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THE TRIPLE HELIX MODEL: FACTORS INFLUENCING SMES´ INNOVATION ACTIVITIES IN SELECTED EU COUNTRIES

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DEDICATION

I dedicate the entire content of this thesis to my late brother Isaac Odei Kwapong, who couldn't live to see this dream materialise. You are fondly missed by all.

ANNOTATION

Universities, industries and governments collaborations have increasingly become a fundamental component of the efficient national and regional innovation systems. Successful innovation collaborations are vital because it enables the actors to gain knowledge, new technologies and other resources needed to stimulate and accelerate their innovation performances and activities. Universities have a compelling role in driving economic growth through their research, teaching and manpower training. Universities have enlarged their entrepreneurial activities in many dimensions, including collaborating with industries in research commercialization, patenting and licensing, wealth creation, contributing to employment and promoting university spin-offs. Despite the numerous advantages this collaboration offers, not all countries, universities and industries have embraced these kinds of R&D collaborations. This thesis seeks to investigate the factors that influence universities industries and governments collaborations in the European Union and in tandem offer the best practices and measures taken in countries where these innovation collaborations are successful so that these measures can serve as a guide to universities and industries managements and policy makers.

KEYWORDS

Collaborations, commercialization, competitiveness, innovation system, innovation, spin-offs, R&D

ANOTACE

Spolupráce univerzit, průmyslových podniků a vlád (na různých úrovních) se stávají stále více základní neopominutelnou součástí efektivně fungujících národních a regionálních inovačních systémů. Úspěšná spolupráce v oblasti inovací je důležitá i proto, že umožňuje jednotlivým aktérům získat znalosti, nové technologie a další zdroje potřebné ke stimulaci a urychlení inovačních procesů a zvýšení produktivity inovací. Původní rolí univerzit je přispívat k ekonomickému růstu produkcí kvalifikované pracovní síly. Novou rolí je pak rozšíření jejich aktivit o podnikatelské činnosti v různých oborech a dimenzích, což zahrnuje i spolupráci s průmyslovými podniky v oblastech komercializace výzkumu, patentů a užitných vzorů, tvorby dalších aktiv a podpory vzniku (univerzitních) spin-off firem. I přes četné výhody, které popisovaná spolupráce přináší, ne všechny země, university nebo podniky kooperují v oblasti výzkumu a vývoje. Tato disertační práce se zabývá zkoumáním faktorů, které ovlivňují spolupráci univerzit, průmyslových podniků a vládních institucí v Evropské unii a současně nabízí analýzu případových studií z různých evropských zemí, jež kde došlo k úspěšné inovační spolupráci. Tyto případové studie mohou pomoci definovat praktické implikace, které mohou využít jak představitelé univerzit, managementy průmyslových podniků, tak tvůrci veřejných politik.

KLÍČOVÁ SLOVA

Spolupráce, komercializace, konkurenceschopnost, inovační system, inovace, spin-off, věda a výzkum

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LIST OF ABBREVIATIONS

AVE	Average Variance Extracted
CEE	Central and Eastern European countries
CIS	Community Innovation Survey
CMB	Common Method Bias
EU	European Union
GoF	Goodness-of-Fit
HE-BCI	Higher Education Business & Community Interaction
HEI	Higher Education Institutions
IPR	Intellectual Property Rights
KMO	Kaiser-Meyer-Olkin
MIT	Massachusetts Institute of Technology
MLE	Maximum Likelihood Estimation
NIS	National Innovation Systems
OECD	Organisation for Economic Co-operation and Development
PhD	Doctor of Philosophy
R&D	Research and Development
RIS	Regional Innovation Systems
SEM	Structural Equation Model
SMEs	Small and Medium Scale Enterprises
SPSS	Statistical Package for the Social Sciences
TH	Triple Helix
TT	Technology Transfer
TTO	Technology Transfer Offices
UIG	University Industry Government collaborations
UK	United Kingdom
USA	Unites States of America
VIF	Variance Inflation Factor

INTRODUCTION

The effective interactive collaborations among the social institutions comprising of universities, industries and government (UIC) has gained prominent attention from researchers because of its perceived contributions to social, economic and regional development. Emphasis is placed on these knowledge interactions because it is the key to the production of innovation. The rapid implementation of knowledge and outcomes of academic research emanating from universities are crucial for firm’s competitiveness. Industries have realized that they do not possess the necessary competencies to perform every in-house operation solitarily. Industries cooperation with the other institutions can help find long lasting solutions to problems they couldn’t handle. In this respect, industries value their partnership with universities.

The main tenet of the collaboration is built around universities and they are therefore expected to play pivotal roles in the society. Universities are required to play its traditional role of teaching and research in tandem with their “third mission”. This new role is that of promoting innovations albeit their core mission has been to create and disseminate knowledge that will help in the social and economic development. Universities are also in recent times leading the way for firms formations from their academic and scientific research. This all new importance accorded to universities places them in a superior position that is above the other collaborators in the knowledge-based economy.

Industries are known to be involved in the production of valuable goods and services traditionally. In recent times industries have also commuted from their traditional function of production. They are partnering with universities and other research organizations to improve their outputs and competitiveness in the market thereby contributing to economic growth and jobs creations. University-industry cooperation can deliver innovative products and services for firms. New knowledge grasped from firm’s engagement with universities can influence innovation performances and improve their productivities. Their overlapping role is also that of absorbing and appropriating the quality research and skilled personnel from universities and other research organizations.

It is proven that the result of these collaborations is innovation. The sustained interactions among these entities will lead to improved ways of doing things. When universities produce lots of knowledge from their quality researches, and firms appropriate this knowledge in their production process, improved outputs will be made available to consumers. Furthermore, when government constantly provides funding schemes to universities and industries as incentives, it will augment the shortage of capital they face especially for small firms at their infant stages. It is based on these endless innovations emanating from these collaborations that lots of attention has been given to R&D collaborations.

This dissertation will be structured as follows, chapter two focuses on the theoretical background on university-industry-government collaboration (UIC), chapter three is devoted to the in-depth description of statistical methods, chapter four focuses on empirical analysis and discussions of findings and chapter five concludes this dissertation with summary of key findings and policy implications.

1. CONCEPTUAL FRAMEWORK

1.1 Knowledge spill overs and endogenous growth

Endogenous theories of economic growth rose to prominence based on its focus on the role played by knowledge in countries economic growth process (Romer, 1986, 1990; Grossman & Helpman, 1994). Other traditional growth theories ignored the role of knowledge in the growth process (see Solow, 1956; Swan, 1956). Solow & Swan (1956) suggested that the level of technological development was influenced by external scientific processes which are independent and not influenced by economic forces. But according to proponents of new growth theories, knowledge is not an accidental occurrence, it takes conscientious means and both public and private resources to produce. Economic agents heavily invest resources in research and development (R&D) to produce novel knowledge.

Knowledge is a public good possessing peculiar property that makes it spill over easily at zero marginal cost (Arrow, 1962). The spill over attribute of knowledge is the basis of the increasing returns that spawn long-run economic growth. Knowledge spill over occurs when knowledge and information pertaining to an activity ultimately trickles down to generate additional prospects for further application in other settings. Knowledge spill overs lead to the development of new services and products that have connections with the reasons why the original idea or knowledge was produced (Stejskal & Hájek, 2015). The implication of knowledge spill over is that the growth rate in the knowledge stock is proportionate to the total number of labours engaged in R&D. Therefore, the policy implication is that providing both public and private subsidies for R&D can increase the quantity of labour apportioned to research will increase the growth rate and the stock of knowledge. Such measures will increase per capita growth in the economy in long-run period

At the core of R&D-based growth (endogenous) model is the belief that technology (knowledge) production function is schematic to the advancement of knowledge generation. Here the amount of new knowledge produced depends on the proportion of labour that are engrossed in R&D as well as the current stock of knowledge available to these scientists. Jones & Romer (2010) have strongly argued that, knowledge spill over in the economy highly depends on the current stock of knowledge. The Romer model is built around two assumptions; first knowledge is classified as economic knowledge and secondly knowledge can spill over. Economic (scientific, technological) knowledge comprises of non-rival and to some extent excludable components of codified knowledge available in papers, books, patent citations, and excludable knowledge which is rival in nature. Knowledge spill overs are the outcomes of inter-temporal spill overs, and this is what generates endogenous growth. Current investments in R&D period automatically generate future returns. Arrow (1962) also highlighted that knowledge inherently differ from the traditional factors of production. New knowledge production depends on the "intertemporal spill over of knowledge" to future scientists "and the efficiency of technology and knowledge production is enhanced by the historical development such as stock of scientific-technology knowledge" (Acs et al., 2009).

The increasing attention given to knowledge spill overs has drifted scholarly attention to the sources of knowledge and innovation i.e. universities and other research organizations. Universities are pivotal in regional development through the spill overs effects of the knowledge they produce on their campuses (Trippl et al., 2015). In the United States the popular Silicon Valley and the "Route 128," have become the epicentres of commercial innovation and are located near to prestigious universities such as MIT, Stanford and other research-intensive centres. This has sparked a new research focusing on geographic proximity to universities and how it speeds knowledge spill overs. The pool of talented graduates, faculty emanating from research universities have helped to expedite the knowledge spill overs process and innovation in Route 128 (Eriksson, 2011). The capability to transmute knowledge into commercial value do not depend solely on skills and expertise, but also on proximity to the science system (universities and other research centres). The complementing linkage of academic inventors and firms aiming to commercialize their knowledge work better when they are both in close proximity to each other allowing swift access to R&D outcomes (Michelacci, 2003).

1.2 Concept of innovation in national and regional innovation systems

Innovation is highly expected to stimulate wealth, economic growth (national and regional) and competitiveness in firms and countries (OECD, 1997). Knowledge and innovations are at the centre of the universities and industries collaborations. Crossan & Apaydin (2010) used the term innovation to denote the "production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome." Innovation refers to the process of converting a novel idea into a commercial outcome to earn revenues and profits (Lafley & Charan, 2008). Firms find themselves in intense market competitions, so firms resort to seeking and transforming knowledge and ideas into products and services, that gives them the competitive advantage over their market competitors.

The growing importance attached to knowledge and technology dissemination requires economic agents to have a better comprehension of knowledge networks: what has become known as the national innovation systems (Owen-Smith & Powell, 2004; Boschma & Ter Wal, 2007). The national innovation system (NIS) refers to the "elements and relationships which interact in the production, diffusion and use of new, and economically useful knowledge. ….and are either located within or rooted inside the borders of a nation state" (Lundvall, 1992). The NIS comprise of the constant flows and interdependence among social institutions such as the science systems, industries, and governments in the advancement of science and technology (Prokop et al., 2018a).

The promulgation of the notion of "innovations systems" (see Lundvall, 1992; Nelson, 1993; Mowery & Nelson, 1999; Nelson, 2013; Grigoriou & Rothaermel, 2017) put emphasis on the interaction among different collaborators in creating competitiveness, innovation and development in sectors and countries (Malerba, 2005; Doloreux, 2002; Veugelers, 2014). The foregoing discussion therefore stresses the cooperation of government, industries and academia (other public and private research institutions). The success of the innovation system is built around the actors' capability to learn and build stronger ties in the system as well as quality of the institutions such as research and knowledge institutes. Since the 1990s approaches to the NIS focused on the linear model. The linear model of innovation policy has been the most principal approach guiding NIS in many countries and it predominantly focused on providing the financial support for companies and technology transfer processes for firms and provision of R&D infrastructure to encourage innovation. Fagerberg et al (2005) described the linear model as an inaccurate interpretation of innovation because it turned a blind eye on firm's absorption capacity and the unequal support for innovation in all regions (Boekema et al., 2000).

The linear model has therefore been flawed for two reasons: It limits the innovation process to the production of scientific knowledge, product development as well as marketing. Secondly, it blocks out the numerous feedbacks loops that happen along the different phases and stages of the production process (Godin, 2006). Recently, innovation has increasingly been considered as non-linear cooperating process among social entities (Etzkowitz & Leydesdorff, 2000; Nelson & Winter, 2002). Non-linearity here indicates that innovation is not only influenced by the interactions of the numerous actors. Furthermore, it stresses on the interactions and collaborations between firms and other knowledge producers such as universities, public and other research institutions.

Four backbones and player groups constitute the foundation of every country; NIS. According to Etzkowitz & Ranga (2015) the NIS consist of academia, industry, governments and public research institutions. Besides these pivotal institutions, there are also two major pillars that buttress the NIS; they are institutions and linkages (Niosi, 2002). The institutional components consist of universities, individual firms, public laboratories, and government agencies. The second constituent is relationships and flows, they are regarded as pillars that can undermine or obstruct the efficient management of the NIS (Niosi, 2002).

Private firms are formidable players in the NIS (Eklund & Waluszewski, 2015). Firm's innovation performances heavily depend the other players in the NIS. Numerous studies have proven that firm's innovation performance and financial performance increases with successful and efficient R&D collaborations (Sampson, 2007; Laursen & Salter 2006; Frenz & Ietto-Gillies 2009; De Noni et al., 2018). Firms value their engagement with knowledge producers such as private and public research institutions and consultants (Tether & Tajar, 2008; Bianchi et al., 2016). Firms that constantly engage in fundamental scientific research have a higher tendency to turn out breakthrough inventions (Della Malva et al., 2015). A study by Belderbos et al. (2015) concluded that firms need to incessantly cooperate with other external partners such as competitors, customers, suppliers and other private as well as public research institutions to better their innovation performances.

On the other hand, the regional innovation system (RIS) is a subset of the national innovation system. It unequivocally analyses the innovation system at the sub-national level (Koschatzky & Stahlecker, 2009). Cooke (2004) defines the RIS as “interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems”. Regional innovation system is a territorially defined model that acknowledges that innovation result from social capital i.e. the formal and informal collaboration between institutions at the regional level, or when these institutions interact with other international actors (Hudec, 2007; Bačić & Aralica, 2017). Similarly, writers such as Asheim (2012) also used a related term “*learning region*” to mean “the increasingly organized co-operation with a broader set of civil organizations and public authorities that are embedded in social and regional structures.” Learning regions are thus regions that are built on social networking of all its economic and social actors for its development. Proponents of the learning region argue that regional development hinges on knowledge production, dissemination and appropriation (Hudec, 2007).

The contributions of regional actors to development has been reinforced by the smart specialization policy of the European Commission. This necessitate policy makers to work in closer partnership with various institutional actors with entrepreneurial capabilities to assess regions opportunities and potentials and develop policies aimed at expediting its entrepreneurial activities (Asheim, 2012; McCann & Ortega-Argilés, 2015; Trippl et al., 2016).
Smart specialization policies are place-based strategies intended to stimulate economic diversification of regions (McCann & Ortega-Argiles, 2015; Boschma, 2014) considering their unique characteristics and assets. The smart specialization concept places greater emphasis on research and innovation-driven development strategies that focuses on regional strength and competitive advantage. The Smart specialization concept allows regions to fuse educational, industrial, and innovation policies that needs to be prioritized for knowledge-based investments, concentrating on their strengths and comparative advantages (OECD, 2013a). It is a strategic move towards economic development that provides direct support to research and development (R&D) and innovation.

The strategy attempts to marshal academic strengths for the economic development of peripheral regions that have local universities and strong research excellence, but little R&D capacity in the public or private sectors. Smart specialization is deeply rooted in the belief that R&D and innovation investment strategies can stimulate scientific, economic, and technological specialization of regions and subsequently improve its competitiveness, productivity and economic growth (OECD, 2013b).

The symbiotic relationships and interdependence of entities in the regional innovation system is depicted in figure 1 below. Universities are the innovations and learning hubs producing and diffusing knowledge in the domestic and global research networks. They in tandem transfer technology to firms that are in dire need of them to improve their competitiveness because they are part of the competitive global production networks. Both universities and business offer valuable contributions and investments in the region. This will be explained in detail in the subsequent sections.

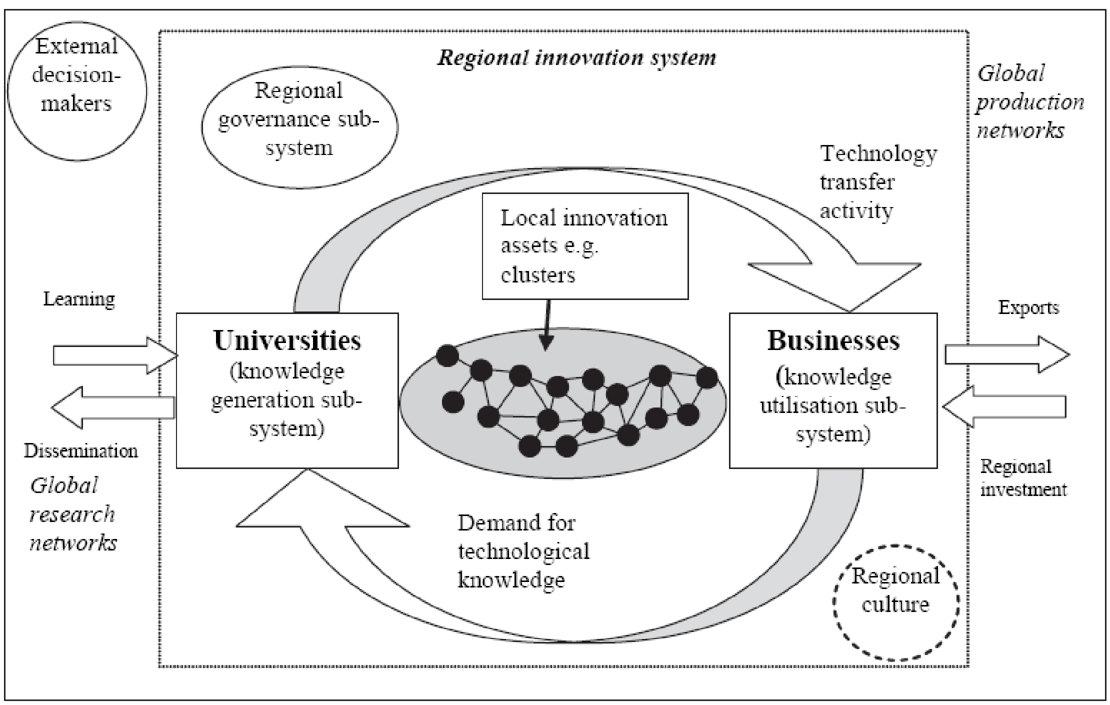

Figure 1: An ideal regional innovation system

Source: adapted from OECD (2008) after Cooke & Piccaluga (2004)

1.3 Role of academia in the national innovation system

Knowledge and its diffusion have been considered as a pillar in the linear model and it's externally produced outside the production structure. Universities produce and make scientific insight available to firms for further adoption and development. This has vouchsafe greater importance to universities because they are avenues for conducting scientific research. The NIS concept therefore demands universities to play active roles in economic development, as well as to foster greater interaction between all innovation entities (Freeman, 1991; Lundvall, 1992). Greater attention is given to the role of universities in boosting geographical clusters and other spatial agglomerations through knowledge spill overs based on their research and development activities (Camagni, 1991).

A study by Mowery & Ziedonis (2015) distinguished between two broad ways universities research can influence innovative activities and regional economic development. The first way is through "knowledge spill overs" which refers to the positive externalities of university research, and secondarily "market-mediated channels" which focuses on the various employment interactions between university scientists and industries. Similarly, Ponds et al. (2007) also showed that knowledge spill over processes such as spinoffs and labour mobility are localized geographically; spill overs from triple helix cooperation spanning longer distances are negligible and might lead to over reckoning of the benefits of geographical proximity and knowledge spill overs.

Governments motivations in facilitating this innovation collaboration is to correct the market failures (Keech & Munger, 2015; Frieden, 2018). This requires government to take several comprehensive policy approaches which will stimulate innovations. They can do this through investments in science and technology education, this will enable research institutions to conduct pure applied research that can be solutions to the numerous social and industrial problems (Wagner et al., 2018). The government can also boost science education by providing the prerequisite infrastructure for innovations such as intellectual property rights etc. Secondarily, government can overcome market failures by creating the conducive ecosystem for businesses to thrive (Bason, 2018). They can use fiscal incentives to bait firms to invest and engage in knowledge transfer activities with the science system (Becker, 2015).

1.4 University-industry-government collaborations (Triple/quadruple helix)

In recent times, there has been a paradigm shift in social interaction from the individual interactions to institutional interactions. Etzkowitz and Leydesdorff (1995) came up with the Triple Helix (TH) model of university–industry–government interaction for expounding the basic developments within the knowledge-based economies. This model lays emphasis on the noticeable proactive role played by universities in the knowledge society (Ranga & Etzkowitz, 2013).

The triple helix model has become the engine of regional development that can be relied upon by underdeveloped regions to promote development because of its strong focus on the interaction among social entities such as higher educational institutions, governments, and the industrial sectors (Huggins et. al, 2008). Social entities such as academia (universities), industries and government have begun mutually beneficial collaborations and interactions. The networks of university-industry-government interaction have been described by (Leydesdorff, 2012) as a ‘neo-institutional arrangements which can be made the subject of social network analyses. Innovation is the consequence of the various interactions that exist between social actors and institutions, these numerous interactions has become known as the national innovation systems (OECD, 1996). Innovation happens because of the constant interaction, communication and feedback sharing among the various social actors.

This collaboration has a three-dimensional flow of resources and outputs in the form of knowledge and innovation between universities, industries and governments (Leydesdorff, 2012). The TH model deliberates on the internal institutional transformations, universities pivotal role has been transmogrified from just teaching to conducting research simultaneously. This transformation is in progress in many countries (Etzkowitz & Leydesdorff, 2000). Universities play key innovative roles which includes research, teaching, community development and entrepreneurial training. Moreover, firms take part in knowledge transfers and innovation. This model necessitates governments to maintain an appropriate sense of balance between when to intervene in the economy and when not to (Dzisah & Etzkowitz, 2008).

There are different kinds of TH models prevailing in countries. In the first model, governments are the key regulators of both industries and universities. This is what is prevalent in most former Soviet Union countries in Eastern Europe, Latin America and other European countries like Norway (Etzkowitz & Leydesdorff, 2000). The laissez-faire is the second model, and it comprises of distinct institutions with strong dividing borders and highly restricted relations (Etzkowitz & Leydesdorff, 2000). In this model the state is expected to play a minimal indirect intervention (Dzisah & Etzkowitz, 2008). Lastly, in the Triple Helix 3 model, there is an overlapping role played by these institutions with each carpeting each other's role resulting in the emergence of hybrid organizations (Etzkowitz & Leydesdorff, 2000)

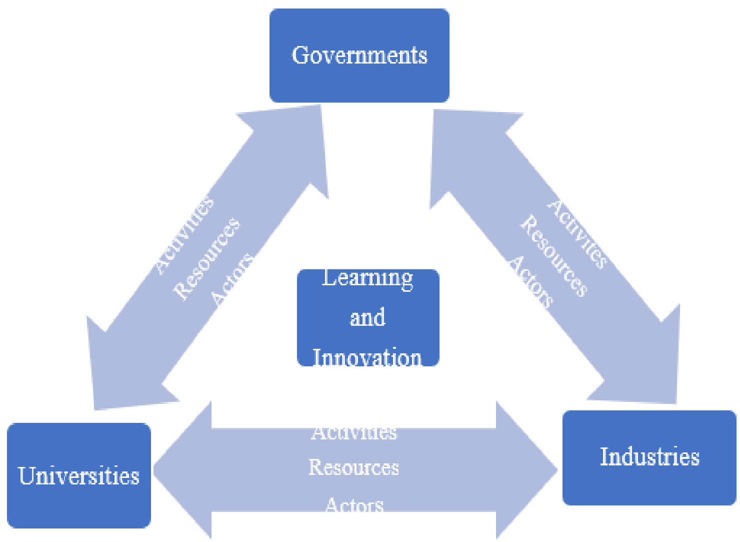

Figure 2: Triple helix model relationship
Source: adapted from (Saad & Zawdie, 2005)

The triple helix is not a static but a dynamic model undergoing some modifications. Scholars have added a new entity to the tripartite network, but this is yet to receive approval and consensus by the academic community. Carayannis & Rakhmatullin (2014) have described the "quadruple helix" as an extension of the TH. The quadruple helix model has added the "public" to the already triple network of university, industry and government. This recent helix or model is built around the influence of civil society, which the media plays a principal role. The model links the media and its affiliates such as creative industries to the existing cooperation (Carayannis & Campbell, 2012). Creative industries are high-growth sectors that can affect jobs and economic growth positively (Cunningham, 2002). Lately, the concept of user-driven innovation has increasingly been used to mean the process in which companies include the public users in the innovation process in various ways (Wise & Høgenhaven, 2008).

1.5 Definition and historical origin of UIG engagements

University-industry-government (UIG) collaboration can be understood as the alliance between universities and firms aimed at the exchange of innovation, technology and knowledge (Agrawal, 2001; OECD, 2002). These institutional collaborations are considered mutually beneficial because it helps these institutions to achieve goals which proves difficult to be accomplished exclusively (Huxham & Vangen, 2013). UIG collaboration, allows universities and industries to exchange information, share knowledge, resources, responsibilities, risks and returns.

This inter-organizational collaboration links universities and firms together (Schartinger et al., 2002; Cohen et al., 2002) and can manifest itself in several folds such as

- joint/collaborative research cooperation
- exploitation or commercialization of research results by universities by way of spin-offs
- licensing patents (Perkmann et al., 2013).
- mobility of university faculty, students and corporate researchers, allows university graduates to transfer their acquired knowledge from universities to industries (Leten et al., 2014).

Academic industry collaboration is not a new development (Lee, 1996; Tether, 2002; Geuna & Muscio, 2009; Paleari et al., 2015). Universities have since time immemorial interacted with industries and other public actors in various forms throughout their histories (Martin, 2003). The history of U-I can be traced to the United States of America and has been termed the “birthplace of academic entrepreneurship” (Bower, 1993; Ndonzuau et al, 2002; Mowery & Sampat, 2004). Universities such as the MIT and Stanford have been at the forefront of collaborating with industries and have successfully created spin off that have been built around the well know Silicon Valley and the Route 128 (Roberts, 1991). The events surrounding the creation of the Silicon Valley can be credited to the actions of academics who sought to disseminate their knowledge from the academic environment by interlacing with industries in the creation of spin off companies. Prior to and aftermath of the Second World War, industries in the developed economies relied on universities as their source of highly skilled manpower for their R&D

laboratories. According to Geuna & Muscio (2009), academic researchers engaged with industrial scientists in the United States and some parts of Europe in this period.

The increasing acceptability of UIG collaboration since the 1980s and its stronger emphasis on innovation, has brought about many dynamisms in this cooperation. This has metamorphosed the role of universities in the economy and has broken the academic empire and ‘ivory tower’ where academics mainly performed research in isolation and confined themselves to their campuses. Universities are now seen as economic organizations that need to engage with industries (Freitas et al., 2011). Certain occurrences such as decreased government support for research funding and calls for government to wean itself from the direct control of the economy paved way for universities in the developed countries to consider collaborating with industries (Geuna & Muscio, 2009). Many governments still support and provide incentives for university that want to cooperate with industries, with the rationale that UIG collaboration outcomes can have spill over effects on economy (Arrow, 1962).

1.6 Current terminologies and typologies of UIG collaboration

1.6.1 Collaborative research

There are various ways universities-industries can collaborate (see Polt et al., 2001; Santoro, 2000; Santoro & Chakrabarti, 2002). The first possible way is through research support provided by industries to universities (Santoro, 2000). These are formal partnerships aimed at cooperating on precise research and development projects (Perkmann et al., 2013). Similarly, the OECD (2013a) has defined collaborative research as situations where “scientists and private companies jointly commit resources and research efforts to projects; research carried out jointly and may be co-funded (in relation to contract research); great variations (individual or institutional level); these range from small-scale projects to strategic partnerships with multiple members and stakeholders (i.e. public-private partnerships).”

The cost of conducting academic research is expensive, most industries making higher profits now apportion and devote some of their profits to fund university faculty through research grants. These monies can be used by universities to carry out new projects and to upgrade their laboratories. The sources of research funding have remained low despite the growing number of researchers seeking support, this has pushed academics to seek support from other alternative sources such as firms (Etzkowitz, 1998). Many of the collaborative research are termed as "pre-competitive" and in most cases, they receive governmental support or co-funding (Perkmann et al., 2013). These academic research supports are aimed specifically at targeted research projects that will provide industries with new knowledge and technologies.

1.6.2 Academic consulting

Another area encompasses collaborative or contract research and technology-related consulting (Polt et al., 2001; Santoro & Chakrabarti, 2002). This can be in the form of an advisory services or research instigated and funded by firms (Perkmann & Walsh, 2008). Faculty members partner their industrial colleagues to work on a single targeted research project. The faculty provides consultancy services and share ideas on these projects. Academic consulting and contract research constitute the largest medium of knowledge transfer and academic engagement (Muscio, 2010).

Academic consulting is increasingly becoming one of the important formal means of interactions between faculty and the non-academic institutions such as industries (OECD, 2013a; Perkmann et al., 2013). Academic consulting services represents the "most widespread" means through which industry and academia engage but this is yet to be institutionalized (OECD, 2013a). Academic consulting represents a frequent means where academic scientists engage in knowledge transfer activities, it represents critical mechanism through which academic research impacts on industrial R&D (Cohen et al., 2002). Academic consulting has been defined by Perkmann & Walsh (2008) as "the provision of a service by academics to external organizations on commercial terms." When faculty provide consulting services to both private and public organizations they earn monies in return and this can be an appreciable stream of income for academic scientists and their universities (Perkmann & Walsh, 2008). Part of these consulting fees goes to universities, but individual researchers benefit the most (D'Este & Perkmann, 2011). In the year 2006 academic researchers in the UK earned about of £2458 from their consulting activities, and this was higher than what they earned from book writing, royalties, licenses and spin-offs (Perkmann & Walsh, 2008). Academic consulting ensures closer contacts between academic researchers and their industrial partners leading to mutually beneficial outcomes to both academic researchers and industrialists. This mode of knowledge transfer provides academic researchers the opportunity to identify new research areas and topics (Buenstorf, 2009). A study by Cohen et al., (2002) on R&D executives in the USA found among others that academic consulting and other academic activities such as conferences and scientific publications were understood to be the most essential avenues for advancing of knowledge and gaining access to university research.

There are diverse reasons and motivation why academic researchers provide consulting services to firms. Perkmann & Walsh (2008) have distinguished three main motives, first, they are opportunity-driven that imply that academics provide these services to be remunerated. They earn personal incomes from consulting services to augment their meagre salaries. Secondly their motivation is research-driven they aim to get more ideas from the industrial settings using their contact with industries for their own research projects. Lastly, these consulting activities are for commercialization purpose that is they share their research ideas with firms for further economic development, mostly commercialization are successful with the involvement of inventors.

Critics of academic consulting as a form of knowledge transfer mechanism have argued that there is a trade-off between faculty research activities and the time they devote to consulting because the time academics spend on their consulting activities conflicts with their primary task of research and teaching (Mitchell & Rebne, 1995; Perkmann & Walsh, 2008). Most faculty members over-concentrate on consulting activities because of its potential monetary gains at the expense of teaching and other faculty activities, implying that they spend few times on their campuses.

1.6.3 Traditional and current roles of universities

Higher educational institutions (universities and public research laboratories) have long played central roles in the national and regional innovation systems (Mowery & Sampat, 2004; Uyarra, 2010; Carayannis et al., 2018). They are kernel in knowledge production and dissemination (Mowery et al., 2015; Denzin & Giardina, 2018; Braunerhjelm et al., 2018). Traditionally, higher educational institutions (HEI) have contributed to the economy by new knowledge production through basic applied research (Sengupta & Ray, 2017). They also contribute to the manpower base by educating the new generations of scientists (Trippl et al., 2015).

In recent times policy makers expect universities to move beyond the supply of human resources, to playing active part in regional development (Wever & Keeble, 2016; Higgins, 2017; Nicolescu, 2018). The role of universities in the regional economy has been reinforced by the triple helix framework (Etzkowitz & Leydesdorff, 2000; Amin & Goddard, 2018), this has supported the conviction that university research capabilities can be leveraged to contribute to regional development. This enhanced and deeper role of universities in regional development is strongly reflected in recent strategies and policies at the European level such as Europe 2020 and flagship initiatives like the innovation union. Albeit universities have long been important actors in regional innovation systems, the inception of the smart specialization policy has amplified and entrenched this role (Carayannis et al., 2018).

Smart specialization affords universities new opportunities to intensify and expand their contributions to regional development and innovations (McCann & Ortega-Argilés, 2015; Balland et al., 2018). It puts universities at the core of their regions, expecting them to forge new collaborations with local and regional authorities, industries and civil society for win-win benefits (Kempton, 2015). According to Foray et al. (2012) "universities have a crucial role to play in creating knowledge and translating it into innovative products and services, in cooperation with research centres and businesses. Successful mobilisation of the resources of universities can have a strong positive effect on the achievement of comprehensive regional strategies".

According to Gunasekara (2006), universities can play two central roles to enhance regional development and territorial development. This can be seen in the generative role, where they can directly promote growth opportunities through knowledge capitalization and entrepreneurial discovery activities such as spin-offs formations and actively, participating with industrial boards. They can in tandem evaluate pitfalls in the regional innovation environments and take the initiative in organizing networks for regional innovation strategy development. Secondarily, they can also influence regional institutions and social capacities advancement. They can accomplish this through the development of regional collaborations and institutional capacity building, in-house training activities as well as mediating between regional, national and international actors (Gunasekara, 2006).

Similarly, Kempton et al (2013) have also suggested that there are seven possible areas universities can engage in regional development and smart specialization strategy. First, they help to outline regional strategy by carrying out arduous assessment of the region's capabilities, knowledge assets and competencies. Secondarily through their academic research universities contribute to local knowledge base and its subsequent transformation into innovative products and services. Additionally, they can weigh into the regional entrepreneurial unearthing process through global awareness and collaborations across the regional boundaries. Universities can in addition aide in building the social relations that underpin the regional innovation system, lastly, they can contribute to regional institutional leadership and smart specialization governance.

Furthermore, universities can provide professional research expertise that can bridge the national and international knowledge networks. Universities can also contribute to regional development through demand sided knowledge and absorptive capacity development through new business formation (spin offs), graduate start-ups and graduate placements, all these are aimed at boosting staff to actively collaborate with local industries. Regional innovative activities as the considerable element of a regional smartness are based on two main capacities: the ability to entice good ideas or information from elsewhere (absorptive capacity) and the ability to utilize absorbed knowledge to generate and develop new products or services (development capacity). Finally, universities contribute to the supply of regional human capital through teaching programs such as lifelong learning and graduate and post graduate courses.

1.6.4 Entrepreneurial universities and research commercialization

The academic setting has undergone several structural revolutions that have transformed the roles of universities in the economy. The first of this kind of revolution took place way back in the 1930s (Schmitz et al., 2017; Etzkowitz, 2017). The first academic revolution was the era where universities embraced research as a university function simultaneously to the traditional mission of teaching (Etzkowitz, 2003; Etzkowitz & Dzisah, 2015) but this did not lead to academic collaborations with industries. It was the second and third academic revolutions that took place in the 1980s (Etzkowitz, 2001; Viale & Etzkowitz, 2005; Clark, 2015) that transformed and paved way for the direct engagement of universities in the economy, and the emergence of entrepreneurial scientists and entrepreneurial universities (Leih & Teece, 2016).

Entrepreneurial universities combine their academic goals of teaching and research and decipher knowledge produced within the university domain into economic and social usefulness. The surfacing of the entrepreneurial university concept has given universities dual responsibilities, first is to create new knowledge and second to take measures appropriate to facilitate the transfer of technology and knowledge spill overs (Audretsch, 2014). The entrepreneurial path taken by universities has emphasized new roles and expectations of university in socioeconomic development and cooperation between external stakeholders such as industries and governments (Sam & van der Sijde, 2014).

Recently universities have in tandem knitted their traditional and their new third mission and this has placed lots of challenges on university and their entrepreneurial activities (Secundo et al., 2016). There is an increasing demand for universities to transfer their knowledge beyond their academic confines to reach other users like industries (Bekkers & Freitas, 2008). Universities are becoming more entrepreneurial because it is believed this will expedite research commercialization and knowledge spill overs (Audretsch, 2014). Many universities have buttressed their entrepreneur drive by setting up specialized supporting structures such as technology transfer offices (TTOs), incubators and science parks within or in proximity to their campuses (Siegel et al, 2003; Clarysse et al., 2005). Most universities in recent times are trying to adjust and position themselves better to embrace their regional development role, so they are in a transition stage i.e. changing from their traditional role to a new role of direct engagement with other social actors like existing industries or helping in the establishment of new firms. It is only when universities can contribute and get involved in the transfer of technology and firm formation that they can be labelled “fully fledged” entrepreneurial universities (Etzkowitz, 2003).

As universities are enthusiastically accepting their new entrepreneurial roles, they flake and break the long-established image of ivory tower; they focus attention on the creation and dissemination of essential knowledge across wider coverage network in the socio-economic structure (Saad & Zawdie, 2011). This means that the industrial sector stands to gain because they benefit by way of utilizing knowledge produced by universities to generate wealth. The entrepreneurial universities role is therefore to put the knowledge they generate from their diverse researches into commercial output and they mostly do so by spin off firms formations (Etzkowitz, 2003). Spin-offs from universities and other HEIs constitute the well-known mode of knowledge transfer. The results of research and academic knowledge are vital resources in start-ups, it is in spin offs that knowledge can be morphed into wealth and marketable.

Universities classified as entrepreneurial are proactive in sponsoring the application and commercial utilization of university research (Etzkowitz & Leydesdorff 1997, 2000). Entrepreneurial universities use spin offs to engage industries (Santoro, 2000; Steffensen et al., 2000; Davey et al. 2011). University spinoffs according to Bigliardi et al. (2013) are "start-up companies that are founded by an academic inventor with the aim to exploit technological knowledge that originated within a university setting to develop products or services".

Spinoffs can therefore be high-tech companies established with the main motive to commercialize scientific or technological research outcomes from universities (Shane, 2004). The guiding principle of entrepreneurial universities is the commercial success. Academic entrepreneurs expect to reap rich rewards from their research commercialization (Mautner, 2005). Research commercialization simply denotes the process of transforming research discoveries from academia and other research institutions to industry to be converted into wealth generating products and services (Zhao, 2004).

The main distinguishing feature of spin offs as a means of U-I collaboration is the direct engagement of faculty who double as the academic inventors who are mostly affiliated with universities (Bigliardi et al., 2013). Academic spin-offs are the bridges that connect industry with academia. Spin offs facilitates the transfer of a knowledge and technology from the academic setting into new companies (Nicolaou & Birley, 2003). Spinoffs are considered as a medium to expedite the transfer and dissemination of university research outcomes and contributing mainly to the economy and diffusing technologies to firms (Rasmussen & Wright, 2015). However, the overconcentration on patenting and spin-off activities may "obscure the presence of other types of university– industry interactions that have a much less visible economic pay-offs but can be equally as (or even more) important both in terms of their frequency and economic impact" (D'Este & Patel, 2007; Geuna & Muscio, 2009; Veugelers, 2014).

The commercialization of academic activities in the form of spin off creation involves some stages but they have not been a consensus in the academic world about the precise process that leads to the creation of spin offs. The process of spin off company creation or development involves some stages or "life cycle process" the path or model that can be followed to establish spin offs (Mustar & Wright, 2010). The stages or the path to the spin off creation is relative to the scholar and his opinion, for instance the model proposed by Shane (2004) consist of five stages whilst (Ndonzuau et al, 2002; Pattnaik & Pandey, 2014) proposed a model that consists of four stages. Others such as (Ndonzuau et al, 2002; Helm & Mauroner, 2007) came up of a model that consisted of three stages.

This dissertation adopted the multistage holistic conceptual model that was developed by Pattnaik & Pandey (2014) based on the way it has been simplified making it easy to follow and understand. They classified the stages for spin off creation into four stages as can be seen from figure 3 below. The first stage involved in the creation of spin off involves the capabilities which are the prerequisite for any research to be carried out. After the competence has been made known, then competence can be recognized. It is through competence that one will be able to know the resources in the form of capital (finance). At this stage, the research can be financed either individually, by the university or by public sources as illustrated in their diagram below.

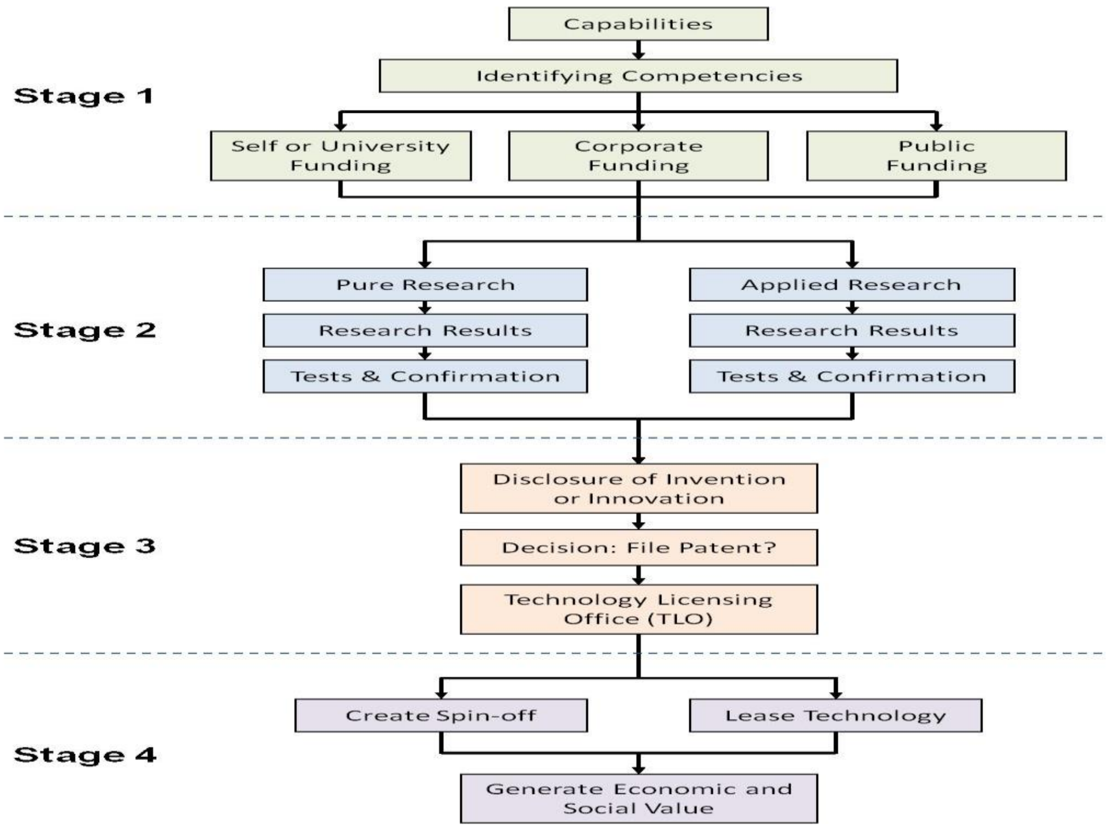

Figure 3: A multistage holistic model for creating university spinoffs
Source: Adapted from Pattnaik & Pandey (2014).

The stage two of the model is centred on the kind of research that is conducted and this can either be pure or applied and the results should be tried and must be confirmed to be viable reliable and valid. This forms the basis for understanding the commercial capability of the anticipated spinoff and the potential should also be evaluated and outlined in this stage. The stage three involves of the outcomes of the research. If the research is a corporate-funded research, then patents discovery is not possible and if it is deemed possible then it must be specified in the terms and conditions of employment.

Understanding the funding makeup is vital because it is the decisive factor that can end up in spinoff establishment (Berbegal-Mirabent et al., 2015; Fini et al., 2017). The final stage of the model is stage 4. This can be classified as the most important stage in the spin off firm formation process. It is at this stage that, the outcome of all the processes mentioned above becomes a reality. At this stage if all the institutional and legal arrangements are fulfilled from the previous stages and have worked out well, then the social and economic worth is established, and it's manifested in the university spinoffs which consist of the commercial or the financial benefit that accrues to the academic inventor or the university or both depending on whether the university has the control of equity based on employment.

However, university spinoffs as other science and technology-based start-up firms are not without problems and this makes them highly susceptible to failure. Universities encourage their faculty members to venture into spinoffs to earn additional revenues from their commercialization, despite this, the financial returns from them are considerably low (Siegel et al. 2003; Shane 2004). Spinoffs also have minimal impact on community and regional economic development (Mustar et al., 2008), because they are mostly small in nature and takes longer times to mature (Degroof & Roberts, 2004) to compete with other high-tech companies (Ensley & Hmieleski, 2005). Their small-scale nature is also an impediment to their survival in the market because their size affects their financial position, meaning they don't have the financial muscles to compete with well-established large firms (Rasmussen & Borch, 2010).

1.6.5 Engaged Universities

In recent times, universities that are heavily dependent on public funding are coerced to "pay back the community" (Payne, 2017). These mounting pressures on universities to pay back to their communities have resulted in the third role of universities. The third role of universities obliges them to contribute to communities using their research and development (R&D), innovation collaborations, and technology transfer with industry (Minshall et al., 2007). Engaged universities use their research and teaching to address specific community needs.

Engaged universities encourage productive collaborations with other institutions and public agencies (Hamner et al., 2002). Universities collaborations with industry are a momentous change from their fundamental mission. Knowledge transfer also embodies the third role of universities. This comprises a widespread scope of university initiatives that contribute to economic growth. Technology transfers (commercialization activities) such as licenses and university spinout, have been studied comprehensively and quantified to demonstrate how universities further local economic development and growth (Jaffe et al. 1993; Etzkowitz 1995; Jensen et al. 2003; Druilhe & Garnsey, 2004).

1.6.6 Knowledge and Technology transfer

An alternative means of academic industry collaboration is through knowledge exchange or technology transfer. This process according to Arvanitis et al. (2008) refers to "any activities aimed at transferring knowledge or technology that may help either the company or the academic institute, depending on the direction of transfer, to further pursue its activities". These knowledge exchanges highlight that cooperation between academia and industries generally encompasses a dual exchange of ideas and knowledge instead of the one-way flow from universities to industry (Fier & Pyka, 2014).

Knowledge exchanges and transfer are direct and highly interactive forms of collaboration among individual researchers and industry collaborators. The benefit of such collaboration is access to industry knowledge and in-kind resources (Perkmann et al, 2013). These collaborations is characterized by personal relationships (Tödtling et al. 2009), that are usually recognized either informally or personal networks or formally through joint R&D projects and contract research (D'Este & Patel 2007; Bishop et al. 2011). These personal links are valuable sources of knowledge that can spoon-feed firms' innovation processes because it paves way for researchers to offer industries direct assistance in problem-solving (Bishop et al., 2011).

Technology Transfer (TT) activities involve the numerous collaborators and partners and they include but not limited to enterprises (large and SMEs), university and industry. Industries and universities are acknowledged as the definitive partners when it comes to TT activities. Most TT activities focus on universities and other large firm's collaboration because they have enough money to carry out research and development. Firms develop their own internal technology, but this process requires a great investment in R&D, what this means is that a diminutive number of firms currently can afford this (Easterby-Smith et al., 2008). Additional firms establish joint research and development projects with universities; this means gives firms greater competitive advantage as against the procurement of technology that does not involve joint projects.

1.6.7 Staff and student’s mobility

The movement of staff and students can represent an effective mode to transfer knowledge from universities to firms (Zucker et al., 2002; Bekkers & Freitas, 2008). This mode can be temporary (staff and student exchanges through internships) and permanent employment of bachelors, masters’ and PhD alumni who have recently graduated directly from universities. Staff and student’s mobility as a form of Knowledge-transfer is becoming more frequent and intensive across the world (Choudaha & de Wit, 2014).

This can take the form of physical mobility where students and staff attend and present their research papers at academic conferences. It can also take the form of study abroad as done in the European Union’ case of Erasmus (European Action Scheme for the Mobility of University Students). This allows students to transfer their knowledge and technological innovations from one country to the other. Mobility is not limited to just students commuting; academic staff exchange is in recent times encouraged among universities (Teichler, 2004). Besides these physical means outlined above, there can also be a non-physical presence of students and staff, but rather they rely on media (electronic media, books) to transfers knowledge to a wider coverage for consumption.

1.6.8 Other forms

There exist other forms of knowledge transfers from universities to industries, but they have not yet received greater attention from scholars. They include

- informal exchanges and networking. Academic-industry cooperative interactions may encompass informal collaboration such as faculty giving periodic advice and unplanned networking activities (Meyer-Krahmer & Schmoch, 1998; Cohen et al., 2002).
- indirect communication through scientific publication of academic reports (Cohen et al., 2002).
- joint funding as well as supervision of students (Master and PhDs dissertations)
- joint conferences, meetings, workshops jointly organized by industry and academia
- joint infrastructure sharing (laboratories apparatus).

1.7 Benefits of UIG collaborations

1.7.1 Academic perspectives

Universities and industries have different motivations for engaging each other. From the academic perspective, their collaboration with industries helps them to produce scientific knowledge and simultaneously grants them access to industrial data (Kaymaz & Eryiğit, 2011). Collaboration positions universities as the hub of scientific knowledge and the effective commercialization of such knowledge and research outcomes has become reliable source of universities revenues as the other traditional sources such as governmental support has dwindled (Turk-Bicakci & Brint, 2005). Revenues received from their collaborations cater for budgetary constraints resulting from cuts in government subventions which can have negative impact on university research funding (Geuna & Muscio, 2009). Numerous studies have confirmed that the main motivation for universities collaboration is to strengthen their access to additional research funding (Fini et al., 2009; Göktepe-Hulten & Mahagaonkar, 2010; Hayter, 2015).

Additionally, another motivation that drives universities to engage industries is to boost job opportunities for their increasing graduates. This collaboration allows students to work as interns during their school years, and this can equip them with the needed job experiences which is important in the competitive job market (Rohrbeck & Arnold, 2009).

A study surveying UK academics by D'Este & Perkmann (2011) also distinguished between four main motivations for academics engaging with industry. According to them academics are motivated to commercialize and exploit knowledge or research. Their second motivation also relates to having access to funding and these funding can either be from public sources and private sources such as co-funding for joint projects or from patent licensing (Ankrah et al. 2013). Thirdly, academics are motivated to engage industries to have access to "in-kind resources" such as industrial equipment and expertise. Lastly, they engage industries to learn: that is to gain deep insight into R&D activities and industrial problems with the hope of getting feedbacks from industry.

1.7.2 Industries perspectives

From the firm's perspective, Perkmann et al. (2011) are of the view that firms mainly engage in collaborations with academia for four main reasons. Firms want access to R&D funding because the intense competitive pressures coupled with declining profits and escalating costs of research have compelled them to partner universities (producers of external knowledge needed to innovate). Industries have increasingly become attracted to university because they know university knowledge is vital for competitiveness. Secondarily, firms are ardent to utilize basic scientific knowledge and they know it's only through cooperating with universities that will enable them have access to emerging technologies that will enhance the firm's knowledge base (Ferreras-Méndez et al., 2015). Thirdly, firm's partnership with universities leads to generic benefits because universities are the origins of new techniques and mechanisms that assist industries to acquire new technologies (Kvon et al., 2018). Academic scientists need in-house equipment to help them carry out their research (Marri et al., 2017). Without university partnerships firms cannot have access to such in-house apparatus because they are expensive to procure. Finally, industries aspire to develop their problem-solving competence and they believe this can be achieved through university assistance and advice on ongoing R&D projects (Cohen et al., 2002). Faculty researchers are known to participate as consultants where they give feedback on intermediate outputs and solve problems (Cook- Sather, 2009; Kurdi et al., 2015).

Through this engagement they have access to the highly skilled workforces needed to produce and exploit novel knowledge (Freitas et al., 2011). Firms benefit from the intellectual skills of faculty and research personnel (Roper et al., 2017). Knowledge gained from academia is valuable for firms because it dwarfs production costs and improves their competitiveness and reputation (Perkmann & Schildt, 2015). Collaborative research helps firms to decrease recruiting costs and improves its efficiency (Ployhart et al., 2017).

Table 1: Reasons why universities and industries collaborate

Institutions	Motivations for collaboration
Industries	Access to university research facilities (for SMEs) Employ well qualified staff Training and support from universities Upgrading R&D potential Accessing and commercialize university-based technologies Responsive to government needs Product development
Universities	Spin-off creation Enhancement of reputation More job opportunities for graduate students Accessing more funding/financial resources Increase publications Access to industrial and empirical data Assisting industries to create more patents Response to government needs

Source: Adapted from Van Horne (2009).

Industries' commitments and desires to collaborate with academia are influenced by their size. Bigger firms are more probable to cooperate with universities and other public research institutions than SMEs. The reason being that larger firms abound in resources to expend on long term R&D activities (Fontana et al., 2006; Baumann & Kritikos, 2016). Conversely SMEs are cash trapped (Hall & Lerner 2010; Czarnitzki & Hottenrott, 2011). Industries with lofty levels of financial slack can participate in funding knowledge sourcing (Bruneel et al., 2015). According to Van Horne (2009) university industry collaboration is based on several motivations. Table 1 above provides a summary of the various motivations.

1.8 Key success of collaboration-based systems

The success or otherwise of these collaborations depend on certain factors (Bruneel et al., 2010; Perkmann & Salter, 2012; Hewitt-Dundas, 2013). Several studies have stressed that trust is the most important factor that can ensure the success of these R&D collaborations (Plewa & Quester, 2006; Bruneel et al., 2010; de Almeida et al., 2015; Bellini et al., 2018). Efficient technology transfer within these entities can be enforced if there is trust (Torfing & Ansell, 2017). Deep trust and commitment have been touted as key drivers of efficacious collaborations (Plewa & Quester, 2006). According to Bruneel et al. (2010), deep trust among these institutions decreases both transaction-related and orientation-related obstacles. Trust ensures that collaborators are eager to exchange useful knowledge and information especially tacit knowledge (Newig et al., 2018) leading to successful collaborations (Kalkman & de Waard, 2017). Trust is of importance in university and industry collaborations because the knowledge exchanged is highly tacit in nature (Chen et al., 2014). The trustworthiness perceptions of other partners in the cooperation are essential because trust diminishes risks and ensures the successful exchange of knowledge among partners.

Another factor that can lead to successful collaboration is better management of the collaborations. Perkmann & Salter (2012) showed that in most cases industries do not plan to manage their cooperation with academia. This same sentiment is also shared by Dodgson (1992). He suggested that effective management benefits firms, he contended that R&D cooperation needs lofty management and managers to develop effective communication footpaths among the collaborating entities.

Other schools of thoughts are also of the view that previous collaboration experience can also lead to successful collaborations (see Petruzzelli, 2011; Murphy et al., 2015; Bodin et al., 2017; Bellini et al., 2018). A study by Bruneel et al. (2010) conducted in the UK affirmed that previous cooperation experience among cooperating institutions truncates orientation-related obstacles (institutional differences and behaviour in firms and academia). Industries and academia can learn some practical lessons from their prior collaborations and they can know and build upon the factors that led to their success. This profundity leads to successful future collaborations.

Another factor that can trigger successful collaborations is proximity. Firms and industries are probable to benefit from collaborations when they are in close geographical proximity (Bishop et al., 2011; Davids & Frenken, 2018). A study by Bishop et al., (2011) concluded that firm's proximity to universities enables swift problem-solving, because of the tacit nature of knowledge exchange, this allows solving intricate problems. Similarly, according to Neffke et al. (2018) geographical proximity diminishes industrial search costs which intend lead to the transfer of tacit knowledge. Proximity additionally encourages trust building leading to efficient and long-lasting collaborations (Abramovsky & Simpson, 2011). Similarly, a related study conducted in

Mexico by De Fuentes & Dutrénit (2016) also concluded that industries with greater absorptive capacities are inclined to cooperate independently with location influencing this cooperation. Hewitt-Dundas (2013) also highlighted the prominence of geographical proximity in the transmission of tacit knowledge from academia. In a similar vein Drejer & Vinding (2007) suggested that firms with less absorptive capacities are probable to collaborate domestically, those with astronomical absorptive capacity tend to cooperate in the global networks.

1.9 Factors hindering UIG collaboration

Certain factors act as barriers to prevent UIG collaboration from achieving its goal of improving industrial competitiveness and universities performances (Bruneel et al., 2010). Universities primarily create new knowledge and to educate the manpower base, industries focused on absorbing these valuable knowledges produced in universities for their competitive advantages. Both collaborating institutions have their different cultures, aims, missions, and different settings (Perkmann et al., 2011).

UIG barriers can be classified into two, orientation-related barriers those connected to differences in the focus of firms and universities, and transaction-related barriers, those linked to conflicts over Intellectual Properties (IP) rights, and universities administrations. The recent increase in research commercialization facilitated by university Technology Transfer Office (TTO) coupled with intensifying efforts by universities to acquire formal IP has affected academic efforts (Shane, 2004). Question of who owns the intellectual property rights short-circuit stronger collaboration. Some scholars have suggested that upsurge in university patenting resulted in reduction in cooperative research collaborations (Bruneel et al., 2010). In most cases universities always bid to obtain all the benefits of research commercial and this usually creates conflicts between universities and industries (Etzkowitz & Ranga, 2015).

Van Dierdonck & Debackere (1988) have classified these obstacles into operational, institutional and cultural barriers. Universities and industries diverge in their viewpoints on the role of knowledge (Schemmann et al., 2016). Culturally, firms obstruct researchers from publishing and sharing information as this threatens their competitive advantages. This industrial view contrast academic motives, universities ultimate goal is to publish scientific outcomes to advance their scientific reputation (Secundo et al., 2015). Institutionally, universities and industries have opposing working natures (Rohrbeck & Arnold, 2009). Universities and industries have contradictory views about what constitute R&D outcomes. From the university's viewpoint, dissemination of knowledge outcomes is regarded as a success. Conversely firms measure their success with their ability to offer new products to the market (Wang et al., 2015).

Operational barriers concern the modus operandi of universities and industries. Universities do not provide incentives to encourage their researchers to conduct more researches; companies are always guided by profit motives, so they have well-defined incentive support systems. Operationally, the lack of detailed knowledge and understanding of the other collaborating partner's processes hinders the effective U-I collaboration. University faculties are not committed to working longer hours to meet deadlines, because they know they are not direct beneficiaries of corporate profits (Arza et al., 2015).

Another barrier preventing the effective UIG collaborations is how these initiatives are managed. Institutional differences and the divergent focus of these two entities makes it extremely difficult coordinate these collaborations. Companies prioritize their customer satisfaction than managing their engagement with academia (Perkmann & Salter, 2012).

Table 2: Factors hindering university-industry collaborations

Factors	**Cooperative barriers**
Operational	Lack of knowledge about the partner and his processes Insufficient coordination and project management Lack of acceptance for results generated by the partner
Institutional	Different nature of work Divergent perception of what the "product" of R&D is Structure change and change of responsibilities on the company's side
Cultural	Divergent missions and goals Conflicting interests concerning secrecy and IPR Different languages and assumptions

Source: Adapted from Rohrbeck & Arnold (2009)

1.10 Public subsidies for UIG collaborations

Public subsidy or in its simplest form financial contributions from government has become a major source of financing R&D collaborations in many parts of the world. The rationale for public subsidies or governmental support for R&D collaboration activities is rooted in the classic market failures (Nelson, 1959, Arrow, 1962; Frenken, 2017). Market failure results when the price mechanism seizes up to distribute limited resources efficiently leading to pervert social welfare. The market failure squabble has now been broadened to cover cooperative R&D schemes involving industries and other public research institutes (Stiglitz & Rosengard, 2015; Mazzucato, 2016; Camagni, 2017; Clark & Dear, 2018).

There are increasing calls for public financial intervention because investment in R&D is so expensive and not all firms can afford this, at the same time returns on such investment is minimal although they may have some social benefits (Roper et al, 2013). Firms tend to underinvest in such collaborative R&D activities if there is no public involvement (Czarnitzki & Lopes-Bento, 2013). Public subsidies are seen as antidote to the removal all forms of obstacles that might hinder social interactions among key players in the innovation system (Foray & Steinmueller, 2003). Public subsidies enable firms to have supplementary financial resources and thus snowballs the financial resources essential for firms to forge external collaboration (Cano-Kollmann et al., 2016; Hottenrott et al., 2017). Similarly, Bronzini & Piselli (2016) have also maintained that R&D subsidies help firms to tweak their innovation outputs because these monies can encourage them to collaborate and expend on R&D projects which has the long-term effect of increasing their innovation outputs (Greco et al., 2017).

Numerous studies have demonstrated that public subsidies influence firm's ability to engage in cooperation (Belderbos et al., 2004; Abramovsky et al., 2009; Carboni, 2012). A study by Czarnitzki & Lopes-Bento (2013) documented a positive influence of R&D investments when firms received these funding from multiple sources. A related study by Franco & Gussoni (2014) using CIS data for seven European countries concluded that public subsidies have a positive influence on firms' tendency to collaborate in R&D especially for firms in the service sectors.

The justification for public funding is to encourage some form of "additionality", a desirable outcome that is not probable in the absence of funding. It is worth mentioning that excessive government spending can result in crowding out private funding. Crowding out refers to a situation when increased government spending causes a corresponding fall in private sector investment and spending (Cogan et al, 2010).

Public subsidies can have three additionality effects. The first is output additionality; the amount of R&D outputs that would have been impossible to produce in the absence of public subsidies (Georghiou, 2002). These outputs consist of direct outcomes like scientific publications, patents and PhD graduates, and indirect outcomes such as new products and services turned out to the market, improved revenue, and increased productivity (Clarysse et al., 2009). The second additionality relates to input additionality that is extra R&D investments resulting from increased public subsidies (Clarysse et al. 2009). Numerous studies have attested that increased public spending increases inputs rather than crowding-out effect (see Duguet 2004; Clarysse et al. 2009). The last additionality talks about behavioural additionality; alterations in the behaviour and processes within firms, the long-term end results is increased input or output additionalities (Falk, 2007). behavioural additionality proponents believe that firm's involvement in publicly funded R&D activities translates into long-term and entrenched changes in behaviour.

R&D subsidies are primarily aimed at influencing firms' innovation outputs and R&D activities as they help in dipping costs of R&D. However, the extant studies conducted to examine the effects of public subsidies and financial support schemes for firm's innovation activities as well as innovation collaborations have yielded mixed results. Table 3 below summarises the results of selected recent studies

Table 3: Summary of recent studies on public subsidies for firm's collaborations

Studies	**Objectives**	**Findings**
Nishimura & Okamuro, 2011.	Examine the effects of support programs of Industrial Cluster Project (ICP) in Japan.	Cluster members that exploit support programs (especially indirect support measures) enlarge their network with industry-university-government.
Kang & Park, 2012.	Study the effects of inter-firm cooperation and the direct and indirect effects of public R&D support for innovation outputs.	Government project funding directly and indirectly stimulates firms' innovation, internal R&D and local upstream and downstream cooperation.
Afcha & López, 2014	Analyse the effects of public R&D subsidies as a strategic issue for firms, their decision to combine both internal and external R&D expenditure.	Public R&D subsidies has a positive effect on internal R&D particularly the decision to perform R&D internally and externally simultaneously.
Franco & Gussoni, 2014	Explore the determinants that affect firms' tendency to engage in R&D collaboration in seven European countries.	Public support positively influence firms' propensity to engage in R&D collaboration in all countries but didn't enhance firms' collaborations in the service sector.
Hottenrott & Lopes-Bento, 2014.	Analyse the impact and effectiveness of targeted public support for R&D investment at the firm level.	Publicly induced R&D is productive as it translates into marketable product innovations.
Arqué- Castells & Mohnen, 2015	Estimate a model of firm's optimal R&D decisions on whether to perform R&D and how much to invest.	Public subsidies offer one-shot trigger and increases both the share of R&D in firms and average R&D expenditures.

Becker, 2015.	Assessing the effectiveness of major public R&D policies in increasing private R&D investment.	R&D subsidies classically stimulate private R&D. Tax credits have unanimous positive effects on R&D.
Bronzini & Piselli, 2016.	Evaluate the impact of an R&D subsidy program implemented in northern Italy.	The R&D subsidy scheme had a significant effect on total patent applications for SMEs.
Grilli & Murtinu, 2018.	Investigate the extent which “selective” subsidies help new technology-based firms (NTBFs) to access R&D alliances.	Selective subsidies positively moderate the likelihood to establish corporate R&D collaborations.
Prokop et al., (2018a)	Examine the factors influencing firm’s collaborations with universities and government research entities in the Czech Republic and Slovakia.	Public funding supports firm’s collaborations with research institutions (universities and other government R&D institutes)

Source: own compilation

2. FACTORS MOTIVATING FIRMS' COLLABORATIONS WITH UNIVERSITIES

Firms have numerous R&D collaborative partners to cooperate with; they have the option to vertically cooperate with customers and suppliers, with firms within the same enterprise group, with other research institutions such as universities and other public research centres. Firms choice of these potential collaborators are influenced by certain factors such as internal characteristics of the firm such as its size and age, firms' decision to compete in other international markets (extent of internationalization), the availability of funding and the expenditures firms expend on their innovation activities.

The **size of firms** is an important factor that influences their collaboration with other economic entities such as universities (Santoro & Chakrabarti, 2002; Fontana et al., 2006). Large firms have the financial might and the technical as well as human resources needed to carryout R&D (Rodríguez et al., 2018). Large firms also have higher absorptive capacities and internal knowledge base that makes them probable to assimilate and absorb external knowledge produced by universities and other research organizations (Tether, 2002). Contrary small firms are characterized as having lower R&D economies of scale, often constrained by limited funding and expertise to carry out in-house innovative activities (Santoro, & Chakrabarti, 2002; Chun & Mun, 2012). Numerous researches have shown that firm size is positively correlated with firm's collaboration with universities (Fontana et al., 2006; Grimpe & Hussinger, 2013). We measured the size of firms using the variables "log of turnover" and whether firms belong to the enterprise group which is a dummy variable (Rõigas et al., 2018).

Firm's collaboration has also been affected by the wave of **globalization**. Most multinational firms are constantly looking for countries with lower operational costs (labour, raw materials etc.) that will help them to maximize their production to reap supernormal profits. Globalization has meant that firms are faced with rising costs on R&D and also increasing competitive pressure has propelled international firms to form research partnerships with universities, clients and customers in both the private and public sector, and public R&D institutes. Harhoff & Thoma (2016) have strongly expostulated that the globalization of technology and innovation has intensified the collaboration between domestic and foreign economic actors. Empirical studies conducted by Tether (2002) and Busom & Fernándes-Ribas (2008) supports the assertion that foreign-owned industries have a greater possibility to engage in innovation cooperation with other collaborators.

Similarly, the propensity of firms to collaborate with universities largely depend on the **availability of funding** (Kafouros et al., 2015; Ankrah & Omar, 2015; Aristei et al., 2016; Dodgson, 2018). The readily availability of funding to industries helps them to overcome financial obstacle that might serve as a barrier to effective collaboration. In individual countries across Europe, governments take several initiatives to provide financial support to buttress universities and industries collaborations (Bruneel et al., 2010). European firms receive funding for their innovation activities from their governments (local and national) as well as from European Union institutions. Copious studies have concluded that firms that have access to funding are exceedingly likelihood to cooperate with other partners (Eom & Lee, 2010; Nishimura & Okamuro, 2018).

Another factor that is capable of influencing firm's collaborations with universities relates to the **expenditure firms spend on their innovation activities** (Prokop & Stejskal, 2017). Firm's quest for innovation means that they must spend on acquiring new knowledge and technology form both external and internal sources. Innovation activities of firms relates to firm's activities such as intramural R&D; acquisition of machinery and other, extramural R&D; acquisition of external knowledge from universities and other public research organizations, in-house training activities such as mentoring, participation in conferences etc (Trantopoulos et al., 2017). When firms realize that they can't acquire these innovations, external technologies and knowledge alone, the only possibility for them is to collaborate with producers associated with such innovations (Tether, 2002). Firms that heavily splurge on their innovation activities are more distinct to cooperate to realize their innovation goals (Becker & Dietz, 2004). Firm's innovation expenditures have progressively been employed as a factor for determining firm's collaboration because, these activities help firms to choose their collaborative partners (Prokop et al., 2018b).

Finally, when firms make the **decision to internationalize**, it influences their collaborations with other partners especially universities (Oyelaran-Oyeyinka & Adebowale, 2017). Competitions in international markets exposes firms to strong competitions, so for new entrant firms, they need to stay abreast with their rivals and so universities become the preferred collaborative partners because they continuously generate new knowledge that can be transformed into new products and services by firms (Belderbos et al., 2015; Dodgson, 2018). Firms in countries with underdeveloped higher educational systems can choose to collaborate with foreign universities in the markets where they operate. Competing in foreign markets through exporting has been shown to have a positive and significant effect on firm's innovations collaborations as well as their choice of collaborating partners (Rodríguez et al., 2018). Foreign markets competitions influence firms to collaborate with universities for innovation.

The review of the multitude of literature have shown that the above-mentioned factors can influence the propensities of firms to decide on their choice of collaborators. However, firm's collaboration is just a single factor that can influence their innovations. Firms innovations in general are determined by numerous factors. These will be the focus of the next section.

2.1 Determinants of firm-level innovations

As shown from the previous sections, proponents of the new growth theories have maintained that innovations propel firm's productivities. Firms innovations are not evenly distributed across sectors and countries. Some firms are more innovative whilst other are not. Innovative firms are those characterized as having the potential to introduce significant and newly upgraded products, processes, organizational changes and marketing methods (Lee et al., 2010). These are the four main areas firms can improve upon to be classified as innovative. Product innovation simply refers to the ability of firms to introduce a significantly new and improved goods or services to the market whilst process innovation entails the implementation of new or significantly improved methods of production or deliveries (Hervas-Oliver et al., 2014). Organisational innovation on the hand refers to firm's ability to implement and employ new organisational methods in their business routines, workplace organisation as well as in their external relations (Henttonen et al., 2016). Marketing innovation entails firm's ability to significantly alter their product packaging (designs), product placement, and product advertisement occasionally (Pino et al., 2016).

Firms' incentives and abilities to innovate hinges on various factors. Some of these determinants are internal, reflecting firm characteristics such as size, and the vital decisions which affect the firm whether in the long or short run such as the decision to participate in international markets or manpower decisions such as the choice to employ highly skilled workers, and availability and access to finance. Externally, firm's innovations are also influenced by the business ecosystem in which firms operate.

Firm size can influence firm's decision to procure new equipment and expertise to develop new process and product innovations. Large firms have the financial endowment and research intensity (human resource base) needed to embark on R&D. A research by Tether (2002) concluded that large firms are preferred for collaborations than SMEs. Conversely, SMEs are branded as having decreasing R&D economies of scale, hampered by inadequate expertise and funding needed to execute in-house innovative activities (Chun & Mun, 2012). SMEs are also less probable to be marketing and organisational innovators. These attributes are highly probable because larger firms usually have marketing departments or personnel who specialise in marketing and tasked with the responsibilities of reviewing prevailing marketing proficiencies and develop new techniques to marketing (Feng et al., 2015). Numerous studies have found a direct relationship between process innovation and firm size (e.g. Forés & Camisón, 2016). These conclusions agree with technology adoption literature that firm size plays a crucial role in shaping how firms adopt new knowledge as well as technologies. As suggest by these studies, it can be expected that large firms will be more likely to be product and process innovators because they have the resource capabilities (Damanpour, 2010).

Similarly, firm ownership can also influence firm's innovations potentials especially product and process innovations. Owners of firms can influence its innovation activities by undertaking new initiatives aimed at affecting the ability of firms to introduce new products or processes, as well as helping to find suitable markets for exports. Foreign ownership relates to ballooned likelihoods of innovations due to their higher spending on in-house R&D. Foreign owned firms are more probable to invest in the acquisition of external knowledge than locally owned firms (Sasidharan & Kathuria, 2011). Multinational firms transfer higher technologies in the form of new products and processes to developing countries using their subsidiaries (Pietrobelli & Rabellotti, 2011). Foreign-owned firms are more likely to introduce new products or processes as well as organizational and market innovations than locally owned firms. However, studies conducted by Crespi & Zuñiga (2012) produced mixed results; multinational firms had both significant and positive as well as negative influence on firms R&D.

The human capital base of firms can also be a driver of firm's innovations (McGuirk et al., 2015). The availability of qualified skilled workforce (usually measured by number of employees with university degrees) is a major prerequisite for effective innovation. Higher education equips students and graduates with specific knowledge, experience and skills needed to survive in the labour market. Skilled labour can contribute to firm's innovation and productivity by generating new knowledge that can be used in firm's production and processes. Highly skilled employees have higher absorptive capacities, this make them capable of integrating new knowledge into their daily work activities (Kobarg et al., 2018). Skilled labour can spur innovations by sharing their ideas and competencies to their co-workers by playing a mentor role. A study conducted by Vivarelli (2014) concluded that the percentage of staff who are university graduates affect the probability of firms to introduce new products or process as well as increasing the likelihood of spending on R&D.

Firms that make the decision to compete in international markets by exporting their products can be more innovative than those with only domestic market orientation (Belderbos et al., 2015). Domestic firms compete in foreign markets when they export their products, this expose them to tougher competitions from usually subsidized and quality foreign products, this compels and incentivize local producers to innovate (Nelson, 2013; Fu et al., 2018). Additionally, when exporting firms participate in foreign markets it expediates their acquisitions of extraneous technologies. According to Bratti & Felice (2012) exporting firms are more likely to undertake R&D which can affect their ability to introduce new products, processes, marketing techniques as well as organizational innovations than their counterparts with sole domestic market focus. This is because exporting to new markets can improve firm's knowledge of foreign production processes and their aptness to assimilate new technologies (Johanson & Mattsson, 2015). Studies conducted by Damijan et al. (2010) for large and SMEs in Slovenia concluded that exporting swells their likelihood of becoming process innovators.

As stated above, decisions made by firms affect their innovations potential, an important of such decisions is the decision to collaborate with other partners. Firms cannot innovate in isolation, so they need to look beyond their internal confines. They can also derive their innovations externally by forming synergies with other partner, such as science system (universities and public research organizations), clients, customers and suppliers and other market competitors (Maietta, 2015). This external innovation collaborations help firms to overcome their innovation barriers and allows them access to knowledge which is seen as kernel in the innovation process (West &

Bogers, 2014). Firms innovations collaboration with other partners increases the likelihood of accomplishing product innovation (Belderbos et al., 2015). Universities especially can primarily be relied upon for achieving product innovations and conducting basic research into particular technologies (Tether, 2002). Universities are a significant source for firm's product innovations especially in emerging technologies.

The availability of funding plays an indispensable role in firm's innovations. The lack of finance is seen as an obstacle to the innovation process, this is true because without adequate finance, firms will be compelled to abandon the development of new products and services (García-Quevedo et al., 2018). Lack of finance obstruct firms from participating in innovative activities, increasing their productivity and meeting their market demands. A study conducted by Crespi & Zuñiga (2012) in Latin American countries concluded that firms that sunk money into R&D were 22 percent more likely to introduce new processes or products. And these firms were 20 percent more probable to introduce marketing or organisational innovations.

2.2 Factors promoting spin-off activities at universities

The burgeoning literatures on university spinoff activities have demonstrated that spinoff firms are not established accidentally, but they require conceited efforts and initiatives. The establishment of academic spin-offs is a multidimensional phenomenon, often determined by numerous factor such as institutional factors and support mechanisms, individual, social and legal framework. Institutional factors clearly influence academic spin-off creations, this is evidenced by the uneven distribution of spin-offs among universities (O'Shea et al., 2005). Some universities are well known to be associated with spinoffs while others struggle to even establish one.

The propensities for universities to spin-out firms to utilize their academic research depend on the availability of support infrastructure and strategies. These instruments include science parks, laboratories, incubation facilities, technology transfer offices (TTO), venture capital, and any other infrastructure which promotes the creation of firms (Fini et al. 2009). University science parks foster spin-off establishment, they are innovation hubs that facilitates and manage knowledge and technology flows between universities and innovation-based firms. According to

Wright et al. (2008), incubators have expansively become pivotal instruments employed by universities since the 1990s to promote the establishment of spinoffs. Start-up incubators are public financed to links industries and academia regionally and locally. TTOs and incubators represent the most important supportive instruments (Bergek & Norrman, 2008) in spin offs creation. TTO act as the mediating agency responsible for identifying the prospects of spinning out companies thus relieving academics of the time and resources to carry out such daunting tasks. TTOs carry out the due diligence and the viability to commercialize an IP (Lockett et al, 2005). These tasks carried out by TTOs leads to the unremitting interaction with industry (Siegel et al., 2003). The incubation services provided by universities science parks intensify the frequency of spinning out new firms as well as dampening start-up costs (Caldera & Debande, 2010).

Research funding also plays a critical role in universities spinoff activities. Without ample access to finance, universities cannot carry out quality research that will have commercial values (Sørheim et al, 2011). Numerous studies have shown that the amount of research funding has a positive influence on university spin-off activities (Van Looy et al, 2011; Rasmussen et al, 2014). Financial resources contribute crucially to the establishment or revamping of new spin off firms, funds are needed to come up with business plans or conduct market research (Vohora et al., 2004). Three types of funding are crucial to spin offs development; they are research funding which has the goal of financing the development of innovation and technologies. Governments the world over are providing these funding schemes to universities and other research organizations because of the spill over effects of such knowledge and its contribution to economic growth (Audretsch & Keilbach, 2008).

Additionally, after the quality research has been carried out and assessed to possess commercial values, universities will require investment funding to kick start the idea of commercial production. This investment funding will be used to establish the premises of the prospective company, pay the scientist and academics involves in the idea and product development etc. (Muscio et al., 2016). Finally, incubator funding will also be required to provide the needed infrastructure needed to sustain the newly established spinoff firm. Establishing science parks to accommodate spinoffs requires huge investment that universities may not be capable of financing. This therefore requires support from governments and business that might be potential beneficiaries. Many European countries such as the UK, Germany, Italy and Spain where universities are known to collaborate with universities have this financial support (venture capital and business angels) critical for the establishment of new spin-offs (Muscio et al., 2016). A study by Lockett et al. (2005) concluded that the number of spinoff firms established by UK universities was positively associated with R&D funding.

Institutional support mechanisms such as incentives also play a central role in universities spinoff activities (Fini et al, 2017; Hayter et al., 2018). Offering financial incentives to faculty members will motivate them to contribute to academic spin offs formation. Providing academic researchers with incentives to augment their research activities and technology transfer activities will make them committed to the university where students and the academic community can continue to enjoy their services. In the UK, government provides financial and political incentive arrangements to boost entrepreneurship (Smith & Ho, 2006). A study by Hayter et al. (2018) has demonstrated that universities that provide astronomical percentages of royalty disbursements to their staffs positively impact the effectiveness of university technology transfer undertakings.

To add to the above-mentioned factors, it is envisaged that the number of people that govern the spin off process from its initiation states to when it becomes fully operational matters a lot. Governance of Knowledge Transfer (KT) activities was mainly spearheaded by faculty members without the involvement of their institutions (Geuna & Muscio, 2009). But this has been institutionalized in many parts of the world with universities taking charge of establishing TTOs to regulate this venture (O'Gorman et al, 2008). The governance structure must be constituted in such a manner that it must involve industrial experts, academics, legal experts, financial experts among others. Effective governance arrangements in extremely uncertain environment encourage experiments and adaptation capable of unearthing the true value of the spinoff. Table 4 below provides a summary of the various studies and the factors that influence universities spin offs activities.

Table 4: Factors promoting university spin off activities

Supporting factors	**Studies**
founder's need for autonomy founder's need for leadership founder's need for personal responsibility founder's risk-taking responsibility founder's preference for flat structure formal contacts between parent and spin-off	Kriegesmann (2000)
founder's opportunity creation founder's career orientation	Gassmann et al. (2003); Beibst & Lautenschlager (2004)
founder's need for independence and autonomy founder's career orientation founder's motivation founder's professional training and education formal contacts between parent and spin-off job-order development	Egeln et al. (2003)
degree of innovativeness stage of development of the technology ability to patent or in general to protect the technology scope of the technology/product itself	Heirman & Clarysse (2004)
financial involvement of the parent competent staff in technology transfer offices transparency and clarity of support policy access to qualified entrepreneurial skills	Smilor & Matthews (2004)
mentoring professional training and education easy access to high qualified competences	Vohara et al. (2004)
financial involvement of the University skills of the personnel employed within the technology transfer office relationships established with capital companies	Lockett et al. (2005)
seed and venture capital availability regional infrastructure University intellectual property policy industry characteristics	O'Shea et al. (2005)

Source: Bigliardi et al. (2013).

3 DISSERTATION AIMS, AND METHODS USED

3.1 Dissertation objective

This thesis seeks to investigate the current trends or situations of university industry collaboration in the European Union and in tandem offer the best practices and measures that have been taken in countries where these university industry collaborations are successful so that these measures can serve as a guide to universities and industries.

3.2 Specific objectives

The review of the extant literature on innovation and university industry and governments collaborations have demonstrated that there a lot of mediums of such interactions. Many of these studies have touted universities as the birthplaces of innovation that can boost the competitive advantage of firms whatever the motives behind this cooperation; science is the sources of innovation in firms (Laursen & Salter 2004; Geuna & Muscio, 2009; Veugelers, 2014). But there is scanty evidence and research on which universities firms can depend on as sources of their innovations. Some studies have been conducted on firms that derive their innovations from universities in countries like the UK, Spain, Italy, Denmark (see Laursen & Salter, 2004; Segarra-Blasco & Arauzo-Carod, 2008; Cassiman et al., 2010; Janeiro et al., 2013; West & Bogers, 2014) only focused on domestic universities. In this study, we believe that the current wave of globalization means that firms can consider partnering foreign universities. We focus on examining the factors that can compel firms to partner local or foreign universities.

This study attempts to throw more light on the factors such as **firm size, market orientations, firms innovation expenditure for innovation activities, and public sector innovation support schemes** that influence can impact on industries choice of collaborators. Here we focus two types of universities, which firms can partner as sources of their knowledge and innovations. We consider whether firms collaborate with foreign or local universities. **Based on the aforementioned, the first objective of this dissertation aimed at analysing the various factors that influence firm's choice of universities as collaborating partners.** In pursuance to meeting this objective, the following research question was addressed as the first specific objective.

C_1: Determinants of manufacturing firm's cooperation with universities.

Q_1: What factors influence manufacturing firms to collaborate with local or foreign universities?

Reviews of recent international studies have proved that numerous determinants influence firm's choice of collaborators such as universities. Table 5 list some selected studies with the that used these same determinants to analyse firm's collaborations with other partners. Based on these studies, this study will also use these determinants.

Table 5: Determinants of firm's collaborations with universities

Determinants	**Studies**	**Description**
Firm size	Tether, 2002; Eom & Lee, 2010; Cao & Zhang, 2011; Beers & Zand, 2014; Maietta, 2015	Measured by the total number of employees a firm has. 1. micro enterprises: less than 10 employees 2. small enterprises: between 10-49 employees 3. medium-sized enterprises: between 50-249 employees 4. small and medium sized enterprises (SMEs): 1-249 employees 5. large enterprises: with 250 or more employees.
Funding	Gulbrandsen & Smeby, 2005; Czarnitzki et al., 2007; Prokop et al., 2018b	Measured by if the firm received some monies from the local, central or EU governments
Innovation activities	Tether, 2002; Schilling, 2015, Prokop et al., 2018a	Relates to activities such as training, R&D activities, feasibility studies, machinery acquisitions etc.
Extent of internationalization	Shrader, 2001; Hessels & Parker, 2013; Belderbos et al., 2015	whether firms compete in international markets by exporting their goods and services

Source: own compilations based on Eurostat definitions

Numerous studies have used the logistic regression for similar empirical analysis (see D'este & Perkmann, 2011; Iacobucci & Micozzi, 2015; Bellucci & Pennacchio, 2016; Drejer & Østergaard, 2017). Hence, this method will also be employed in this dissertation. The main reason for choosing this method is that it enables the researcher to predict the likelihood that an observation can be grouped into one or two groups of dichotomous dependent variable against one or more predictor variables that can be categorical or continuous (See section 3.5.1 for in-depth description of these methods)

The second specific objective is a follow up of the previous objective stated above. Proponents of the endogenous growth theories have continuously supported their arguments that innovation propels firm's development of new products and services and general competitiveness (Caiazza et al., 2015). The European Innovation Scoreboard 2018[1] has proven that the innovation performance in the EU is improving. But despite these positive results, the EU is lagging and trailing behind its innovations competitors such as Japan, Canada and the United States (Biegelbauer & Weber, 2018). Innovations in Eastern European countries are also improving and most of these countries falls in the moderate group of innovators (Prokop & Stejskal, 2017) with their performance lying between 50% and 90% of the EU average (Asheim, 2018). But little is known about the factors driving firm's innovations in these countries. Improving the innovation performance of firms in Visegrád countries calls for further research. The second objective is devoted to examining the factors that drive firm's innovations in Visegrád Group of countries. Greater premium will be placed on factors such as the influence of **public innovation funding support, the extent of firm's internationalization and expenditures on firms R&D activities**. Other firm characteristics such as firm size and ownership will also be controlled for to see how they influence firm's innovation performances. Therefore, the second specific objective and research question to be addressed focused on

C_2: Firms innovation performance and the various factors determining them.

1 The European Innovation Scoreboard make available comparative information on innovation performance among EU countries. It provides assessments of countries national innovations systems strengths and weaknesses with the aim of helping them to improve. Seehttps://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en

Q_2: Does market competitions, innovation activities, and innovation funding drive innovations in CEE countries?

The method used for this analysis is the probit regression model. Numerous studies (Veugelers & Cassiman, 2005; Rasiah & Govindaraju, 2009; Oyelaran-Oyeyinka & Adebowale, 2017) have used this method for similar empirical analysis. The probit regression was the method of choice because our dependent variables were dichotomous in nature and it consisted of 1, if firms introduced and innovation and 0 if they didn't. The probit model was used to estimate the probability that the observation under consideration will fall within a specific category using the maximum likelihood estimation (MLE) function.

The first two specific objectives focused on firm-level innovations performance and factors driving their collaborations decisions. Attention is now turned to higher educational institutions (universities) and the factors that influence their innovation collaborations with industries. We focus on spin off activities at universities. Spinoffs are considered as a medium to expedite the transfer and dissemination of university research outcomes and contributing mainly to the economy and diffusing technologies to firms (Rasmussen & Wright, 2015; Odei & Stejskal, 2018). The extensive literature reviewed showed that not all higher educational institutions are successful in spinning new industries to commercialize their researches. This section examine the various factors that promotes spins off activities at universities. The aim is to come out with recommendations that can help universities aiming to become entrepreneurial to emulate. With the above stated, the third specific objective tested the following hypothesis:

H_1: Universities supporting infrastructure contributes to universities collaborations strategies and activities.

H_2: The availability of research funding supports universities collaboration strategies.

H_3: Incentives support provided to faculty promotes their collaboration strategies and activities

H_4: Effective governance does not contribute to university knowledge transfer strategies

H_5: Having well-established IP rights does not contribute to universities collaboration strategies

H_6: Universities with collaboration strategies are likely to spin off firms

3.3 Sources of data

Data for this dissertation was mainly from secondary sources. Data for the empirical analysis of *C1 and C2* was sourced from the Eurostat Community Innovation Survey (CIS)[2] conducted between 2012 - 2014. CIS provides harmonised information about innovation activities within enterprises in different sectors of countries and it provides data on the various aspects of firm-level innovation activities, providing detailed information on the sources of knowledge and information, public funding, firm sizes, economic activities undertaken by these firms and the expenditures expended on innovation. The CIS forms part of EU science and technology statistics and they are conducted every two-years in EU Member States. The CIS 2014 provides data for 15 countries excluding Denmark, Ireland, Netherlands, Austria, Poland, Slovenia, United Kingdom and Malta. Numerous studies have employed the CIS data to analyse firm level innovation activities (eg Leiponen & Helfat, 2010; Odei & Stejskal, 2018).

The CIS data was preferred for this dissertation because, it is the most comprehensive database on firm-level innovation activities and its usage for innovation analysis is on the ascendancy (Leiponen & Helfat, 2010). It provides data on countries innovations, so it enables researchers to determine which of these countries are innovative and which are not. These country level data helped this dissertation to draw conclusions on countries innovations and the various factors influencing them.

The second source of data was from the Higher Education Business & Community Interaction (HE-BCI) survey conducted for the 2016/17 academic year. This survey is conducted by the Higher Education Statistics Agency (HESA) every academic year and its obligatory for all state funded higher education institutions in Wales and England (Hewitt-Dundas & Roper, 2010). The HE-BCI survey[3] provide information on a range of knowledge transfer activities from universities to industries. It provides information on universities research activities and measures undertaken to commercialisation intellectual property (IP). It also provides information on other activities or services UK universities render to their communities such as lectures, professional

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[2] More information about the Community Innovation Survey, the countries and firm's types that undertook this survey can be found from the website of Eurostat https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey

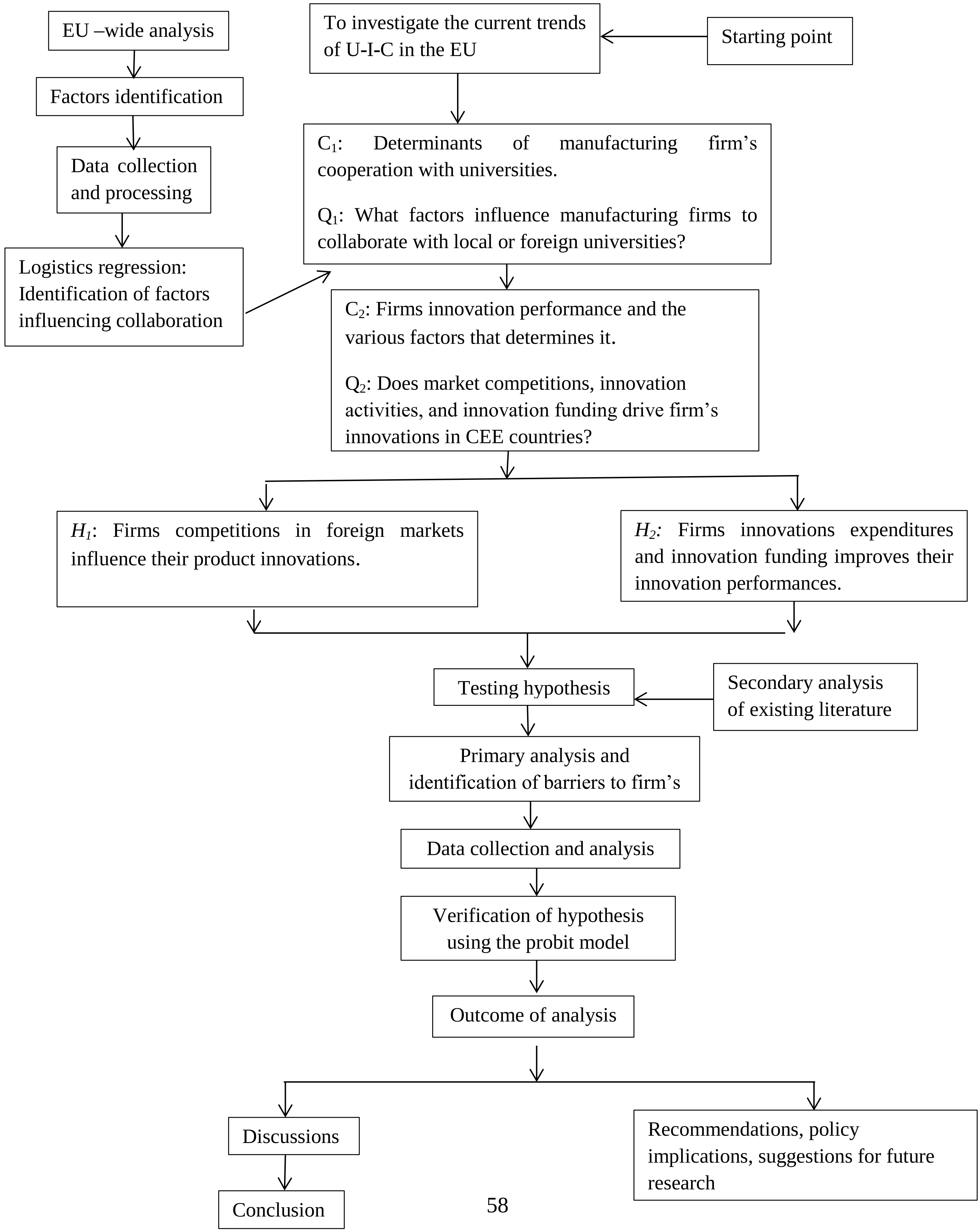
[3] More information on the Higher Education Business & Community Interaction (HE-BCI) survey can be found at https://www.hesa.ac.uk/collection/c17032/introduction

development and lifelong learning courses among others. Numerous sets of empirical studies have relied on this data for similar analysis (Harrison & Leitch, 2010; Abreu & Grinevich, 2013; Hewitt-Dundas & Roper, 2018).

3.4 Research process

Having stated the aim and the gaps identified from the literature, this dissertation will be carried out in the following way as outlined in figure 5 below to fulfil the research objectives and the overall dissertation. The research will first begin with assessing the determinants that influence firm's choice of universities as their collaboration partners. After this has been answered, the next focus will be on finding out the factors that influence firm's innovation performances.

Figure 4: Research process



3.5 Methods used in this dissertation

As shown from the previous chapter it is clearly evident that numerous determinants influence firm's successful implementations of innovations and innovations activities leading to improved innovation performance and general economic and social development of society. These factors include for instance a favourable innovation ecosystem, government policies on innovations and some firm level characteristics. In most rare instances, innovations also occur unexpectedly with firms having no influences. Until now, researchers have not been able to come to consensus on generally accepted methods for measuring universities, industries and governments collaborations that would provide results that could be unanimously acceptable.

This dissertation employed the quantitative research design since it is very compatible with the objectivity philosophy (Williams, 2007). The quantitative research design can broadly involve any kind of empirical research about a social phenomenon, that begins with testing suppositions involving numerical variables and using statistical methods to analyse the variables to determine whether the theory explicates or augury the phenomena of concern (Creswell & Creswell, 2017). The quantitative research methods are employed to explore the relationship among variables with the main goal being to analyse and represent the existing relationship mathematically using statistical analysis. Quantitative research helps to bring forth answers to questions about the rate at which an event or phenomenon occurs over a particular time, or the magnitude of how the sample population is affected by the phenomenon.

The quantitative research approach necessitates the formulation and testing of hypotheses, as well as seeking answers to series of research questions posed (Glaser & Strauss, 2017). Every research can be generally lumped into four categories according to its rationale; exploratory, descriptive, explanatory and emancipatory research (Saunders & Lewis, 2012; Nardi, 2018). This dissertation is very empirical in nature, so it strictly adhered to all scientific approaches. This will enable the findings to be generalized to cover many European countries where the samples were taken from.

In this dissertation, the explanatory study method was used. This approach was the method of choice for this research because explanatory studies enable the researcher to establish the causal relationships between variables that are used for this study and explained in the analytical sections. As shown above, the researcher is interested in establishing the relationships between factors influencing firm's collaborations with universities (local and foreign) as well as finding the factors that influence firm's innovations potentials across selected EU countries. Causal relationship elucidates how a change in one variable triggers a change in another variable i.e. dependent and independent variable (Fox & Bayat, 2008).

Explanatory studies help to improve knowledge and understanding of real-world situations through fact findings solutions to problems by utilizing practical methods such as survey. Furthermore, it investigates to advance new insights, authentication or testing of new facts, examination of interrelationships, and development of new tools through observations and practical experiences (Singh, 2006). The outcomes of explanatory research can lead to innovative thinking by changing how things are. Explanatory or empirical research is generally applied to provide practical implications for decision makers and policy practitioners.

For this dissertation, three research methods i.e. logistic regression, probit regression, and the partial least square structural equation model were used. The binary logistic regression model was used to analyse the determinants that are likely to influence firm's collaborations with local and foreign universities. The results of this analysis will shed more light on the countries where these innovative collaborations are well established firm's innovations, to see which of them influence their collaborating decisions and their choice of partners. Subsequently, the probit regression model was employed to analyse the various determinants that have the propensity to influence firm's innovation performances in Visegrad countries. Finally, the structural equation model was used to analyse the various factors that influence universities technology transfers activities such as spin offs.

The statistical software used for the empirical analysis include Statistical Package for the Social Sciences (SPSS 20). SPSS was employed for the logistic and well as the probit regression models. Numerous authors have used this statistical software for similar analysis (see Lai, 2011; Galán- Muros & Plewa, 2016). Subsequently, the Structural Equation Model was performed using the ADANCO version 2.0.1 Excel was also used to organise the data for the empirical analysis.

3.5.1 Logistic regression

Logistic regression also known as the logit model examines the relationship between multiple independent variables and a categorical dependent variable and assesses the probability of occurrence of an outcome by fitting data to a logistic curve (Park, 2013). The logistic regression is often chosen if the independent variables contain a mixture of both continuous and categorical variables (Tranmer & Elliot, 2008). The goal of logistic regression model is to examine the best fitting model to describe the relationship between the dichotomous dependent variable and a set of independent variables (Maroof, 2012). Logistic regression model generates standard errors, coefficients and significance levels that can be used to predict the logit transformation of the likelihood of presence of a characteristic of interest.

The logistic regression model formula is given by (Park, 2013) as

$$ln\left[\frac{P_i}{1-P_i}\right] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} \qquad (1)$$

where

subscript *i* represents the *i*-th observation in the sample,

P is the probability of the outcome,

β_0 is the intercept term

$\beta_1, \beta_2, \dots, \beta_k$ are the coefficients associated with each explanatory variable X_1, X_2, …, X_k.

A positive coefficient denotes the log of odds increases as the resultant independent variable increases. The coefficients can also be interpreted in terms of odds $\left[\frac{P}{1-P}\right]$ or probability *(P)* of the outcome by observing the relationship between P,$\left[\frac{P}{1-P}\right]$ and$ln\left[\frac{P}{1-btlP}\right]$. It can be illustrated that $\left[\frac{P}{1-P}\right]$ is a monotonic function of P and $ln\left[\frac{P}{1-btlP}\right]$ is a monotonically increasing function of $\left[\frac{P}{1-P}\right]$. Therefore, if the log of odds $\left\{ln\left[\frac{P}{1-P}\right]\right\}$ is positively (negatively) correlated to an independent variable, both odds $\left\{\left[\frac{P}{1-P}\right]\right\}$ and probability *(P)* of the outcome are also positively (negatively) related to that variable. The coefficients in the logistic regression are estimated using the concepts of maximum likelihood and probability estimation methods (Harrell, 2001).

3.5.2 Probit regression

The probit regression like the logistic regression in the previous section is used to model binary (binomial) response in which the dependent variable is a binary or dichotomous random variable that takes on only two values such as yes or no (Horowitz & Savin, 2001). The probit model is used to estimate the probability of an observation with particular characteristics will be lumped into specific categories. This model is preferred for this analysis because in the collaboration literature, firms, universities and government institutions are asked whether they have any form of collaborative arrangement and the responses are usually binary such as a yes or no responses.

The probit model belongs to the probability models' group. It usually works by estimating the model' parameters based on the maximum likelihood technique. The maximum likelihood estimates parameters by maximising the overall likelihood of the given data predicting the probability that the event might occur. This makes the maximum likelihood estimation the best estimator for most economic problems (Cappellari & Jenkins, 2003; Miura, 2011).

The Probit model is more preferred to the ordinary least squares (OLS) regression because it does not provide inadequate analysis and results when the dependent variable involves finite values (Agresti & Kateri, 2011). The formula for the probit regression is given by Rasiah & Govindaraju (2009) as follows

$$prob(Y_i = 1|X_i) = \int_{-\infty}^{x'\beta} \emptyset(t)dt = \emptyset(X'i\beta) \qquad (2)$$

where

β is a vector of parameter estimates

$\emptyset$ is a cumulative distribution function (the normal, logistic, or extreme value)

X is a vector of explanatory variables

P is the probability of a response

t is the natural (threshold) response rate

Horrace & Oaxaca (2006) have argued that the probit model is the most preferred probability model because they are consistent and the best when modelling binary data is concerned. This consistency and asymptotic efficiency are based on the models use of the marginal effect β1 instead of the raw coefficients. The marginal probability effects refer to the partial effects of the explanatory variable on the likelihood that the observed dependent variable is equal to 1 (i.e. Y=1). The marginal effects in the probit model measures the instantaneous rate of change and its effect on the dependent variable.

In economics the marginal effect has become popular because it frequently provides good estimates to the magnitude of change in the dependent variable when there is a unit change in the independent variables (Ai & Norton, 2003). In addition, the marginal effects allow for easy comparison that allows researchers to know what happens when there are any additional changes in the independent variables, something which the parameter estimates fail to do. The formula for the marginal effect is given Ai & Norton (2003) as

$$\frac{\partial \Pr(y-1)}{\partial x_k} - \emptyset(x\beta)\beta x \tag{3}$$

where

$\emptyset(x\beta)$ is the standard normal density calculated at xβ

βx is the weighted by a factor f that depends on the values of regressors in x

The values of the marginal effects are interpreted as follows, positive values of βx means that increasing $x\beta$ will increase the likelihood of the response and negative values imply that decreasing βx will decrease$x\beta$.

3.5.3 Partial Least Squares Structural Equation Modelling (PLS-SEM)

Researchers have used the Partial Least Squares Structural Equation Model (PLS-SEM) in analysing university industry collaborations (Huang & Chen, 2017; Schlesinger et al, 2017; Tseng et al., 2018). The PLS SEM is a component-based statistical program for multivariate data analysis that can model several endogenous and exogenous latent variables in a sole structural model (Kock, 2014). Usage of SEM has soared because of its capability to model latent variables by considering all the numerous methods of measurement errors, as well as assessing underlying theories in a structural way (Pakpahan et al., 2017). SEM' ability to combine numerous techniques ensure accurate estimations leading to valid conclusion.

The PLS SEM offers a one-step, broad-spectrum and convenient framework for statistical analysis as it combines most of the numerous traditional statistical methods such as factor analysis, regression analysis, multivariate procedures, canonical correlation and discriminant analysis (Kock, 2014). SEM has increasingly become attractive among researchers because of its potential to estimate parameters and relationships among theoretical constructs graphically (Henseler, 2017). The model was chosen because of its distribution-free assumption, the predictive focus and the explanatory model development approach for understanding the determinants of university spinoff activities (Kock & Hadaya, 2018). Path analysis in SEM, allows for all coefficients of association in multiple regression models to be estimated at once (Kock, 2011). SEM uses standardized regression coefficients estimates (path coefficients) therefore it can be used to measure the relationships among latent variables.
The model specification of the partial least square is given by Zawojska (2010) as

$$z_k = \beta_0^{(k)} + \sum \beta_i{}^{(k)} z_i + v_k \quad (4)$$

where*:*

z_k = explained variable (UIC collaborations)

$\beta_0^{(k)}$ = constant term

$\beta_i{}^{(k)}$ = regression coefficient

v_k = residual term

The PLS SEM uses two main complementary approaches to measure the causal connection between indicators and their associated latent variables (Kock & Lynn, 2012). Albeit, these two approaches are complementary, there exist some enormous variations statistically (Hair et al., 2011). The first approach is the covariance-based SEM (Schumacker & Lomax, 2004). This method estimates model coefficients (path coefficients) by using the minimization of differences among covariance matrices. It is the method of choice if the hypothesized relationship involves one or more common factors (Henseler et al., 2009). It uses parametric assumptions in the coefficients calculation and this serves as a foundation for calculating significance levels (P values) (Hair et al., 2017).

The second SEM approach is the variance-based or PLS-based SEM (Kock & Lynn, 2012), this approach models coefficients by using scores of latent variables based on weighted aggregations of indicators. The variance-based technique produces proxies using linear arrangements of experimental variables to estimate parameters. It is usually the preferred method when the hypothesized relationship comprises of composites (Hair et al., 2016). It doesn't use parametric assumptions in P values calculations. The variance-based SEM combines several techniques such as principal components analysis, regression analysis based on sum scores and partial least squares path modelling among other PLS (Tenenhaus, 2008). The PLS is therefore seen as the "most fully developed and general system" among all the variance-based SEM methods (McDonald, 1996).

Typically, in confirmatory composite analysis, the bootstrapping technique is used to generate inferential statistics and empirical estimates to help detect any model discrepancies and reliability (Dijkstra & Henseler, 2015). Bootstrapping can be run to obtain precise estimates of probability (p values), this enables researchers to test the fitness of the null hypothesis (Henseler, 2017).

According to Cheah et al. (2018), SEM' general assessments usually begins with the overall goodness-of-fit (GoF) estimations. The researcher needs to ensure that the model correctly fits the data so that valid conclusions can be drawn with the results. GoF can be assessed using two main approaches with the first been using tests of model fit and the second by using fit indices. Bootstrapping can be used to tests the model fit using unweighted least squares (dULS) while the geodesic discrepancy (dG) can be utilized to assess a model' general goodness of fit (Dijkstra & Henseler, 2015). Reliability measures are also used to assess how adequately reliable the model's results can be trusted. Usually the Jöreskog's rho, Dijkstra & Henseler rho (ρA) and Cronbach's alpha (α) are used to measure internal consistency of a model (Henseler et al., 2016), with minimum values of 0.7 indicating acceptable reliability, it has a maximum value of 1. Higher values closer to 1 are more preferred because they are deemed reliable.

A model assessment also needs to be valid. Two main validity measurements are widely used i.e. the discriminant validity and average variance extracted (AVE). AVE values of 0.5 or above are suitable (Bagozzi & Yi, 1988). With regards to discriminant validity, authors such as Henseler et al., (2015) have suggested that the heterotrait–monotrait ratio of correlations (HTMT) provides a better assessment of discriminant validity. Additionally, models can be contaminated with collinearity issues (Kock & Lynn, 2012). The variance inflation factor (VIF) is used evaluate collinearity issues. There is no general consensus as to what the best VIP range is. Authors such as Hair et al., (2011) have suggested that VIF values not exceeding 10, are not having collinearity issues. Other researchers like Kock & Lynn (2012) also recommend VIF values equal to or less than 3.3 are without collinearity issues (common method bias).

SEM use of effect size calculations which was introduced by Cohen in 1988 as a remedy to using path coefficients comparison to determine the actual size of an effect (see Cohen, 1988). But this comparison is seen to be with flaws because they are heavily predisposed by other numerous explanatory variables which may be highly correlated (Cohen, 2016). Based on Cohens effect size (f^2) values equal to or greater than 0.35 can be classified as having a strong effect, whilst values of 0.15 or greater can be classified as having moderate effect, and a weaker effect falls in the range 0.02 or less (Cohen, 1988).

4 DETERMINANTS OF FIRM'S R&D COLLABORATIONS WITH UNIVERSITIES: EMPIRICAL EVIDENCE FROM EUROPE

In the previous sections, we discussed how firms benefit when they collaborate in R&D with universities. Universities are knowledge centres constantly generating tacit knowledge that firms can depend on to complement their in-house knowledge and innovations. However, till date not all firms are cooperating with universities for their innovations, due to the individual differences between these two institutions. Some countries also have weakly developed universities that do not conduct any economic research that can be appropriated by industries. This leaves industries to collaborate with other market partners or they have the choice to collaborate with foreign universities. In this section, we focus on the probable factors that might compel firms to collaborate with local or foreign universities. This comprehensive analysis focuses on selected European countries that took part in the Eurostat Community Innovation Surveys (CIS 2014). The last part of this chapter provides a summary of the results of the empirical analysis and offer recommendations and practical implications for industries in countries that are not forging innovations collaborations with universities.

4.1 Determinants influencing firms' choice of university as a collaborative partner across the EU

To examine the various determinants that influence firm's choice of collaborating universities, two models were used. The first model was used to predict the probability of firms cooperating with local universities. The dependent variables (cooperation with local and foreign universities) all dummy variables and the independent variable were mixture of dummies and categorical variables. The manufacturing firms were selected for this analysis because they consist of diverse technology intensive firms that are driven by knowledge, so they are bound to collaborate with universities for this knowledge for their innovations (Laursen & Salter, 2004; Maietta, 2015).

4.1.1 Variables and sources of data

Data for this analysis were sourced from the Eurostat Community Innovation Survey (2012-2014). The CIS dataset was preferred for this analysis because it provide comprehensive data on firm characteristics, sources of funding for innovation, sources of firm's knowledge, various partners for firm's innovation among others. Numerous factors influence firm's efforts to collaborate with other entities such as universities (Polt et al, 2001). Some of these determinates are mostly used for similar analysis are summarised below

1. Firms size (Tether, 2002; Eom & Lee, 2010; Cao & Zhang, 2011; Beers & Zand, 2014; Maietta, 2015).
2. Funding (Gulbrandsen & Smeby, 2005; Czarnitzki et al., 2007; Prokop et al., 2017).
3. Innovation activities (Tether, 2002; Schilling, 2015).
4. Extent of internationalization (Shrader, 2001; Hessels & Parker, 2013; Belderbos et al., 2015).

4.1.2 Results and discussions

The results of the logistic regression of firm size, funding, innovation activities and internationalization are shown in table 6 and 7 below. The initial analysis was carried out in all countries that partook in the CIS survey, but the results of most of the countries failed to predict these collaborations with both local and foreign universities, so they were not included in the analysis.

As shown in Tables 6 and 7, the predictive powers of our model with local universities ranges between 9% and 75% for Cox and Snell R^2 and Nagelkerke R^2 respectively. This means that the model has statistically significant predictive powers.

Table 6: Factors influencing firm's collaborations with local universities

Collaboration with local universities													
	Bulgaria	Croatia	Czech Rep.	Hungary	Greece	Portugal	Latvia	Lithuania	Romania	Slovakia	Spain	Germany	Norway
Firm size													
Enterprise group	-0.087 (0.851)	1.076 (0.014)**	0.521 (0.003)***	1.012 (0.001)***	0.768 (0.015)*	0.142 (0.599)	3.631 (0.034)*	-0.193 (0.627)	-0.090 (0.885)	0.747 (0.136)	0.455 (0.000)***	0.013 (0.923)	0.172 (0.592)
Turnover	0.000 (0.195)	0.000 (0.734)	0.000 (0.025)	0.000 (0.069)*	0.000 (0.540)	0.000 (0.047)*	0.000 (0.148)	0.000 (0.126)	0.000 (0.523)	0.000 (0.238)	0.455 (0.000)***	0.000 (0.004)***	0.000 (0.008)**
Internationalization													
National markets	0.453 (0.506)	1.419 (0.221)	0.254 (0.409)	-0.078 (0.918)	1.636 (0.149)	0.401 (0.377)	-0.877 (0.608)	-0.295 (0.608)	0.831 (0.465)	2.785 (0.037)*	0.394 (0.329)	0.535 (0.034)*	-0.158 (0.648)
European markets	0.761 (0.357)	18.831 (0.999)	0.382 (0.287)	-0.043 (0.947)	0.906 (0.076)*	0.701 (0.215)	15.571 (1.000)	-0.443 (0.584)	-0.552 (0.459)	18.869 (0.999)	0.113 (0.608)	-0.199 (0.349)	0.585 (0.068)*
Other markets	-0.766 (0.126)	0.063 (0.897)	0.566 (0.004)***	-0.071 (0.833)	0.051 (0.873)	0.240 (0.511)	-4.007 (0.085)*	0.539 (0.391)	0.619 (0.323)	0.569 (0.313)	-0.134 (0.388)	0.849 (0.001)***	0.144 (0.573)
Innovation activities													
Extramural R&D	-0.612 (0.186)	-1.461 (0.002)***	-0.525 (0.003)***	-1.295 (0.000)***	-0.732 (0.025)*	-1.021 (0.000)***	-2.184 (0.092)*	0.428 (0.108)	-0.730 (0.397)	-0.450 (0.372)	-0.525 (0.000)***	0.658 (0.001)	N/A
Machine acquisition	0.124 (0.837)	1.470 (0.089)*	-0.333 (0.103)	-0.558 (0.104)	-0.176 (0.675)	0.603 (0.044)*	-4.316 (0.043)*	-0.365 (0.445)	-0.320 (0.560)	-0.331 (0.540)	0.224 (0.084)*	N/A	0.176 (0.520)
External knowledge	0.702 (0.160)	0.005 (0.991)	-0.258 (0.231)	0.897 (0.020)*	0.220 (0.469)	-0.149 (0.627)	-0.107 (0.936)	0.879 (0.062)*	-0.181 (0.731)	0.578 (0.294)	0.431 (0.182)	N/A	-0.065 (0.782)
Training	-0.218 (0.683)	0.345 (0.527)	0.358 (0.068)*	0.115 (0.704)	0.727 (0.035)*	0.263 (0.352)	-1.733 (0.341)	-0.353 (0.457)	1.703 (0.048)*	1.278 (0.009)**	0.282 (0.033)*	N/A	0.697 (0.009)**
innovation introduction	0.366 (0.453)	1.204 (0.014)**	0.467 (0.009)**	0.708 (0.015)*	0.161 (0.619)	-0.385 (0.171)	7.653 (0.012)**	1.029 (0.024)*	-0.821 (0.388)	0.087 (0.859)	0.108 (0.363)	N/A	0.225 (0.348)
Funding													
Public funding	0.953 (0.046)*	0.058 (0.897)	1.345 (0.000)***	0.500 (0.095)*	0.579 (0.071)*	1.054 (0.000)***	2.465 (0.137)	0.694 (0.143)	1.750 (0.002)***	1.098 (0.096)*	1.116 (0.000)***	2.364 (0.001)***	.753 (0.003)***
EU funding	0.549 (0.263)	1.109 (0.132)	0.734 (0.000)***	0.977 (0.001)***	0.837 (0.064)*	0.606 (0.028)*	4.891 (0.008)**	0.773 (0.058)	-0.432 (0.550)	1.476 (0.023)*	1.028 (0.000)***	0.236 (0.119)	1.151 (0.007)**
Model fit summary													
Observations	5724	1104	3069	3123	1050	3382	457	882	3739	1013	9257	3250	1231
Cox and Snell R^2	0.118	0.267	0.222	0.229	0.155	0.225	0.435	0.196	0.139	0.284	0.093	0.312	0.156
Nagelkerke R^2	0.209	0.404	0.314	0.336	0.223	0.302	0.747	0.286	0.220	0.338	0.161	0.340	0.210

Source: Own calculations

Legend: Stars indicate significance levels of p<0.05*, p<0.01**, p<0.001*** p values in parenthesis

Table 6 provides the combined effects of all the indicators influencing firm's cooperation with local universities. The results show there is a positive and significant relationship between firm size and the propensities of these firms to collaborate with local universities. Size was a significant factor influencing manufacturing firm's collaboration with local universities in all the countries in the analysis except for Bulgaria, Lithuania, Romania and Slovakia.

The results also show that there was no association between firms' competitions in foreign markets and their likelihood to collaborate with local universities. We find that only firms in Germany and Slovakia competing n national markets were highly likely to cooperate with local universities. Firms in Norway and Greece also exporting to other EU markets were likely to collaborate with local universities. Firms in Germany and the Czech Republic with markets focus outside the EU were probable to partner local universities for their knowledge and innovations.

Table 7: Factors influencing firm's collaborations with foreign universities

Collaboration with foreign universities													
	Bulgaria	Croatia	Czech Rep	Hungary	Greece	Portugal	Latvia	Lithuania	Romania	Slovakia	Spain	Germany	Norway
Firm size													
Enterprise group	-0.454 (0.689)	1.691 (0.172)	**0.754 (0.066)***	0.414 (0.554)	0.684 (0.286)	**1.134 (0.018)***	0.092 (0.962)	0.806 (0.393)	-43.373 (0.994)	0.397 (0.533)	**1.022 (0.001)*****	0.422 (0.135)	0.103 (0.858)
Turnover	0.000 (0.961)	0.000 (0.173)	0.000 (0.463)	0.000 (0.920)	0.000 (0.465)	0.000 (0.124)	0.000 (0.500)	0.000 (0.814)	0.000 (0.474)	0.000 (0.392)	**0.000 (0.012)****	-0.000 (0.254)	**0.000 (0.012)****
Internationalization													
National markets	17.699 (0.997)	-0.855 (0.527)	0.239 (0.775)	**-2.128 (0.044)***	18.756 (0.999)	0.021 (0.975)	0.561 (0.769)	-1.445 (0.236)	17.442 (0.998)	20.297 (0.999)	17.165 (0.997)	**-1.314 (0.011)****	**-1.190 (0.021)***
European markets	16.823 (0.998)	16.659 (0.999)	0.552 (0.634)	16.120 (0.998)	0.179 (0.876)	-1.175 (0.145)	-30.406 (0.999)	17.262 (0.998)	-2.327 (0.375)	17.689 (0.999)	0.265 (0.667)	**1.744 (0.015)***	18.932 (0.996)
Other markets	-1.071 (0.338)	-1.049 (0.409)	**1.480 (0.019)***	0.303 (0.735)	0.585 (0.396)	-0.141 (0.838)	-1.896 (1.000)	-0.315 (0.811)	32.519 (0.992)	1.792 (0.100)	-0.255 (0.520)	**0.889 (0.057)***	0.789 (0.109)
Innovation activities													
Extramural R&D	-1.317 (0.299)	-1.486 (0.220)	0.012 (0.975)	-1.238 (0.162)	-0.881 (0.205)	**-1.146 (0.054)***	-17.926 (0.997)	0.571 (0.401)	-18.258 (0.998)	-0.849 (0.250)	**-2.840 (0.006)****	**0.525 (0.062)***	-
Machine acquisition	-0.363 (0.803)	-1.167 (0.486)	-0.710 (0.119)	0.284 (0.797)	-0.007 (0.993)	-0.106 (0.843)	15.971 (0.998)	-0.058 (0.963)	0.988 (0.592)	-0.185 (0.794)	0.031 (0.919)	N/A	0.154 (0.748)
External knowledge	**2.976 (0.084)***	18.642 (0.995)	-0.255 (0.556)	**1.247 (0.069)***	-0.450 (0.479)	**0.961 (0.032)***	2.182 (0.334)	-0.330 (0.752)	2.373 (0.159)	0.707 (0.245)	0.644 (0.285)	N/A	0.444 (0.247)
Training	**-2.763 (0.087)***	0.514 (0.761)	0.672 (0.195)	18.103 (0.994)	-0.097 (0.883)	-0.111 (0.841)	18.100 (0.996)	0.198 (0.839)	-13.906 (0.995)	0.175 (0.776)	0.414 (0.172)	N/A	0.196 (0.678)
innovation introduction	2.104 (0.150)	1.422 (0.309)	**1.056 (0.023)***	-0.765 (0.243)	-0.174 (0.788)	**0.964 (0.047)***	15.655 (0.997)	0.381 (0.708)	16.532 (0.994)	0.588 (0.324)	-0.299 (0.310)	N/A	**0.774 (0.061)***
Funding													
Public funding	1.486 (0.222)	-0.593 (0.572)	0.129 (0.739)	0.183 (0.768)	**1.507 (0.009)****	**1.044 (0.079)***	1.482 (0.512)	**1.870 (0.035)***	-50.430 (0.994)	0.402 (0.640)	0.307 (0.267)	**0.998 (0.001)*****	0.665 (0.180)
EU funding	-0.012 (0.991)	1.319 (0.302)	**1.401 (0.000)*****	0.873 (0.157)	**3.081 (0.000)*****	**1.822 (0.000)*****	-1.342 (0.441)	**2.245 (0.066)***	32.214 (0.992)	0.292 (0.690)	**2.734 (0.000)*****	**2.401 (0.001)*****	**2.260 (0.000)*****
Model fit summary													
Observations	**5724**	**1104**	**3069**	**3123**	**1050**	**3382**	**457**	**882**	**3739**	**1013**	**9259**	**3250**	**1231**
Cox and Snell R^2	O.072	0.163	0.055	0.096	0.166	0.158	0.138	0.112	0.177	0.153	0.062	0.317	0.189
Nagelkerke R^2	0.352	0.525	0.193	0.348	0.412	0.333	0.565	0.350	0.672	0.261	0.304	0.345	0.359

Source: Own calculations

Legend: Stars indicate significance levels of p<0.05*, p<0.01**, p<0.001***, p values in parenthesis.

At the polar end, size was not a significant predictor influencing firms' cooperation with foreign universities. Firms that belong to the enterprise group are highly likely to collaborate with foreign universities in Czech Republic, Hungary, Portugal and Spain. Turnover as a measure of firm size predicted the propensity of firms in Croatia, Spain and Germany to collaborate with foreign universities.

The extent of openness did not significantly influence manufacturing firm's cooperation with both local and foreign universities the only except being in Czech Republic and Spain. Firms that targeted markets outside the EU collaborated with local universities.

Again, conducting in-house activities was a significant determinant influencing cooperation with local universities in three countries (Hungary, Romania, and Spain). External R&D influenced cooperating with local universities in eight (8) countries with the only exception being Romania and Slovakia. External R&D significantly influenced collaboration with foreign universities only in Hungary, Spain, Slovakia and Germany.

Surprisingly firms investing in machinery are less probable to collaborate with local and foreign universities. It is probable that they collaborate with other partners like within the enterprise group, governments suppliers etc. The reason can be due to the fact that universities do not manufacture machines.

External knowledge sources significantly influenced cooperation with local universities in four (4) countries. In the Czech Republic it rather decreased the likelihood of firm's collaboration even with local universities. On the other hand, firms in three (3) countries (Bulgaria, Romania and Spain) collaborate with foreign universities their knowledge.

Firms in Bulgaria, Hungary and Spain collaborate with local universities for their training activities. In Germany training activities decreased the likelihood of cooperation with local universities. Only Slovenian firms collaborated with foreign universities for their training activities.

As seen from the literature public funding schemes can be means of support to induce firms to cooperate with universities. The results have demonstrated that public funding strongly increases the prospect to cooperate with local universities in all the countries. Public funding strongly influenced collaboration in Germany as evidenced by the highest coefficient of 1.872. Most of the public support was aimed at local universities collaborations than with foreign universities. On the other hand, EU funding schemes influenced collaborations with local universities in 6 countries. Surprisingly in Romania, Portugal, Hungary and Bulgaria, EU funding did not contribute to firm's propensities to collaborate. EU funding didn't influence collaborations with foreign universities in new EU countries such as Bulgaria, Romania, and Slovakia.

4.1.3 Conclusion and practical implications

The chapter sought to examine the various factors influencing firm's collaboration with local and foreign universities for knowledge and innovations. We find out that firm size was highly probably to influence these firms' collaborations with local universities with the only exception been Bulgaria, Lithuania, Romania and Slovakia. We also find that firms in Slovakia and Germany with national market focus, and those in Norway and Greece Czech Republic, and Germany with EU market orientations were all likely to choose local universities for their collaboration. The results also show that conducting extramural R&D was less likely to influence firms to collaborate with local universities, but the result was positive for Germany. Local universities were preferred for external knowledge in Hungary and Lithuania. For training activities, the firms in the Czech Republic, Greece, Romania, Slovakia and Spain preferred local universities. Lastly, we find that public support for innovation influenced these firms to collaborate with local universities in all countries except Croatia, Latvia and Lithuania.

When it comes to firm's cooperation with foreign universities, we find that firms in the enterprise group in Czech Republic, Portugal, Spain preferred foreign universities, so did those making huge turnover in Spain and Norway. Marketing orientations were not a significant determinant influencing these firms to partner foreign universities in majority of EU countries, with the only exception been Germany. We concluded that firm's innovation activities were not a significant factor influencing their collaborations with foreign universities in many EU countries. Finally, the results show that public financial support influenced firms in Greece, Portugal Lithuania and Germany to partner foreign universities for knowledge and innovations. EU innovation support funding also induced firms in the Czech Republic, Greece, Portugal, Lithuania, Spain, Germany and Norway to network with foreign universities.

The results of this chapter call for valuable insights and practical implications that might be considered by industrial managers, universities management and policy makers to boost universities industries R&D collaborations.

- firm managers of these industries aiming to be innovative can achieve this motive by forging simultaneous external R & D collaborations with both local and foreign universities. This can help to complement their in-house knowledge potentials.
- we encourage these firms in Slovakia and Germany that are not internationalized to explore their collaborations with local universities because they can conduct insightful market research that can influence their innovations, productivity and customer satisfactions.
- also, internationalized firms in Greece, Czech Republic, Germany and Norway can also consider collaborating with local universities to survive the intense competitions that prevails in foreign markets. Local universities produce global knowledge that can complement the local knowledge and help stimulate firms' innovations.
- firms in Hungary and Lithuania can collaborate with local universities for their external know-how and technical expertise needed to drive productivity and innovations. They can reconsider collaborating with faculty and students in this regard for external knowledge.
- public support for innovations was very significant in influencing firms' collaborations with local universities in many countries in the sample. Governments and policy makers must consider increasing these financial supports to firms aiming to collaborate with national universities because this can have spill over effects on the entire country. These finances must also be extended to these universities to carry out viable research that can be commercialized for more gains.
- we also encourage exporting firms in Germany to entrench their R&D collaborations with foreign universities because these universities know the market conditions prevailing in their respective countries and can provide profitable knowledge to them about measures, market research to undertake to survive in these markets.
- firm managers in Bulgaria, Hungary and Portugal are highly recommended to potentially explore collaborating with foreign universities for their external knowledge because of

their weakly developed innovation potentials. Foreign universities especially those in innovation leading countries may be considered in this regard.

- finally, another imperative policy implication for industrial managers, policy makers in New EU countries such as Bulgaria, Czech Republic, Slovakia etc. is to put in measures to increase the absorptive capacities of these firms so that they will be able to soak and make good use of innovation funding that will help them to collaborate with both local and foreign universities.

4.2 Determinants of firms' innovation performance: the case of Visegrád countries

The analysis carried out in the preceding chapters provided a general overview of the extent of universities and industries collaborations across the European Union. It became evident that determinants such as firms' size, firm's innovation activities, marketing orientations and public support for innovations stimulated firms' collaborations with foreign and local universities. The extent of collaborations was higher in Western European countries such as Norway, Germany and Spain. A look at the results for Eastern European countries in the transition process also demonstrated that these innovation collaborations are lower. These determinants didn't significantly influence firms R&D collaborations with universities in Visegrád Group (V3). In this section, we analyse whether these same determinants influence firm's innovation performances in Visegrád Group (V3) comprising of the Czech Republic, Slovakia, and Hungary. For this dissertation, Poland was not included in the analysis due to data unavailability. These V3 countries share the same economic and social characteristics and are all transmuting from communism to market economies (Hudec & Procházková, 2018).

We first begin the analysis by providing some brief description of the characteristics of firms used in the empirical analysis. We selected all firms in the manufacturing sectors in these countries (NACE 10-33). These industries were chosen for this analysis because, they constitute the largest sector in all the V3 countries and contributing immensely to these countries growth and development. The manufacturing sector in these countries contribute decisively to the economy's health, employment and driving increases in wages and salaries. For instance, the automotive industry alone in the Czech Republic employs about 120, 000 people and contributes about 47.3% of GDP (Dvořák et al., 2017). Similarly, in Hungary the manufacturing sector accounts for about one quarter of the country's GDP and attracts foreign direct investments (FDI) about EUR 71.6 billion, the highest figure in Central and Eastern Europe (Brada & Singh, 2017). In Slovakia this sector alone contributes over 20% of GDP and providing over 30% of total jobs (Olczyk & Kordalska, 2017).

4.2.1 Firm characteristics

This section of the thesis provides some characteristics of firms that constitute the manufacturing sector in the three countries considered for the analysis. The attributes are summed up in table 8 below.

Table 8: Description of firm's characteristics

Firm characteristics	**Mean/Frequency**
Size	SMEs (20.7%), large enterprises (4.3%), no (75%)
Ownership	Locally owned (2.2%), Multinationals (6%), no (75%)
Exporters	Europe (77%), other markets (35%)
Innovation performance	Product (15.4%), process (12.5%), organizational (10.1%), marketing (7.9%)
Dominant sectors	Basic metals (4.5%), rubber & plastic products (3.3%), machinery & equipment repairs (3.3%), manufacture of machinery & equipment (2.2%), transport equipment (2%), textile manufacturing (1.6%)
Turnover growth	14.8%
Employment growth	24.8%
Percentage of staff with university degrees	10-24%
Innovations collaboration	Yes (44%), No (56%)
Innovation support	Local governments (4.8%), national governments (28.1%), EU (25.3%)

Source: own calculations based on CIS 2014 data

From the table 8 above, based on the total number of employees it is seen that, majority of firms in the manufacturing sectors in these countries can be classified as Small and Medium scale enterprises 20.7% meaning they have between 10-249 employees, while large firms constitute 4.3% of valid responses (firms that employed between 250 or more). Majority of these firms export their products to other European countries probably due to proximity, this is confirmed by other studies such as (Breckova, 2016; Ključnikov & Popesko, 2017). Majority of these firms are foreign owned or multinationals. With regards to innovations performances, on average 15.4% of these firms are product innovators, while about 13% are process innovators. 10% are organizational innovators while 8% of these firms introduced market innovations between 2012 and 2014. We conclude that innovations within firms in V3 countries are low (Hudec, 2015)

The dominant firms are those that manufacture basic metals and fabricated metal products constituting (4.5%) followed by those that manufacture rubber and plastic products (3.3%, while manufacturing and repairs of machinery also constitute (3.3%). Also, between 2012 and 2014, the growth in turnover from firms in this sector was 14.8%. Also, for the same period under consideration, these industries employment grew by 24.8%. The percentage of employees with university degrees is very important for firm's innovation this is usually used to measure firms R&D intensity (Cohen & Levinthal, 1990). The results show that between 10-24% of all employees in these sectors have university degrees or are university graduates. The with regards to the extent of firm's innovation collaborations 44% of these firms have some collaborations with other partners whilst 56% do not collaborate at all. Chunk of innovation funding (support) available for these firms comes from the central governments of these countries 28.1% followed by funding from the EU 25.3%.

4.2.2 Method and data description

For this analysis, the probit regression model described in the previous section was used. This model was preferred for this analysis because of the dichotomous nature of the dependent variables. The probit model was used to estimate the probability that firm's innovations would be dependent on predicted probabilities that certain factors (determinants) such as their participation in foreign markets, their innovation activities among others (see table 9). For the empirical analysis, we used the truncated data from the Community Innovation Survey (CIS) conducted between 2012 and 2014. CIS provides harmonised information about innovation activities in enterprises and it centres on the various aspects of developing firm-level innovation, providing detailed information on the sources of knowledge and information, public funding and innovation expenditures. In accordance with the literature (see Bolli & Woerter, 2013), we sampled a total of 7, 204 manufacturing industries (both large and SMEs) in the NACE classification 10-33 that carried out R&D activities in the period 2012-2014 in the Czech Republic, Hungary and Slovakia (3,069, 3,122 and 1,013 respectively). Numerous studies have used the CIS datasets to measure firms' innovations (see Faems et al., 2010; Vásquez-Urriago et al., 2014; Prokop et al., 2018).

4.2.3 Measures

Dependent variables

The variables considered for the analysis are product, process, market and organizational innovations. In the innovation literature, innovations have been measured using products, process, marketing and organization (see e.g. Laursen & Salter, 2006; Ballot et al., 2015; Dodgson, 2018). In the CIS datasets, product innovations measure firm's ability to introduce to the market a newly improved goods or services. Two variables constitute product innovations, so this study merged these two variables to make it a single variable i.e. product innovation.

The second dependent variable considered for our model consisted of process innovation which denotes firm's potential to implement new or significantly improved methods of production and distribution or any supporting activities that are new to the firm. This variable also consisted of three variables i.e. improved methods of production, improved delivery techniques for inputs goods and services, and finally new or improved supporting techniques for processes such as maintenance and operations. So, we merged them all into a single variable to denote process innovations (see e.g. Ballot et al., 2015; Naranjo-Valencia et al., 2016).

The third dependent variable in out model was marketing innovations. It involves firm's aptness to implement new marketing strategies novel to the firm. This marketing strategies need to affect firm's product designs, and pricing policies. Marketing innovations also has four components namely design (packaging), product promotions, product placements, and pricing of goods and services. So, all these variables were merged into one variable market innovations.

Finally, the last dependent variable in our model was organizational innovations. It simply refers to changes within firm's organization and its external relations with other organizations. It also consisted of three variables namely novel business practices, organization of firms work responsibilities and organizing it external relationships. We again merged them into a single variable organizational innovation.

Explanatory variables

Our independent variables were carefully selected variables that have the propensities to influence firms' innovations. Firms marketing orientations can influence their innovations especially firms competing in foreign market (Baum et al., 2015; Li et al., 2017). We considered firms exporting to other European countries and other non-European countries.

Funding for innovations also ensures firms have access to sustainable innovations (Czarnitzki & Lopes-Bento, 2014). These funding can come from local or regional governments as well as from central governments of individual countries. The EU has also become a reliable source of funding for firms' innovations (De Massis et al., 2018).

We also included the variable for expenditures firms devote on R&D activities. We included expenditure on intramural R&D, monies spent on conducting R&D, monies spent to procure advanced machinery and equipment, firms also spend money to acquire external knowledge especially from their collaboration with higher education and research institutions among others.

We also controlled for firm size because this can have significant influence on firm's innovation performance (Braunerhjelm et al., 2018). Based on Eurostat classification, we classified firms as microenterprises firms (10-49 employees), medium enterprises when they have between 50-249 employees and large firms if they have between 250-499 employees.

Finally, we also controlled for firm's ownership. This is because ownership can have tremendous on firm's innovation quest (Chen et al., 2017; Kwon & Park, 2018). We classified firms into those locally owned and those that have their headquarters in other

Table 9: Description of variables used in the model

Variables	Description	Studies used
Dependents		
Innovations	Product innovations	Laursen & Salter (2006), Ballot et al., (2015), Naranjo-Valencia et al., (2016), Azar & Ciabuschi (2017), Dodgson (2018).
	Process innovations	
	Organizational innovations	
	Marketing innovations	
Explanatory		
Market competitions	Firms exporting to other European countries	Coe et al. (2009), Damijan et al. (2010), Boermans & Roelfsema (2015), Tavassoli (2018).
	Firms exporting to other non-European countries	
Financing	Public funding from local or regional budgets	Czarnitzki & Lopes-Bento (2014), Guan & Yam (2015). Prokop et al., (2017), De Massis et al., (2018)
	Public funding from national budgets	
	Public funding from European budgets	
Expenditures for innovations activities	Intramural R&D	Becker & Dietz (2004), Classen et al., (2014), Piening & Salge (2015), Hájek & Stejskal (2018).
	Engagement in R&D	
	Acquisition of machinery	
	Acquisition of external knowledge	
	Training for innovative activities	
	Market introduction of innovation	
	Design activities	
	Other preparations	
Innovation collaborations	Collaborations for innovation activities with other partners	Wu (2014), Hottenrott & Lopes-Bento (2014), Belderbos et al., (2015), Un & Rodríguez (2018).
Control variables		
Firm size	Firms with 10-49 employees (microenterprise)	Griffith et al. (2006), OECD (2009), Forés & Camisón, 2016; Braunerhjelm et al., (2018)
	Firms with 50-249 employees (medium-sized businesses)	
	Firms with 250-499 employees (Large companies)	
Ownership	Firms has its headquarters locally (locally-owned companies)	Crespi & Zuniga (2012), Dachs & Peters (2014), Chen et al., (2017), Kwon & Park (2018)
	Firm has headquarters in Europe or rest of the world (Multinational companies)	

Source: Own compilation.

countries (multinational firms). To be able to do this analysis, we merged the data for the three countries into a single data and the variables described above are summarized in table 9 above.

4.2.4 Model's reliability tests

This part provides results of the determinants of firm's innovation performance i.e. drivers of firm's innovations using the variables described in table 9 above. We carried out some test to determine the reliability and internal consistency of the model. We used the Cronbach's alpha test for the reliability test. Cronbach's alpha is undoubtedly the most used metric to estimate reliability and internal consistency related to scores obtained from a scale (Hair et al., 2011; Tavakol & Dennick, 2011). A Cronbach's alpha with the minimum value of equal to or greater than 0.7 is acceptable (Hair et al., 2011).

Table 10: Item-Total Statistics

Variables	Cronbach Alpha	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Exports to EU markets	0.755	6.24	12.022	0.164	0.756
Exports to Non-EU markets		6.58	11.388	0.271	0.750
Product innovations		6.61	11.039	0.381	0.740
Process innovations		6.71	11.208	0.341	0.744
Organizational innovations		6.86	11.575	0.278	0.748
Market innovations		6.85	11.619	0.258	0.750
Intramural R&D		6.51	10.996	0.402	0.738
Engagement in R&D		6.82	10.985	0.465	0.733
Acquisition of machinery		6.32	12.051	0.111	0.761
Acquisition of external knowledge		6.94	11.774	0.265	0.749
Training for innovative activities		6.63	10.851	0.443	0.734
Market introduction of innovation		6.75	10.777	0.499	0.730
Design activities		6.73	10.895	0.450	0.734
Other preparation		6.66	10.669	0.505	0.728
Local government funding		7.04	12.273	0.157	0.755
National government funding		6.81	11.323	0.340	0.744
EU government funding		6.84	11.856	0.169	0.757
R&D collaborations		6.65	11.142	0.351	0.743

Source: Own calculations

From table 10 above, the Cronbach's alpha estimate for our models exceeded the recommended minimum reliability value of the 0.7 threshold meaning that 76% of the variance was internally consistent suggesting a good model (Hair et al., 2006). Some authors have suggested that the recommended item-total correlations need to range between 0.20 and 0.70 for a suitable scale (Ferketich, 1991). A critical look at our variables reveal that some of the corrected item-total correlations were as low as 0.1, but the difference between when they are deleted and the actual Cronbach for the model was insignificant, so they were maintained and included in the model.

Furthermore, Table 11 provides the model fit summary, it can be seen that the explanatory power of the probit regression models ranges from 6% to 25% respectively for Cox and Snell R^2 and Nagelkerke R^2 and correctly classifies 76% of the cases signifying a good model, this indicates that out models have statistically significant explanatory powers and predictive accuracies (Urbach & Ahlemann, 2010).

4.2.5 Analytical results

Four separate models were run with each representing firms' innovations i.e. (product, process, organizational and market). The analysis in table 11 below have proven that firm's organizational innovations are positively correlated with their competition in other markets outside the European Union. This is because their continuous interactions and competitions with other firms in foreign markets coerce them to adopt modern methods of production, technologies that can improve upon their products, services, packaging and distributions methods. Again, serving foreign customers also pushes firms to innovate. Contrary, there was a negative or no association between firms' participations in EU markets and all measure of innovations. However, their competitions in EU markets rather has a negative influence on their market innovations. When they compete in EU markets they do not gain valuable knowledge from their market partners such as other firms or consumers.

With regards to innovation expenditures, the results have pointed out that firm's engagement in intramural R&D positively influenced their products and market innovations. But on the other hand, firm's engagement in intramural R&D rather had a negative influence on their organisational innovations. A very positive and significant factor that influenced firm's innovation was their engagement in R&D. Engaging in R&D had biggest impacts on all firms' innovations. This is because through R&D, firms can gain more knowledge and know-how that can have a significant influence on their products and process and their ability to introduce to the market improved products. R&D expenditures can increase firms' absorptive capacity by making them to acknowledge the importance of new information and increases their potential to commercialise it (Cohen & Levinthal, 1990). Expenditures on the acquisition of machinery also has a significant and positive relationship on firms process innovations, but it rather had a negative influence on firm's product innovations.

There was also a positive and significant relationship between machinery acquisition and process innovations. Contrary, there was a negative correlation between machinery acquisition and product innovations. This means that when firms spend to procure machines and other technologies, it doesn’t impact their processes. Surprisingly, acquisition of external knowledge from other market and knowledge institutional partners didn’t have any significant impact on firms’ innovations and the tranche on other preparation didn’t have any influence on firm’s innovations at all. Also, there was a significant and positive association between expenditures on design activities and firm’s product, organisational and market innovations.

The results show a positive and significant relationship between innovations training and process and organizational innovations. These regular training equip firms with vital knowledge and skills that can help to transform their ability to offer to the market improved goods or services.

Table 11: Factors influencing firms' innovations in Visegrád countries

Variables	**Product innovation**	**Process innovation**	**Organizational innovation**	**Market innovation**
Exports to EU markets	-0.075 (0.363)	-0.105 (0.198)	-0.051 (0.570)	**-0.151*** **(0.084)**
Exports to Non-EU markets	0.020 (0.738)	0.074 (0.222)	**0.116*** **(0.077)**	0.080 (0.224)
Intramural R&D	**0.199***** **(0.001)**	0.080 (0.198)	**-0.114*** **(0.093)**	**0.127*** **(0.063)**
Engagement in R&D	**0.480***** **(0.000)**	**0.273***** **(0.000)**	**0.271***** **(0.000)**	**0.216***** **(0.003)**
Acquisition of machinery	**-0.178**** **(0.008)**	**0.329***** **(0.000)**	0.096 (0.191)	-0.034 (0.627)
Acquisition of external knowledge	-0.105 (0.196)	-0.005 (0.948)	0.092 (0.252)	-0.008 (0.921)
Training for innovative activities	0.049 (0.433)	**0.185***** **(0.002)**	**0.246***** **(0.000)**	-0.111 (0.101)
Market introduction of innovation	**0.465***** **(0.000)**	0.039 (0.563)	0.061 (0.401)	**0.401***** **(0.000)**
Design activities	**0.261***** **(0.000)**	0.089 (0.179)	**0.122*** **(0.087)**	**0.455***** **(0.000)**
Other preparation	0.099 (0.130)	0.075 (0.249)	0.037 (0.598)	-0.088 (0.214)
Local government funding	**0.435***** **(0.001)**	**0.264*** **(0.033)**	0.156 (0.221)	0.112 (0.387)
National government funding	**0.173**** **(0.008)**	**0.129*** **(0.041)**	-0.005 (0.942)	-0.009 (0.900)
EU government funding	**-0.251***** **(0.000)**	**0.155**** **(0.013)**	0.108 (0.108)	-0.073 (0.285)
R&D collaborations	-0.049 (0.418)	0.002 (0.975)	**0.110*** **(0.087)**	0.032 (0.619)
Microenterprises	**-0.989***** **(0.000)**	**-0.456***** **(0.001)**	**-0.668***** **(0.000)**	**-0.389**** **(0.008)**
Small and Medium-sized enterprises	**0.136*** **(0.064)**	0.060 (0.410)	0.066 (0.404)	0.112 (0.157)
Large firms	**0.312***** **(0.000)**	**0.184*** **(0.030)**	0.035 (0.708)	0.096 (0.300)
Locally-owned firms	**0.325**** **(0.012)**	**0.242*** **(0.053)**	-0.053 (0.686)	0.125 (0.369)
Multinational firms	0.120 (0.295)	0.099 (0.381)	0.025 (0.831)	0.052 (0.683)
Intercept	**0.652***** **(0.000)**	**1.022***** **(0.000)**	**1.117***** **(0.000)**	**1.188***** **(0.000)**
Model fit summary				
LR (X^2)	525.30***	255.61***	161.61***	222.20***
Log Likelihood	2501.99	2601.28	2203.18	2201.67
Cox & Snell R^2	0.187	0.096	0.062	0.084
Nagelkerke R^2	0.249	0.130	0.093	0.125
Observations	7, 204	7, 204	7, 204	7, 204

Source: Own calculations. Note: P values in parenthesis

Note: *** Parameter significant at 99 % level, ** significant at 95 % level, * significant at 90 % level.

With regards to support for firm's innovations, the results have shown that they didn't contribute immensely to firm's innovations performances. Funding from local governments, national and the European budgets positively impacted only on firm's products and process innovations. Funding is kernel for firm's innovations because the lack of requisite funds will mean that, firms are highly likely to abandon new products and process development. Public funding can also result in improved innovations (output additionality) through new products and process development (Clarysse et al., 2009; Stejskal & Hajek, 2015).

Firms innovations collaboration with other partners increases the likelihood of accomplishing product innovation (Belderbos et al., 2015). But our analysis has proven that when firms have any form of collaborations with other partners, it only influences their organizational innovations, but not the other forms of innovations. Our result is consistent with the findings of researchers such as (Arundel et al., 2015; Guan & Liu, 2016).

The control variables in our model behaved in a manner consistent with conventional expectations. There is statistically significant but negative association between microenterprises and innovations. This means they are not likely to be innovative because they have decreasing R&D economies of scale and may lack the requisite capital to engage in R&D (Chun & Mun, 2012). Small and Medium-sized enterprises are also shown to be product innovators. This corroborates the findings of (Subrahmanya, 2015; Cowling, 2016). As suggest in the literature, it can be expected that large firms will be more likely to be product and process innovators because they have the resource capabilities (Damanpour, 2010). Our result is contrary to the claim that multinational companies are more likely to introduce new products or processes than locally owned firms (Pietrobelli & Rabellotti, 2011).

4.2.6 Conclusion and policy implications

This section of this thesis investigated the factors influencing firm's innovation performances across Visegrad countries. We assessed whether competing in international markets (the extent of internationalization), innovations expenditures, innovation funding from central and EU governments, while controlling for firm size, and ownership have influence in firm's innovation performances. By using an empirical framework at the firm level, we estimated four models to help establish the causal relationship on whether firm's innovation performances depend on their market orientations, innovation expenditures, innovation funding and other firms characteristics.

Our findings proved that there was a significant but negative relationship between market innovation and exporting to markets in the European Union. Also, there was a positive and statistically significant relationship between organizational innovations and exporting to other markets outside the EU. Contrary, we found that there was no statistical relationship between competing in international markets and product and process innovation. This means that when these firms in Visegrad countries participate in international market, it doesn't influence their innovations. Furthermore, there was a positive and significant association between intramural R&D and product as well as market innovation, but it also had a negative influence on organizational innovations. For these firms, engaging in R&D was very significant because it influenced all their innovations. These firms need to focus so much on conducting R&D as this can influence their processes, products, marketing and organizational innovations. Similarly, we showed that training activities for innovations propels firm's innovation performance because we established a positive association between training and process and organizational innovations. Also, there was a positive statistical correlation between funding from local, national and European governments and both product and process innovations. But surprisingly, these funding didn't contribute to market and organizational innovations.

Finally, our results have also showed that microenterprises are not innovators because we found that there were significant but negative relationships among all the innovation performances. However, larger firms were product and process innovators. We also saw that locally owned firms were also both product and process innovators.

The results have imperative implications that helps to understand the various factors influencing firm-level innovations and how that can be studied and achieved within firms.

- an important policy implication is that firms in emerging markets cannot achieve effective and efficient innovations merely by focusing on their national markets. Ideally, they need to invest and take the longer-term decision to internationalize by exporting to other markets in foreign countries because these foreign markets competitions would allow an uninterrupted flow of knowledge, technologies and know-how.
- the results also demonstrated that engaging in R&D significantly impact or stimulate firms' innovations, so firms are encouraged to spend more to engage in R&D and its related activities. They can reinvest their profits and borrow from domestic and international banks to fulfil this objective.
- firms may consider contracting out training activities for their employees by for instance collaborating with consultants, universities and other research organizations on regular basis. This can refresh and build upon existing knowledge within employees and the firm.
- firms are also encouraged to invest internally or contract out market research activities to consultants or universities. This market research activities can help them to know the market conditions and consumers taste and preferences which can be factored in the production, design and advertisement needs.
- in relation to policy prescriptions, the findings warrant that policies that encourage firms' innovations such as funding and subsidies from central and European governments need to be promoted because they positively influence product and process innovation performance.

4.3 Factors influencing spin-off activities at universities– case study of the United Kingdom

This section of this thesis is devoted to meeting objective three of this dissertation which sought to examine the various factors that influence technology transfers activities at universities[4]. In accordance with the literature, numerous factors influence technology (spin offs creation), we aim to ascertain how these factors influence spin off creation. We focused on universities in the United Kingdom (UK). UK universities were selected for this analysis because numerous researches have shown that they are well-known for spinning of companies from their academic researches (see Harrison & Leitch, 2010; Rasmussen & Wright, 2015; Cooke & Huggins, 2018).

4.3.1 Sources of data and hypothesis

To fulfil this objective, we used data from the Higher Education - Business and Community Interaction (HE-BCI) survey conducted for the 2016 academic year for the empirical analysis. The HE-BCI Survey is compulsory for all higher education providers in Wales and England. The HE-BCI Survey is the vehicle for evaluating the volume and direction of collaborations between UK higher education providers and industries and the general community. The survey also collects information on capacity and strategies of HE and their research and development financial support data about their third-stream activity concerned with the production, use, application and utilization of knowledge and other HE provider capabilities outside academic environments. We considered all higher educational institutions with spin off activities.

In accordance with the literature, the following hypotheses were tested in this section of the dissertation.

H_1: Universities supporting infrastructure contribute to universities collaborations strategies and activities.

H_2: The availability of research and commercialization funding supports universities

[4] The chapter was prepared from the results of the analyses of factors influencing spin-off activities at universities: empirical evidence from the United Kingdom, supported by the Grant Agency of the Czech Republic. The dissertation author is the co-researcher of the project and the initial results have been published at a conference (see list of publications at the end of the thesis).

collaboration strategies.

H_3: Incentives provided to faculty members promote their collaboration strategies and activities

H_4: Effective governance does not contribute to university knowledge transfer strategies

H_5: Having well-established IP rights does not contribute to universities collaboration strategies.

H_6: Universities with collaboration strategies are likely to spin out firms.

4.3.2 Measures

Dependent variables

We considered two dependent variables with one as a mediating variable. The mediating variable was strategies of industrial engagement. We believe that when universities have in place strategies related to academics collaborations, it will enable them to spin out firms (see Berbegal-Mirabent et al., 2015; Muscio et al., 2016; Miller et al., 2018). The decision to spin off will constitute a part of universities strategies of collaborations and engagements. The second dependent variable was spin offs established. Here we considered firms established with universities, academic faculties and graduate's involvement both directly and indirectly (Soetanto & Jack, 2016; Abbate & Cesaroni, 2017).

Independent variables

We included the variable incentives support because we believe that with adequate rewards for academics, they will be motivated to spin out more firms to utilize their academic research results. Numerous studies have concluded that incentives encourage academics to spin off companies (Hayter, 2016; Fini et al, 2017; Hayter et al., 2018).

Our second independent variable was funding for research and commercialization. Funding plays a kernel part of embarking on quality research that can be commercialized and establishing spin offs. Several studies have concluded that adequate funding can influence spin offs creation (Cadavid et al., 2017; Meoli et al., 2018), hence we also included this variable in our analysis.

We included support mechanisms (infrastructure) at universities that can facilitate spin offs establishments. These support mechanism such as science parks, laboratories, incubation facilities, technology transfer offices (TTO), venture capital, and any other infrastructure promotes the creation of firms (Lockett & Wright, 2005, Fini et al. 2009; Salvador, 2011).

The fourth independent variable used in the analysis was management and governance of spin offs. It is expected that when the governing board of universities are well constituted to include experts from industries, academics, legal and financial experts can influence the prospect of spin off establishment (O'Gorman et al, 2008; Geuna & Muscio, 2009).

Lastly, we included the variable on IP rights. The extant literatures have all demonstrated that IP rights enables scientist to enjoy the full benefit of their labour. When there is a well-established IP regime, academic scientist can collaborate with industries without fear of losing ownership of their inventions (Rasmussen et al., 2014; Odei, 2017). We therefore foresee that IP rights can influence academics to spinoff companies.

4.3.3 Data suitability checks

Before building the empirical model for the analysis, we carried out series of measures to test the suitability of the data for structure detection to fit the model. We used the factor analysis statistical method for this measure. Factor analysis is usually used to describe variations between observed and correlated variables (Chatfield, 2018). Factor analysis methods allowed the researcher to know the interdependencies amongst the observed variables and helps the researcher to reduce these variables from the dataset. We first used two measures, the Kaiser-Meyer-Olkin measure of sampling adequacy and the Bartlett's test of sphericity.

Table 12: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.908
Bartlett's Test of Sphericity	Approx. Chi-Square	6966.178
	df	351
	Sig.	0.000

Source: Own calculations.

The Kaiser-Meyer-Olkin measure of sampling adequacy was used to assess the percentage of variance in variables capable of been caused by fundamental factors (Tabachnick & Fidell, 2001).

Values close to 1.0 normally indicate that using factor analysis may be suitable with the data. According to Allen & Bennett (2010), value less than 0.60 means that the outcome of the factor analysis won't be very valuable. From table 12, our Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) value was high at 0.908 (exceeding the 0.6 threshold). Similarly, the Bartlett's test of sphericity was used to examine the hypothesis that our correlation matrix will be the same as the identity matrix, this helped to signify that our variables are unconnected and so unsuitable for structure detection. Values less than 0.05 of the significance level show that the factor analysis is suitable with our data. Table 12 also show that our Bartlett's test was significant ($p= 0.000$) for all factors, implying that the principal component analysis was essential and appropriate (Allen & Bennett, 2010).

Lastly, the Harman's single factor test was used to measure common method bias (CMB) effects which can undermine the empirical results. Authors such as Podsakoff et al. (2003) have suggested that if the first component of the total variance explained is less than 50%, it means the instrument is devoid of any major CMB effect. From table 13, our result for total variance explained is 39.53% so we can conclude that our instrument is CMB free. This is also indicative of the fact that our model is without multicollinearity issues (see appendix 1 for information on VIF).

Table 13: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	10.671	**39.521**	**39.521**	10.671	**39.521**	**39.521**
2	3.456	12.800	52.321			
3	1.854	6.866	59.187			
4	1.501	5.560	64.747			
5	1.201	4.450	69.197			
6	0.955	3.539	72.735			
7	0.936	3.465	76.201			
8	0.867	3.212	79.412			
9	0.729	2.698	82.110			
10	0.676	2.504	84.615			
11	0.626	2.317	86.932			
12	0.564	2.089	89.021			
13	0.477	1.767	90.789			
14	0.387	1.435	92.223			
15	0.354	1.312	93.535			
16	0.284	1.053	94.589			
17	0.256	.948	95.536			
18	0.229	00.847	96.384			
19	0.203	0.751	97.135			
20	0.161	0.595	97.730			
21	0.146	.540	98.270			
22	0.125	0.462	98.733			
23	0.102	00.378	99.111			
24	0.088	0.325	99.436			
25	0.069	0.256	99.691			
26	0.050	0.185	99.876			
27	0.034	0.124	100.000			

Source: Own calculations

4.3.4 Models Assessments

We employed various tests to assess the model's goodness of fit, reliability and validity. For the goodness of fit, we used the unweighted least squares (dULS), geodesic discrepancy (dG) and the standardized root mean square residual (SRMR) to quantify the degree of fitness of the model (Henseler et al., 2014). According to Dijkstra & Henseler (2015) for a true model fitness, the (dG) values must not exceed the values of both the 95%-percentile (HI95) and 99%-percentile (HI99) bootstrap results. Additionally, for a good fitness, the SRMR values of the models should not exceed 0.08 (Hu & Bentler, 1999). Our results in table 14 indicate that for both the saturated and estimated models, all these measures for model's fitness assessments met the requirements for true fitness. Our SRMR values are 0.058 and 0.061 respectively for the saturated and estimated models, and our dG in both models are all less than the 95%-percentile (HI95) and 99%-percentile (HI99) therefore we can conclude that our model is well-fitted and accurate for the analysis.

Table 14: Goodness of fit measures

Saturated model				**Estimated model**		
	Values	HI95	HI99	Values	HI95	HI99
SRMR	**0.0583**	0.0525	0.0567	**0.0605**	0.0571	0.0617
$\mathbf{d_{ULS}}$	0.9374	0.7600	0.8887	0.0103	0.9010	1.0500
$\mathbf{d_{G}}$	**0.4771**	0.5254	0.6030	**0.4964**	0.5338	0.6049

Source: own calculations
Note: the estimated model= specified model, saturated model= model where all constructs can covary spontaneously.

Again, we calculate the model's internal consistency and reliability using the composite reliability which is the recommended technique to deal with reflective measurements (Hair et al., 2014). Researchers are progressively resorting to using the composite reliability method of Dillon-Goldstein's rho (or Jöreskog's rho ρc), with values equal to or more than 0.70 indicating acceptable reliability, with the maximum threshold of 1 (Werts et al., 1974; Chin, 1998). This method was preferred to the well-known Cronbach's alpha, because Jöreskog's rho does not assume that each items scale is of proportionate significance, because its theories are modelled on factor loadings instead of items correlations, this therefore makes it a more precise reliability measure (Vinzi et al., 2010). From table 15 below, all our constructs surpassed the 0.7 minimum threshold. Table 15 also shows information about the cross loadings matrix which provides information about the correlations among indicators and their corresponding constructs. Authors such as Gorsuch (1974) have suggested that loading values of equal to or greater than 0.40 are acceptable, but values less than this threshold need to be eliminated from the model. From table 15, it is also evident that all loadings are higher than 0.5 demonstrating acceptable convergent validity of all latent variables (Hair et al., 2006).

Table 15: Reliability and convergent validity measures

Constructs	**Items**	**Outer loadings**	**AVE**	**Jöreskog's rho (ρc)**
Collaboration strategy	Strategy 1	1.000	1.000	1.000
Incentives	Incentive 1	1.000	1.000	1.000
Governance	Gov 1 Gov 2 Gov 3 Gov 4	0.964 0.899 0.677 0.823	0.718	0.909
Supporting infrastructure	Support 1 Support 2 Support 3 Support 4 Support 5 Support 6 Support 7	0.823 0.911 0.923 0.875 0.925 0.938 0.877	0.804	0.966
Funding	Funding 1 Funding 2 Funding 3 Funding 4	0.782 0.799 0.861 0.610	0.591	0.851
IP rights	Patent 1 Patent 2 Patent 3	0.931 0.934 0.626	0.710	0.877
Spin off	Spin 1 Spin 2 Spin 3	0.680 0.768 0.552	0.452	0.709

Source: Own calculations

Our AVEs surpassed the 0.5 value except for the spin off construct, this indicates that the reflective constructs show adequate unidimensionality (Fornell & Larcker, 1981). Also, for the discriminant validity, the Fornell-Larcker criterion (Fornell & Larcker, 1981, Hair et al., 2006) assumes that all the construct's average variance extracted (AVE) needs to be higher than the squared inter-construct correlations of all the model' constructs. As can be seen from table 16 all our latent variables have values surpassing the highest correlation coefficients.

Table 16: Discriminant validity

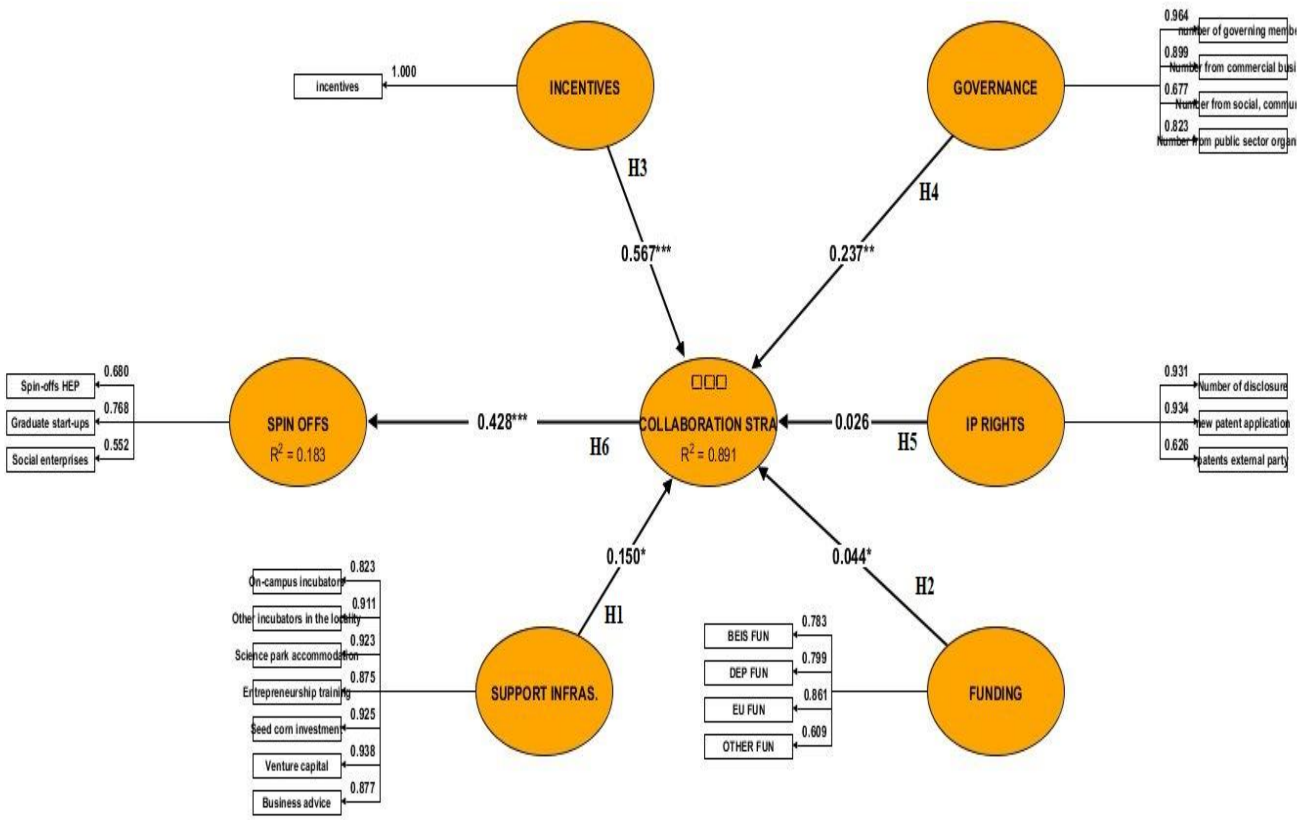
Constructs	COLL. STRATEGY	INCENTIVE S	GOVERNA NCE	SUPP. INFRAS .	FUNDING	IP RIGHT	SPIN OFFS
COLL. STRATRGY	**1.000**						
INCENTIVES	0.862	**1.000**					
GOVERNANCE	0.812	0.811	**0.718**				
SUPPORT INFRAS.	0.729	0.708	0.772	**0.804**			
FUNDING	0.115	0.103	0.102	0.063	**0.591**		
IP RIGHTS	0.083	0.075	0.076	0.081	0.001	**0.7101**	
SPIN OFFS	0.183	0.208	0.135	0.078	0.015	0.025	**0.452**

Source: Own calculations
Note: Squared correlations, with AVE boldened in the diagonal.

4.3.5 Results and discussions.

We first begin the results and discussion with the predictive power of our model using the coefficient of determination (R^2). From figure 5 below, the predictive power or the variance explained by the mediating variable is approximately 90% and this can also accurately predict spin off establishment by 18%. This indicate that our model has statistically significant explanatory powers and predictive accuracies (Urbach & Ahlemann, 2010). Our model can therefore be said to have **substantial predictive** accuracy for the mediating variable (collaboration strategy) and **moderate predictive accuracy** for spin off creations (see Cohen, 1988).

From the results of the direct effects as shown in figure 5 and table 17 (see appendix 2 and 3 for indirect and total effects results), there is a statistically significant and positive relationship between university supporting infrastructure and collaboration strategies. This implies that when universities have science parks, on-campus and other incubators as well as venture capital, it influences their collaborations strategies and the prospects to collaborate with industries or establish spin offs. **This supports our *H1* stated above**.



Source: Own computations
Figure 5: Structural model and hypothesis testing

Secondarily, we also found that there is a statistically significant and positive association between funding support for R&D commercialization and collaboration and universities collaborations strategies. This implies that when universities have ample funding, it will inform their strategies on collaborations with industries or spinning off firms. **This confirms our hypothesis *H2.***

Again, table 17 and figure 5 also show there exist a positive and statistically significant relationship between incentives support for faculty members and collaboration strategies. When faculty members are rewarded in cash or kind, they will be incentivised to collaborate or establish spin offs companies. **This supports our hypothesis *H3***.

Our results also show that there is a positive and statistically significant correlation among the variables governance and collaboration strategies. When universities governing board is well composed of experts and industrialist, it eases the burden of them establishing contact with industries and these experts can guide and support their spin off creation process by giving them expert advice etc. **This support hypothesis *H4*.**

Table 17: Standard bootstrap and f^2 results

Relationships	**Beta**	**Mean values**	**t-values**	**p-values**	**Cohen' f2**	**Hypotheses decisions**
SUPPORT INFRAS. → COLLABORATION STRATEGY	0.150	0.146	2.179	0.030*	0.044	Supported
FUNDING → COLLABORATION STRATEGY	0.044	0.045	1.975	0.049*	0.016	Supported
INCENTIVES → COLLABORATION STRATEGY	0.567	0.567	8.523	0.000***	0.517	Supported
GOVERNANCE → COLLABORATION STRATEY	0.237	0.241	3.260	0.001**	0.071	Rejected
IP RIGHTS → COLLABORATION STRATEY	0.026	0.027	1.362	0.174	0.005	Supported
COLLABORATION STRATEGY → SPIN OFFS	0.428	0.446	12.998	0.000***	0.224	Supported

Source: Own computations

Note: ***, ** and * signify statistical significance at 1, 5 and 10 percent levels correspondingly.

Surprisingly, **our hypothesis H5 was supported**, we found out that the IP rights and the numbers of patents filed and granted didn't necessarily contribute to universities collaborative strategies. There was no relationship amongst these variables. This result is not consistent with the literature and other similar studies (see Bruneel et al., 2010; Rasmussen et al., 2014).

Lastly, our results pointed out that there was a positive and statistically significant relationship between collaborative strategies and total number of spin offs created by universities. When universities have collaborative strategies, they are highly probable of spinning out firms. **This supports our hypothesis H6.**

Finally, we provide the results of the effect size using the Cohen's f^2 criteria (Cohen, 1988). The results in table 17 show that incentives had a strongest effect on universities collaboration strategies (0.517). These incentives can compensate faculty for their time devoted to collaborations and augment their salaries. Also, collaboration strategies had a medium effect on total number of spin offs created by universities (0.224). Three variables had a small effect on universities collaborative strategies namely, support infrastructure, funding and governance (0.044, 0.016 and 0.071 respectively). Lastly, the results show that IP rights had virtually no effect on universities collaborative strategies (0.005).

4.3.6 Summary and practical implications

This section aimed at investigating the factors influencing university spin off activities. We focused on factors driving universities in the United Kingdom to collaborate with industries. We hypothesise that universities supporting infrastructure contributes to universities collaborations strategies and activities. Secondary, we postulate that the availability of research funding supports universities collaboration strategies. It's also assumed that incentives support provided to faculty promotes their collaboration strategies and activities with industries. Effective governance does not contribute to university knowledge transfer strategies. Having well-established IP rights does not contribute to universities collaboration strategies. Finally, we hypothesis that universities with collaboration strategies are likely to spin off firms.

This study concluded that universities having collaborative or engagement strategies were highly probable to spin out firms. Our results mean that universities aiming to establish spin offs or collaborate with industries need to have a strategy. The study also found out that support infrastructure such as venture capital, incubators, science parks, advisory services all contribute and influence universities collaborative strategies. Incentives available to faculty members was a very significant factor influencing universities collaborative strategies. The number of people on universities governing boards also had a significant influence on their ability to spin off companies to utilize their research outcomes. Confoundedly, our results demonstrated that IP rights (patents) was not a significant factor influencing UK universities collaborative strategies. There was no association between universities IP rights and their collaborative strategies or decisions.

The results obtained in this analysis are consistent with earlier empirical findings such as (Bruneel et al., 2010; Salvador, 2011; Rasmussen et al., 2014; Rasmussen & Wright, 2015). However, our results need to be interpreted with great caution because we didn't examine the magnitude if these spin off activities as they vary across universities in the United Kingdom (e.g. entrepreneurial and research orientations and across time periods (short-term and long-term).

Notwithstanding, our study contributes to the increasing academic literature on spins off creation and universities R&D collaborations with industries. We provide new evidence of the effects of universities collaborations strategies and the various factors that influence these collaborations decisions and we showed that they have a positive impact on universities spin off firm's formation, which means that these universities collaborate with industries in forming new or revamping old industries with their economic viable R&D related research.

With regards to policy discussions, our findings support the argument that universities that have strategies geared towards faculty and industries collaborations are highly capable of spinning out firms to utilize their research outcomes (Benghozi & Salvador, 2014; Soetanto & Jack, 2016). Our results have shown that without any collaborations decisions or strategies and incentives in place, universities and faculty members will be reluctant to collaborate with industries. The necessary policy implications for university and industrial management are

- universities aiming to spin off or collaborate with industries must consider having strategies that support their innovations collaborations and must work in line with these strategies to ensure successful collaborations or spinning offs.
- our results show that incentives support provided to faculty members has a strong effect on their collaboration decisions, universities need to have enticing rewards to faculty members to lure them to collaborate with industries. These rewards can be in cash or kind such as given them the full or majority of the benefits that accrues from the collaborations.
- another implication of the results is that universities aiming to collaborate with industries need to invest in supporting infrastructure that has been proven to greatly support spin off activities. A perfect instance will be to establish TTOs to manage the collaboration processes to save faculty their time to concentrate on their academic work. They can also

invest in upgrading their laboratories so that they can conduct quality industry oriented economic research that can be appropriated for commercialization.

- industries can also play a key role in facilitating this spin off creations and R&D collaborations by providing the needed funding to these universities to carry out these vital economic researches.

CONCLUSION

It has become evident that globalization has opened and connected the world in terms of trade and knowledge creation as well as its exploitations. This has also exposed firms to global competitions from other firms and for customers. These intense competitions mean that firms are increasingly looking for survival strategies to give them the competitive edge over their market rivals. Knowledge and innovations have been touted as the means that can ensure firms increase their productivity and competitiveness. The national innovation system highlights the relevance of collaborations among industries, higher educational institutions and other public research organizations for the attainment of innovation. This mutually beneficial innovation partnership collaborations are the engines for growth and development of firms and national economies. Governments the world over support this innovation networks through fiscal incentive schemes, laws, and policies. This dissertation on the *triple helix model: factors influencing SMEs´ innovation activities in selected EU countries* has the desideratum of assessing the various factors influencing these institutional innovations synergies from both industries and universities perspectives. In this thesis, the researcher developed integrated research models to examine the internal and external factors and firm characteristics that influence SMEs innovation collaborations and activities across the European Union. This dissertation is divided into three sections based on the specific objectives.

The first specific objective sought to examine the various factors influencing firm's choice of local and foreign universities as collaborating partners. We examined the influence of firm size, firms' innovations activities, and public innovation has on firm's choice of universities as collaborating partners across selected EU countries. **The results of the empirical analysis demonstrated that in general these firms preferred to collaborate with local universities than with foreign universities**. We found that firms' size was a significant factor that informed firms decisions to partner local universities. We also concluded that the extent of firm's internationalisation was not necessarily an influential factor deciding on their choice of local universities. Firms preferred local universities for their innovation activities such as external knowledge, training and innovation introduction. This study also concluded that firms' collaborations with local universities we not probable in countries classified as modest innovators such as Bulgaria, Croatia and Romania, and in moderate innovators such as Slovakia, Lithuania and Portugal. **Finally, we saw that public support from central governments for innovations were significant factor influencing firms' collaborations in all the countries but Croatia, Latvia and Lithuania**. Also, EU funding significantly influenced firm's collaboration except in modest innovator countries such as Bulgaria and Croatia.

The second specific objective is follow-up study of the first specific objective. We concluded that determinants such as firm size, innovation activities, market orientations or the extent of internationalizations and public support of innovations influenced firms' collaborations with universities. In the second specific objective, we examined whether these determinants have significant influence on firm's innovation performances. We focused on analysing the above relationship with firms in Visegrad countries. The results show that firms internationalization decisions didn't exert significant impact on their innovations performances, only firms exporting to Non-EU markets were probable to be organizational innovators. The results showed that conducting R&D had a positive and significant influence on firms' product, process, organisational and marketing innovations. Also, our results proved that engaging in intramural R&D also positively impacted product and market innovations. We also conclude that training for innovation activities also positively impacted on process and organizational innovations. We also found that design activities influenced all firms' innovations except their process innovation. Funding support from local, central and EU sources influenced firms' products and process innovations. Finally, we discovered that firm characteristics such as size influenced products and process innovations and that microenterprises in the three Visegrád countries were not innovators. SMEs were product innovators while large firms were both product and process innovators. Locally owned firms were probable to be product and process innovators while multinational firms were not likely to introduce any innovations.

Finally, the last specific objective focused on analysing the factors influencing universities collaborations with industries. This study analysed the effects of supporting infrastructure, research and commercialization funding, incentives supports, governance of spin off related activities (TTOs), and IP rights influence on universities spin offs creation. The results of the mediation analysis showed that universities with collaborating decisions are highly probable to spin off firms that will utilize their research outcomes. **We concluded that incentives, funding, governing boards, support infrastructure all influenced universities collaboration strategies**

which subsequently influenced the total number of spin offs establish by universities. Our results show that collaboration strategies at universities had a medium effect on spin off creations. We also found that the incentive support provided or available at universities has the highest effect on collaboration decisions at universities. Surprisingly, we found that IP rights patent applied and acquired did not affect universities collaboration strategies.

The results and conclusions of this dissertation offers several contributions to theoretical, practical and policy implications that can strengthen the collaborations of universities, industries and governments. The implications are enumerated below

Main scientific benefits of this dissertation

1. this dissertation contributes to the growing international literature on the triple helix collaborations across Europe and particularly Visegrad countries.

2. knowledge about the factors influencing firms' innovations performance can help industrial managers to improve upon their competitiveness, productivity, innovations and profitability.

3. the findings of this dissertation can be of immense benefit to universities aiming to be entrepreneurial as it has shed more light on the factors influencing universities and industries collaborations using spin offs as a medium.

4. it can also be of help to governments and public policy makers, by serving as a practical guide to help them come up with appropriate support mechanisms for national innovation policies and support for firm's innovation activities.

5. it can serve as a guide for further scientific research and can be a reference material for pedagogical activities for the faculty of Economics and the University of Pardubice as a whole.

Practical implications for policy makers

1. governmental support schemes need to focus on buttressing firms' partnerships with local and foreign universities and encouraging the efficient use of **local, central and EU funding schemes to strengthen this innovations collaboration especially with foreign universities in new EU countries with weakly developed innovation potentials**.

2. **EU governments need to support and reform their higher educational structures to have strong entrepreneurial focus by providing them with the needed financial and support infrastructure such as incubators and science parks to facilitate their collaborations with industries**. Local universities need to be restructured and extend their cooperation arrangements from inward-looking to firms with international focus.

3. firms aiming to collaborate with both local and foreign universities need to strengthen their absorptive capacity by **providing support for in-house innovation activities and R&D.**

4. the study also proposes strengthening university-industry-government partnership in countries especially new EU countries because of the weaker level of collaboration due to divergent interest of these collaborators. This study proposes to the establishment **of spin-off, and other intangible means such as joint publication** etc.

5. University-industry collaboration can be strengthened through **cluster policies** like science parks as this can pool physical, financial and human resources for innovation to exploit the benefits of proximity such as knowledge spill overs and exchanges between the parties involved.

6. **R&D tax incentives** can be instituted as targeted instrument to encourage and support innovation investment.

7. universities need to **produce and disseminate quality research that could be commercially appropriated for industrial use**. This will magnet industries to collaborate with them.

8. we provide new evidence of the effects of universities collaborations strategies on their probability to spin off companies, this means that if they want to intensify their collaborations with industries, they need to first of all consider having strategies and decisions and they must review these strategies constantly.

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APPENDIX

Appendix 1: Structural model collinearity assessment

Constructs	COLL. STRATEGY	INCENTIVES	GOVERNANCE	SUPPORT INFRAS.	FUNDING	IP RIGHTS	SPIN OFFS
Strategy 1	1.000						
Incentives 1		1.000					
Gov 1			7.701				
Gov 2			4.935				
Gov 3			1.547				
Gov 4			2.212				
Support 1				2.581			
Support 2				4.615			
Support 3				5.363			
Support 4				3.520			
Support 5				5.393			
Support 6				6.720			
Support 7				3.664			
Funding 1					1.511		
Funding 2					1.729		
Funding 3					2.007		
Funding 4					1.303		
Patent 1						3.450	
Patent 2						3.572	
Patent 3						1.225	
Spin1							1.072
Spin 2							1.062
Spin 3							1.051

Source: Own calculations, VIF $\ngtr$ 10 (Hair et al., 2010).

Appendix 2: Indirect effects results

Relationships	**Beta**	**Mean value**	**Standard error**	**t-value**	**p-value**
INCENTIVES → SPIN OFFS	0.247	0.253	0.037	6.556	0.000***
GOVERNANCE → SPIN OFFS	0.101	0.107	0.033	3.052	0.002**
SUPPORT INFRAS. → SPIN OFFS	0.064	0.065	0.031	2.094	0.037*
FUNDING → SPIN OFFS	0.019	0.020	0.010	1.867	0.062*
IP RIGHTS → SPIN OFFS	0.011	0.012	0.009	1.276	0.202

Source: Own computations

Note: *** Parameter significant at 99 % level, ** significant at 95 % level, * significant at 90 % level.

Appendix 3: Total effects inferences

Relationships	**Beta**	**Mean values**	**Standard error**	**t-value**	**p-value**
COLLABORATION STRATEGY → SPIN OFFS	0.428	0.446	0.033	12.998	0.000***
INCENTIVES → COLLABORATION STRA.	0.567	0.567	0.067	8.523	0.000***
INCENTIVES → SPIN OFFS	0.243	0.254	0.037	6.556	0.000***
GOVERNANCE → COLLABORATION STRA	0.237	0.241	0.073	3.260	0.001**
GOVERNANCE → SPIN OFFS	0.101	0.107	0.033	3.052	0.002**
SUPPORT INFRAS. → COLLABORATION STRATEGY	0.150	0.146	0.069	2.179	0.020**
SUPPORT INFRAS. → SPIN OFFS	0.064	0.065	0.031	2.094	0.037*
FUNDING → COLLABORATION STRA	0.044	0.045	0.023	1.975	0.049*
FUNDING → SPIN OFFS	0.019	0.020	0.010	1.867	0.062*
IP RIGHTS → COLLABORATION STRATEGY	0.026	0.027	0.019	1.362	0.174
IP RIGHTS → SPIN OFFS	0.011	0.012	0.009	1.276	0.202

Source: Own computations

Note: *** Parameter significant at 99 % level, ** significant at 95 % level, * significant at 90 % level.