauss and Kesting, 2017).

To add up to this Najafi-Tavani, Najafi-Tavani, Naudé, Oghazie, Zeynaloo (2019) also researched on the direct connections between collaborative innovation and product and process innovation. Their finding suggested that advanced collaboration with different partners tends to influence different firms' innovation potential. However, this could only happen if firms develop the capacity to detect and reach out to external knowledge sources. **In further detail,** these authors also found that product innovation was more sensitive to collaboration of research institution and competitors whereas in the case of process innovation, it had a higher sensitivity to supplier and organisational collaboration.

Another factor assessed and affirmed by other firms as relevant to product and process innovation occurrences is Human capital. Innovative Human Capital is a crucial concept to analyse in the preparation of innovation-oriented policy programmes. According to McGuirk, Lennihan and Hart (2015), **human capital concept** encompasses features like training, education, willingness to change in the workplace and job satisfaction. They researched on human capital by estimating the innovative human capital influences on firm-level innovation. Evidence from their findings show that innovative human capital was more essential to small firms with less than fifty (50) employees especially in the variables of “training” and “willingness to change”. This supported their hypothesis and buttresses the significance of Human capital for firm innovation (Capitanio, Coppola, Pasucci, 2010).

Cooperation or collaboration has also been proven to be a strong determinant of product and process innovation in firms (Capuano and Grassi, 2019) and countries (Robin and Schubert 2010). An evaluation of the of cooperative impact within public research institutions on firms' innovative activities revealed that in France, High-tech and High-/Medium-tech manufacturing industries were more likely to cooperate. On the other hand, when Germany was analysed the likelihood to cooperate public research institutions is was found to be statistically insignificant across different across sectors, baring Low-tech manufacturing industries. It was also found that cooperation tendencies in public research institution statistically was significant in generating process innovation. Notwithstanding the measurement criterial used the degree of increment was twice more in Germany than in France. Their results further unveiled that cooperation returns for process and product innovation were relatively higher in Germany than France relatively. are higher in Germany than in France, not only for product, but also for process innovation. Furthermore, Wu (2014) also assessed the connection between coopetition, product innovation and how they were moderated by firm-specific technological capacities and alliances with Universities and research institutes. Results revealed an inverted U-shaped relationship between coopetition and successful introduction of new products. Additionally, strong technological capability and collaboration with universities or research institutes rather negatively moderated the relationship between co-opetition and the success of product innovation. This could be held to be the case due to studies being conducted on cooperation among socially common background rather whole units with different experiences.

1.4.2. Organizational and Market Innovation

Marketing efforts and organisational cultural set ups have been recognised **as an influential factor** that drives firm product and process innovation (Anzola-Román, Bayona-Sáez and García-Marco, 2018). Marketing innovation refers to “the implementation of a new or significantly improved marketing method, concept, or strategy, such as a new way of advertising or promoting tourism products or offering alternative tour packages" (ABS, 2013). According to literature, Nieves, Gonzalo Diaz-Meneses (2016), marketing innovation is driven by factors of competitiveness that are initiated by learning and knowledge exchange. **Innovation in service sector** is usually more marketing and organisational oriented whilst innovation in product sector usually relates to products and process enhancements. In a study conducted in the Hospitality industry, they established that garnered knowledge has a positive effect on new marketing and sales channels created and also had an indirect influence through absorptive capacity. Additionally, the impact of the knowledge held by individuals on marketing innovation is only exhibited through the inherent potential of firms and the absorptive capacity of firms engaged with such intentions. They also indicated that marketing innovation even had direct influences from product, process and organisational innovation forms as also buttressed by Divisekera and Nguyen (2018).

According to literature, **collaboration of firms and** personnel has been posited as a strong factor in the creation of marketing innovation (Divisekera and Nguyen, 2018). In a study conducted by Backman, Klaesson and Oner (2017), on over 900 Swedish firms, they concluded that the factors that affect firms' marketing innovation tendencies are more tended towards inherent firm features rather than external firm features. They also revealed that collaboration had a positive influence on firms' marketing innovation as revealed by Dyer (2000) as well. A study conducted in the food processing industries in Italy also revealed that collaboration with other actors in the innovation pattern, like suppliers and customers also represent a familiar underlying feature of all SMEs that innovate.

As also noted in the literature, presence of relationships between firms do not nurture their innovativeness, but also the stakeholders involved in the collaboration exercises that influence the firm's innovation objective (Minarelli, Raggi and Viaggi, 2015). They added that horizontal collaboration looked to have a strong impact on the achievement of process and marketing innovation and even on business models. However, this was contrary to the studies of Tether (2002) as he believes the relationship was more meshed than direct. In the context of organisational innovation studies conducted by Laforett (2016). his findings reveal that an authoritarian organisational culture type does not have a positive effect on family firm innovation performance, however, an exogenously oriented and more open culture and long-term oriented. Similarly, an internally focused culture such as, the founder culture was found to inhibit innovation; while an externally focused culture like external orientation culture positively influences family firm innovation performance (Laforett, 2016).

Investments in marketing innovation also offers a significant influence on marketing innovation tendencies. Innovative product design, improved packaging, promotional pricing and innovation distributional strategies can be an essential initiator of new product even if the new products are not based on technological innovation. Investments in sales channels and product design possessed the same potential to create superior innovation performance as financial commitments do. It is believed that the influencers of marketing innovation are like factors influencing product and process innovation. This could be said to be true as research by Divisekera and Nguyen (2018) on marketing innovation reveals that collaboration, size of firms, tehnology infrastructure, financing and market competition directly affects marketing innovation in the tourism industry. Figure 4 below will best reveal the influential marketing innovation factor and how they affect the innovation chart.

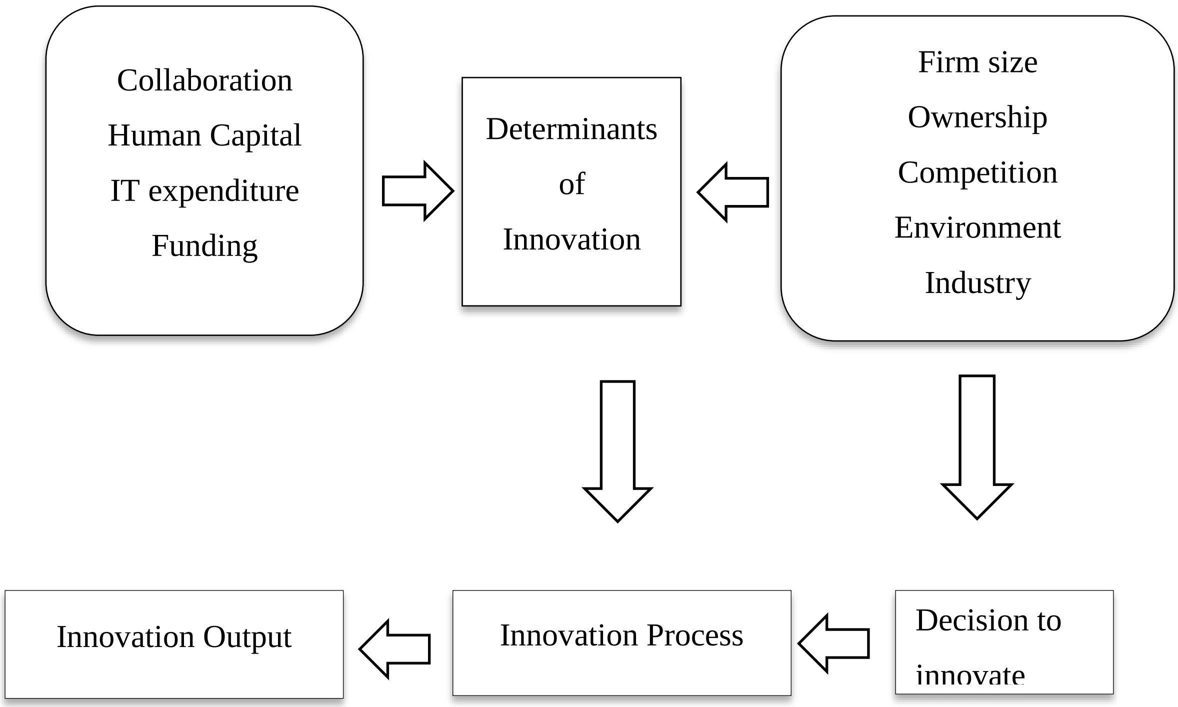


Figure 4: Influential Variables affecting Firms' Marketing Innovation.

Source: Author's own design created from the work of Divisekera and Nguyen (2018)

Regarding organisation innovation, this quest is fundamental for companies that are overcoming strategic hurdles since they culminate in bolstered performances in organisation's management. This is represented by changes or newly proposed organisational method especially in relation to workplace structures, personnel attitude internal and even exogenous relationships with suppliers, customers and other relevant stakeholders (Ganzer, Chais and Olea, 2017). Workplace practices that drive learning, absorption capacity and knowledge sharing, and employee cooperation all hinges on the structure of organisational set up.

Despite these catalysts for innovation, there are several factors as well that inhibits the seamless functioning of the innovation “wheels” in SMEs and large multinational enterprises (LME) essentially inhibiting the competitive urge or regions as well as other productive entities (Coad, Pellegrino and Savona, 2015). Ranging from financial, structural to legal, these factors will be assessed considering their emanative locations, key areas affected and their sectoral touch as well.

1.5. Barriers to Synergetic Value Creation for Innovation

Barriers to innovation may arise from **endogenous or exogenous** threats to the firm (Weenen, Fernald, Pronker, Commandeur and Classen, 2013). They may also be grouped according to how they are perceived by firms, resulting in the endogenous and exogenous categories. Endogenous barriers may arise usually due to unwritten organizational dogmas, availability of technical expertise, or human-related barriers e.g. risk-adverse top managers. Conversely, it could also be assessed considering the sector-difficulties- academia, SME, Government. For the sake of this research, both dimensions will be adopted in classifying the heckles that derails the innovation in its track.

In the academic sector, research has revealed web of social, human and economic issues as affecting the innovation platform of these institutions. Lately these institutions have quickly expanded, which has tremendously warped the nature of higher education. It has been reported of a rise in the number of international students and expansion of research collaboration thus Higher Education institutions have expanded and become increasingly competitive in the United Kingdom for instance (Lašáková, Bajzíkováa and Dedze, 2017). Results of a study of ten European Universities revealed that a certain disconnection in relation to higher education institutions and the practical policy creators, firms, and students and in some cases managers and their subordinates. They also identified nepotism, **transparency issues, corruption,** instability of economic regimes, inflexibility, issues of trust and poor collaboration as strong inhabitants to innovation in the education sector (Lašáková, Bajzíkováa and Dedze, 2017). Further studies of 172 universities across all continents revealed that the **main barriers** against sustainable innovation lied with management of the university, the administration and environmental committees in some cases (Ávila, Leal Filho, Brandli, Macgregor, Molthan-Hill, Özuyar and Moreira, 2017)

the deployment of innovation and sustainability tend to be connected with management (i.e. the university administration, environmental committees, the introduction and/or support of management systems; management in terms of policy and formal guidelines)). **Other barriers** to this can also be connected to classified as largely technological and issues with resource endowments**.** However, the authors opined that eliminating these barriers, without active handling of issues associated with the management, this will only amount to very little progress in this quest.

Furthermore**, human capital limitations** have also been raised as a deterring factor to innovators in Small and Medium scale Enterprises despite their low impact on cost of production. In the petrochemical industry, inadequacy of personnel and time is a general barrier to improving any kind of existing process. Looking at employment in chemical industrial sector in the United States for instance, it was reduced by 4% during 1994–2004 (CEN, 2005), despite the long held and unreasonably low labour cost of 1% of petrochemicals production costs (Burchmore et al., 1993). Although we value the essence of highly skilled and motivated personnel as primary success factor for innovation (Brentani, 2001; Orfila-Sintes Mattsson, 2009; Grissemann, Pikkemaat, and Weger, 2013), fluctuations in demand caused by seasonality of the employment status and comparatively low wages could cause a countless of issues with human capital, low forman education levels (European Commission, 2019), skill availability issues and key personnel availability (Howells and Tether, 2004), are the causes of low absorptive capacity. In a slightly different dimension of human capital deficiencies, in the tourism sector in Spain revealed that lack of knowledge in different areas including business management and administration, management of human resource, project management, and the intent to cooperate deeply affected the innovative tendencies of the SMEs in this field (Birgit, Mike and Chung-Shing, 2018).

Insufficient research funding and unfriendly environmental innovation environment affects were also strong factors revealed to affects firms within the European Union. In the chemical industry for instance, the results from the Community Innovation Survey (2014) revealed the top three barriers to developing new processes were: lack of research funds, structural or industrial barriers and pressures to conform to environmental friendliness. This could also be held to be a deterring factor for huge sources of support provided by even the regional and public authorities. Essence of funding cannot be underestimated when innovation is under consideration (Hashi and Stojčić, 2013; Lundvall, 2010; Glennon, Lane and Sodhi, 2018).

Lastly, research conducted on twenty-eight thousand (28.000) SMEs in the UK using Community Innovation Survey (2002-2010) revealed that demand-side factors, especially **market concentrated** and insufficiency of demand, were as crucial as financial factors in facilitating innovation failures. This evidence throws more light on other barriers by considering demand deficiencies, market set ups and legal and regulatory factors that contributes to diminished firm innovation performance (Pellegrino and Savona, 2017). They also found also that firm innovation tendencies is significantly restrained by regulatory interventions.

Hence, in comparative terms, it could be **concluded** that financial heckles are equally influential as market factors influencing innovation (performance) success but are more influential than regulatory factors. Table 1 below, however, delineates the key issues driving these innovation barriers, sectoral impacts and their further delineations.

Table 1: Delineations of Barriers to Innovators.

Factors	Factor delineations	Classification	Key factor Problems	Causes	Authors
Cost factors	Excessive perceived economic risks	Exogenous	Insufficient finance	Small firm size with limited finance Limited funding from government	(D'este, Iammarino, Savona and Tunzelman, 2012; Coad, Pellegrino and Savona, 2016)
	Direct innovation costs too high	Endogenous and Exogenous			
	Cost and availability of finance	Endogenous and Exogenous			
Knowledge factors	Lack of qualified personnel	Endogenous	Resource deficiency and trust issues	Lack of trust among employees, between firms in an industry or poor relationship with users of the product.	(Howells and Tether, 2004; Cooper, Lichtenstein and Smith, 2006; ECORYS, 2009; Cordeiro and Vieira, 2012; Mistilis and Gretzel, 2013)
	Inadequate information on technologies.	Endogenous and Exogenous			
	Inadequate market information	Endogenous and Exogenous			
Market factors	Inadequate market information	Endogenous and Exogenous	Information deficiency	Demand deficiency which caused by poor target marketing or market barriers to entry.	Seiffert and Chattaraman (2012)
	Uncertain demand for innovative goods/services	Exogenous			

Regulation factors	Need to meet UK Government regulations	Exogenous	Unfavourable Regulations	Political instability and unfavourable or, unprotective policies for locally innovative firms.	(Zhu, Wittman and Peng, 2012; Michailova, McCarthy and Puffer, 2013)
	Need to meet EU regulations	Endogenous and Exogenous			
Personnel constraints	Unavailability of quality personnel, Insufficient and limited training materials for personnel		Turnovers	Limited essence of traditional career paths, low motivation to learn and innovate, low absorptive capacity, limited technical expertise,	(ECORYS, 2009; Shaw and Williams, 2009; Scott, 2013; Mistilis and Gretzel, 2013)
Resource endowments	Technical limitations, lack of technology or compatibility among technologies	Endogenous and Exogenous	Resource constraints	Unavailable technical personnel or poor security structures to protect or spur technical growth.	(Howells and Tether, 2004; Mistilis and Gretzel, 2013)
Infrastructural	lack of a developed infrastructure, imbalanced innovation environment	Endogenous and Exogenous	Resource constraints	Poor financial endowments or unavailable or insufficient firm resources committed to infrastructures	Jabbouri, Siron, Zahari and Khalid (2016)

Source: Author’s design modified from the work of D’este, Iammarino, Savona and Tunzelman (2012) and Najda-Janoszka and Kopera (2013)

1.6. Regional Differences in Innovation Indicators' Contribution

Differences in regional innovative performance may stem from multiple firm factors endogenous and exogenous as well. It could even be exacerbated by region specific resources or even firm endowed limitations (Griffith, Huergo, Mairesse and Peters, 2006).

According to a research by Griffith et al. (2006), in France, information sourced from competitors were very strongly significant to the generation of process innovation of firms unlike in Germany and United Kingdom although it was weakly significant in Spain. This could conveniently point to cooperation diversity and a well-harnessed relationship with an admirable level of trust among competitors. Although this might not mean that it is non-existent in the other countries mentioned, it is evidence of relevant information for contribution to firm and regional innovation needs.

Furthermore, **in a study conducted on OECD countries**, it was recorded that **impact of the export intensity** is significantly positive to all countries assessed (Blind, 2012). Obviously serving customers from abroad gives opens firms to diverse ideas and information however, even more important as well is the degree of openness of an economy which cannot be overestimated. The Human Development Indicators developed by the United Nations consistently reveals that both more active feedback from users and obviously a highly educated workforce are influential for the innovative performance of OECD members countries. Therefore, the degree of education, the degree to which lifelong learners are engaged in the innovation chain and their effectiveness and efficiency also strongly affects the innovation performance of countries assessed as well.

In another study which took on a social dimension, using confirmatory factor analysis, a study was conducted on the **cultural significance of countries** on their innovative performance**.** Results revealed that in line with Hofstede's (1980) four cultural variables used, these four variables were all significant to the innovation performance of the countries assessed.
Attemps to evade uncertainty and display masculinity have been shown to strongly affect innovate negatively. Power distance was also revealed as restraining factor especially on the innovation inputs but not on the outputs.
Uncertainty avoidance and masculinity was revealed to have a strong negative relationship with all innovation indicators used. Power distance though was negatively related to innovation. Even as team worked is deeply admired to cause cooperation, individualism was also found to

be positively related to innovation outputs. Although, these are not all the studies conducted on regional innovation differences, culture, educational structure and financial endowments can conveniently be pointed out as relevant factors that determines the performance or even as a catalyst for an expedited or much improved technologically innovative performance.

1.7. Connection of Innovators to the Creation of Technological Innovation

In capitalist economies, it is an open secret that economic development is largely moved by technological innovations, which occurs through a dynamic process of “creative destruction”. In this regard, innovation iss presented as a novel born from the death of an already existing technology rendered obsolete by new societal issues (Fritsch, 2017). This ideology has led on to the struggle among firms and regions to consistently innovation in various forms- product, process, marketing and organisational wise.

Considering the new innovation system of technological innovation, questions have been asked **whether the measure of patents applications**, trademarks and design applications are actively determined by these aforementioned innovators. For instance, some authors are of the view that organisational innovation is predominantly culture oriented and strongly tends towards affecting actual product innovation and not directly on patent or trademark generation in itself (Tether, 2002) whilst there is already little research on innovators- product, process, marketing and organisational innovation- on patent, trademarks and design applications.

Nevertheless, recent studies confirm that internal and external innovation sources positively influences organisational innovation in an effort to generate technological innovation. confirmed the results confirm the existence of positive effects of internal R&D and externally sourced innovation practices, as well as a positive influence of organizational innovation on the realization of product and process innovations (Anzola-Román, Bayona-Siez and Garcia Marco, 2018). In their study, they pointed out these external and internal connection as having a moderating effect on the probability of occurrence of these technological innovation

On the other hand, based on a sample of Benelux and Community trademarks, it was found that brand trademarks were more connected to product innovation. Additionally, they also found negative effects of a trademark’s industry scope on its connectedness to product innovation, and also of trademark’s geographic scope to service innovation (Flikemma, Castaldi, De man and Seip, 2019). Despite these results and its wide acclaim, heavy reservations have been held by multiple researchers on the use of the trademarks and patents as relevant measures of technological innovation (Pakes and Griliches, 1980; Acs, Anselin and Varga, 2002).

Patents, Trademarks and Design applications

Technological innovation for some researchers represents the end-product of experimental development (Grupp, 1998) while others see it as the prelude of diffusion of technological innovation itself (Grupp, 1998). Most nations in contemporary times have resorted to the active generation of it as a reliable success ladder to raise their competitive advantage. However, technological innovation on its own is no guarantee of business or economic success. There is the need for technological innovation to be merged with the business model of firms which expertly revels the target market and value capturing strategies to enable firms harness the entire value of it (Teece, 2010). Firms without properly structured technological innovation support has a high tendency of leading to the (self-) destruction of creativity of enterprises than to a viable creative destruction.

However, patents have largely been used as a measure of technologically innovative capacity in most studies (Alcacer and Gittelman, 2006; Buesa et al., 2010) and have also been consistently argued as inadequate in covering all innovations. The foundations of this argument were laid by Hall, Jaffe and Trajtenberg (2001) who asserted that in as much as patents were useful measures for creation of new technologies, they were handicapped in measuring the economic value of these technologies. Patents were also argued as a faulty measure of technological innovation owing to the claim that not all new innovations are patented and that patents differ significantly in their economic impact (Griliches, 1979; Pakes and Griliches, 1980).

Literature based innovation output, another measure of technological innovation, was proposed by Pavitt, Robson and Townsend (1987) and Edwards and Gordon (1984) and the methodology was further developed by Acs and Audretsch (1993) and Kleinknecht (1991). It was generated via sampling the new product sections of trade and technical journals. Even though it had the advantage of capturing innovation at all levels, it was claimed to underrepresent innovations of large firms as they may feel less urge to report new product relative to small firms (Acs, Anselin and Varga, 2002). Asay (2018) also opined that patenting creates economic and psychological motivation to essentially use that patent which defies the creator’s original motive to obtain the patent. Serjerson and Hansen (2018) also questioned the growing presence of patent as a key policy indicator and its consequence on organisational practices. They found that ‘number of patents’ moved from posing as a measure of innovative capacity to be a policy goal to be achieved, essentially producing a goal displacement that is hypothetically damaging for both academic research and innovation capacity of the surrounding society. Due to this focus shift, current scientists are increasingly engaging in patenting mainly to achieve organizational targets and acquire much more funding, rather than promoting the commercial usage of their findings. This substantive and reverse effect affirms the case made against patents by Boldrin and Levine (2013) also suggested that patents awarded has no correlation with productivity neither does it change the rate of technological progress further perforating the arguments for the use of patents as an innovative measure.

Regarding trademarks, it has been portrayed as a **complementary measure of innovation** together with patent and can even have stronger effects when combined with patents (Schwiebacher and Müller, 2009; Zhou, Sandner, Martinelli and Block, 2016). Trademarks are usually filed by SMEs for various reasons depending on the SME (Gosch and Hipp, 2014). First among them is this issue of size limitation. Due to the limited size of SMEs, they usually engage in differentiating their products from their competitors as their liabilities hinders them from enjoying the advantages of economies of scale. Secondly, trademark is also more convenient for resource scarce firms as they are relatively less costly and non-complex and, thus, may serve an important appropriation innovative and intellectual property measure for SMEs (Gotsch and Hipp, 2012).

Primarily, trademarks are **mainly used to identify firms’ services** from other potentially similar provision from competitors especially when patenting is not possible (Schmoch, 2003). This was buttressed by Gotsch and Hipp (2012) who revealed that global distribution markets, competitive market forms, and standardised amenities contributes to raising the number of trademark registrations of firms. On the other hand, there have also been the contrary held opinion about the validity of trademarks as an innovation indicator (Blind et al 2003; Davies, 2009). It is argued that services with a low level of innovation are the ones that are trademarks effectively casting doubt on the innovation quality levels of trademarks (Davies, 2009) and their statistical value (Blind et al., 2003).

Nevertheless, prior investigations have shown positive relationship between trademarks and productivity (Greenhalgh and Rogers, 2007) or stock market value (Block, Fisch, Hahn and Sandner, 2015) and trademarks have been used to larger extent, by most researchers as a measure of technological innovation as well (Gatrell and Ceh, 2003; Malmberg, 2005; Mendonca, Pereira and Godinho, 2004; Millot, 2009; Schmoch and Gauch, 2009). To sum it all up, the author recognises patents as an evidence and measure of innovation generated that intends to be protected and is much more comprehensive in its use when it is combined with trademarks as well as design applications used by European Innovation Survey (2019). For a more robust results, patents together with trademarks and design application will be combined and recognised as the indicator of technological innovation of member states to offset the applications not submitted as patents.

1.8. Research Gaps and Motivation

Cooperation networks have been fraught with issues of involvement of other entities, organizational barriers affecting the seamless transmission of knowledge for innovation and even the misappropriation and true usage of funds allocated for financial needs and whether they do influence firm collaborative and innovative needs is also conundrum. Furthermore, large database of researches carried out on assessing technological innovation have usually pegged a single measure, such as patents to largely represent the output of technological innovation (Alcacer and Gittelman, 2006; Buesa et al., 2010; Sampat, 2018). However, in recent times, most firms do not employ patent for the purpose of keeping technology created or recording their innovation results but is rather largely dependent on the type of innovation created whether design oriented which may call for such efforts to be recorded as design applications as it’s been done by mobile phone giants like Apple and Samsung. It may also be related to entirely new product or as it is in most cases now, trademarks are rather opted either to replace or complement patenting. Technological innovation tendencies have also been argued to be related to geographical tendencies rather than just firm innovation orientations hence it is imperative to discover those which prevail in the European Union, the conditions that affect it and how these human, financial other input factors that influence technological innovation.

In achieving this innovation goals, recent researches have entrenched and added the irreplaceable essence of cooperation of firms and individuals and organisation in expediting the course of innovators. Knowledge circulation which generates further knowledge and creates spill-overs for endogenous and exogenous growth have also been addressed but with little focus on how innovation created are efficiently diffused to achieve the purpose for which it was initially intended (Afzal, 2014; Carayannis et al., 2015;). Having known this, it was found imperative to assess the financial, structural and institutional influence on the environment for creation of technological innovation. This will expertly assist in proper allocation of relevant resources in the Union. It will also reveal the interactive essence of these factors in supporting one another in the quest for innovation creation in the Union. Furthermore, it'll also disclose how funding provided affects cooperation and knowledge generated among in different spatial sectors of the Union, how product, process and marketing innovation efforts of firms are sharpened or dulled by framework conditions for technological innovation and eventually how they affect the technological innovation among member states in the EU. With these being discussed, the **aim** of the research is:

- **To assess the contributory role of financial, interactive, institutional and structural factors in the network of technological innovation generation**.

Contrary to current literature that emphasizes on the leading role played by public sector in diffusing and directing innovation, the goal of this paper is to add to the current stream of literature by revealing the differentiated and systemic impact of innovation elements in creation and dissemination of technological innovation in the European Union. The structure of the paper can be best referred from figure 5 of this document below.

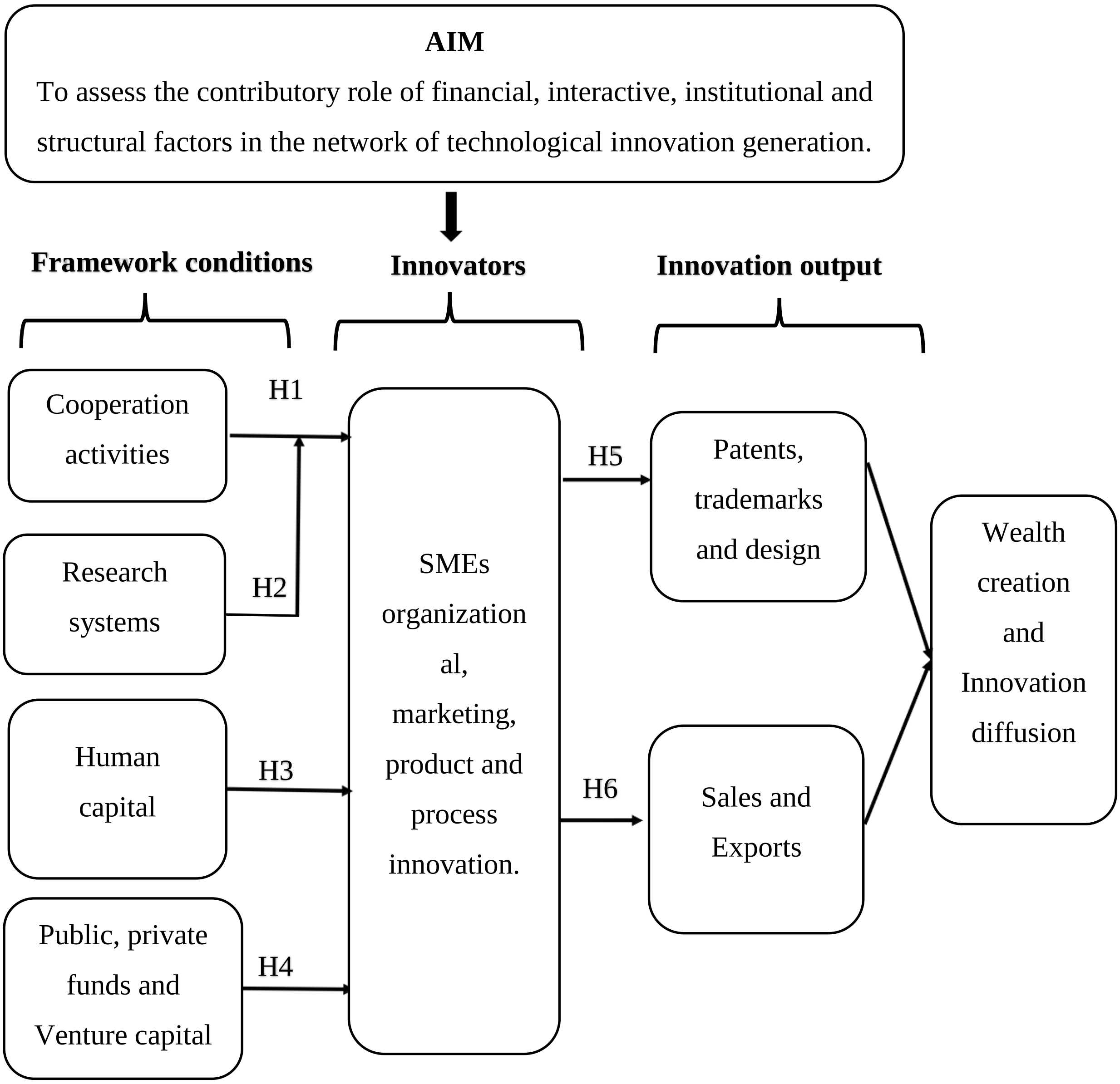


Figure 5: Structure of Research

Source: Authors own creation based on the findings of Rogers (2003), Kwiek (2015), Maietta (2015) and Seifert and Chattaraman (2017)

1.9. Technological Innovation: Measurement Variables

According to the Oslo Manual (2005), technological innovation can occur both in the production process and/or products of the firm and in ancillary supporting activities supplied by its purchasing, sales, accounting, computing or maintenance departments. In practice it will be very difficult to identify product innovation in ancillary services. Technological innovation requires an objective improvement in the performance of a product or in the way in which it is delivered. In the case of many goods and services sold directly to consumers or households, the firm may make improvements in its products which make them more attractive to the purchasers without changing their "technological" characteristics.

The Oslo classification takes away organisational and managerial innovations are excluded from technological innovation surveys (Oslo Manual, 2005; Camison and Villar Lopez, 2014). Oslo Manual segregated the definition of technological innovation into product and process innovation and defined it as *"a technological product innovation is the implementation/commercialisation of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer. Furthermore, a technological process innovation is the implementation/adoption of new or significantly improved production or delivery methods. It may involve changes in equipment, human capital, working methods or a combination of these".*

Regarding the measure of technological innovation, patents have largely been resorted to as a measure of innovative technological capacity of firms (Alcacer and Gittelman, 2006; Buesa, Hejis and Baumert, 2010). Igami and Subrahmyam (2015) researched on the validity of patents a measure of innovation in the Information technology industry found that patents predict innovation than random guess but even a simple refinement will make it even more useful although it has been argued to be inadequate in covering all innovations. The foundations of this argument were laid by Hall, Jaffe and Trajtenberg (2001) who asserted that in as much as patents were useful measures of new technology, they didn't measure the monetary value of these machineries as discussed earlier.

In a nutshell, the author recognises patents as an evidence and measure of technological innovation generated that intends to be protected and is much more comprehensive in its use than other indicators such as research and development efficiency. For more robust measurements, patents together with trademarks and design application submitted will be combined and recognised as the indicator of technological innovation of member states to offset the applications not submitted as patents.

1.10. Aims and Objectives

Many studies have questioned the relevance of the stated framework indicators to the entire innovation set up. Rahman and Ramos (2013) also researched on the limitation of innovation and found that high wage levels is contributing to dearth of skilled manpower, which is in effect creates a dearth of skilled resources effectively creating glitches in enabling purchasing power.

Research system have been lauded as a catalyst for expediting technological innovation and also the creation of a stronger knowledge network and an effective information relay and transmission mesh. However, it is believed that not all persons are influenced by higher compensation and human capital quality and quantity can equally be adversely influenced by an attractive learning and research structure hence the need for the study.

This study will **add to current literature** by revealing the differentiated and systemic impact of elements selected in the generation of patents, trademarks and design applications in the European Union and to unveil the interactive essence of these factors in supporting one another in the quest for innovation creation in the Union. This will reveal the sub variables that not only affect technological innovation but also shows the degree to which such indicators respond to each other in a catalytic and synergistic structure. This will supplement resource efforts expended by policy makers by mitigating focus on what funding can do for innovation efforts and rather focusing also how factors in play can interact supportively to create a favourable environmental presence for innovation generation. Three objectives will be set to achieve the stated aim.

The **first objective** of the study is:

- To assess the influence of the framework conditions on innovators in the European Union.

To achieve this objective, based on the literature, it is hypothesized that:

H1: Cooperation activities within the European Union significantly affects the innovators of firms.

H2: Research systems significantly moderates influence of cooperation on the innovators of the European Union.

H3: Human capital significantly influences the innovators in the European Union.

Innovators**,** in this context, comprises of SME’s product, process, organization and marketing innovation as defined by European Innovation Scoreboard (2018) and the Community Innovation Survey (2014). Furthermore, entrepreneurial climate or activities performed by Seeck and Diehl (2016) have argued that framework development centers contribute to the attractiveness of a regional climate. As a mix of socio-economic, political, and technological factors contribute to the attractiveness of a regional research system, it is undeniably, a very sensitive factor for internal and external investors (Raszkowski, 2013). It is even more imperative as venture capital levels in the European has fallen sharply behind the rivals in the past couple of years. Furthermore, considering the increasingly ageing workforce of the European Union and the efforts to boost the rectify this, this study is expertly positioned to assist with this and hence hypothesize that

H4: Funding support within the European Union significantly affects innovators of firms.

Seeck and Diehl (2016) have argued that framework conditions, which are direct result of the regional characteristics have no effect on such innovators. This study will serve as a control check to assess the influence these foundational variables have in the chain of technological innovation generation. It is also very imperative as efforts towards innovation creation have been centered on the bottom-up policy with the introduction of the Cohesion policy (2014-2020) in the EU.

The **second objective** of the study is:

- To evaluate the influence of innovators on the generation of patents, trademarks and design applications in the European Union.

Hypotheses constructed to fulfill the objective will be thus posited as:

H5: SME's innovators significantly affect creation of technological innovation measured by patents, trademarks and design applications.

H6: SME's innovators significantly affect creation of technological innovation measured by sales impact.

Cooperation has been entrenched as a factor in the generation of product and process innovations. In the context of innovation, collaborative approach seen a significant rise in the era of open innovation (Jacobs, 2013). Cooperation with suppliers, consultants, laboratories, R&D institutes, universities, and other higher education institutions is positively associated with the results of innovation (Siedschlag, Zhang and Cahill, 2012) and product and process innovations (Carvalho, Madeira, Carvalho, Moura and Duarte, 2018). Having seen the essential role cooperation play in innovation structure and funding generation, there is a need to reveal the defined essence of innovators in the creation and patents, trademarks and design applications.

This study will reveal the how the innovators assessed in the previous objectives transition and affect the creation and diffusion of patents, trademarks and design applications. Consequently, this will reveal the innovators that presents more impact in the creation of technological innovation in the European Union.

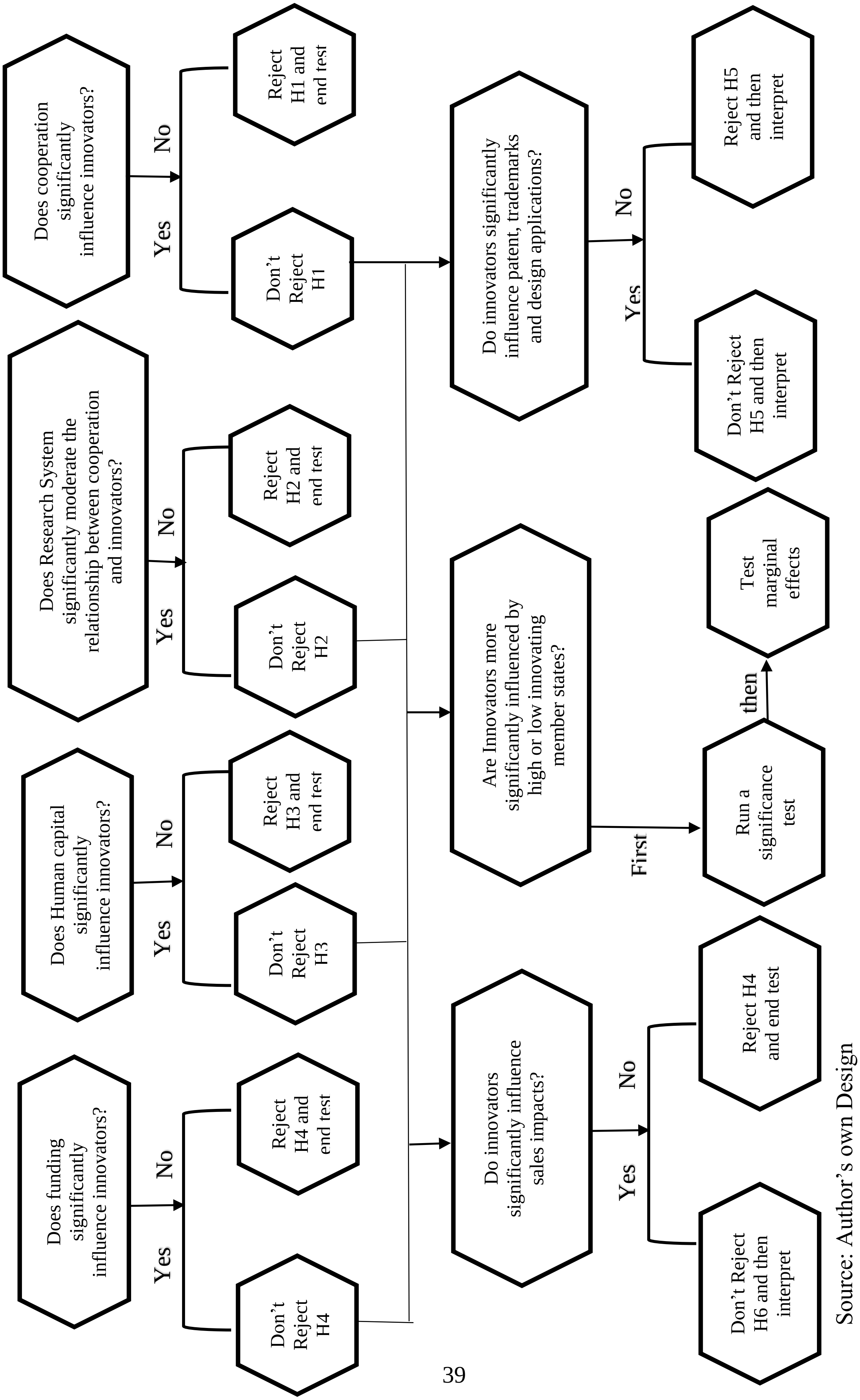
Having realized the significance of innovators to the cause of technological innovation in the EU, as a follow up study to the earlier objectives, the research will undertake a classified analysis for the member states in the European Union following the taxonomy used by European Union in the preparation of European Innovation Scoreboard. The study will segment the member states according to their innovation scores i.e. **innovation leaders, strong innovators, moderate innovators and modest innovators** to analyse their contribution to the technological innovation environment and assess their marginal contribution to the mediator, innovators.

The **third objective** of the study will be:

- To assess the marginal contribution of different innovation classes of EU member states to the technological innovation environment.

This study will **initially** reveal any potential of the first objective being bias or deeply influenced by highly innovative member states. This will, effectively giving us a peek into the different response of different innovation class of member states in the Union and their innovation needs. It will **also add up** to this study the exclusive marginal contribution to the technological innovation cause. In simplest terms, it will reveal the unit increase in innovators when there is a unit increase in the independent variables in question for different innovation classes of member states in the European Union. This will conveniently allow policy makers to decide on rationing of resources based on innovation necessities and also provide a more up-close and customized response to member states in reference to their innovation needs and how much they output we can expect to acquire from the support provided to these member states.
Figure 6 below will give a visual interpretation of research objectives and proposed hypothesis of this research.

Figure 6: Decision Tree Structure of Proposed Objectives and Hypotheses.



2. METHODOLOGY

This section describes the data sources selected for the research and the various analytical tools assessed to be used for to achieve the above stated objectives. Predominantly, the quantitative method of study was resorted to owing to the type of data acquired and its advantage of accuracy in measurement. European Member states were also selected as the subject of the research due to their grand innovation schemes introduced and the need to quickly innovation and diffuse innovation to ensure efficient use of resources expended to firms for innovation, raise the innovation levels of firms and the efficiency of diffusing to the stakeholders involved.

2.1. Dissertation Objective

The focus of the paper is to assess the contributory role of financial, interactive, institutional and structural factors in the network of technological innovation generation in the European Union. The research will consequently reveal the innovation focus variables, how other variables moderate the workings of the others and analyse the degree of influence and marginal contribution according the taxonomy of innovation classification by the European Innovation Scoreboard (2019).

2.2. Specific Objectives

From the various literature reviewed on technological innovation and the evolving trends, it has been revealed as a pressing objective of the European Union to press on and achieve farther heights in terms of innovation investment and consequently innovation generation in light of the quickly growing Chinese innovation level, the dwindling EU active workforce as well and the inconsistent and lagging innovation performance of most of the EU countries, especially the latest acceded member states (European Commission, 2018; Carayannis et al., 2015). In spite of the the flexibility in innovation generation of member states, there seemed to be productivity issues most likely caused by insufficiency of inputs employed or ineffective means of diffusing these innovations to recover the funds invested. Andrews, Criscuolo and Gal (2016) revealed that over the past decade the productivity gap between top firms and follower firms has stretched. Chief factor could be aligned with insufficient and inefficient diffusion of technological innovations across countries, which essentially translates to inputs invested to innovation generating entities. Furthermore, even though innovation has been reported to have driven the European Union economy in the years prior, report from the European Commission shows reveals that companies in the EU spends relatively less on innovation when compared with United States and China (European Commission, 2019). The levels of venture capital have also been shown to be underdeveloped. A key factor driving companies to ecosystems with quicker growth opportunities. In this regard, new EU directive have admonished countries to set their research and expenditure levels to 3% of Gross Domestic product (GDP) by 2020, however, this has also been deeply heckled by the erratic foreign direct-investment (FDI) performance from 2007. Data from European Commission in the year 2017 shows that inflow foreign-direct investment into the EU as a percentage of GDP experienced a reduction from year of 2016. In this study, we believe that not all inputs are crucial to the Unions efforts at innovation due to wide socio-economic and cultural differences of member states.

In this regard, the study will hinge its analysis on the variables used in innovation analysis by the European Innovation Scoreboard (2019) and undertake a thorough analysis of the framework indicators, that is the foundational elements that initiates the innovation generation in the bloc. Having revealed these pressing concerns about the innovation growth in the Union, the **first specific objective** is set to *assess the influence of the framework conditions on innovators in the European Union.*

To achieve these objectives, we created hypotheses to support it as presented earlier in the literature reviewed. Furthermore, the second section of the research intends to also assess the connection of innovators to the creation of technological innovation of the European Union. Such that, consequently, it will reveal the roles of the framework indicators and mediating innovators in the environment for the creation of technology innovation. This translates to the hypothesis 5 and hypothesis 6 and **second specific objective** which is *to evaluate the influence of innovators on the generation of patents, trademarks and design applications in the European Union.*

Numerous studies conducted by researchers have applied the variables used in the research for various dimensions of innovation analysis and R&D. For this analysis, with the presence of mediation variable, we employ a systemic analytical view using the Partial Least Square Structural Equation Modelling (PLS SEM) which have been used by multiple researchers (Hair, Sarstedt, Ringle and Mena, 2011; Albort-Morant, Leal-Millán, and Cepeda-Carrión, 2016; Castaño, Méndez,and Galindo, 2016; Mohsin, Halim, and Farhana 2017; Leal-Rodríguez, and Albort-

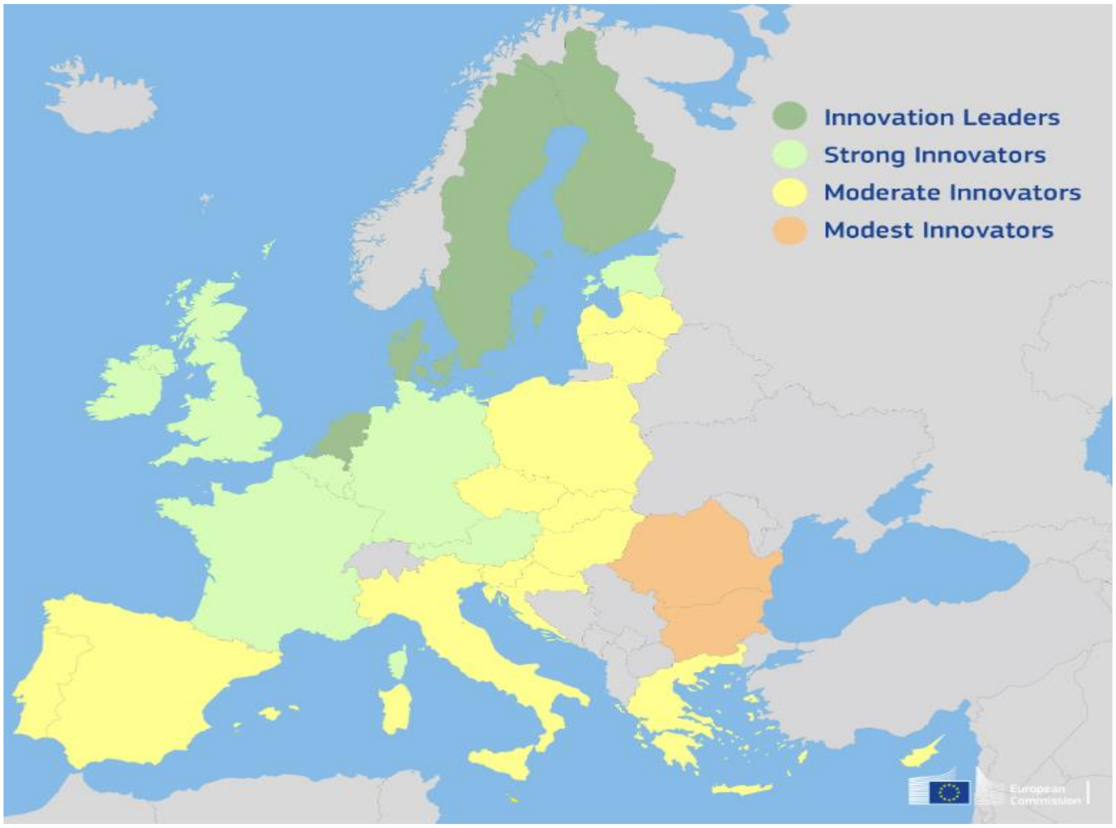
Morant, 2016; Ringle, Sarstedt, Mitchell and Gudergan, 2018; Sanz-Valle and Jiménez-Jiménez, 2018; Aliyu, Ahmad, and Nordin, 2019; Acosta-Prado, López-Montoya, Sanchís-Pedregosa and Vázquez-Martínez, 2020) for similar researches. This method was selected due to its compatibility for our analysis which will show the direct, indirect, mediating and moderating effects of these variables in the environment of technological innovation. This objective set for the research focuses on analysing the connection of the framework indicators and innovators to technological innovation.

The final part of the research captures the various innovation levels and country classifications that potentially influence the results of the European Union as a bloc. In this regard, we delve into analyzing the various innovation levels using the taxonomy created by the European Innovation Scoreboard (2019). This classification ranks the innovation level of member states and classifies them as an **innovation leader, strong innovator, moderate innovator and modest innovator**. Using this nomenclature, ordinary least square regression analysis will be used to assess the statistical and practical connection of the framework indicators to the innovators and to technological innovation as have been used by most researchers (Lorentzen, Landry, and Yasuda, 2014; Coccia, 2015; Petrakis, Kostis and Valsamis, 2015; Fernández, López and Blanco, 2018; Dincer, 2019). This method was chosen for the convenience of analysing the framework condition and innovators with the introduction of control variables in the model for the various innovation classifications. This analysis conveniently reveals not just the differentiated contribution of the various segmented innovation scores by member states but also their changes in operation with the when various controls are incorporated in the model of each group. Below is the member states and their innovation classifications as of 2019. This leads us to the **third and final objective** which is *to assess the marginal contribution of innovation classes to the technological innovation environment.*

2.3. Research Area

This thesis chose to focus on the innovation variables of the European Union as a bloc and the member states that have ceded authority to the Union. The EU is single market with an almost 500million Inhabitants endowing it with attractive potential for technological innovation generation and consequently dissemination of innovation. According to the World Bank (2018), the Gross Domestic Product (GDP) of the EU seems to lag relative to its counterparts such that, in 2018, GDP grew at annual rate of 2% compared to 2.9% of the United States and 6.5% of China. This GDP growth of China compared to the EU, strikingly, mimics the consistent innovation growth rate of three times that of the EU as reported by EIS (2019). This further buttress the interesting coincidence of GDP growth with innovation levels.

Below is the geographical landscape of the European Union together with their various delineations of the innovation classifications of the member states as computed by the European Innovation Scoreboard (2018). We chose to focus on EU member states due to their progressive public investment trends and comparatively low private investment, venture capital investments compared with United States and China. We also considered their progressively lagging innovation performance in relation to China, even though it just surpassed the United States in innovation performance for the first time. However, even though United Kingdom left the European Union January 31st, 2020, they were included in the analysis as most of the analysis had been conducted prior to that time.



Source: European Innovation Scoreboard (2019)

Table 2 below gives further interpretation to the European landscape by revealing the enlisted member states by innovation performance according to their relative scores with the EU average. The first group was termed as Innovation Leaders were the member states who recorded innovative performance twenty (20%) above the EU average namely: Denmark, Finland, Netherlands and Sweden. The second group were classified as Strong Innovators are those recorded scores close to or quite higher above the EU average but not more than the 20% of the average. The third group was classified as Moderate Innovators and included Member States whose performance is between fifty (50%) and ninety (90%) of the EU average and the fourth, the Modest Innovators, were the member states that showed a performance level below fifty (50%) of the EU average.

Table 2: Innovation Classification of EU member states.

Innovation Leaders	Strong Innovators	Moderate Innovators		Modest Innovators
Denmark (DK)	Austria (AT)	Croatia (HR)	Italy (IT)	Bulgaria (BG)
Finland (FI)	Belgium (BE)	Cyprus (CY)	Latvia (LV)	Romania (RO)
Netherlands (NL)	France (FR)	Czech Republic (CZ)	Lithuania (LT)	
Sweden (SE)	Germany (DE)	Estonia (EE)	Malta (MT)	
	Ireland (IE)	Greece (GR)	Poland (PO)	
	Luxembourg (LU)	Hungary (HU)	Portugal (PT)	
	United Kingdom (UK)	Slovenia (SI)	Slovakia (SK)	
			Spain (SE)	

Source: European Innovation Scoreboard (2019)

2.4. Sources of Data

The data used for this research was extracted from European Innovation Scoreboard (EIS) of the European Commission from the years of 2011- 2018. Panel data was used to analyse the innovation performance to overcome potential outliers that could affect the robustness of the data and the capture over a wide period the contributory variables and their impact in the environment of technological innovation. The EIS a website officially run by the European Commission and provides variables for comparative innovation measurement scores and analysis for all EU-28 member states. Innovation scores of member states are provided as indices and composite indexes encompassing various factors that presses country level innovation and EU innovation as a bloc. This provides a more comparative analysis and measure of research and innovation performance of the EU Member States and the individual strengths and weaknesses of their innovation structures. These results allow member states to analyse their defective areas and focus more on defective and receding areas that needs. The EIS records extracts data from various renowned and scientifically used sources such as OECD (2018), Eurostat (2018), latest data from Community Innovation Survey (CIS), Global Entrepreneurship Monitor, EU Industrial Research and

Development Investment Scoreboard, OECD, World Economic Forum, World Bank: World Development Indicators and World Bank: Worldwide Governance Indicators.

Regarding the selected data source, this secondary data source was preferred due to its comprehensive data availability for innovation scores, the age of the data and its ability to allow country-to-country innovation comparisons on relevant variables (Schibany and Streicher, 2008) that are internationally used to evaluate and benchmark innovation performance of the EU as a bloc and of member states. Below is the set of variables using the description of the variables according to the EIS (2018).

Table 3: Descriptive Information of Variables

Technological Innovation Components	Interpretation	References
Human capital		
New doctorate graduates	This measures the supply of new second-stage tertiary graduates in all fields of training especially PhD graduates.	European Innovation Scoreboard 2019; Knapper and Cropley 2000; Kirch 2018; Żelazny and Pietrucha, 2017
Population completed tertiary education	This generally measure the pply of advanced skills. It is not limited to science and technical fields, because the adoption of innovations in many areas, in the service sectors, depends on a wide range of skills. The measure typically focuses on a relatively younger age ranging between ages of 25 to 34,	(Community Innovation Survey, 2014; European Innovation Scoreboard 2019)
Lifelong learning	This measure takes into consideration all purposeful learning activity, formal and informal but must be undertaken on an ongoing basis with the sole aim of bolstering one's knowledgeability and competence.	(Field, 2000; European Innovation Scoreboard 2019)
Research systems		
International scientific co-publications	This used as a proxy for the quality of scientific research as it has been widely proven that collaboration improves scientific productivity.	(Heinrichs and Baelz; 2011; Giu, Liu and Diu, 2018; European Innovation Scoreboard, 2019)
Scientific publications among top 10% most cited	This matrice is used as a measure of the efficiency of research system. This follows the dogma that highly cited publications are assumed to be of higher quality.	(European Innovation Scoreboard, 2019)
Foreign doctorate students	The share of foreign doctorate students assesses the short-term mobility of students seen as an effective means of disseminating knowledge. It is also thought that attracting doctoral students of higher skill ensures a steady supply of researchers.	(Razkowski, 2012; European Innovation Scoreboard, 2018)

Innovation-friendly environment		
Broadband penetration	Electronic commerce and a steady stream of internet connection is very essential for commerce and trade. This indicator measures the use of this by the share of companies that that have access to fast broadband.	(European Innovation Scoreboard, 2019)
Opportunity-driven entrepreneurship	This indicator measures the degree to which persons engage in entrepreneurship out of opportunities provided to users.	(European Innovation Scoreboard, 2019)
INVESTMENTS		
Finance and support		
R and D expenditure in the public sector	R&D expenditure stands one of the key drivers of creating economic growth in a knowledge-based economy. In this regard, R&D is used as a measure of future competitiveness and wealth of the EU. Spending on research and development are imperative in the transforming an economy to a knowledge intensive one and to stimulate national growth	(Aschauer, 1989; Guellec, 2003; Community Innovation Survey, 2014;)
Venture capital investments	This measures the relative degree of dynamism of new business ventures. Venture capital is often the only available means of financing business especially for enterprises who intend to take higher risks initially.	(Community Innovation Survey, 2014; European Innovation Scoreboard 2018)
Firm investments		
R and D expenditure in the business sector	The indicator measures the internal generation of new knowledge in firms. It is particularly essential in the science-based sectors (like pharmaceuticals, and electronics) where most new inventions are created in the laboratories.	(Guellec, 2003; Falk, 2007; Community Innovation Survey, 2014)
Non-R and D innovation expenditure	This indicator measures non-R and D innovation expenditure as a percentage of total turnover.	(Eurostat, 2018; European Innovation Scoreboard, 2019)
Enterprises providing ICT training	This indicator measures the portion of enterprises that overall skills development of employees. ICT skills are fundamentally essential to the growth and improvement of employees.	(Eurostat, 2018; European Innovation Scoreboard, 2019)

INNOVATION ACTIVITIES		
Innovators		
SMEs with product or process innovations	This is used as the production of new or significantly improved products or processes in the market.	Seiffert and Chattaraman (2012; Community Innovation Survey, 2014 European Innovation Scoreboard, 2019)
SMEs with marketing or organisational innovations	Many firms, in the services sectors, innovate through other non-technological forms of innovation. Examples of these are marketing and organisational innovations. This indicator captures the extent to which SMEs innovate through non-technological innovation	Seiffert and Chattaraman, 2012; Community Innovation Survey, 2014; European Innovation Scoreboard, 2019)
SMEs innovating in-house	This indicator assesses the degree to which firms, that have introduced any new or significantly improved products or production processes, have innovated in internal setups.	(Eurostat, 2018; European Innovation Scoreboard, 2019)
Cooperation		
Innovative SMEs collaborating with others	This also assesses the degree to which SMEs are engaged in innovation co-operation This reveals the transmission of knowledge between public research institutions and firms, and also among and between firms and others. This is typically limited to SMEs, because almost all large entities are engaged in innovation co-operation.	Hadjimanolis, 2006; Fernandez-Olmos, M Ramírez-Alesón, 2017; Leckel, S Veilleux, LP Dana, 2017; European Innovation Scoreboard, 2019; Tobiassen and Pettersen, 2018)
Public-private co-publications	This also reveals public-private research connections and active collaboration activities between business sector scientists and public sector researchers bringing about scholarly distribution.	(European Innovation Scoreboard, 2019; Ivanová and Masárová, 2019)

Private co-funding of public R and D expenditures	This typically measures public-private co-operation activities. Focuses specifically on University and government financed R&D activities that are funded by the private sector.	(Beaudri and Allaoui, 2012)
Technological Innovation		
PCT patent applications	This indicator compiles the number of patent applications submitted to the European Patent Office (EPO)	(Feeny and Rogers, 2003)
Trademark applications	Trademarks are an essential innovation indicator, especially for the service sector. It fulfils the three essential functions of a trademark: Singles out the origin of goods and services, ensures consistent quality, and also operates as a form of communication of brand confidence.	(Porter and Stern, 2001; Mendonca, Pereira and Godinho, 2004)
Design applications	A design represents the outward appearance of a product or part of it from the lines, contours, colours, structure, texture, materials and/or its ornamentation. Disassembled and reassembled products are also classified under this indicator.	(Porter and Stern, 2001; Community Innovation Survey, 2014)
Medium and high-tech product exports	The indicator also measures the technological competitiveness of the EU, i.e. the ability to disseminate the results of R&D and innovation in international markets	(Sandu and Ciocanel, 2014; European Innovation Scoreboard, 2018)
Knowledge-intensive services exports	The also measures the attractiveness of the knowledge-intensive services sector. The indicator reflects the capacity of an economy, to export high and value-added services in the knowledge-intensive global value chains.	
Sales of new-to-market and new-to-firm innovations	This indicator measures the turnover of new or significantly improved products to the market.	(Buesa et al., 2010; Community Innovation Survey 2014)

Source: European Innovation Scoreboard (2019)

2.5. Data Analytical Methods Used

From the literature discussed, various variables have been revealed to affect the technological innovation component of member states consequently leading up to innovation dissemination and a continuous resolution of societal cankers and issues. In the European Union, the components range from human capital, research structure of firms and member state, the finance provided and the source of it, and the participation of collaborative knowledge exchange. However, various methods ranging from Structural equation modelling (PLS-SEM) (Del Giudice and Della Peruta, 2016) to probit regression (Janeiro, Proenca and Da Conceição Gonçalves, 2013) and ordinary least square regression (Fernandez and Lopez, 2018) have been applied to reveal the influence of these variables on dependent variable.

This research will employ the quantitative research design to complete its objectives as this is more compatible with this study considering the data type available (William, 2007). This research design embodies research component that entails any form of empirical test about a social phenomenon, testing hypothesis using numerically measured variables by means of statistical methods for analysis of the constructs and variables (Cresswell, 2007). Backed by theoretical justifications, quantitative research explores relationship among variables usually with a primary goal of analyzing and producing valid proxies for representing the measured relationship. This type of research, relative to qualitative studies, helps to reveal answers to questions about the occurrence rate of a phenomenon over a particular time, or the extent of how the sample is influenced by the phenomenon The usage of this approach warrants hypothesis formulation and testing of hypothesis and possibly research questions that may have been posed (Glaser and Strauss, 2017). According to Nardi (2018), every research can be generally categorised into four categories; exploratory, descriptive, explanatory and emancipatory research, however, this research will fall in the quantitative category considering the need to test, reject or not reject stated hypothesis.

Furthermore, this dissertation will employ an explanatory perspective in terms of the analysis and interpretation. This was employed as it will afford us the potential to operate with explanatory variables to create causal relationships among variables used for the study. Causal relationship informs of how a change in one factor causes a change in another variable i.e. dependent and independent variable (Fox and Bayat, 2008). Therefore, as the research is aligned towards verifying the influence of framework conditions on innovators and eventually unveiling its mediating influence and it how it affects technological innovation, the use of explanatory study will be perfectly fit for this study.

Explanatory studies will also better improve the knowledge overview of understanding of the ground-level occurrences by revealing facts via possibly surveys or questionnaires. This form of study also affords an in-depth study to advance into new and uncharted research zones, authenticates validity and reliability of variables, tests and examines interrelationships and revealing novel information from observations and practical experiences as well (Singh, 2006). Consequently, this could lead to more innovation thoughts, sharply improving current research world and also providing more practical applications and implications for policy stakeholders. For the purpose of this research, this dissertation will employ two methods for research. i.e Ordinary least square regression and Structural equation modelling (PLS-SEM) analysis which will be discussed in detail below. The statistical software SMART PLS will be used for this tool as used by Ringle, Da Silva and Bido (2015) and Wong (2013). The use of the structural equation modelling (PLS-SEM) will give a detailed analysis into the first and second objective of revealing the influence of framework conditions on innovators, the mediating role of innovators and how they consequently influence technological innovation measured with patents, trademarks and design application and sales of new or significantly improved products. These results will inform us of the mediating influence of innovators and effectively also provide a bloc level revelation of the role of elements in the environment for the creation of technological innovation. Ordinary least squares will also be used to support the above further analysing the country level influence of these variables by conducting test of significance of these elements according to the innovation classification of member states as innovation leaders, strong innovators, modest innovators and moderate innovators. The statistical software GRETL and STATA will be used to conduct ordinary least square analysis.

2.6. PLS-SEM Analysis

For the assessment of significance of the variables to be used, constructs will be constructed to accommodate the multiple variables, and this will be perfectly suited to the use of partial least squares technique (PLS-SEM) analysis using SMART PLS modelling application. SEM has become the dominant analytical tool for testing cause-effect-relationships models with latent variables. When the aim of a research is to acquire substantial information about the influencers of, for example, customer contentment or reputation of an entity, SEM is the technique of choice. For many researchers, SEM is equivalent to carrying out co variance-based approach (CB-SEM) (Hair et al., 2014)

PLS SEM on its own offers a suitable framework for statistical analysis as it combines factor analysis, regression with multivariate variables and discriminant analysis as well. This tool allows the user to create latent variables and measure multiple relationships using standardized estimates and its bootstrapping feature in SMART PLS application. Researchers have used the Partial Least Squares Structural Equation Model (PLS-SEM) in analysing technological innovation components (Camisón and Villar-López, 2014; Del Giudice and Della-Peruta, 2016; Azar and Ciabuschi, 2017). The PLS SEM is a statistical program for multivariate data analysis with the potential to model various endogenous and exogenous latent variables in a single structural model (Kock, 2014). The application of SEM has permeated various industries such as marketing (Hult, Hair and Proksch, 2018), tourism (Seric, Mikulic and Gil-Saura, 2018), hospitality (Beldona, Schwartz and Zhang, 2018) because of its capability to model latent variables interactively with a valid theoretic backbone to support it (Pakpahan, Hoffmann, and Kröger,2017)

Mathematically, PLS SEM as demonstrated by Zawojska (2010) is given as

$$\mathrm{Z_k} = \beta_0^{(k)} + \sum \beta_1^{(k)} z_{1+V_k}, \quad (1)$$

where:

Z_k	= explained variable (innovation activities or technological innovation),
$\beta_0^{(k)}$	= constant,
$\beta_1^{(k)}$	= regression coefficient (co-efficient of human capital, cooperation, research systems, funding and innovation activities as well),
V_k	= residual term.

two main complementary approaches are used in PLS-SEM to assess the causal connection between indicators and constructs (Kock and Lynn, 2012). Complementary as they may be, , there exist some fundamental variations statistically (Hair et al., 2011). The first approach is covariance-based SEM (Schumacker and Lomax, 2004). This method approximates beta coefficients of the model by minimizing the differences among covariance matrices. It is a method one can opt for if a theorized relationship posess one or more underlying factors (Henseler, Hubona, and Ray, 2016). It runs parametric assumptions in the calculation of coefficient's, and this serves as a foundation for calculating significance levels (P values) when bootstrap is run (Hair et al., 2017). The variance-based SEM, on the other hand, integrates multiple techniques like regression analysis, principal components analysis, and also PLS path modelling technique (Tenenhaus, 2008). PLS, in this regard, can be considered to be "most fully developed and general system" among all the variance-based SEM methods (McDonald, 1996).

To use SEM analysis, it is imperative to run a test of the goodness of fitness of the model (Cheah, Memon, Chuah, Ting and Ramayah, 2018). The researcher is supposed to ensure the model properly fits the data to buttress and justify validity of findings and conclusions. The test can be assessed in two ways: first is the use of the model fit and next is the use of fit indices. In the bootstrap section in SMART PLS, it enables the test of model fit using (dULS) and geodesic discrepancy (dG) (Dijkstra and Henseler, 2015). Additionally, reliability tests are also run to test reliance that another researcher can achieve the same results with the given data. Both Jöreskog's rho, rho (ρA) and Cronbach's alpha (α) are used to measure internal consistency of a model (Henseler et al., 2015), with a preferred values range of 0.6 to one (1). This indicates an acceptable reliability according to Hair et al. (2011), it has a maximum value of 1. Higher values closer to 1 are more preferred because they are deemed reliable. Furthermore, model validation is also another essential requirement for data check. Validity can be checked with two widely used measurements methods: discriminant validity and Average variance extracted (AVE). AVE values of 0.5 or above are suitable (Bagozzi and Yi, 1988).

With regards to discriminant validity, authors such as Henseler et al., (2015) have suggested that the heterotrait–monotrait ratio of correlations (HTMT) delivers a preferred assessment of discriminant validity. Additionally, it is well known that a model can be infested with collinearity issues (Kock and Lynn, 2012). The variance inflation factor (VIF) is used evaluate collinearity issues. In some cases, cross loadings of indicators and VIF can both be used to measure the discriminant validity even though heterotrait-monotrait is the most preferred one (Ringle et al., 2015) There is no agreed consensus on the best VIP range. Hair et al., (2011) opined that VIF values should not exceed a value 10, such that figures below are deemed not to have collinearity concerns. Other researchers also also recommend VIF values equal to or less than 3.3 to be without collinearity issues and hence also free of (common method bias) (Kock and Lynn, 2012)

Additionally, SEM also uses effect size computations which was primarily ushered by Cohen in 1988 as a remedying feature to the use of path coefficients comparison to interpret the actual impact of the influence (see Cohen, 1988) and reflect the degree of impact of the relationship of the variables mapped. He opined that f^2 values equal to or more than 0.35 can be termed as having a strong effect, whilst values of 0.15 or more have a moderate effect, and a smaller effect can be deemed for values of 0.02 or less (Cohen, 1988).

Additionally, in mediating analysis, direct, indirect and total effect are combined to interpret the mediating and indirect relationships between paths modelled. The direct effect is known as the inner model loading on dependent variable. The indirect effect measures the product of the regression coefficient for independent and mediating variable by the mediating variable and the corresponding depending variable. The total effect of captures the sum of direct and indirect effect. A Bootstrap run will also reveal the *p*-values of the effect together with relevance from the *f*-test.

2.7. Ordinary Least Squares Approach

Linear regression analysis is a common mathematical technique for demonstrating the linear connections between two or more variables. This model posits an exogenous variable and and endogenous variable and attempts to map the relationship between one or more endongenous variables on the exogenous variable. Such that that the behavior of exogenous variable can be predicted from the changes in endogenous variables if the relationship exists. The model is given as

$$y = \beta \sum_{j=1}^{k} \beta_j X_j + \varepsilon_j, \tag{2}$$

where: Y = response variable 0, 1…k,

β = partial regression coefficients,

X = predictor variables,

ε = error term.

The primary goal of linear regression is to line a straight path through the data that foresees *Y* based on *X* as seen from the table above. This essentially alerts to the need for linearity condition in regression. The least squares method is commonly to approximate the intercept and slope regression parameter that controls the line charted. Although the regression analysis operates more efficiently with the assumption of linearity, there may be differences with the data structure which may prevent the curve from being linear. **In this regard**, parameters are computed such that the sum of squared residuals (which represents the differences between the observed values of the outcome variable and the fitted values) are minimized (Zou, Tuncali and Silverman, 2003). The fitted *y* value is further on calculated as a function of the given *x* figure and the approximated intercept and slope regression estimate. For example, in a regression function, once the approximations of a (intercept) and β are acquired from the regression analysis, the predicted y value at any given x value is calculated $a + bx$, mathematically.

In the causes and limitations of ordinary least square analysis, Zou et al. (2003) cautions that Additionally, it is not advisable for regression to be actively engaged for prediction or estimation beyond the range of sample given by the independent variables notwithstanding the strength of the relationship revealed in the analysis. Lastly, he cautioned the misinterpretation of regression analysis being implied as causation in correlation analysis.

3. RESULTS AND DISCUSSION

To fulfil the objectives of the research, we created a PLS-SEM model using SMART PLS to fulfil the first and second objectives (see appendix E) and finally, we run a regression analysis using GRETL software to fulfil the third objective. However, to begin these, we initially run a test of reliability, validity, robustness and presence of common method bias of the data for the study.

3.1. Tests of Data Suitability

Just like other methods of analysiss, PLS-SEM complies with a set of principles in evaluating the model estimated (Chin, 2010, Hair et al., 2014a, Henseler et al., 2016). These guidelines are contingent on the type of model created and the direction of the indicators to the latent variable-reflective constructs or formative constructs. Visully shown in figure 7 below is a discussion of each of these criteria as explained by Sardstedt, Ringle, Smith, Reams and Hair (2014) below.

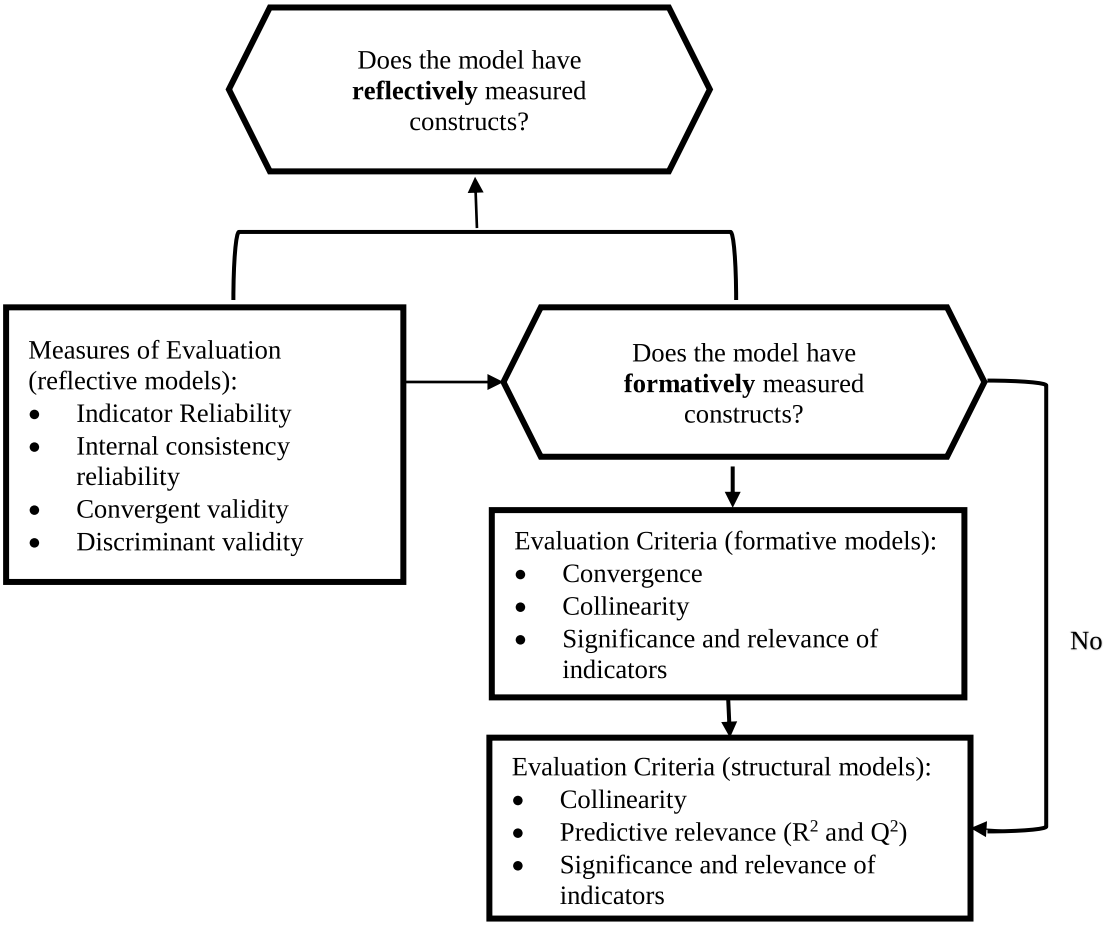


Figure 7: Criteria for PLS-SEM analysis.

Source: Sardstedt, Ringle, Smith, Reams and Hair (2014)

Following the evaluation criteria stipulated above by Sardstedt, Ringle, Smith, Reams and Hair (2014), we proceed to initially verify the reliability and validity of the constructs and indicators set up as dependent and independent variables as shown in table 4 below.

Table 4: Construct Reliability and Validity

Constructs	**CA**	**Rho_A**	**CR**	**AVE**
Cooperation	0.74***	0.75***	0.88***	0.79***
Funds	0.70***	0.76***	0.84 ***	0.64***
Human capital	0.57***	0.66***	0.78***	0.55***
Innovation friendliness	0.70***	1.38	0.84***	0.73***
Innovators	0.91***	0.92***	0.96***	0.92***
Moderating Effect: RS on Cooperation	0.77***	1.00	0.82***	0.54***
Research systems	0.84***	0.85 ***	0.93***	0.86***
Patent. Trademarks and Design apps		1.00		
Sales		1.00		

Source: Authors own selection

NOTE: Significance at 99% confidence interval (CI)-***; significance at 95% CI-**; significance at 90% CI-*

In terms of convergence validity assessment, the selected variables were found to be valid in its test according to the Barclay, Thompson, and Higgins (1995), Hair et al. (2006) and Urbach and Ahlemann (2010). These authors recommend that constructs that records an average value of > 0.5 in the AVE test is sufficient and can be termed as valid. According to Gefen and Straub (2005) and Fornell and Larcker (1981) when constructs have a loading of $p < 0.05$ and AVE > 0.5, but CR <0.6 respectively, the convergent validity of the construct is still adequate which still applies to our model hence the model satisfies the convergent reliability requirements. We further ran a complete bootstrap of the model to assess the significance of the tests. We found that with a bias corrected and accelerated (Bca) bootstrap of a two- tailed test, set at 500 sub-samples and significance level $p<0.05$, the test results of the hypothesized variables were strongly statistically significant at 99% confidence interval as shown in table 5 above.

Item Significance

Furthermore, to validate the significance and essence of the indicators used, we progress to the undertake tests of validity of the constructs using the outer loadings. According to Hair et al., (2017) this shows the estimated relationships for reflective measurement models (represented by directional arrows from the latent variable to the assigned indicators) and determines an item's absolute contribution to its assigned construct.

For formative indicators, Hair et al., ((2017) and Ringle et al. (2015) proposes that outer weights be used to assess the latent variables contribution to their respective constructs, hence, to validate our results and findings, we checked the loadings and the weights of the indicators as shown in appendix A. Loadings from the indicator variables that makes up the formative and reflective constructs, were found to be significant and hence valid baring "design applications".

According to and Gorsuch (1974) indicators with loadings with a value of more than 0.4 or preferably >0.5 (Nunnally, 1978; Hair et al., 2006) validates the use of the item. Looking at our results (see appendix A) This condition is fulfilled and confirms the variables used are reliable (see appendix A).

Further test using the Cronbach alpha also fulfilled the conditions set by Nunnally (1978), and Urbach and Ahlemann (2010). They opined that valid items should have cronbach alpha of > 0.7 where as Lyberg, BIemer, Collins, Leeuw., Dippo, Schwarz, and Trewin (1997) recommended a score of > 0.60 which is sufficed by the variables used. A significance test also ran at 500 subsamples on two-tailed complete bootstrap revealed the indicator variables were significant at 99% confidence interval. Hence, we conclude that item reliability has been established in the model.

We also tested the data for Common Method Variance (CMV), which informs of the tendency of the research instrument to affect estimated relationship among variables in a systematic way. Such that the estimated relationship among variables of interest could be overestimated or underestimated. Bagozzi, Yi, and Phillips (1991) suggested a method of assessing the impact of CMV by using the correlations of latent variables. They asserted that there will be evidence of CMV when there is a substantially large correlation among key constructs ($r > 0.9$). However, CMV can be considered as not an issue in a study if the correlation among constructs is less than 0.9 (Bagozzi et al., 1991). In this respect, considering the correlation matrix in Appendix C, we can conveniently confirm that Common method Variance is not an issue in this study.

Discriminant Validity

To ensure that reflective constructs has the strongest relationships with its own indicators other that the other constructs, we ran discriminant validity checks via an evaluation of the cross loadings and the variance inflation factor also for multicollinearity. We recorded cross loadings of indicators to be higher than 0.5 on each indicator assessed. Furthermore, according to Kock and Lynn (2012) and Hair et al., (2006), a variance inflation factor (VIF) of less than 5 or less than 10 respectively suffices the condition of discriminant validity. For our data to fulfil the condition of discriminant validity, we use both cross loadings and VIF to test for this (see appendix 2 and 3). As can be seen from the referred section, the highest VIF recorded was 3.374 and the cross loadings of the indicators was all found to just 0.5 or more which is way below the threshold set by both authors.

3.2. Test of Robustness

According to Sarstedt, Ringle, Cheah, Ting, Moisescu and Radomir (2019) most authors have largely ignored robustness checks in PLS-SEM analysis even though it is fundamentally a regression-based technique. Robustness checks adds more methodological rigour to the PLS-SEM analysis according to Hair et al. (2017). To implement the test in a PLS-SEM context, we used the two-stage procedure as used by Hair et al. (2018). We initially estimated the construct scores from the PLS-SEM analysis and then used these scores from the PLS-SEM analysis to run a Hausman test of endogeneity as used by Terza, Basu and Rathouz (2008). In this regard, we used a two-stage least square technique (TSLS) incorporating the log of instrumental variables to check for the robustness. The results are found in table 5 below.

Table 5: Two-Stage Least Square Test of Endogeneity.

Constructs	**Coefficient**	**Std. Error**	**t-ratio**	**p-value**
Cooperation	0.160673	0.102233	1.572	0.1207
Funds	0.586215	0.101368	5.783	<0.0001***
Human Capital	−0.231045	0.102049	−2.264	0.0268**
Mean dependent variable	0.643113		S.D. dependent var	0.444104
Sum squared residuals	13.49685		S.E. of regression	0.445514
Uncentered R-squared	0.145273		Centered R-squared	-0.021000
F(3, 68)	48.82910		P-value(F)	6.03e-17***
Model summary				
Number of observations	71			
Dependent variable	**Innovators**			
Instrumented	Cooperation	Funds	Human Capital	
Instruments	Const, log of Cooperation, log of Funds, log of Human Capital, log of Sales, log of Patent, Trademarks and Design apps, log of Innovation friendliness			

Source: Author's own computation

NOTE: Hausman test -Null hypothesis: OLS estimates are consistent
Asymptotic test statistic: Chi-square (3) = 6.54359 with p-value = 0.087959

The null hypothesis of the data is that the OLS estimates are consistent and the instruments are valid. Therefore, results of the Hausman test of endogeneity **maintains the null hypothesis** such that p> 0.08 which is statistically insignificant at 95% confidence interval. Hence, we declare that this study has no endogeneity issues which further strengthens the robustness of the results of our model (Hult et al., 2018). Having confirmed the robustness of the data and the validity of the data for the study, we then proceed to run the analysis to fulfill the study objectives.

3.3. Influence of the Framework Conditions on Innovators in the European Union

To fulfil the **first** objective, a set of dependent and independent variables are selected to fulfil the objective of *assessing the influence of the framework conditions on innovators in the European Union*. As used by multiple authors in literature and as enlisted in the methodology we posit the construct of innovators as our dependent variable and cooperation, human capital, funding and research system as our independent variables which covers the frameworks indicators.

3.3.1. Dependent Variables

In this regard, the research resorted to the use of innovators a consisting of product, process, market and organisational innovation as the dependent variables. These variables have been used by several researchers in the analysis of technological innovation in the past (Azar and Ciabuschi, 2017). This category encompasses the innovative efforts initiated by both the product and service organisations as influenced by the framework indicators. Most researchers have posited this as the product of technological innovation of innovative firms.

3.3.2. Independent Variables

The independent variables consisted of the variables that instigate the creation of innovation new or significantly improved products introduced (product innovation), new or significantly improved process (process innovation), introduction of new sales channels and brand designs (marketing innovation) and introduction of changes in organizational culture (organizational innovation). Four variables were used as independent variables and has widely been used by various organizations (European Innovation Scoreboard, 2019; Community Innovation Survey, 2014) and research (Carayannis et al., 2015, Snihur and Wikland, 2019**)** as reliable initiators of technological innovation.

The first independent variable used is Human capital as a construct. This construct consists of three indicator variables namely: Lifelong learning, new doctoral graduates and the percentage of population aged between twenty-five (25) and thirty-four (34) that have successfully completed tertiary education. This, in composite, measures the human resource available for contributing to the innovation foundations of firms and regions in general. This variable has been used by Knapper and Cropley, 2000; Community Innovation Survey, 2014; Kirch 2018).

The second independent variable used was the element of cooperation which has drawn contrasting views from most researchers. This construct consist of two indicator variables – innovative small and medium scale enterprises (SMEs) and Public private sector co-publications and private co-funding of public research and development expenditure (Brink, 2017; Fernandez-Olmos and Ramírez-Alesón, 2017; Leckel Veilleux and Dana 2017; Tobiassen, and Pettersen, 2018; Pleśniarska, 2018).

Research systems was the third independent variable used. This construct essentially represents the research component of the region and how they appeal to the international world. We represented this using two indicator variables: Foreign doctorate students as percentage of all doctoral students and international scientific co-publications per million population. This variable has been used by Hayati and Didegah (2010), Haustein, Tunger, Heinrichs and Baelz (2011); Giu, Liu and Diu (2018) and Giu, Liu and Du (2019).

Lastly, funding was also captured as a contributor and initiator to the regional innovative efforts. We set up this construct to encompass venture capital as a percentage of GDP, research and development expenditure in the business sector as a percentage of GDP and research and development expenditure in the public sector as a percentage of GDP. This construct has been used by most researchers in the analysis of knowledge exchange an interaction (Guellec, 2003; Falk, 2007; Community Innovation Survey, 2014). The tabular categorization of the above-mentioned variables can be found below in table 6.

Table 6: Structure of Variables Used

Independent Variables	**Latent variables**			
Human capital	New doctorate graduates	Lifelong learning	Population completed tertiary education	International scientific co-publications
Research systems	Scientific publications among top 10% most cited	Foreign doctorate students		
Cooperation	Innovative SMEs collaborating with others	Private co-funding of public R and D expenditures	Public-private co-publications	
Finance and support	R and D expenditure in the public sector	R and D expenditure in the business sector	Venture capital investments	Non-R and D innovation expenditure
Dependent Variable	**Latent variables**			
Innovators	SMEs with product or process innovations	SMEs with marketing or organisational innovations	SMEs innovating in-house	

Source: European Innovation Scoreboard (2019)

3.3.3. Discussion of Results

This section in present and discuss the results of the hypothesis created under the first objective which is to *verify the influence of the framework conditions on innovators in the European Union as a bloc.* As we proposed to achieve this objective with hypotheses in the methodology and literature, we show results of hypotheses in table 7 below.

Table 7: Results of Test of Hypotheses

Relationships	**Beta**	**SD**	**T Statistics**	**F^2 test**	**Hypothesis**
Cooperation -> Innovators	0.519	0.064	**8.174*** **	**0.229**	**H1- Not rejected**
Funds -> Innovators	0.300	0.080	**3.775*** **	**0.077**	**H4- Not rejected**
Human capital -> Innovators	-0.467	0.107	**4.381*** **	**0.118**	**H3- Not rejected**
Innovation friendliness -> Innovators	-0.118	0.089	1.331	0.014	**Insignificant**
Innovators -> Patent. Trademarks and Design apps	**0.601**	**0.038**	**15.815**	**0.566**	**H6- Not rejected -**
Innovators -> Sales	0.655	0.035	18.621	**0.752**	**H5- Not rejected**
Moderating Effect: RS on Cooperation -> Innovators	-0.448	0.056	**7.952*** **	**0.40**	**H2- Not rejected**
Research systems -> Innovators	0.542	0.084	**6.459*** **	**0.262**	**Significant**
Model summary					
No of observations- 224					
	Innovators	**PTD**	**SALES**		
R^2	0.698***	0.361***	0.429***		
Adjusted R^2	0.690***	0.358***	0.427***		

Source: Author's own analysis

NOTE: Significance at 99% confidence interval (CI)-***; significance at 95% CI-**; significance at 90% CI-*

We begin this analysis by verifying the model's predictive essence with the coefficient of determination (R squared) and adjusted coefficient of determination which interprets as the predictive power or the variance explained by the independent variable. This was found to be approximately 70% in the model constructed indicating that our model is statistically significant in regards it its explanatory prowess and accuracy of prediction (Urbach and Ahlemann, 2010). Hence, we can conclude that our model has significant predictive precision for the mediating and independent variable (innovators) (Cohen, 1988).

Regarding H1, results from table below shows that construct of cooperation was found to be positively and statistically significant generating innovators in the European Union. In practical terms, cooperation can be said to have a moderate effect over the generation of product, process, market and organisational innovation in the European Union, **hence this hypothesis, H1, statistically, cannot be rejected.** Over the past decade, various European Commission programs have been geared towards SME collaboration for research and innovation such as "Innovation for SME" program initiated through the Eurostars Joint primarily aimed at promoting collaboration of SMEs. Product innovations are usually initiated by firms that are engaging in several cooperative relationships with various stakeholders unlike isolated firms This finding was corroborated by the findings of Najib (2011), Le Roy, Robert and Lasch (2016), Stejskal, Merickova and Prokop (2016).

Regarding H2, we tested for interaction effect by assessing how the influence of cooperation on innovators in the European Union is moderated by the presence or adequacy of research systems. When posited as a moderator, with a strong effect size of more than 0.35, research system was found to be positive and statistically significant in influencing how cooperation affects the creation of innovators. This strong effect size grants it more practical relevance and could be held that an area with a more available and quality research structure has a higher tendency of influencing the degree of innovators are developed. **With this finding H2 cannot be rejected** and will be maintained. This finding has rarely been researched but is closely related to the findings of Guimarres, Thielman and Guimarres (2016) who found firms absorptive capacity to be a strongly significant moderator to innovation creation of firms.

Furthermore, Human capital was found to be negative but strongly statistically significant to generating innovators recognized as product, process, market and organisational innovation. This suggests a rise in human capital growth has a negatively significant influence on creation of innovators. As contrasting as it might sound, this could even be more prevalent in areas when new doctorate graduates are forced into fields not within the domain actively involved in creation of innovators, unemployed or even find funds actively channelled to development of human capital and creation of human capital but with no real contribution to innovators. This could also be the case if active resources are channelled away into unproductive human capital developed this could most likely be the case. Practically speaking, despite the being contrary to the results McGuirk, Lenihan and Hart (2015) who found innovative human capital to be positively significant to innovation in small firms, we believe there may be the need of an intermediary or interactional factor to even effectively and actively translate this human capital amassed into generation of innovators. This idea was further affirmed by work of Kianto, Sáenz, Aramburu (2017) after assessing one hundred and eighty (180) companies in Spain using PLS-SEM. This posits that **H3 could not rejected hence maintained**. This finding may be closely corroborated by the findings of Seeck and Diehl (2016) who advocated for proper management of human capital and D'este, Rentocchini, and Vega-Jurado (2014) who found that human capital eliminates the barriers of innovation which he represented by knowledge shortages and uncertainties.

Finally, on H4, we tested to verify the influence of public, private and venture capital on creation of innovators. Results reveal that even though it does have a small effect based on the reported effect size, the funding support from public, private and venture capital were found to have a statistically strong and positive effect on the generation of innovators. Even though a bottom up approach is applied in the EU and innovation is essentially customized according to regional strength, this funding requirements seems to cut across as a general need in the EU. This has been largely corroborated by various researchers such as Kerr and Nanda (2015) and Seiffert and Chattaraman, (2017). **Hence, H4 cannot be rejected.**

3.3.4. Summary of Implications and Recommendations

This section focused on analysing the influence of framework indicators on the established mediator and dependent variable that is innovators consisting of product, process, market and organisational innovation. We initially hypothesized that cooperation of SMEs and public and private sectors has a significant influence con creation of innovators. We further hypothesized that the availability of research system moderates this influence cooperation has on innovators. Thirdly, we hypothesized that human capital generated significantly strengthens the generation these innovators and lastly, we postulated that funding including venture capital significantly influences generation of innovators.

This first hypothesis revealed that cooperation involving SMEs collaboration and public private collaborative support were positively and statistically significant to the creation of innovators in the European Union. In this regard, we recommend an incentivised and more rewarding cooperative ventures involving SMEs and public and private ventures. As it is adopted in Baden Württemberg, fruitful cooperative ventures among should be afforded with more rewards for a more intensified cooperative ventures to support further innovation in this era of nested knowledge networks.

H2 was also maintained such that research systems were found to have a negative and strongly significant effect in moderating the relationship between cooperation and innovators. Essentially this could be interpreted that, with a reduced form of research system, represented by number of international scientific co-publications, scientific publications among top ten percent (10%) most cited and foreign doctorate students, this will incite a stronger cooperative influence on generation of innovators. This could be explained to align with the findings of brain drain in the EU such that resources that are expended on the education of foreign students does not seem to actively be involved in the innovation pipeline of the Union either due to brain drain or possibly enrolment in other ventures not directly related to innovation. It would be imperative to develop active programs that exclusively attract these students to not only collaborate and leave the EU but to stay and actively engage in innovation ventures.

Furthermore, H3 was also maintained. This hypothesis supposed that human capital had a significantly influence on the generation of innovators in the EU. The findings showed that it was negatively and strongly significant in this regard essentially informing that the lower the human resource availability, the more productive the generation of innovators. This could be interpreted as excess resources un-utilised or inefficiency in the usage of human capital. Unemployment levels the EU hasn't been a problem for years; coupled with the ageing labour it could be interpreted not an issue of availability or quality but efficiency. Hence, we admonish the proposition of more results-based compensation taking into consideration the age whilst not discriminating against the ageing labour. Innovative firms could offer more jobs on contract basis with a strong supervision to encourage a direct effect of quality of human capital on the quality and productivity of innovators generated.

Finally, funding on innovation from public, private and venture capital was found to have a strong and significant influence as well on the generation of innovators. Considering the consistently low foreign-direct investment levels relative to that of China and United States from 2013 to 2017 and the added potential of slipping into market failure due to indiscriminate funding, this result is very crucial and sensitive to the economic landscape of the EU. Venture capital, as well, has been relatively poor in the EU such that the it still falls behind in the venture capital comparisons with other continents, especially United States and China. An assessment of the start-up values of firms in the EU was reported as as $1billion compared with $109 billion dollars in the United States and $59 in China. Research and development expenditure for buisineses also stood at 1.3% far cry from 2% in the United States and 3.3% in China as well. Furthermore, an European Commission report captioned '*How is the internal market integration performing?*' in 2006 long showed a revealed a relatively poor inflow of even foreign direct investment (FDI) into the service sector which still stands as the most sensitive sector in terms of total GDP contribution in the EU (Eurostat 2018).

To add up to it, it could also be viewed as a lower number of acceptance of mergers and acquisitions, even though it might not be so economically attractive for such new start-ups. It is however recommended that firms with funding engage active proactive to regulate and monitor the usage and proper assignment of funds to the knowledge generation sources. We also recommend further control measures after implementation to ensure an even more direct relevance and efficient use of funds for knowledge engaging activities. Lastly, even as a wider platform for attracting investors are created, this must be supported with an equally stable political and economic landscape to entrench further confidence and influence other funding sources such as FDI.

In practical terms, these findings will actively structure and customise policy makers' decision regarding the investments they inject into these framework indicators. Effectively contributing to rationing of resources and proper apportioning of resources. Theoretically, this adds to the vast literature on cooperation, human capital, funding and research systems in generating innovators in the Union, their allocative significance as well as the degree of influence for the European Union from 2011 to 2018.

3.4. Influence of Innovators on the Creation and Dissemination of Patents, Trademarks and Design Applications

This objective will shift our focus to the role-played innovators in the technological innovation environment and their consequent influence they exert on the constructs of technological innovation we created. This is to give statistically reveal how patents submitted to the European Patents office (EPO), the trademark applications, the design applications, Medium and high-tech product exports and knowledge-intensive services exports.

To fulfil this objective, a set of dependent and independent variables are selected to fulfil the main objective of *evaluating the influence of innovators on the generation of patents, trademarks and design applications in the European Union*. As used by multiple authors in the literature and as enlisted in the methodology, we posit the construct of innovators as our independent variable and two technological innovation constructs as the dependent variables.

3.4.1. Dependent Variables

For this objective, the dependent variables in this context were technological innovation proxied by patent submitted to the European Patent Office (EPO), trademark applications and design applications. This is meant to capture technological innovation from various sectors from the product and service ventures. These variables have been applied by various authors such as Buesa et al., (2010), Gallie and Legros (2012), Arora, Bei and Cohen (2016), Mann (2018) and Morales, Flikkema, and Castaldi, (2018). We also created a construct for measuring technological innovation from the dissemination aspect as used the European Innovation Scoreboard and Community Innovation Survey (2014). This was set up to comprise of medium and high technology exports and knowledge intensive service exports

3.4.2. Independent Variables

We selected the use of innovators as a composite construct consisting of product innovation, process, marketing and organisational innovation. As opposed to previous model, these variables have been used by several researchers in the analysis of technological innovation in the past (Azar and Ciabuschi, 2017). This category encompasses the innovative efforts initiated by both the product and service organisations as influenced by the framework conditions for technological innovation. Most researchers have posited this as the product of technological innovation of innovative firms, however we believe it could serve as a mediating variable between the initiators of technological innovation and technological innovation itself which we measure by patents, trademarks and design applications. **To fulfil this objective,** we'll refer to the SMART PLS model results of table 7 and 8.

3.4.3. Discussion of Results

From the model created in figure 5, a look at the direct and indirect effect of the innovators permits it to be statistically and theoretically posited as a mediator between the framework indicators and technological innovation in the EU. Although the framework conditions have been proven in some studies to rather have a direct relation to latent variables of technological innovation used in this research, we want to further investigate this role innovators in the technological innovation networks using table 7, 8 and 9.

Table 8: Specific Direct effect

Relationships	**Mean**	**SD**	**T Statistics**
Cooperation -> Innovators -> Patent. Trademarks and Design apps	0.306	0.046	6.797***
Funds -> Innovators -> Patent. Trademarks and Design apps	0.183	0.052	3.504***
Human capital_ -> Innovators -> Patent. Trademarks and Design apps	-0.274	0.065	4.304***
Innovation friendliness -> Innovators -> Patent. Trademarks and Design apps	-0.080	0.054	1.319
Moderating Effect: RS on Cooperation -> Innovators -> Patent. Trademarks and Design apps	-0.268	0.037	7.302***
Research systems -> Innovators -> Patent. Trademarks and Design apps	0.326	0.051	6.370***
Cooperation -> Innovators -> Sales	0.332	0.051	6.656***
Funds -> Innovators -> Sales	0.197	0.051	3.896***
Human capital_ -> Innovators -> Sales	-0.298	0.073	4.171***
Innovation friendliness -> Innovators -> Sales	-0.086	0.058	1.341
Moderating Effect: RS on Cooperation -> Innovators -> Sales	-0.291	0.040	7.413***
Research systems -> Innovators -> Sales	0.355	0.062	5.759***

Source: Author’s own analysis

NOTE: Significance at 99% confidence interval (CI)-***; significance at 95% CI-**; significance at 90% CI-*

From table 7 and table 8 (above), the total indirect effect of the indicator variables on the constructs of technological innovation displayed a **strongly significant** indirect effect, effectively asserting that despite the mapped direct relationships, technological innovation experiences significant effect from these indicators. Looking into innovators, and their effect size on technological innovation, it proved to have **a strong mediating effect** on among all the hypothesized constructs technological innovation, effectively informing that the creation of innovators has a better practical connection to the creation of technological innovation especially taking into consideration the effect size from table.

Table 9: Total Indirect Effects

Constructs- Total Indirect effects	SD	T Statistics
Cooperation -> Innovators		
Cooperation -> Patent. Trademarks and Design apps	0.046	6.797***
Cooperation -> Sales	0.051	6.656***
Funds -> Innovators		
Funds -> Patent. Trademarks and Design apps	0.052	3.504***
Funds -> Sales	0.051	3.896***
Human capital -> Innovators		
Human capital -> Patent. Trademarks and Design apps	0.065	4.304***
Human capital -> Sales	0.073	4.171***
Innovation friendliness -> Innovators		
Innovation friendliness -> Patent. Trademarks and Design apps	0.054	1.319
Innovation friendliness -> Sales	0.058	1.341
Innovators -> Patent. Trademarks and Design apps		
Innovators -> Sales		
Moderating Effect: RS on Cooperation -> Innovators		
Moderating Effect: RS on Cooperation -> Patent. Trademarks and Design apps	0.037	7.302***
Moderating Effect: RS on Cooperation -> Sales	0.040	7.413***
Research systems -> Innovators		
Research systems -> Patent. Trademarks and Design apps	0.051	6.370***
Research systems -> Sales	0.062	5.759***

Source: Author's own computation

NOTE: Significance at 99% confidence interval (CI)-***; significance at 95% CI-**; significance at 90% CI-*

Nevertheless, regarding the H5 created from table 7, it could be seen that innovators, as a construct, had a very strong effect and was found positively and statistically significantly to technological innovation proxied by medium to high tech exports and knowledge intensive service exports. With an effect size of over 0.7 and its level of significance at 99% confidence interval, it **conveniently maintains** H5. This result corroborates the findings of Becker and Egger (2013). These authors used a matching approach based on score propensity from German Survey data of German firms available from the IFO Institute, the authors found that there was statistically significant bias of the effect of product and process innovations on propensity to export such that product innovation was found to be more supportive of exports than process innovation.

Lastly, innovators were also found to have a strong effect, as shown by the effect size of 0.56, and positively and statistically significant to technological innovation proxied by patents, trademarks and design applications. This finding endorses that an increment in product, process marketing and organisational innovation strongly and directly influences the technological innovation as referred to the beta coefficient of over 60% direct influence. **Hence, H6 cannot be rejected and therefore maintained**.

3.4.4. Summary of Implications and Recommendations

These results expertly touch on the generic influence of latent indicators -product, process, marketing and organisational innovation. Findings above show very strong effect size and as well a strongly significant influence on technological innovation variables used- patent trademarks, design applications, medium and high technology exports and knowledge intensive service exports. We created hypotheses such that “innovators significantly influence technological innovation proxied by patents submitted to EPO, trademark applications and design applications” – as H6 and “innovators significantly influence technological innovation represented by sales of new or significantly improved products”- as H5. Our findings sufficed both and effectively maintained both hypotheses, H5 and H6. This endorses a fact supposed belief that product, process, marketing and organisational innovation has a strong correspondence with the creation of technological generation in the European Union and hence ample to accelerate or change the direction of technological innovation should be driven largely at this driver. In this vein,

- We recommend that National and European institutions, even as they keep an eye on the tendency of market failure from excessive investment, should channel investment and focus it primarily on the business needs that are directly connected to the innovation results of the firm.
- More essence and attention should also be given to marketing channels because underdeveloped and not-so-popular channels could quickly deplete the efforts to convey products to consumer. Hence, managers should thoroughly assess the viability and reach of those channels that are resorted to for sales reasons.
- Firms should adopt marketing channels with more convincing potential of improving the sales volume. These channels should also be structured support seamless intermediary activities whilst still opening itself for new market opportunities.
- Accountability and interim control sessions should be frequently run to ensure proper relevance to targets. Expenditure shlelved on acquisition of knowledge via open innovation should be deeply aligned with research results on customer’s behavioural changes and the position of the product with the users.
- Seeing the extreme practical effect on technological innovation by sales of new products, it is recommended that untapped markets are aggressively pursued by admonishing member states as well to empower Small and Medium Scale enterprises (SMEs) to rather feed into the small and unattended market that are rather overlooked by larger entities.

Looking the practical implications, this objective is a relatively new venture and even though various researchers have rightly posited innovators as sometimes end result of innovation, but further connecting and extending the perception in line with the Oslo Manual's definition of technological innovation will also allow policy makers to acquire an overarching view on the performance of the EU in a panel dimension (8 years) and as well borrow this results as a perceptive view of the conversion rate of innovators to technological innovation. This will also rightly enable policy makers to align support for technological innovation in line with any new programme or objective.

In terms of theoretical significance, this finding intends to add up on the literature on the degree of conversion of product and process innovation to technological innovation and consequently on the dimension of dissemination of technological innovation. This adds to the already vast research on innovators and the drivers of technological innovation in the research arena.

3.5. Assessment of Marginal Contribution to Technological Innovation by Innovation Classes.

Having found the strong practical effect of innovator generation on technological innovation and how much the framework conditions outlined by the European Innovation Scoreboard (2019) affect the generation of innovators, we also **intend to assess** whether these findings are driven largely by the highly innovating class of innovation in the EU to ensure our findings are not biased or skewed results largely by the most innovative class. This **will also** provide us with an assessment of marginal contribution of the innovative variables to the technological innovation environment according their different innovation classifications of the EU.

Looking at the findings of the first and second objective, this section will also seek to reveal whether the most innovative class of innovation drives the relevance of the regional innovative elements that drives the creation of innovators in the European. In doing this, we resorted to the EIS (2019) classification of innovation of EU member states into **innovation leaders, strong innovators, moderate innovators and modest innovators**.

3.5.1. Dependent Variables

Innovators was posited as the dependent variable for all classes of innovation for the ensuing analysis. Product, process, market and organisational innovation makes up the composite of innovators as mentioned in prior discussions. These variables have been used by several researchers in the analysis of technological innovation in the past including Azar and Ciabuschi (2017).

3.5.2. Independent Variables

To fulfil this objective, we used the variables applied earlier with little segmentation. We first selected **Human Capital** as a construct. This construct consists of three indicator variables namely: Lifelong learning, new doctoral graduates and the percentage of population aged between twenty-five (25) and thirty-four (34) that have successfully completed tertiary education. Next was **cooperation** which consisted of innovative small and medium scale enterprises (SMEs) and Public private sector co-publications and private co-funding of public research and development expenditure**.** Third variable used was **Research systems**, which consisted of international scientific co-publications, scientific publications among top 10% most cited and foreign doctorate student. Fourth variable used was **innovation friendliness** consisting of broadband penetration in the region, opportunity-driven entrepreneurship. Finally, we also incorporated funding but divided it into **finance and support**- public funding and venture capital and **firm investments**.

3.5.3. Discussion of Results

We undertook analysis to debunk the highly likely possibility that the highly innovative member states might be influencing the responsiveness of the innovators to the regional innovative elements as opposed to the lowly performing member states. An analysis of results of both modest and moderate innovators are presented in table 10 below.

Table 10: Regression Results of Innovation Leaders And Strong Innovators

Dependent variable	**Innovators**			
	Modest Innovators		**Moderate Innovators**	
	Marginal Effect (dy/dx)	**T statistics**	**Marginal Effect (dy/dx)**	**T statistics**
Independent variables				
Human Capital	0.182	0.680	-0.703	-3.190***
Research systems	-0.104	-0.100	1.143	10.640***
Innovation friendly environment	-0.245	-1.070	-0.119	-1.090
Finance and support	0.221	1.190	0.054	0.480
Firm Investments	0.501	4.130***	0.458	2.880***
Cooperation	0.971	6.130***	0.480	2.650***
Model Fit				
Number of Observation	16		112	
Prob>F	0.000		0.000	
R- squared	0.874		0.529	
Root MSE	0.033		0.142	

Source: Author's own computation

NOTE: Significance at 99% confidence interval (CI)-***; significance at 95% CI-**; significance at 90% CI-*

Results of table 10 above show that over an eight-year period (2011–2018), human capital, research systems, firm investments and cooperation had a significant influence on the generation of innovators- product, process, marketing organisational innovation. However, human capital albeit significant was negatively related to the creation of innovators as revealed in the first objective. Most countries that fall in this region are the accession countries from 2004 and after and some research has reported brain drain in these countries to other economically stronger EU member states or even other countries in search of better prospects. This finding could point out the dominant source of brain drain conundrum of the EU and a helpful start on where to defeat it.

In terms of marginal effect of their influence, research systems had the highest influence such that a percentage improvement in the research system resulted in a more than one unit increase in innovator generation, almost bordering on elastic relationship. A percentage increment in cooperation and firm investments of moderate innovators results in an almost half a unit increment in generation of innovation. Human capital influence did reveal to have a high negative marginal effect of 0.7 revealing how well EU loses out their labour in either exit or possibly efficiency.

On the other hand, for modest innovators, firm investments research funding from firms and cooperation of firms, private and public sectors contributed significantly to the generation of innovators. Looking at their marginal effects, it could be interpreted such that human capital and regional structures to attract innovation did not form a strong part of their innovative contribution but rather they relied more on direct connection of persons and institutions and direct business funding for research. We further proceed to also analyse the highly innovative member states below in table 11.

Table 11: Regression Results of Modest and Moderate Innovators

Dependent variable	Innovators		Innovators	
	Strong Innovators		Innovation Leaders	
	Marginal Effect (dy/dx)	T statistics	Marginal Effect (dy/dx)	T statistics
Independent variables				
Human Capital	-0.865	-2.750***	-0.343	-0.770
Research systems	0.655	3.410***	-0.358	-1.340
Innovation friendly environment	0.058	0.260	0.233	1.090
Finance and support	-0.220	-1.290	-0.178	0.790
Firm Investments	0.872	3.230***	0.094	0.490
Cooperation	-0.579	-4.140***	0.470	0.760
Model Fit				
Number of Observation	64		32	
Prob > F	0.000		0.172	
R-squared	0.403		0.255	
Root MSE	0.132		0.073	

Source: Author's own computation

NOTE: Significance at 99% confidence interval (CI) -***; Significance at 95% CI-**; Significance at 90% CI-*

Table 11 above shows an analysis of strong innovators and innovative leaders which are the highest ranked innovative member states, 2nd and 1st respectively, according to the European Innovation Scoreboard (2019). Results of this analysis reveal that, surprisingly, over the eight (8) year period (2011-2018), the current crop of innovation leaders did not report any significant influence on innovators unlike the strong innovators who reported a strong and significant contribution to the generation of innovators in the European Union in four of the six (6) variables. Just like the moderate innovators, the strong innovators reported a negative and significant influence in terms of human capital contribution to generating innovators which further buttresses the issue of possible brain-drain of human resources or inefficiency of available human resources. In terms of funding, finance and support consisting of public and venture capital were not influential as compared to firm investments. However, the cooperation, human capital, research systems and firm investments all reported a marginal effect of more than fifty percent (50%) on innovators buttressing how reliant innovators are on these components. However, further research is recommended to investigate the inverse significance of cooperation in the generation of innovators among this class of innovation.

3.5.4. Summary of Implications and Recommendations

This objective was set out to assess whether highly innovative classes of innovation, i.e. strong and moderate innovators in the European Union were more influential in the generation of innovators in the Union contrary to the relatively low-level ones- moderate and modest innovators. Findings recorded on this revealed that using the crop of innovation classification of 2019 with data from (2011-2018), the moderate and strong innovators were found to have more relevance of their firm investments, cooperation, research systems and human capital in creating product, process, marketing and organisational innovation more than the most innovative and the least innovative member states.

Looking at their marginal effects and direction of significance, human capital had an inverse connection and more than 50% influence on innovators. Looking at the essence of human capital to economic growth, productivity and to technological innovation, it is worrying to reveal a deeply negative connection to what has been touted as a key to gaining competitive advantage in the modern times. It is recommended that deeper research is run into the efficiency of human capital in the EU. If brain drain is a true significant cause of this, ample avenues to apply such locally produced knowledge should be availed and advertised to reach out and hopefully attract these personnel who has been supported so much with European Union Structural funding or any other.

As it has been revealed that research systems strongly moderate how much cooperation influences the creation of innovators in the first objective, it is imperative to strengthen more foreign-connection within the research arena whilst simultaneously admonishing research graduates to stay with attractive conditions and compensation packages. Furthermore, it is encouraging to find business expenditure very positively significant to the efforts to create innovators. However, further research should be undertaken to verify the failure of the public funding in these individual industries and member states with such reports so that funds can possibly be redirected, or a more suitable innovator contributor can be supported to enable funds to be released in other needy areas.

As encouraging as it is to realise that not just the most innovative member states are the ones with relevant indicator connections to affecting innovators as analysed, it creates a platform for the innovative member states to be benchmarked and analysed against the relatively low performing classes to reveal any underlying success factors that may be applicable or feasibly employed by other member states which may not have been obvious from the analysis above.

4. CONCLUSION

Innovation from technologies has dominated the better part of the past three decades quickly moving firms and businesses to encourage positive transformation in organisational culture, brainstorm new ideas, develop new products and devise effective marketing channels, routes and segments to penetrate to effectively disseminate technologies created. To acquire competitive advantage over other member states and leap ahead of competition whilst reaping the benefits from the innovation, products and processes are patented, trademarked or applied to be protected via design application. This race to acquire the latest or most relevant invention however, is clouded in a set of interactive and integrated set of socio-economic and infrastructural set ups that collectively react to generate technological innovation in member states. **This dissertation relied on the TIS perspective** to assess the various systemic interdependencies between these elements in the technological innovation environment. In this dissertation, the researcher developed an integrated model to assess the contribution of human capital, cooperation, research systems and financial support to technological innovation environment among the twenty-eight (28) EU member states.

In this regard, the first specific objective sought to assess the influence of the framework conditions on innovators in the European Union. To achieve this, we modelled the framework conditions or regional innovative elements - cooperation, human capital, research systems and funding sources on innovators in the EU- i.e. product, process, marketing and organisational innovation. **The results of the empirical analysis revealed that** cooperation of SMEs and public and private entities had the strongest influence in the generation of innovators in the Union looking at the effect size and beta**,** however, it was strongly negatively moderated by the available research systems in the Union. Our findings also revealed human capital hat it was negatively and strongly significant in this regard essentially informing that the lower the human resource availability, the more productive the generation of innovators. Further findings on the financial presence also revealed that funding on innovation from public, private and venture capital was found to have a strong and significant influence as well on the generation of innovators in the Union. This result is even more imperative looking at the persistently low foreign-direct investment and venture capital levels relative to that of China and United States from 2013 to 2017.

The second specific objective followed up on first objective to reveal the transforming role of the innovators as a mediator and an initiator to generation of technological innovation in the EU which we represented by patent, trademarks and design applications submitted to the European Patent Office (EPO) as well as sales of new or significantly improved products. Focusing solely on the EU 28 member states, we concluded that innovators positively and strongly determines the degree of technological innovation in the EU from both measured constructs. Results of the study showed that with a very strong effect size as well, innovators were strongly significant to the creation of technological innovation variables represented by patent trademarks, design applications. A second test conducted on technological innovation represented by sales of new or significantly improved products also showed to be strongly significant even with a much higher practical beta and strength of significance. This finding revealed that **in as much as marginal increases in product,** process marketing and organisational innovation strongly influences the technological innovation's disseminator role than protective means, it is was also found to strongly mediate the transition of regional innovative elements to technological innovation.

Having known the strong relevance of innovators to the generation of technological innovation in the EU, the third objective to assess the highly innovative classes of innovation, i.e. strong and moderate innovators in the European Union were more influential in the generation of innovators in the Union contrary to the relatively low-level ones- moderate and modest innovators. This is meant to eliminate the possibility of the results being largely influenced by the most innovating member states and to reveal the how these different innovation classes respond to supports from these innovation variables. Findings in this regard revealed that using the crop of innovation classification of 2019 with data from (2011-2018), the moderate and strong innovators were found to have more relevance of their firm investments, cooperation, research systems and human capital in creating product, process, marketing and organisational innovation more than the most innovative and the least innovative member states.

Regarding the **novelty** of the study the research will reveal the domineering variables deeply relevant to the generating EU generation of innovators and how key EU innovation variations perform in the realm of EU technological innovation environment. Having not had access to latest data for specific country and firm level analysis, this was quite a **limitation** to our research, hence, we recommend that in light of the expediency of brain drain and personnel issues in the European Union, further research may focus on a specific country level analysis on the moderation of research systems in the Union focusing on the influence of cooperation on generation of innovator.

The research also offers theoretical contributions as enlisted below:

- The study adds to the vast literature on cooperation, human capital, funding and research systems in generating innovators in the Union, their allocative significance as well as the degree of influence for the European Union from 2011 to 2018.
- It also offers a different dimension to the literature regarding the degree of conversion of product and process innovation into technological innovation, their margin of influence they offer in the EU and consequently on the dimension of dissemination of technological innovation.
- Provides a differentiated and systemic impact of elements selected in the generation of patents, trademarks and design applications in the European Union and to unveil the interactive essence of these factors in supporting one another in the quest for innovation creation in the Union.
- The study also reveals the sub variables that not only affect technological innovation but also shows the degree to which such indicators respond to each other in a catalytic and synergistic structure.
- This study further offers ample knowledge to supplement resource allocation needs by policy makers by mitigating focus on what funding can do for innovation efforts and rather focusing also how factors in play can interact supportively to create a favourable environmental presence for innovation generation.

Practically, the research also offered many practical relevance and connections. In practical terms, these findings will:

- Actively structure and customise policy makers' decision regarding the investments they inject into these framework indicators. This will essentially allow policy makers to make informed decisions regarding rationing and proper apportioning of resources.
- Also allow policy makers to acquire an overarching view on the performance of the EU in a panel dimension (eight (8) years) and as well
- Further grants policy makers a perceptive view of the conversion role of innovators to technological innovation and rightly align support for this variable in line with any new programme or objective.

In line with these findings, we recommend policy makers to follow these lines of thought below.

1. Fruitful cooperative ventures should be afforded more incentives for a more intensified cooperative ventures to support further innovation in this era of nested knowledge networks.
2. Develop active retention programs that exclusively attract foreign students to not only collaborate and leave the EU but to stay and actively engage in innovation-oriented ventures.
3. Results-based compensation should be considered by mostly service-oriented firms strictly taking into consideration the age of the employees but not discriminating against them.
4. Offer more jobs on contract basis with strong supervision to encourage a direct effect of quality of human capital on the quality and productivity of innovators generated.
5. Active control measures regarding the usage and proper assignment of funds to assigned knowledge generation sources.
6. Post control measures should be implemented to ensure an even more direct relevance and efficient use of funds for knowledge engaging activities.
7. A wider platform for attract investors should be adopted and supported with an equally stable political and economic landscape to entrench further confidence and also influence other funding sources
8. Importance should also be placed on marketing channels on the grounds that poor and unpopular channels may result in wasted efforts of conveying products to consumers, hence credibility of websites resorted to for sales as well as the potential of reach of these channels should be highly vetted as well.
9. More essence and attention should also be given to marketing channels because underdeveloped and not-so-popular channels could quickly deplete the efforts to convey products to consumer. Hence, managers should thoroughly assess the viability and reach of those channels resorted to for sales reasons.
10. Untapped markets are aggressively pursued by admonishing member states as well to empower Small and Medium Scale enterprises (SMEs) to rather feed into the small and unattended market that are rather overlooked by larger entities

APPENDIX

Appendix A: Outer loadings of latent variables

Indicators	**Outer Loadings**	**T Statistics**	**Outer weights**	**T Statistics**
Lifelong learning <- Human capital	0.908	64.622***	0.56	16.476***
Broadband penetration <- Innovation friendliness	0.715	10.566***	0.27	3.741***
Design applications -> Patent. Trademarks and Design apps	0.578	5.880***	**-0.012**	**0.090**
Employment in knowledge-intensive activities (% of total employment) -> Sales	0.985	61.999***	**0.764**	**6.627****
Foreign doctorate students as a % of all doctorate students <- Research systems	0.918	83.041***	0.505	38.473***
Foreign doctorate students as a % of all doctorate students * Innovative SMEs collaborating with others (% of SMEs) <- Moderating Effect: RS on Cooperation	0.655	9.441***	0.333	5.522***
Foreign doctorate students as a % of all doctorate students * Public-private co-publications per million population <- Moderating Effect: RS on Cooperation	0.486	3.425***	0.22	1.821
Innovative SMEs collaborating with others (% of SMEs) <- Cooperation	0.906	92.980***	0.601	30.892***
International scientific co-publications per million population <- Research systems	0.937	135.351***	0.572	37.426***
International scientific co-publications per million population * Innovative SMEs collaborating with others (% of SMEs) <- Moderating Effect: RS on Cooperation	0.731	11.980***	0.607	5.122***
International scientific co-publications per million population * Public-private co-	0.393	2.544***	0.053	0.494

publications per million population <- Moderating Effect: RS on Cooperation				
Knowledge-intensive services exports as % of total services exports -> Sales	0.884	24.289***	**0.280**	**2.183*****
New doctorate graduates per 1000 population aged 25-34 <- Human capital_	0.739	12.721***	0.448	8.621***
Opportunity-driven entrepreneurship (Motivational index) <- Innovation friendliness	0.974	75.498***	0.829	14.979***
PCT patent applications per billion GDP (in PPS) -> Patent. Trademarks and Design apps	0.904	24.694***	**0.842**	**12.308*****
Percentage population aged 25-34 having completed tertiary education <- Human capital_	0.530	6.445***	0.301	4.889***
Public-private co-publications per million population <- Cooperation	0.873	52.737***	0.522	32.652***
R&D expenditure in the business sector (% of GDP) <- Funds	0.903	53.743***	0.633	21.371***
R&D expenditure in the public sector (% of GDP) <- Funds	0.907	52.332***	0.462	20.627***
SMEs introducing marketing or organisational innovations as % of SMEs <- Innovators	0.955	147.109***	0.499	60.361***
SMEs introducing product or process innovations as % of SMEs <- Innovators	0.962	220.831***	0.543	51.674***
Trademarks -> Patent. Trademarks and Design apps	0.560	7.412***	**0.439**	**4.621*****
Venture capital (% of GDP) <- Funds	0.537	8.375***	0.302	6.333***

Source: Author's own computation

NOTE: Significance at 99% confidence interval (CI)-***; significance at 95% CI-**; significance at 90% CI-*

Appendix B: Cross loadings of Latent Variables

Indicators	CP	Funds	HR	INN_F	INN	MOD: RS_COP	PTD	RS	SLS
Lifelong learning	0.738	0.819	**0.908**	0.825	0.506	0.049	0.835	0.798	0.605
Broadband penetration	0.335	0.479	0.565	**0.715**	0.158	0.252	0.465	0.489	0.235
Design applications	0.220	0.366	0.275	0.358	0.347	0.026	**0.578**	0.401	0.383
Employment in knowledge-intensive activities (% of total employment)	0.569	0.462	0.595	0.458	0.645	-0.131	0.669	0.798	**0.985**
Foreign doctorate students as a % of all doctorate students	0.603	0.623	0.680	0.623	0.573	0.103	0.550	**0.918**	0.764
Innovative SMEs collaborating with others (% of SMEs)	**0.906**	0.590	0.626	0.428	0.643	-0.006	0.514	0.614	0.485
International scientific co-publications per million population	0.806	0.701	0.839	0.770	0.649	0.007	0.787	**0.937**	0.758
Knowledge-intensive services exports as % of total services exports	0.547	0.484	0.576	0.532	0.579	0.060	0.580	0.749	**0.884**
New doctorate graduates per 1000 population aged 25-34	0.610	0.641	**0.739**	0.470	0.405	0.083	0.490	0.462	0.261
Opportunity-driven entrepreneurship (Motivational index)	0.678	0.744	0.779	**0.974**	0.484	0.045	0.693	0.752	0.526
PCT patent applications per billion GDP (in PPS)	0.762	0.885	0.809	0.700	0.544	0.132	**0.904**	0.634	0.512

Percentage population aged 25-34 having completed tertiary education	0.459	0.275	**0.530**	0.413	0.272	-0.067	0.316	0.562	0.531
Public-private co-publications per million population	**0.873**	0.820	0.860	0.755	0.559	0.165	0.836	0.760	0.568
R&D expenditure in the business sector (% of GDP)	**0.781**	0.903	0.754	0.619	0.550	0.068	0.794	0.595	0.425
R&D expenditure in the public sector (% of GDP)	**0.702**	0.907	0.731	0.679	0.548	-0.055	0.698	0.553	0.272
SMEs introducing marketing or organizational innovations as % of SMEs	0.579	0.520	0.472	0.346	**0.955**	-0.331	0.506	0.597	0.646
SMEs introducing product or process innovations as % of SMEs	0.716	0.657	0.574	0.500	**0.962**	-0.268	0.641	0.668	0.612
Trademarks	0.243	0.132	0.241	0.261	0.337	-0.183	**0.560**	0.453	0.563
Venture capital (% of GDP)	0.319	**0.537**	0.470	0.481	0.359	0.006	0.357	0.611	0.548

Source: Author's own computation

where**:** CP- Cooperation,

HR- Human capital,

INN_F –Innovation friendliness,

INN – Innovators,

MOD: RS_COP – Moderator of research systems on cooperation,

PTD- Patent, trademarks and Design applications,

RS – Research system,

SLS- Sales.

Appendix C: Variance Inflation Factor (VIF) Scores

Indicators	**VIF**
Lifelong learning	1.687
Broadband penetration	1.405
Design applications	1.899
Employment in knowledge-intensive activities (% of total employment)	2.658
Foreign doctorate students as a % of all doctorate students	2.085
Foreign doctorate students as a % of all doctorate students * Innovative SMEs collaborating with others (% of SMEs)	2.101
Foreign doctorate students as a % of all doctorate students * Public-private co-publications per million population	3.256
Innovative SMEs collaborating with others (% of SMEs)	1.517
International scientific co-publications per million population	2.085
International scientific co-publications per million population * Innovative SMEs collaborating with others (% of SMEs)	2.164
International scientific co-publications per million population * Public-private co-publications per million population	3.317
Knowledge-intensive services exports as % of total services exports	2.658
New doctorate graduates per 1000 population aged 25-34	1.426
Opportunity-driven entrepreneurship (Motivational index)	1.405
PCT patent applications per billion GDP (in PPS)	1.177
Percentage population aged 25-34 having completed tertiary education	1.250
Public-private co-publications per million population	1.517
R&D expenditure in the business sector (% of GDP)	2.677
R&D expenditure in the public sector (% of GDP)	2.700
SMEs introducing marketing or organisational innovations as % of SMEs	3.374
SMEs introducing product or process innovations as % of SMEs	3.374
Trademarks	1.674
Venture capital (% of GDP)	1.078

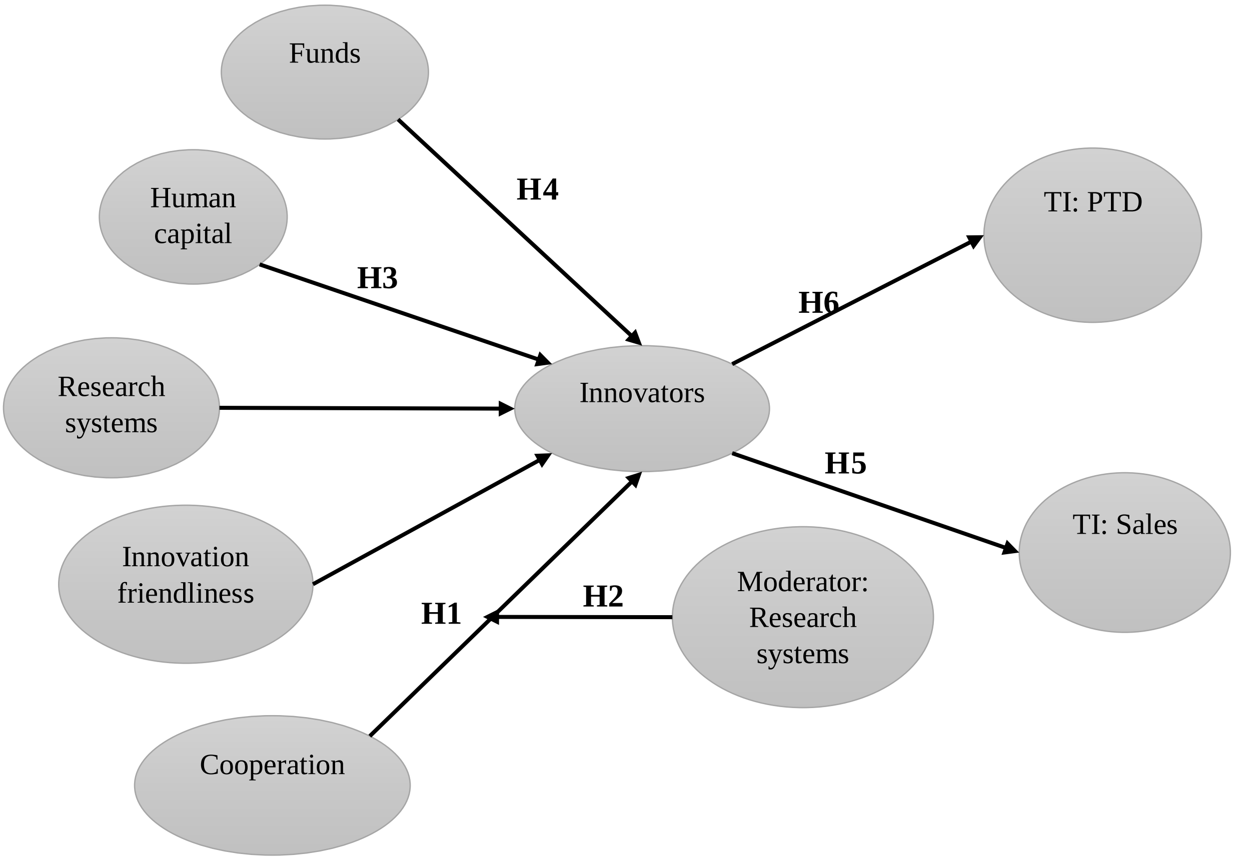
Source: Author’s own computation

Appendix D: Correlation Matrix of Constructs

Cooperation	Funds	Human Capital	Innovation friendliness	Innovators	Patent, Trademarks And Design applications	Research Systems	Sales	Constructs
1.0000	0.7828	0.8252	0.6518	0.6782	0.7450	0.7661	0.5877	Cooperation
	1.0000	0.8291	0.7462	0.6168	0.7985	0.7158	0.4886	Funds
		1.0000	0.7979	0.5475	0.7832	0.8240	0.6161	Human Capital
			1.0000	0.4442	0.7000	0.7553	0.4991	Innovation friendliness
				1.000	0.6011	0.6613	0.6552	Innovators
					1.0000	0.7282	0.6736	Patent, Trademarks and Design applications
						1.0000	0.8196	Research systems
							1.0000	Sales

Source: Author’s Own Computation

Appendix E: Model of Hypothesis Analysis



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