University-industry interactions: A comparative analysis of the influence of formal and informal university knowledge transfer mechanisms on innovation performance in firms in Ghana

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By

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Declaration

I declare that this work has not previously been accepted in substance for any degree and is not being concurrently submitted for any other degree.

I further declare that this thesis is the result of my own independent work and investigation, except where otherwise was stated (a bibliography is appended).

Finally, I hereby give consent for my thesis, if accepted, to be available for photocopying, for inter-library loan, and for the title and abstract to be available for outside organisations.

__________________________________________
Abdul-Fatahi Abdulai

30th May 2018
Dedication

To my family and friends
Acknowledgement

In the first place, I would like to express my sincere gratitude to my director of studies, Dr. Lyndon Murphy, for his kind support, extreme patience and everlasting encouragement during the study process. His guidance, advice, feedback and general mentorship were instrumental from the start to the final completion of this study. Also, I will take this opportunity to extend my heartfelt gratitude to Professor Andrew Thomas; a very helpful and constructive supervisory team member who offered valuable comments and critical suggestions to ensure that good outcome was achieved. Professor Brychan Thomas cannot be forgotten for his unflinching great support in reading several drafts of this thesis, offering and also valuable comments that have helped in the improvement of the thesis over the entire period.

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Abstract

Knowledge transferred from universities is known to pass through many mechanisms to influence innovation in firms. Nonetheless, research on university knowledge transfer in less developed economies is not readily available in the extant literature. At the heart of this is a lack of analytical framework to guide university knowledge transfer in developing economies. The current study therefore elicits a comprehensive understanding of university knowledge transfer in the West African country of Ghana. The study adapts a generic integrated university knowledge transfer framework that suits the context of developing economies and evaluates how university knowledge transfer mechanisms influence innovation in firms in primary, manufacturing and service sectors in Ghana.

To achieve the study aim, explanatory sequential mixed methods was employed from which the study contends that universities interactions with industry in Ghana are effective through both formal and informal mechanisms. However, the two are found not to directly lead to the ultimate results of innovation performance in firms and will have to be expedited through other means such as technology transfer offices, knowledge networks and collaborative research projects between universities and firms.

In addition, the study shows that firms in different sectors of Ghanaian economy have some similarities as well as differences by which they acquire new knowledge from universities to significantly improve their products and services. These disparities in particular are explained accordingly by specific characteristics the sectors, pace of innovation adoption in each sector and greatly influenced equally by size, socio-cultural factors and general background of management staff in all sectors. Based on these, primary and manufacturing sectors firms are found to have comparatively weak relations with universities, whereas service sector firms have stronger interactions.

The study concludes that interactions driving universities and industry are productive and worth pursuing as one of many instruments for innovative changes in all aspects of Ghanaian economy. The study suggests that knowledge generation players in Ghana need to have a well-defined national innovation agenda that seeks to facilitate and address sector specific needs. Significantly, the government of Ghana needs to create avenues for local firms, particularly small to medium scale enterprises in primary and manufacturing sectors to gain additional capabilities to absorb knowledge. Nevertheless, a stronger relationship between universities and firms in Ghana will by no means usher in the required knowledge for wealth and prosperity.

Finally, the study recommends a rigorous adjustment in current universities’ physical and administrative structures to accommodate industry interactions and create knowledge that suits basic characteristics needs of individual sectors. Most of all, economic policies will have to be carefully designed and efficiently directed by dedicated experts to work to successful realisation of the country’s industrialisation objective. Lastly, more research will need to be conducted in the area of innovation policy effectiveness and impact evaluation for deeper understanding and to help to create ideal environment for productive research outcomes in all sectors of the economy.
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Publications

Peer reviewed journal article


Conference papers


Conference proceedings


Abdulai, A.-F., Murphy, L. and Thomas, B. (2016) ‘The influence of technology transfer offices on firm-level innovation in Ghana’, International Conference for Business and
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Book Chapter

Chapter 1. Introduction
1.1. Introduction

The continent of Africa witnessed the beginning of the collapse of colonial rule in the late 1950s, up to the 1970s when agitation for self-governance saw most countries gained political independence from Westminster (MEST, 2010). To the newly sworn governments, industrialisation and economic growth through scientific and technological developments were the next priorities and enormous challenges for the new nations (Iddris, 2014, IHERD, 2013). Through national development plans designed to achieve the set objectives, many forms of infrastructure were put in place. With that, many of the countries actually experienced remarkable progress in economic growth in the 1960s and early 1970s (Amankwah-Amoah, 2016, Cloete et al., 2011).

Significantly, with Kwame Nkrumah as a Pan African activist and an advocate for self-governance, Ghana became the first African country, south of the Sahara, to demand and gained political independence from British colonial rule in 1957. Education, science and innovation were put at the forefront of economic growth and development. In effect, universities and other public research organisations like the Council for Scientific and Industrial Research (CSIR) were established in 1968 as subsidiary institutes under the National Research Council contribute in the area of research towards economic growth and development. Since then, CSIR controlled and coordinated 13 other research institutes that still cover natural resources, agriculture, industrial and policy research studies (Iddris, 2014). However, of all these, the specific concept of knowledge transfer, innovation and entrepreneurship issues in the country have not since been researched or not tackled in an effort to achieve all the ambitious plans (Robson et al., 2008).

In a conference of African ministers of industries held in Addis Ababa, Ethiopia in 1971, industrialisation was recognised as a priority and fundamentally important in the structural transformation of African countries. Popularly called the Addis Ababa Declaration, the ministers expressed their confidence in industrialisation as a strategic element for social progress of Africa as a whole (Osabutey and Jin, 2016). Further to the optimism of the new nations, another declaration was also adopted in Monrovia in 1979 by heads of states and governments of the Organisation of African Unity (OAU) in Liberia. This declaration placed food sufficiency in Africa first on Africa’s development agenda, followed by industrialisation as an African strategy.
for the following decades. An ambitious strategy that would only later unfortunately see African countries within the same decades suffer severe social and economic crises, and eventually led the industrialisation pace to decline to a record low (Mwamadzingo, 1996).

In a desperate move to keep track of the development agenda of Ghana, Kwame Nkrumah University of Science and Technology (KUNST), which was established in 1948 was upgraded from college status to a fully functioning university in 1961 with the main aim of producing high calibre of skilled graduates with expertise and knowledge that will advance the industrial and socio-economic conditions of Ghana (Barry and Sawyerr, 2008). For economic development in Africa for instance, University of Nigeria in Nsukka, Enugu state, was opened to business in 1960, then Ahmadu Bello University in 1962. In 1970, University of East Africa was dissolved to form three fully-fledged independent universities (Makerere University in Uganda, University of Dar es Salaam in Tanzania and Nairobi University in Kenya (Mwamadzingo, 1996).

Several conferences followed and systematic arrangements were made at an African level and at the level of the United Nations. An example is the Conference on Science and Technology for Development (UNCTAD) which took place in Vienna in 1979 (Mwamadzingo, 1996). At this point the conference attendees agitated for conceptualisation and implementation of unambiguous national science and technology policies directed at accelerating the process of social and economic growth and development in Africa. Yet still, the complex concept of knowledge transfer never reflected in academic literature or policy documents stating how innovation could be achieved through university generated knowledge in African countries. What was also neglected in discussions around science and technology was the influence that formal and informal mechanisms of university knowledge transfer could manifest on innovation in industry and at sector levels. Actually, this leaves a gap in the knowledge transfer literature on the continent when most firms in Ghana in particular, and in Africa in general, mostly used informal means to innovate (Obeng et al, 2012).

Notwithstanding the barrage of conferences and declarations around the world and on the continent, and in spite of the agitations and the ambitions on the role of science and technology for development and industrialisation, African countries did not make sufficient investment in
research and development (R&D). There had not been any conscious effort to train and produce the required skilled manpower for development and sustenance of scientific creativity and technological innovation. Up to 1970, R&D expenditure on the continent of Africa was less than 0.4% of GNP while that of advanced economies as a whole was about 2.23% (UNESCO, 1991). Notably, as of 2008, Ghana Government expenditure on R&D in particular stood at 0.3% of GDP (UNCTAD, 2011).

On the whole, African countries are still behind in accumulating knowledge for innovation, generally because of weak research institutions and low absorptive capacities of firms. For this reason, the understanding of how firms on the continent can acquire knowledge becomes imperative for economic development (AAU, 2012, Cloete et al., 2011, Iddris, 2014). In contrast, the literature on how firms in developing economies gain knowledge through external interactions for innovation performance is very limited and needs further development. Astrid et al. (2008) identify two specific forms of interactions in developing countries that supply indigenous firms with their knowledge needs, and in this they refer to SMEs. Accordingly, the first is interactions with multinational companies (MNCs) where they absorb spill-overs resulting from foreign direct investments (FDI) and the other is from interactions with universities. The latter is the subject matter for the current study and the rest of the thesis delve deeper to achieve the purpose.

Added to that, modern day economies seem to be increasingly adapting to innovation for economic prosperity such as those in Europe and North America and to a large extent, becoming dependent on knowledge generated from research institutions and universities (Kruss et al., 2012). In much the same way, developing nations including Ghana, Nigeria and Kenya are by no means responding to the tenets of the fast growing knowledge-based markets for 21st century economic and social development (Cooke and Leydesdorff, 2006, Etzkowitz, 2000).

Owing to this, the importance of knowledge transfer from universities to industry has received a lot of attention in both practice and in academic literature of late (Deiaco et al., 2012; Landry and Amara, 2012; Guimon, 2013). In spite of the emergence of the literature on university-industry interaction in developing economies, there is no comprehensive study that offers any analytical
framework to adequately explain how university knowledge transferred through formal and informal mechanisms actually influences innovation in firms at sector levels in developing economies. More so, Kruss et al. (2012) report of governments in developing economies and universities adopting policies and university-industry interaction frameworks on whole sale basis to promote knowledge transfer without adequate reconditioning and appropriation. It is even evident that the implementations of these frameworks are without proper understanding of the specificities of the different contexts of the recipient countries. Crucially, with the current spate of pervasive knowledge intensification and recognition of university-industry interaction and innovation as fundamental elements of economic growth and development, one can strongly argue that it is about time for the development of a firm-level innovation framework that will guide developing economies on university knowledge transfer and innovation performance. This will in turn fill the persistent gap in the existing body of literature.

In response to that, the current study intends to investigate and present the very first comprehensive review, given a proposed firm-level innovation framework, of connectivity between university generated knowledge and innovation performance in a developing economy such as Ghana. The framework without doubt is further used to investigate how formal and informal mechanisms of university knowledge transfer influence innovation in firms in various industrial sectors of Ghana in this study and will be available for future research in other developing economies, particularly in the West African Sub-region. It could equally be used to evaluate how university knowledge transfer mechanisms can better be managed to gain productive use of research outcome from universities in developing economies.

In general, there is a growing body of academic knowledge on universities engagements with firms for innovation and economic growth and development in countries. Evidence of this is abound (e.g. AAU, 2012, Banal-Estanol et al., 2011, January and Thomas, 2013, Rossi and Rosli, 2013), however, there is equally another growing body of literature that questions the readiness of universities and firms in developing economies to engage in knowledge generation, transfer and innovation in firms, to attain the much desired economic development and industrialisation (AAU, 2012, Krupnik et al., 2015, Kruss et al., 2012, Sawyerr, 2004a). The obvious doubt of such interaction between the spheres is exacerbated by the lack of research on
the conditions of universities and firms in less income nations and their potential to interaction with each other as they do in advanced economies (Chudnovsky et al., 2006, Guimon, 2013, Hart et al., 2009). Moreover, the capability to produce usable knowledge for industry coupled with the needed orientation and ability to transfer through knowledge productive channels, Boubakar and Sawyerr (2008) express, face further questions in the situation of developing economies.

Considerably, universities on the supply side of the equation must have the capability and flexibility to not just produce knowledge, but supply to firms with technical graduates training on the scale and in fields that are relevant to industry. On the other hand, the technical capabilities of management staff of firms need to be at least reasonably strong to accommodate new knowledge. For these reasons, Tetteh and Essegbey (2014) also casts some doubt about the readiness of most firms, particularly small to medium sized ones in Africa, arguing that it may be generally low or weak.

Unfortunately, there is no great deal of information in the literature rich enough to inform researchers and policy makers on how universities in developing economies actually contribute to economic development. To understand why, Kruss et al., (2012) claims that the changing role of universities in the learning process of firms have yet to take shape in the West African sub region, one could take a look at the failure rates of national innovation systems frameworks imported from advanced economies to the sub region in particular, that he puts as high, meaning, they do not work. For this paradox of the innovation success stories from developed economies and failures of the concept in the sub-region and other developing economies, the issue of university engagement has become an interesting domain for further theoretical investigation among researchers.

Martynovich (2001) and Tuunainen (2002) have recounted that universities’ involvement in social advancement and prosperity is not new though as may be claimed, they insist, suggesting that what is lacking in struggling economies is the appreciation of the mechanisms of interactions between universities and civic society (AAU, 2012, Bawakyillenuo et al., 2013). Worst of all, African countries and Ghana in particular are not able to strengthen existing institutions and
structures to improve their effectiveness and efficiency for larger society to fully benefit from direct results of university research (Boubakar and Sawyerr, 2008, Sawyerr, 2004b).

For higher education to contribute and effectively meet the needs of industries and increase its impact on innovation process and subsequently industrial growth, tertiary institutions, for that matter, universities in developing nations must inevitably reform, modernise and suitably cooperate with industry fully (Fu et al., 2014, OECD, 2013). Unfortunately, this is not a usual case in developing economies in general. What is prevalent in developing nations is that universities concern themselves with their own internal and urgent problems of teaching, peer-review publications, staffing, expansion, student numbers and finance (Cloete et al., 2011, IMF, 2006). Industries on their part too are preoccupied with their individual issues of lack of adequate markets and infrastructure. The intricacies of innovation perhaps are not yet understood by these significant knowledge players in the developing world and institutional boundaries remain rigid still, not allowing an interdisciplinary approach to systemic problems solving (Mwamadzingo, 1996). Academics and entrepreneurs alike do not still comprehend how much they could benefit from each other in an interactive space for knowledge needed for the good of all (Frazer, 2005, Fu et al., 2015).

It does not mean though that university-industry interaction is not a possible phenomenon in developing countries, it happens on a comparatively low scale, definitely leaving a form of chasm. What is purposely required to close the chasm is a comprehensive understanding of the complex issues surrounding the sustainability of the existing situation and thus stitching the loose ends, which are what the current study seeks to do, thus, suggests coherent and systematic policies for productive communication or a link between industry and universities (Islam et al., 2013, NDPC, 2010).

As a matter of fact, industries learn and innovate in a variety of ways depending on their areas of specialisations, markets, technologies and disciplines. Note the fact that a lot of organisations use similar mechanisms of knowledge transfer (Etzkowitz, 2002, January and Thomas, 2013). Also note that, available mechanisms of interest here includes contract research, consultancy services, financing PhD research students, joint research projects, university staff taking positions in
businesses and sometimes a complete labour mobility or staff flow into industry thereby transferring knowledge for innovative performances (Bekkers and Freitas, 2008). As good as it may sound, admittedly, not all firms have the capacity to embark on most of these types of projects especially small and newly formed organisations that have not yet gained enough market shares and are still at the early stages of their product life cycles (Bekkers and Freitas, 2008, Huggins et al., 2012a). Innovation therefore is said to vary with the age of firms as older firms are more likely to develop innovation capability than late entrants into industry (Huergo and Jaumandreu, 2004). In several studies, there have been positive and significant association found between firms’ ages and their technological capabilities in Tanzania (Deraniyagala and Semboja, 1999). Also, due to accumulated business experience gained over years, a study in Mauritius concluded that a firms’ age may be positively associated with its involvement in innovation activities (Wignaraja and Ikiara, 1999, Wignaraja, 2002). A similar conclusion was made in Ghana given that the majority of Ghanaian firms are small, early entrants, informal and most of them lose out in innovation performance because of low capacities in finance, lack of absorptive capacity and technical support (Robson et al., 2009).

For now, governments of developing countries are beginning to play the expected role by facilitation in university-industry interactions as proposed by Etzkowitz and Leydesdorff (1997) within the frame of Triple Helix concept; a neo-evolutionary model that calls for an interface among industry, universities and governments in a social contract where actors take up the traditional role of each other in an ‘innovation space’ (Etzkowitz, 2002). In response to current economic development through innovation, Ghana launched a National Science, Technology and Innovation Policy in 2010, ushering in a national key policy document that was intended to drive research and innovation in the country (Iddris, 2014). Clearly, per the requirement of the neo-evolutionary models currently available to set up an effective innovation system, Ghana incorporated the roles of the required institutional actors into the policy document to shape the national innovation system and fast forward the progress of the economy towards a middle-level income status (Gondwe and Walenkamp, 2011, MEST, 2010). Besides, based on Ghana’s, Science, Technology and Innovation Policy Review presented at the United Nations Conference on Trade and Development (UNCTAD, 2011), accordingly spelt out the main actors to be universities and research institutions, the Government of Ghana and the private sector. However,
without the appropriate knowledge and workable analytical framework tailored to developing economies on university knowledge transfer and innovation as required in the overall aim of this current study, there is very little in terms of relevant knowledge to guide policy makers and practitioners on the way forward to innovation and industrialisation. What is more, with numerous universities and colleges set up in Ghana in both private and public sectors, resulting in an astronomical increase in students enrolment numbers, very few students are recruited into the sciences (NCTE, 2014). Meanwhile, government policies have outlined science, technology and innovation strategy as the pivot around which industrialisation of the economy will revolve (Cloete et al., 2011, MEST, 2010). To illustrate this irony, between 1999 and 2006, eighty two percent (82%) of the student population in the country’s largest public university enrolment was to the humanities whilst only eighteen percent (18%) was in the sciences (UNCTAD, 2011). This worrying situation was not in any way different in the private universities and colleges all around the country. Another constrain was the lack of support from policy makers for successful implementation of the document after it was adopted by the legislative wing of the government in parliament in 2010 (MEST, 2010, NDPC, 2010). To make matters worse, the government annual budgetary allocation for research has never been adequate and translated into inadequate facilities, lack of training of staff and funds available could barely pay staff, leaving virtually nothing to conduct research (Iddris, 2014). Nonetheless, that is not to say that public R&D institutions in other developing economies or those in sub-Saharan African countries are better; studies conducted in Uganda, Zimbabwe, Tanzania and Kenya have found the general lack the facilities to be common; there is neither physical and human resources to provide adequate support to industry nor any means to assess their technological needs (Deraniyagala and Semboja, 1999, Wignaraja and Ikiara, 1999). Surely, public universities and research institutions in developing economies are currently not positioned in any way better to affect any accelerated economic development to the public that funds them (Bailey et al., 2011, Bawakyillenuo et al., 2013). Finally, most of private sector firms are SMEs and largely informal with little capacity to invest in R&D. (UNCTAD, 2011, Tetteh and Essegbey, 2014).

In contrast, just as any other model in principle, the innovation system framework as currently employed in Ghana and other developing economies to achieve industrialisation can be subjected to criticisms for both theoretical and practical reasons. Firstly, Tuunainen (2002) criticises such
frameworks especially for theoretical ambiguity and inconsistency with empirical evidence. On the other hand, he confesses that they have yielded empirical data that facilitate further research. This criticism converges with that of Martynovich (2001) who argues that recent advocates of innovation frameworks have not acknowledged the pioneering work of previous proponents enough. Saad et al. (2010) also suggest that the proposition by the proponents of recent innovation models for all universities to be entrepreneurial institutions could be counterproductive at some point and that such institutions could run out of ideas to capitalise knowledge and will need new ones in the long run from universities that will still be involved in the generation of knowledge for the sake of exploration.

In spite of criticisms of the frameworks, many innovation system frameworks have been tried, tested and are still widely used, particularly in developed economies. Their contributions to growth and sustainable economic development are evident as governments, industry and academia have appreciated their significance as key to democratic approach to innovation, particularly in advanced economies (Bessant et al., 2012, Castro-Martínez et al., 2010). Implicitly, a comprehensive analytical framework on university knowledge transfer designed as proposed in the current study could offer a solution to Ghana and other developing economies as a guide on how best to transfer and use university knowledge for innovation performance in industry and subsequent economic development. It can bridge the current gap between academia and industry in less fortunate economies as it is in more advanced nations. The absence of such a analytical framework certainly leaves a gap in the innovation literature which this current study seeks to fill.

1.2. Research problem

‘We believe not only in pure research as a legitimate endeavour, but we also attach great importance to applied research. Modern science has taught us enough, and has already given us enough, to be able to tackle our agricultural, industrial and economic problems. ....Only the mastery and unremitting application of science and technology can guarantee human welfare and human happiness’ Osagyefo Dr. Kwame Nkrumah; See Obeng (1997, p. 309).

This notwithstanding, Ghana’s belief in both basic and applied research as a legitimate endeavour, the mastery and unremitting application of science and technology for almost six
decades has neither sufficiently tackled agricultural, industrial and economic problems nor guaranteed any human welfare and happiness to Ghanaians (NDPC, 2010, Narteh, 2008). Ghanaian universities which were meant to pursue the said endeavour have so far made little impact on industry and social development for ordinary Ghanaians (Fu et al., 2014, IHERD, 2013). For Ghana at the moment, technological innovation is still paramount for middle income status target by the year 2020 according to the government’s vision (IHERD, 2013). Yet, numerous constraints and obstacles prevent firms from innovating in the country. Prominent among which is the lack of an effective link between universalities and industry (AAU, 2012, Sawyerr, 2004a).

Indeed, interaction between universities and industry has of late been given much attention by policy makers and scholars in both developed and developing economies in a frantic attempt to access new knowledge and enhance business competence (Mathew, 2016, Singh et al., 2015). Coupled with that, there is the growing need within firms in Ghana to gain competitive advantage and meet the increasing needs of today’s knowledge-based market (Lockett et al., 2009, Leydesdorff, 2001). Emphatically, the transfer of knowledge from universities to firms is top of the agenda for economic and social development for regional, national and international economic policy makers (Cooke and Leydesdorff, 2006, Victoria et al., 2015). More so, economies at the bottom end of the development pyramid are yearning for research driven productive sectors to attain middle level income status at stated time in their development plans (Mohamedbhai, 2008, Mensah-Bonsu and Jell, 2011).

Nonetheless, the existing knowledge transfer literature mostly concentrates more on developed economies and on how university based researchers measure the success of collaborating universities (Léger and Swaminathan, 2007, Barnes et al., 2006). Similarly, other studies look at university-industry knowledge transfer mechanisms from the perspective of research resulting in patents, intellectual property (IP), licensing or the number of spin-offs universities create, again, in developed economies and largely in the physical and life sciences (D’Este and Perkmann, 2010, Chapple et al., 2005). More so, the importation of system frameworks from America and Britain have not worked at all for developing economies, notwithstanding the complete absence
of a suitable one in the extant literature to offer any guide and direction for developing economies.

Finally, the influence of formal and informal mechanisms of university knowledge transfer on the innovation landscape remains largely un-charted in the literature and specifically in developing economies particularly Ghana (Krupnik et al., 2015, Winkelbach and Walter, 2015). Interestingly, an estimated 40% of Ghana’s contribution of GDP is from informal sector whose main source of knowledge and innovation is informal and predominantly through social networks. Even large corporate bodies face many challenges in more formal R&D co-operation with universities for knowledge (Fu et al., 2014, D’Este and Perkmann, 2010). Crucially, the development of an analytical framework to study and understand these mechanisms in the Ghanaian context could not be more significant at a better time than now.

1.3. Motivation for the study

In spite of six decades of self-rule, Ghana has yet not developed any credible science and technology, capable enough of increasing its GDP per capita to concomitantly raise the living standard of its citizens. Equally, there has not been the form of economic progress made like that of countries in South East Asia, whose levels of development were not in any way better than Ghana’s at the time of independence. To illustrate this, Malaysia gained political independence, coincidentally, also from British rule, the same year as Ghana (Yusof, 2010). Interestingly, at the time, Ghana was popularly described then as the wealthiest nation in Sub-Saharan Africa and prominently was the first nation to struggle diplomatically and gained political independence in the sub-region. According to IMF World Economic Outlook (2017), just before independence, Ghana had a per capita income which was about equal to that of South Korea. Similarly, by 1960, Ghana and Malaysia also had pretty comparable GDP per capita (Diao, 2010). Put in context, whilst Malaysia had US$234.81 per capita, Ghana had a slightly lower of US$182.98. Paradoxically, as of 2015, Malaysia had US$9,768.33 as compared to a GDP per capita of US$1,369.70 for Ghana and US$27,221.52 for South Korea (Herbert, 1994, IMF, 2017). Figure 1.1 shows trends in GDP per capita for a few countries that had similar starting point in economic growth where the resemblances and divergences are clear over approximately the last six decades.
Even with the current science and technological dispensation globally, Ghana has not had an authoritative framework and regulation as a National Science, Technology and Innovation (STI) policy document that guides and defines a policy direction for all sectors of the economy (Okantey, 2014, Mensah-Bonsu and Jell, 2011). Also, universities and industry have yet to demonstrate their individual and collective contributions to GDP like their counterparts in South East Asia have done. By comparison, there is sufficient evidence of a positive and productive effect of university knowledge on the progress of advanced economies in the extant literature and equally obvious in other current emerging economies like China, Singapore, India, and South Korea. Likewise, there is a strong correlation between collaborative research; thus; academic and research institutions and industry R&D in technological innovation and economic performance. This regrettably is not the case in developing countries or those in the West African sub-region, and Ghana in particular (IMF, 2006, Oppong et al., 2014). All of these notwithstanding, Ghana now have reputable universities that are highly recognised in the sub-region and all over the world and a vibrant corporate sector, ready to face the challenges of the 21st century. Following that, the current study believes what is missing at the moment is adequate knowledge of the kind.
of interaction that best suits the Ghanaian phenomenon of university knowledge generation, transfer and innovation in firms and how these can be achieved for economic growth and development. To this, the consolation currently in Ghana is that, it has been the most peaceful country in the sub-region and equally represents an epitome of multi-party democracy for nearly three decades without disturbances (Diao, 2010).

Lastly, a more compelling motivation is the recent discovery of oil and gas in Ghana in 2003, which invited a lot of interest from the public, suggesting a swift move to structural transformation and trade liberalisation for industrialisation (Annan, 2011). Given the bitter experience of neighbouring oil-rich nation; Nigeria and that of the mining sector even in Ghana, there is the excitement and anxiety at the same time from the citizens on how the rent could be used for economic prosperity. Certainly, relative to the size of the economy, oil revenue holds the potential to transform the Ghanaian economy for better. Without doubt, the recommendation from empirical study is that Ghana needs diversification away from mining and oil revenue if it is to escape the experience of the ‘paradox of plenty’; a ‘resource curse’ that some oil-rich nations face in Sub-Saharan Africa. Alas, the Ghanaian economy has largely depended on primary products mainly from agriculture and mining for decades and now oil and gas. Considerably, the agricultural sector in particular, which employs a greater percentage of the workforce in Ghana needs to be strengthened with innovative means of production to add value to primary production and products. Of course, this calls for heavy industrialisation through knowledge generation and transfer from universities for innovation in the sectors. A move away from over-reliance on primary product, such as crude oil, raw diamond, iron ore, raw Gold and pineapple will certainly save and stabilise the economy from price fluctuations.

Quite surprisingly, the issue of university knowledge transfer and innovation performance in firms in the primary sector is crucial to the economic development of Ghana and these oil-rich countries but are rarely researched and discussed. Even the problem of over reliance on primary products in Sub-Saharan Africa has lingered for decades; there is no empirical study really available or a feasible framework in the academic literature to guide policy decisions across these nations, leaving a persistent literature gap. Available innovation models are vague, either over simplified or complicated and not even suitable for developing economies. Most of all,
there are no models that tackle sector specific knowledge transfer problems. For these reasons, the current study proposes a more comprehensive conceptual framework that addresses the concepts of university knowledge transfer from Ghanaian universities to industry sectors taking empirical characteristics of the sector firms into consideration.

1.4. **Purpose and scope of the study**

Broadly speaking, the body of the literature on the link between universities and industry on economic development has spiralled up considerably over the past two decades. Simultaneously, how universities actually transfer knowledge to industry to affect economic development has been widely treated and documented in academic circles (Guimon, 2013, Ponds et al., 2010, Rossi and Rosli, 2013). However, there are still a lot of gaps left in the extant literature in this particular area (Boldrin and Levine, 2012, Borrás and Edquist, 2013, Caniels, 2005). To mention a few, there is comparatively little research work which focuses on how formal and informal mechanisms of university knowledge transfer directly affect innovation at firm-level (Grimpe and Hussinger, 2013, Michels, 2015, Perkmann et al., 2013). Neither have there been any considerable studies on the mechanisms within the context of developing economies, nor any studies conducted with a mixed method sequentially designed to fill the gap in the literature (Bailey et al., 2011, Bawakyillenuo et al., 2013, Gondwe and Walenkamp, 2011, Creswell, 2014). In this situation, the few studies available are mainly in the context of advanced economies and mostly conducted as case studies in the qualitative tradition (Barnes et al., 2002, Barnes et al., 2006, Chapple et al., 2005, Mowery and Sampat, 2005a). Indeed, this study seeks to address these gaps by contributing to the exiting body of knowledge in the areas below:

1. To develop a university-industry interaction framework for firm-level innovation that is suitable for Ghana and other developing economies in the West African Sub-region.
2. To empirically investigate the influence of formal and informal mechanisms of university knowledge transfer on firms’ innovation performance in Ghana using the framework.
3. To extend understanding on how university interactions with businesses actually influence innovation at industrial sector level in Ghana and other developing economies in the Sub-region.
Guided by these, the study employs explanatory sequential mixed methods to examine universities-industry links as a necessary condition for knowledge and technology transfer, using a cross-sectional survey to collect data in Ghana on firms’ interaction with universities for the quantitative aspect. Face-to-face thematic interview with a semi-structured guide is used for the qualitative aspect to obtain in-depth knowledge on business engagement from five traditional universities and ten firms in both urban and semi-urban firms.

Above all, it will be acknowledged at this point that university-industry interaction is a bi-directional (Abreu et al., 2008, Dooley and Kirk, 2007) process (an exchange between actors) but in this current study the focus is solely on a uni-directional transfer, thus; the transfer of research outcome from university to industry. For this purpose, the study explores direct and indirect influence of formal and informal mechanisms of knowledge transfer from universities to industry.

Consequently, the scope of the study covers only issues currently surrounding the transfer of knowledge from research conducted in more established universities in Ghana. Importantly, those that were first set up primarily to produce skilled manpower needs and conduct research to support science, technology and innovation (STI) strategic plans of the newly independent nation of Ghana (MEST, 2010, NDPC, 2010). Without doubt, the concept of knowledge and knowledge generation and transfer is broad and complex and therefore cannot be completely covered in a study of this nature, especially one that is limited by resources and time. The study hereof seeks to critically investigate the mechanisms of transfer of knowledge from universities and their researchers in Ghana placing emphasis on how it is manifested in local firms. Additionally, structural dimensions of social capital are also considered in the study for the role of social capital in university knowledge transfer and on innovation in firms. Ideally, firms of all sizes and shapes and traditional universities in Ghana represent the statistical units of analysis for the study (OECD, 2005a).

1.5. Aim and objectives of the study

The aim of the study is to critically analyse university-industry interactions and how firms at industry sector levels respond in terms of their innovation performance in Ghana. The study uses
explanatory sequential mixed methods to achieve the aim. Nonetheless, the study is largely quantitative by design and the qualitative research is intended to offer a far deeper understanding with its explanatory tendencies.

Overall aim of the study is:

- To design and evaluate a university-industry interaction and firm-level innovation framework that will inform productive interaction between academia and Ghanaian businesses to enhance firms’ innovation performance.

The overarching reason for undertaking this study is the fact that for almost six decades of teaching and research in universities and concerted efforts with both local (public) and foreign support to link universities and the productive sector in Ghana, there is comparatively very little evidence to show in the country’s social and economic development through science, technology and innovation. Therefore, the end result of the study seeks to map a university-industry interaction/innovation framework for Ghana and evaluate it with hypothesis tests using empirical data from the country. This is intended to show how formal and informal mechanisms of university knowledge transfer influence innovation performance in firms.

To achieve the above aim, the set objectives are:

- to critically analyse direct and indirect effects of both formal and informal mechanisms of university knowledge transfer on innovation performance at firm-level in Ghana.
- to conduct mediation and moderation (industry sectors) analysis to assess the influence of collaborative research, technology transfer offices and knowledge networks on innovation performance at sector levels in Ghana.
- to critically evaluate how public policy instruments can support effective university-industry interactions for innovation performance in firms in Ghana.

1.6. Innovation in Ghana context

The next section presents a narrative on Ghana in the West African subcontinent, to putting the country’s university knowledge transfer and innovation agenda into context. The section starts
with strategies that the country has used over the years to achieve its innovation aims. The development and current state of higher education and the link with innovation are also discussed and ends with the state of entrepreneurship and how innovation is achieved also at the firms’ level in economic activities.

1.7. Science, technology and innovation in Ghana

The national innovation system of Ghana is actually small compared to even middle-level income countries like India (Mensah-Bonsu and Jell, 2011, Fu et al., 2015). Though in the last eight years the political landscape has continued to evolve, the size of the system remains the same. Interestingly, the macroeconomic conditions still assume that of the post-colonial policy structure which gives prominence to industrialisation at the expense of development of small and medium-size businesses (Robson et al., 2009, Fu et al., 2014, Osei et al., 1993, Tetteh and Essegbey, 2014). Factually, the literature acknowledges the upsurge of entrepreneurship in Africa but with little innovation particularly; radical, specifically, in small firms (Pickernell et al., 2006, Makanyeza and Dzvuke, 2015, Okantey, 2014, Oppong et al., 2014). Mostly, entrepreneurs in Africa have a comparatively low level of education; thus, technical and managerial skills to add value to productivity at firm-level (Mensah-Bonsu and Jell, 2011, Oppong et al., 2014, Robson et al., 2009, Tetteh and Essegbey, 2014). Just like any African economy, innovation in Ghana is seen as a preserve of the multinational companies and sometimes only resulting from foreign direct investment (FDI) (Cloete et al., 2011, Evstigneeva, 2015, Glass and Saggi, 1998, Keller, 1996, Osabutey and Jin, 2016). The situation is captured in the statement below;

‘Most of the semi-modern enterprises are relatively small-scale African-owned operations running on simple machinery and on low-level technical and managerial skills. They generally produce lower-quality goods geared to the domestic market. The informal sector is entirely African and operates on even simpler technologies’ (United Nations, 2003, p. 43).

Relatively, in Ghana, science and technology is widely used as a preferred terminology for research and innovation and institutional players recognise both innovation and technology to seek the same objectives of economic wealth creation (MEST, 2010, OECD, 2013).
Notwithstanding, the slow progress of technology development in Ghana, the management of research, knowledge generation and innovation in the country is designed on key mechanisms that are supposed to provide the potential for current and future technology development. Accordingly, the machinery has been the backbone of Ghanaian national innovation system for decades (MEST, 2010).

Naturally, the mechanisms are well established institutions that are set up and mandated to carry out respective tasks in the system for the collective interest of industries in the country. The Ministry of Education (MOE), the Ministry of Environment, Science and Technology (MOEST) and the National Development Planning Commission (NDPC) are found to be typical examples of government establishments that are directly responsible for institutional policies that guide the creation and commercialisation of research and innovation in the interest of economic prosperity (IMF, 2006, Osei et al., 1993). Cumulatively, universities, polytechnics, including other tertiary institutions, the National Council for Tertiary Education (NCTE) and research institutions that are under the Council for Scientific and Industrial Research (CSIR) all form part of the system put in place to facilitate technological progress. Recent Science and Technology, and Innovation (STI) policy offers support to regulatory establishments and legislations to usher in stable macroeconomic and political conditions that are vital for innovation and development (UNCTAD, 2011, NDPC, 2010, NIP, 2003). Nonetheless, the Ghana government budgetary allocations for research over the years are surprisingly very low. For example, in 2008, the government of Ghana spent only 0.005% (see Table 1.2) of its total budget on basic research and just about 1% on science and technology as a whole.
Table 1:1 Science and technology in Ghana’s total budget, 2008

<table>
<thead>
<tr>
<th>Budget line item*</th>
<th>New Ghanaian cedis**</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total government expenditure</td>
<td>4,292,084,203</td>
<td>100.00</td>
</tr>
<tr>
<td>Basic research</td>
<td>201,500</td>
<td>0.005</td>
</tr>
<tr>
<td>R&amp;D general public services</td>
<td>151,412</td>
<td>0.004</td>
</tr>
<tr>
<td>R&amp;D economic affairs</td>
<td>44,314,486</td>
<td>1.032</td>
</tr>
<tr>
<td>R&amp;D health</td>
<td>3,942,081</td>
<td>0.092</td>
</tr>
<tr>
<td>Total S&amp;T</td>
<td>48,609,479</td>
<td>1.133</td>
</tr>
</tbody>
</table>

** New Ghanaian cedis and United States dollars were close to a 1:1 exchange rate during the 2008 budget year.


It may be argued that while there is a global need for innovation for production and socio-economic prosperity, policy makers in Ghana may be insensitive to research and innovation after all (MEST, 2010). There is generally no definitive or prescriptive national science, technology and innovation (STI) policy that explicitly defines the direction, vision, goals, achievable objectives and priorities for STI in line with knowledge transfer from universities. In fact, there is usually no strategic implementation plan. For instance, in 2000 there was an STI management document without implementation and another one was prepared in 2004 and did not escape from the repercussions of the previous policy documents (MEST, 2010, NDPC, 2010, Osei et al., 1993, IHERD, 2015).

Consequently, to address these shortcomings, in January 2009, the Ministry of Environment, Sciences and Technology was reconstituted and the current National Science, Technology and Innovation Policy is now being implemented and monitored to encourage Ghana’s scientists and technology experts to collaborate with international research centres for basic research and to create knowledge and impact on industry (MEST, 2010). Meanwhile, the private sector is still not responsive to existing incentives from macroeconomic measures by governments to innovate, adopt new technologies and raise productivity. Perhaps, more fiscal and legal incentives could be offered to local entrepreneurs to promote innovation in private firms in the country (Abdulai et al., 2015, Burns and Squires, 2011, Fu et al., 2014, Kremer and Williams, 2010). Above all, one may conclude that the local productive sector is not really adjusted to investing in innovations to
help improve productivity (Robson et al., 2009, Tetteh and Essegbey, 2014). Notwithstanding, the government has always maintained a firm belief in both basic and applied research right from infancy as rightly stated;

‘Our whole educational system must be geared to producing a scientifically-technically minded people. Because of the limitations placed on us, we have to produce, of necessity, a higher standard of technical education than is necessary in many of the most advanced countries of the western world... I believe that one of the most important services which Ghana can perform for Africa is to devise a system of education based at its university level on concrete studies of the problems of the tropical world. The university will be the coordinating body for education research, and we hope that it will eventually be associated with research institutes dealing with agriculture, biology, and the physical and chemical sciences which we hope to establish... ’ (McWilliam and Kwamena-Poh, 1975, p. 94).

Although for now, stringent measures put in place could be effective; there is the Policy, Planning, Monitoring and Evaluation Directorate of the ministry that formulates strategies appropriate for monitoring and evaluation of the STI process in the country (MEST, 2010). Also, there is the mechanism to measure the performance of science, technology and innovation. Equally, there are structures now in place to promote the development and utilisation of STI capabilities and to strengthen the protection of intellectual and innovative property rights. Debatably, what is different this time is that the government is relentless in its efforts in financing science and technology in all sectors of the economy to ensure the required progress of Ghanaian society (MEST, 2010). Eventually, the private sector is admonished to actively participate more this time as the engine of growth in this direction and it is being asked to take responsibility to co-corporate with government and other stakeholders for the collective good of the economy (UNDP, 2014, UNECA, 2013).

### 1.8. Universities in Ghana; science, technology and innovation

The Republic of Ghana with a total land area of 238,537 square kilometres is geographically located on the coast of West Africa and shares bordering with three francophone countries, namely: Burkina Faso in the north, Togo to the east and Côte d’Ivoire to the west (GSS, 2015). As seen in Figure 1.2; to the south is the Gulf of Guinea in the Atlantic Ocean. As a former British colony, Ghana gained independence and became a republic on the 6th of March 1957,
and joined the British Commonwealth of Nations on the 1\textsuperscript{st} of July 1960. Accra was named as the new administrative and political capital, and the seat of government with a multi-party democracy (MEST, 2010, Sawyerr, 2004a). With 10 administrative regions, Ghana’s most recent population and housing census (2010) puts the population at 24.7 million and the 2016 annual budget stated a GDP growth rate of 4%. Inflation was at 16.4\% at the end of January 2015 and the Bank of Ghana interest rate stood at 25.0 percent in September the same year (GSS, 2015b, GSS, 2015, MOF, 2015).

**Figure 1:2 10 administrative regions of Ghana**

![Ghana Administrative Map](image)

Source: Google maps
According to the Minister for Finance, in his Ghana Government budget statement to the parliament on the 13\textsuperscript{th} October 2015, the service sector of the economy remains the largest contributor to Gross Domestic Product (GDP) and the fastest growing sector of the economy, growing at 9.1\%, and expected to increase its contribution to GDP from 51.9 percent in 2014 to 54.1 percent in 2015. The next is the manufacturing (industry) sector, which contributes 27\% of GDP and grows at 4.7\%, and agriculture in the primary sector also contributes 22\% of GDP. Meanwhile, the GDP itself has been declining since 2012 after a height of 14.0 in 2011 and was at 4.1 as of 2015. Table 1.2, 1.3 and 1.4 show the primary, manufacturing and service sector’ growth and Figure 1.3 also shows GDP growth from 2010 to 2015 (GSS, 2015a, GSS, 2015b, GSS, 2015, MOF, 2015).

\textbf{Table 1:2 Primary (Agriculture) sector growth performance (Percent)}

<table>
<thead>
<tr>
<th>Activity</th>
<th>2013</th>
<th>2014*</th>
<th>2015**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Outturn</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>5.7</td>
<td>4.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Crops</td>
<td>5.9</td>
<td>5.7</td>
<td>4.1</td>
</tr>
<tr>
<td>o/w Cocoa</td>
<td>2.6</td>
<td>4.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Live stock</td>
<td>5.3</td>
<td>5.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Forestry and Logging</td>
<td>4.6</td>
<td>3.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Fishing</td>
<td>5.7</td>
<td>-5.6</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Source: Ghana Statistical Service
*Revised
** Provisional
o/w: of which
### Table 1:3 Manufacturing (industry) sector growth performance (Percent)

<table>
<thead>
<tr>
<th>Activity</th>
<th>2013</th>
<th>2014*</th>
<th>2015**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Outturn</td>
<td>Per cent</td>
</tr>
<tr>
<td><strong>Manufacturing (industry)</strong></td>
<td>6.6</td>
<td>0.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Mining and Quarrying</td>
<td>11.6</td>
<td>3.2</td>
<td>3.3</td>
</tr>
<tr>
<td>o/w Petroleum</td>
<td>18.0</td>
<td>4.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Processing</td>
<td>-0.5</td>
<td>-0.8</td>
<td>-1.8</td>
</tr>
<tr>
<td>Electricity</td>
<td>16.3</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Water and Sewerage</td>
<td>-1.6</td>
<td>-1.1</td>
<td>-0.7</td>
</tr>
<tr>
<td>Construction</td>
<td>8.6</td>
<td>0.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Source: Ghana Statistical Service
*Revised
** Provisional
o/w: of which

### Table 1:4 Services sector growth performance (Percent)

<table>
<thead>
<tr>
<th>Activity</th>
<th>2013</th>
<th>2014*</th>
<th>2015**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Outturn</td>
<td>Per cent</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td>10.0</td>
<td>5.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Trade, Repair Of Vehicles, Household Goods</td>
<td>14.5</td>
<td>1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Hotels and Restaurants</td>
<td>24.6</td>
<td>-1.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Transport and Storage</td>
<td>-0.5</td>
<td>0.3</td>
<td>3.5</td>
</tr>
<tr>
<td>Information and Communication</td>
<td>24.3</td>
<td>38.4</td>
<td>21.2</td>
</tr>
<tr>
<td>Financial Intermediation</td>
<td>23.2</td>
<td>22.</td>
<td>9.5</td>
</tr>
<tr>
<td>Business, Real Estates, and others</td>
<td>-17.5</td>
<td>-1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Public Administration &amp; Defence; Social Security</td>
<td>8.4</td>
<td>-4.7</td>
<td>2.1</td>
</tr>
<tr>
<td>Education</td>
<td>6.9</td>
<td>7.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Health and Social Work</td>
<td>7.8</td>
<td>-1.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Other Community, Social &amp; Personal Services A</td>
<td>36.5</td>
<td>-1.6</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Source: Ghana Statistical Service
*Revised
** Provisional
o/w: of which
Chapter 1. Introduction

Figure 1:3 Annual real GDP growth, 2010-2015

![GDP Trend Chart](image)

Source: Ghana Statistical Services (2015)

To boost higher education in the country, in the 2000 fiscal year, the Ghana Education Trust Fund (GETFUND) was introduced as a public trust fund, set up by an act of parliament as part of the government of Ghana plan to improve the educational system in the country. As a consequence, this provided educational infrastructure which also helped all universities in the country to contribute formidably in the economic growth and development machinery (GSS, 2015a, GSS, 2015b, GSS, 2015, MOF, 2015) as stated in the quote below;

‘The university must become a primary tool for Africa’s development in the new century. Universities can help develop African expertise; they can enhance the analysis of African problems; strengthen domestic institutions; serve as a model environment for the practice of good governance, conflict resolution and respect for human rights, and enable African academics to play an active part in the global community of scholars’. By Kofi Annan (Bloom et al., 2006, p. 2).

As a matter of fact, when Ghana became politically independent in 1957, universities and research institutions were accordingly set up primarily to produce skilled workforce for the new nation and research to facilitate industrialisation of the fragile young economy (Mwamadzingo, 1996, MEST, 2010). Significantly, knowledge, science and technology became the cornerstone
for the country’s economic growth and development strategic plan (Sawyerr, 2004b, Sawyerr, 2004a). Namely, the first president of the first government of Ghana, Osagyefo Dr. Kwame Nkrumah put up a national development strategy in place to develop a strong higher education system to achieve this (Idris, 2014, IMF, 2006, NDPC, 2010). Nonetheless, there was no immediate and effective link between university education and science and technology (MEST, 2010). The situation became worse when the government was overthrown in a military takeover in 1966, and better still there was no national STI policy document spelling out any clear objectives for the pursuit of science, technology and innovation for economic progress. Since then though, public and private universities have continued to spring up and by 2012 Ghana had 9 public universities, 54 private universities and university colleges, 10 polytechnics. Each of Ghana’s 10 regions can now boast of at least one polytechnic (IHERD, 2013, Idris, 2014). Most of these universities were supposed to undertake research and strengthen innovation to complement the efforts of research institutions and together feed the countries development agenda (Atuahene, 2011, Bailey et al., 2011, Barry and Sawyerr, 2008, Bawakyillenuo et al., 2013). In spite of the fact that some gains have been made with respect to innovation by 2012, research in some of these research institutions and universities have not been able to satisfactorily support the economic growth and development agenda of the country (The Global Innovation Index, 2015). Evidently, Table 1.5 shows the history of the establishment of public universities in Ghana.
Table 1:5 History of development of public universities/institutions in Ghana

<table>
<thead>
<tr>
<th>No.</th>
<th>University</th>
<th>Date of establishment</th>
<th>Legislation for full university status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>University of Ghana, Legon.</td>
<td>1948</td>
<td>Act 79, 1961</td>
</tr>
<tr>
<td>2</td>
<td>Kumasi College of Technology which later became.</td>
<td>1952</td>
<td>Government Ordinance on 6th October, 1951 Act of Parliament</td>
</tr>
<tr>
<td></td>
<td>Kwame Nkrumah University of Science and Technology, Kumasi</td>
<td>1961</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>University of Cape Coast.</td>
<td>1962</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>University for Development Studies, Tamale.</td>
<td>1992</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>University of Education, Winneba.</td>
<td>1992</td>
<td>Act 672, 2004</td>
</tr>
<tr>
<td>6</td>
<td>University of Mines and Technology, Tarkwa.</td>
<td>2001</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>University of Health and Allied Sciences, Ho.</td>
<td>2011</td>
<td>Act 828, 2011</td>
</tr>
<tr>
<td>8</td>
<td>University of Energy and Natural Resources, Sunyani.</td>
<td>2011</td>
<td></td>
</tr>
</tbody>
</table>

Source: (IHERD, 2013).

Despite this obvious rapid increase in the number of institutions of higher learning in Ghana, they are not enrolling, educating and training enough technical graduates, thus; with the requisite and innovative skills to trigger more technological innovation for effective economic growth and development. This has instigated a monumental setback in Ghana’s national innovation system (Atuahene, 2011, Cloete et al., 2011, Deiaco et al., 2012). Even with that, on a broader scale, the enrolment numbers are generally low in Africa as a whole and sub-Sahara in particular as captured in the statement: ‘The skills base is very weak and the educational system is generally not geared to meeting the skill needs of industrial competitiveness’ (United Nations, 2003, p. 16). Figure 1.4 puts the status of university enrolment by region into perspective. Comparatively, five
percent (5%) of the enrolment ratios for Ghana is way too low with world average being 24%. From the figures, East Asia and the Pacific have (23%) with North America and Western Europe being 70%. Also, Figure 1.5 presents the gross enrolment ratios by relevant year in the regions and some countries, where sub-Sahara Africa is seen to be the lowest (9%) among the regions (note Ghana is also low (16%) in the sub-region in Figure 1.5). In fact, the percentages of the lower middle level income countries (23%), upper middle level income countries (37%) and the higher income countries, thus; 86% for North America and 63% for Europe and Central Asia, show the difference between these countries and can be seen to explain the corresponding link between education and social and economic growth and development around the world (Barry and Sawyerr, 2008). Definitely, a weak educational enrolment system breeds weak skills’ base and uncompetitive local industries, a situation where Ghana happens to find itself.

**Figure 1:4 Tertiary gross enrolment ratios (GER) in 2004**

![Tertiary gross enrolment ratios (GER) in 2004](image)

Similar trends have been experienced in other developing economies like Kenya and Uganda, and a report by the OECD on the governance of higher education, research and innovation describes the extent of co-ordination and co-operation among institutional actors in science, technology and innovation as still weak (Mensah-Bonsu and Jell, 2011, Giuliani and Rabellotti, 2012, IHERD, 2013). Specifically, the bottom line in Ghana is, even after six decades of self-governance, it will be fair to state that policy makers still lack awareness and capacity to design policy frameworks that will take into consideration economic growth and development priorities and effectively manage national research and innovation system (IMF, 2006, OECD, 2013). Meanwhile, past governments have previously designed and adopted several science and technology strategies according to the Ministry of Environment, Science and Technology. Clearly, this is evident in the National Science, Technology and Innovation policy document (NSTI, 2010). Even with that, the resulting impact; yet still, falls short of the expected progress on the socio-economic lives of Ghanaians. Actually, the country had a steady increase in Gross Domestic Product (GDP) at 6% on average in 2007 but this was attributed to prices of agricultural products like cocoa and gold which unfortunately also fluctuate. In view of that,
Ghana’s economic progress still depends on agricultural resource-based products as against technology-based products (Barry and Sawyerr, 2008).

1.9. Entrepreneurship and firm-level innovation in Ghana

The concepts of entrepreneurship and enterprise have been in Ghanaian culture even earlier than the influx of Europeans in the fifteen century to the then Gold Coast (Robson et al., 2009). Owing to this, Ghanaians have been engaged in a broad variety of business activities and enterprises which can be put under a wide range of industries. The existence of local and long-distance trading was evident and enhanced by the evolution of cross-border trade. Customarily, it was seen as a cultural institution and tradition that promoted the proliferation of different occupations among Africans far and wide on the continent (Takyi-Asiedu, 1993, Buame, 1996).

Largely, among other goods traded were salt and fish and up to precious minerals between business partners and agents. Unfortunately, in modern day Ghana, government policies in the post-colonial era saw the slow growth of entrepreneurship and enterprise development in the country. Thus, this is actually a phenomenon that has perpetuated throughout the continent of Africa over the last six decades (Okantey, 2014, Oppong et al., 2014).

Today, local business growth, especially smaller ones, which dominate the corporate world in Ghana, has been particularly difficult and slow because of over reliance on innovation and technology from R&D abroad and at best, government funded projects. More so, SMEs mostly rely on local private and public institutions which do not have the capacity to generate and transfer knowledge to small businesses (Oppong et al., 2014, Osei et al., 1993, Mensah, 2004). That is not all, institutional red tape, dysfunctional frameworks and corruption that have engulfed the public sector over the years have taken a devastating toll on growth and development of innovation in Ghana. Actually, the same bottlenecks are equally prevalent in many sub-Saharan African countries and in many African countries as a whole. These have accounted for why 77% of Ghanaian small businesses being in the informal sector (Robson et al., 2009, Sackey, 2005, Mensah, 2004). As has been noted, the informal sector offers ‘fertile soil’ for businesses to avoid government bureaucracies, corrupt officials and taxes to the detriment of government getting enough revenue to support R&D. Failure of the Ghana government to incorporate the informal
sector firms into the tax bracket and to enforce tax laws is due to weak regulations and unstable public policies. Consequently, this has affected the quality of human capital too (Robson et al., 2009). Moreover, it has affected private research and development efforts, limiting local firms to underdeveloped traditional production methods in cocoa, mining, fishing, aquaculture, crafts, textile, lumber, farming, furniture, tourism, pottery, wood, bananas and food and beverages (Fu et al., 2015, Fu et al., 2014, Robson et al., 2009, Sackey, 2005).

Generally, firm-level innovation is very much determined by the internal resource capabilities and in turn connected to the size according to available literature (Pickernell et al., 2006, Pickernell et al., 2008). Resource-Based-View theory affirms that, a combination of resource provides a competitive advantage to see firms strive well in the market with innovative technologies (Grant, 1999, Garud and Nayyar, 1994). Regrettably, most Ghanaian firms are either slow to innovate or still use obsolete indigenous technologies and lack competitive advantage to grow in size. To exemplify, in a quantitative study to investigate entrepreneurship and innovation in Ghana, Robson et al. (2009) noted that social class and educational background of Ghanaian entrepreneurs has a direct effect on innovative capabilities of their firms; meaning the higher the social class and education, the higher the innovative capabilities of their firms. Similarly, this was also found in the work of Tetteh and Essegbey (2014). Also, there was a positive relationship between the size of a firm and the extent of innovation in their findings. Most of all, these are in consonance with other existing empirical findings which further indicate that medium and large firms in Ghana have better growth and innovative productivity than small firms. Larger firms in Ghana are also observed to have more capabilities to undertake both product and process innovation activities than small-sized firms (Frazer, 2005, Chudnovsky et al., 2006). Surprisingly, traditional entrepreneurship model was found to be used for training in Ghana and therefore was not found to positively affect innovation despite 54% of firms sampled in the study invested in training and capacity development. In another study by Mensah-Bonsu and Jell (2011) it was revealed that firms in Ghana faced a lot of challenges that included unfavourable macroeconomic conditions like high inflation, lack of infrastructure and limited access to financing. Distinctively, another reason for low innovation and sluggish technology adoption in Ghana is that about 5% of people in the country have access to formal finance facilities in the banking sector (Murphy et al., 2018, Basu et al., 2004). Access to credit
by SMEs in the country is limited, therefore hinders their capacities to innovate (HFC Bank, 2004). The only source available to most SMEs in particular is through personal savings and sometimes business angels who are also limited in their abilities to assist SMEs to adopt modern technology (UNIDO, 2002). Comparatively, few companies are financed from commercial bank loans or government assistance programmes (Osei et al., 1993, Bani, 2003). Increasingly, lack of financial assistance henceforth constitutes a huge setback for entrepreneurs in Ghana (Abor and Biekpe, 2006). Financial constraints have been identified in most empirical studies to restrict small firm’s innovative practices in fast growing and emerging economies like Ghana (Arthur, 2003, Mensah, 2004, Deakins et al., 2008).

Without doubt, the role innovation plays in firms’ growth in every economy and particularly in developed countries is extensively documented in the literature. However, the impact innovation has on firms’ growth in developing countries is still a comparatively under-researched phenomenon (Fu et al., 2014, Fu et al., 2015). Seemingly, one of the major reasons for this lack of understanding is the difficulties on how to measure innovation in the context of less-income countries and how to generate appropriate data for empirical studies. As a result, of these there is little knowledge on the connection between firm-innovation and firms’ growth in low income countries like Ghana and those in the sub-Sahara region (OECD, 2005b).

Of late, Ghana has had institutional level improvement for innovation to thrive, thus; the education system has been reformed from high school to tertiary level and more are added (Bawakyillenuo et al., 2013). Primarily, innovation strategies are drawn to encourage and accommodate more interactions between universities and industries and relatively more funding is provided for R&D (AAU, 2012, IHERD, 2013). Generally, all of these provide a potential fertile ground in the country for innovation to stimulate economic growth and development. The past three decades have also seen Ghana undertaking structural reforms intended not only to increase participation but also to strengthen the role of private sector firms in the economic growth of the country (Bani, 2003, Bawakyillenuo et al., 2013, Cloete et al., 2011). An example is the industrial policy that was adopted in 2010 and designed within the context of the country’s long-term strategic vision to achieve middle-income status by 2020. After all, the main objective of the policy was to transform the country into an industry-driven economy and by that recognise
the role of innovation as the fundamental factor for its success. Remarkably, the overall role of science, technology, research and development for innovation at firm-level is given prominence in the policy to steer the development agenda of the country (Gondwe and Walenkamp, 2011, NDPC, 2010). Notwithstanding that, with all the effort and reforms, the majority of firms in Ghana still remain small and informal while larger firms are also still constrained by managerial and technical skills with difficulties in accessing high interest rate loans from the banking sector (Fu et al., 2015, NICTP and NDPC, 2003).

1.10. Organisation of the study

Generally, the thesis is divided into six major chapters, with the first one being the introduction, which provides a contextual background on the role of universities in social and economic growth and development through science, technology and industrialisation in developing economies such as Ghana. Typically, the chapter, starts with how newly independent African countries ambitiously planned initially and failed abysmally in their bid to achieve industrialisation after British colonial rule. Significantly, it contains literature on how universities were set up to generate knowledge and technology for the achievement of the set goals.

In the first chapter, there is a brief overview of university’s core mandate as established in Ghana and how it has evolved in recent years in response to current world economic dynamics. In addition to that, an equally changing role of universities in developing economies is critically discussed and reported as a case of interest to the current study and compared to developed economies to make a case for the study aims and objectives. It also has the purpose statement of the research, which justifies the case for the current study, the significance, the focus and the organisation of the study. The last section of the chapter deals with innovation, science and technology in Ghana in the context of how universities are positioned and expected to contribute to economic development.

Chapter two is divided into two sections, starting with critical review of available relevant literature starting first on innovation giving an overview and definitions to develop a robust definition for this research study. Social capital and absorptive capacity and their effects on
innovation in firms are discussed ostensibly to put the study into perspective, highlight the literature gap and position the thesis of the study as a further justification for investigation. Discussion on university-industry interactions, technology transfer offices and knowledge networks are included in the first section. The second part of the chapter considers the conceptual framework for the study where generational models for innovation are reviewed to reveal their limitations and to adopt and modify a more integrated and robust knowledge transfer framework to guide the study.

Chapter three contains the research methodology for the study and starts with the study design, a detailed justification for choosing two research approaches in one study. A stance supported by the pragmatic philosophy. Here is where the research techniques adopted by the study are duly outlined systematically, exploring how inferences and generalisations on issues confronting the subject matter of the investigation are arrived at. Ethical considerations, the population of interest to the study, the type of survey conducted, and the methods of data collection and analysis are all covered in the chapter. This chapter provides discussion of a pilot survey conducted prior to the main study where lessons learnt are presented.

The chapter also presents detailed analysis of the quantitative element of the study with a layout showing the link between the main segments of the quantitative and qualitative analysis. The chapter continues with extensive exploratory data analysis where the general demographic characteristics of the sampled firms are closely examined. The final part of the chapter delves into the qualitative aspects of the study and discusses integration of inductive and deductive methods of qualitative data analysis adopted in the study after data transcription. Lastly, various forms of coding employed are explained highlighting the merits of traditional method qualitative data analysis gained in the research process.

Chapter four discusses the research findings from both the quantitative and qualitative approaches and discusses the integration of key findings and sector comparisons. Furthermore, all the qualitative findings are captured here to make more sense of the results of the hypotheses in the inferential part of the analysis through integration of interpretation and reporting of
findings. Statements made by respondents during face-to-face interviews are used to critically discuss, support and explain statistical outcome of the hypotheses here.

Chapter five discusses the findings, makes comparisons to available empirical research findings in innovation theory for conformity, expansion and divergence in the findings. This is designed to make sense of the result of the quantitative analysis and issues that emanated from the interviews.

Finally, Chapter six contains the conclusion where the findings are interpreted in the context of both empirical and theoretical meanings and polity implications drawn from the investigation. Interestingly, significant findings and observations highlighted in the discussion of the results are emphasised in this chapter and reflected upon with suggestions made to inform innovation policy decisions. The implications to policy makers in Ghana and other comparatively low income countries are documented here together with the study’s contribution to knowledge. Critical evaluation of the study with the limitations and recommendation for further studies are presented here.
Chapter 2. Literature review
2.1. Introduction

This chapter presents the extant critical review of literature on university-industry interaction; explaining theories and mechanisms of knowledge transfer from universities to industry for innovation performance in firms which form the subject matter of the thesis. Largely, the chapter provides a critical analysis on the relevant available literature on the significance of the institutions and mechanisms that are identified to play various roles in university knowledge transfer to industry. Throughout this chapter, ‘industry’ and ‘firms’ may be used interchangeably as a production unit and remain the statistical unit of analysis for discussing innovation performance. Also, other components such as collaborative research, technology transfer offices and knowledge networks are also discussed in the literature. In addition, social capital is also discussed with the relevance to university knowledge transfer and innovation performance in this chapter.

The chapter is divided into two broad areas; the first part critically reviews and discusses innovation in the literature, university-industry interaction and other mechanisms of knowledge transfer from universities to industry and ends with a look at the conceptual framework development on the theoretical bases for the research hypotheses (Appendix A-2). Accordingly, hypotheses are developed for further testing in Chapter 3 (Research Methodology). Finally, the conceptual framework that underpins the study objectives is mapped up and ends with a statement on the research gap that also re-enforces the overall aim of the study.

2.2. Innovation: An overview

The purpose of this section is to present a brief overview of the concept of innovation and to critically analyse innovation by looking at its evolution over time from streams of reputable academic work to understand the process. The intention here is to provide a basic background of the nature of innovation as a basis for understanding its essence in context of the study. The section also seeks to question whether available innovation definitions and literature are ideal for present day innovative firms in advanced and developing economies and to argue that the subject of innovation needs a new theoretical examination that considers changes and conditions of developing economies.
Modern day knowledge-based market challenges and dynamics of economies have exposed the deficiencies and unfitness of available definitions and frameworks for innovation (Leydesdorff, 2001, Šakalytė and Bartuševičienė, 2013, Thomas, 2013). Worse of all, the case of less developed economies is still faint or completely neglected in the literature (Hobday, 2005, Sleuwaegen and Goedhuys, 2002, Srholec, 2011). Even in the wake of numerous attempts to define and classify innovation in various sectors and disciplines, there is still much work that needs to be done to clearly separate what innovation is and what it is not to settle the case (Fagerberg and Godinho, 2004, Fischer, 2001, Fu et al., 2015). The work of Bessant (2003) demonstrates the disconnected nature of innovation definitions and frameworks and even innovation process. Nonetheless, its significance and relevance to economic growth and development has been a subject of immense interest to scholars and policy makers alike for centuries (Abdi and Ali, 2013, UNU, 2009). Innovation has been known to serve the purpose of providing comfort and to facilitate the lives of human beings. The term innovation is from the Latin word ‘innovar’ which stands for ‘to make something new’ (Abdi and Ali, 2013, Tidd and Bessant, 2009). Also, its immediate effect on organisational performance is well documented in the literature (Makanyeza and Dzvuke, 2015, Michels, 2015). It is however not a new phenomenon and has historically been an outstanding supporter of not only the survival and well-being of individuals but also of entities, nations and civilisations (Meissner and Kotsemir, 2016, UNU, 2009).

The understanding of innovation and its process, thus; its overall impact on individual and nations’ welfare across the globe, has over the last decades changed dramatically due to extensive academic studies (Cohen et al., 2002, von Ripple, 1988). Notwithstanding, Jiménez (2008) raises issues with the proclaimed benefit of science, technology and innovation to society in terms of economic development and holds innovation, responsible for inequality between nations in terms of wealth and power; wide spread social exclusions, irreversible collateral and ecological damage, citing weapons of both small and large scale destruction as examples. One may argue that innovation is knowledge that is sometimes free and does not diminish in use therefore available to all nations with the potential to grow and develop. If nations engage in knowledge search through R&D, the chance for equal development on the globe could increase. Unfortunately, the lack of definition and framework for innovation as a guide for its studies in
developing economies constitutes a major hindrance and a blockage to its progress (Bogliacino et al., 2012). Using Europe as a benchmark in terms of well-established findings from innovation surveys conducted, Bogliacino et al. (2012) explains how innovation surveys conducted in developing countries replicate and adopt innovation models that are first developed in Europe. In a review of the relevant body of knowledge, they found methodological issues emanating from the use of innovation frameworks not originally meant to guide surveys in developing countries. Therefore one could argue from this premise that surveys of such nature could only produce flawed findings with serious validity problems since right from the start their frameworks guiding the measurement of innovation, data source; the method of data collection would be flawed. This claim is supported by Kruss et al. (2012) who add that innovation frameworks from advanced nations are being adopted and refined in developing countries in order to inform policies without any bespoke model of their own.

In essence, innovation is often considered as the exploitation of new ideas with emphasis on ‘newness’ which remains at the centre of the concept. Yet, current innovation scholars have battled to offer a comprehensive definition which could offer an analytical framework that is applicable in all economic conditions and sectors. Largely, discussions on innovation describes contributions to the definition so far, still as fragmented and inconsistent making it extremely difficult to carry out comprehensive studies particularly in developing economies where conditions are vastly different from advanced economies (Costello, 2015). Prominent among scholars is Fagerberg (2005) who concludes that; ‘our understanding of how knowledge-and innovation-operates at the organisational level remains fragmentary’. Fagerberg (2005) calls for more work and asserts, ‘that further conceptual and applied research is needed’. For this, Costello (2015) also laments, calling it ‘a scarcity of progress’.

Arguably, the unsettled state of the conceptual definition of innovation poses a heavy empirical challenge to researchers especially in developing countries. Manoochehri (2010, p. 1) contends that innovation is ‘an elusive, dynamic and broad concept that is difficult to define’ considering the nature of its function. Calling for its measurement to reflect on specific industries, sectors and markets’ needs, he admits that deciding on what activities to measure as innovation is a very challenging task to all companies and economies. This is attributed to the fact that there is no
widely accepted concept as the standard metric appropriate for innovation measurement. One may conclude that all innovation surveys conducted in developing economies may be without any concrete framework to direct the process and may be based on what each and every investigator thinks constitutes innovation or as may be chosen for them by their sponsors. Implicitly, innovation study of this nature could not be said to be consistent with scientific rigour and implies that issues relating to innovation definition and framework remains largely underdeveloped and still requires further attention.

In any case, the introduction of innovation can be traced to the seminal work of Joseph Schumpeter (1934), titled, ‘Theory of Economic Development’ as a response to realities of contemporary economic and social changes. In this pioneering work, he defines innovation as ‘the reflection of novel outputs of a new good, a new method of production, a new market, a new source of supply, or a new organisational structure’ where he attributes ‘newness’ to products (or goods), methods of production (or processes), sources of supply, and finally, newness in the exploitation of markets and ways to organise business. Consequently, this was revised in later years to put large corporations as innovating firms behind innovation, driving and stirring the development of leading economies. Notably, whereas entrepreneurs develop new combinations of existing resources in his former definition, in the later discussions, firms are the drivers of economic development with innovation. From the very early years, discussions on innovation and what it is about grew extraordinarily, leading to expansion into many disciplines for that matter numerous definitions in fragments in the academic literature (Costello, 2015). For example, despite copious attempts by researchers to explain the conceptual perspectives of innovation, it is still been described as loose and fragmented in the literature. In his work, Wolfe (1994) concludes that the fragmented nature of innovation literature has made very little contribution to the understanding of innovation performance in firms and criticises the current state as being ‘inconclusive, inconsistent and characterised by low levels of explanation’.

More interestingly, it should be noted that researchers and practitioners alike often confuse innovation with invention, as Bessant (2003) laments and explains that whilst the former has an element of economic significance in its incidence and ‘first occurrence’, the latter does not but
being ‘first attempt to carry it out in practice’. It is on the basis of this that Freeman (1982) notes in his clarification of the concepts that;

‘an “invention” is an idea, a sketch or model for a new or improved device, product, process or system” whereas an “innovation” in the economic sense is accomplished only with the first “commercial” transaction involving the new product, process, system or device...’ (Freeman, 1982, p. 7).

Essentially, the above clarification is given credence by Conway and Steward (2009) who contend that innovation occurs when an invention is put to a commercial or social use. In another sense, a process that also has an element of newness and uniquely synonymous to innovation is ‘imitation’ which is emphasised by some scholars, that;

‘As long as the idea is perceived as new to the people involved, it is an ‘innovation’ even though it may appear to others to be an “imitation” of something that exists elsewhere’ (Van de Ven, 1986, p. 604).

For a long time, there has not been one comprehensive and widely agreed definition of innovation in theory; henceforth the review of innovation remains one of the main challenges of scholars with the range of definitions in the wide body of literature. For instance, in certain areas of the innovation ecosystem, innovation is defined as an ‘exercise in the management and reduction of uncertainty’ (Kline and Rosenberg, 1986a, pp. 275-6). To some, notably, Edquist (2001) it is;

‘New creations of economic significance normally carried out by firms (or sometimes individuals). They may be brand new, but are more often new combinations of existing elements. It is a matter of what is produced by firms and how’ (Edquist, 2001).

It is clear from the two definitions that even though the two tend to discuss the same phenomenon of innovation, the former concerns itself on uncertainty and how to reduce it, perhaps in the market. The latter on the other hand, dwells more on newness and this also has an element of market as the target though. Alike, Nelson and Winter (1982) and Rosenberg (1982) consider innovation as a process that brings improvement in solving problems whether business or social, (newness in method). Similarly, Crossan and Apaydin (2010) define it along the lines
of a process involving commercial use (a new business process). This bears resemblance with Edquist’s (2001) definition since the two also hinge on innovation as a process. Also, for Lundvall (1992), innovation is an ongoing process that searches and explores for new products, new techniques, and new forms of organisation in new markets. In a slight twist, but in line with Schumpeter’s (1934) ‘first generation’ discussion, Drucker (2002) looked at innovation as a specific function of entrepreneurs and talks about the means by which an entrepreneur either comes up with a new wealth-producing resource or improves on the efficiency of existing resources with superior potential for creating wealth.

In a more organisational perspective, again from Schumpeter’s ‘second generation’ discussion, Damanpour (1996) takes a holistic dimension approach to innovation supporting the view that;

‘Innovation is conceived as a means of changing an organisation, either as a response to changes in the external environment or as a pre-emptive action to influence the environment. Hence, innovation is here broadly defined to encompass a range of types, including a new product or service, new process technology, new organisation structure or administrative systems, or new plans or program pertaining to organisation members’ (Damanpour, 1996, p. 694).

Arguing from the field of ‘Knowledge Management’ which is the discipline under which this subject can be classified, knowledge is seen to be vital for innovation or even considered to be a type of innovation as emphasised in the definition below;

‘Innovation as the creation of new knowledge and ideas to facilitate new business outcomes, aimed at improving internal business processes and structures and to create market driven products and services. Innovation encompasses both radical and incremental innovation’ (Plessis, 2007, p. 21).

Parallel to innovation discussions over the years, discussions in business management also reached a point where there was a growing scholarly interest in organisational change in business practices through knowledge management (Gault, 2016). In fact, using knowledge management practice as a case of analysis in a survey by the organisation for economic cooperation and development (OECD) in its participating nations, it became empirically obvious that with the same measurement techniques, business practice could be treated as a technology (OECD, 2003).
This arguably seemed to have offered a turning point in the discourse and it is even argued that the discourse around innovation was also deeply influenced by experimental innovation surveys of the 1970s and 1980s by OECD which first unveiled how to codify and define innovation for measurement purposes in the 1992 manual (OECD 1992). Eventually, with the national systems of innovation pioneered by Freeman (1987), Lundvall (1992) and Nelson (1993) used as a reference point for defining innovation; debatably the OECD appears to present the most comprehensive definition of innovation so far, stating that;

‘An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations’ (OECD, 2005b, p. 46).

Arguably, it will be prudent to posit that innovation researchers are in constant confusion at the moment with what innovation really is therefore trying to account for the variations in the definition. Increasingly, it is quite clear from above definitions that the latter part of the 20th century through to the very early 21st century ideological struggles to design a definitive framework for innovation to make sense of it for progress has rather made it more eclectic and inconclusive. Considerably, definitions of innovations from conception have continuously changed because they fail to stand the test of time. Worryingly, the absence of a consensual view of the theoretical framework in the discipline actually severely hampered it and opens the concept to further criticisms. The one thing that researchers have widely agreed among themselves is that, as Bessant (2003) put it, thus; ‘it is a mutating and shifting puzzles - and firms have to try and find their own particular ways of solving them and continue to be able to do so as the puzzles shift and change’. In fact, this unstable nature of innovation could be attributed to reasons why earlier definitions could not stand the test of time since every definition fell short in its coverage and limited in approach. Whereas some define innovation around the firm as the actor and performer of innovation, others perceive it as the role of the entrepreneur who identifies and takes advantage of opportunities. Alas, there is even debate as to whether innovation is an ‘object’ or a ‘subject’ (OECD, 2005b). It does not stop there but draws in another contention among researchers as to whether it can be described as a ‘noun’ or a ‘verb’ or even an ‘adjective’, therefore indicating that the literature is still fragmented, inconsistent and lacks a comprehensive framework for the concept (Costello, 2015, McInerney, 2004). Obviously,
this confusion has attracted a lot of attention from many other related disciplines and is of considerable interest to researchers of late. Another significant attempt is by the researcher, Slappendel (1996) who has since mapped the literature of the innovation landscape, specifically in organisations into three theoretical perspectives, thus: the individualist perspective, the structuralist perspective and the interactive process perspective. Nonetheless, this is in the discipline of Information Systems (IS) and remains outside the scope of the current study.

However, what has been consistent in innovation definitions since Schumpeter’s seminal work in the early years is the insistence on newness and the final product getting to market (Bessant, 2003, Crossan and Apaydin, 2010, Plessis, 2007). Effectively, the market is where the value is created and where innovation drives economic growth and goes further to help to address social challenges. Without mincing his words, Fagerberg (2005, p 2) concludes that;

‘Our understanding of how knowledge -and innovation -operates at the organisational level remains fragmentary’ and ‘that further conceptual and applied research is needed’ (Fagerberg, 2005, p. 2).

Actually, there are many claims for what innovation does in the academic literature; nonetheless, researchers still lack a workable analytical framework to work with in developing economies. Even, given the volume of innovation literature, the absence of a widely agreed theoretical framework is a case for concern. It could be suggested that the involvement of researchers and practitioners and even beneficiaries of innovation worldwide to include both advanced and developing economies could yield a better definition. Just like the OECD trying to involve researchers from all member nations in the search for what is most appropriate and workable in innovation framework. Considering the absence of a widely accepted framework and the calls for its development, the current study tries to fill the gap in the literature.

As a matter of necessity, the purpose of this study is to set the stage for the development of a university knowledge transfer/innovation framework for firms-level innovation analysis in developing economies to offer guidance to the method of data collection and analysis. So, a critical review the literature on existing definitions of the concept could lay a solid theoretical foundation to accurately capture innovating firms in Ghana. In fact, the position of the study is
the same as Fagerberg (2005, p. 2) ‘that further conceptual and applied research is needed’ and therefore intends to make recommendations for further theory development for a more robust and inclusive framework for innovation analysis across the board. To understand the principal subject that the definitions of innovation try to capture, we discuss effects of innovation in the next section.

2.3. Effects of innovations on firms’ performance

The obvious lack of empirical evidence signifying the effect of innovation on firms’ performance, coupled with weak theory so far linking the two, have yet to be resolved by researchers on whether innovative measures employed with the intention to increase firms’ performance indeed lead to the intended increase (Janz et al., 2004, Tetteh and Essegbey, 2014). Implicitly, the claim for automatic increase in performance with given innovation adoption in firm is yet to be tested as controversies rage among researchers. More so, investment in R&D continues to increases in the mist of conflicting research findings on the connection between R&D and innovation performance (Godin, 2009, Trajtenberg, 2002). Indeed, empirical evidence in many studies shows that innovation for that matter R&D enhances the performance of firms in several respects including increase in market share and competitive advantage (Abdi and Ali, 2013, UNU, 2009). Although, Tidd and Bessant (2009) also agree to this, they contend that the impact of innovation performance is actually weak at industry level. This can be argued that may be the reason for increase in R&D budgets in many organisations across the world is to research into valuable strategies for competitive advantage in the market (Muscio et al., 2013, Sainsbury, 2007, Trajtenberg, 2002). As fundamental as it is claimed to determine firms’ performance, Geroski (1994) views the impact of innovation from two perspectives. The first is in its product differentiation or in the introduction of new processes that consolidate a firm’s competitive position against its rivals. He however warns that profits and growth may not be steady and will usually be temporary or may not last for long if the innovating firm cannot continually improve on its core competence and guard against possible replication by rival firms. The second in his view is the ability of a firm to enhance its internal capabilities to respond quickly and appropriately to market pressures than its rival firms. Certainly, both perspectives are widely acknowledged in scholarly literature (Chang et al., 2015, Penrose, 1999). However, researchers like Porter (1991, p. 108) are still apprehensive of such a claim and warn that;
‘Resources are not valuable in and of themselves, but because they allow firms to perform activities that create advantages in particular markets [...] The competitive value of resources can be enhanced or eliminated by changes in technology, competitor behaviour, or buyer needs which an inward focus on resources will overlook’ (Porter, 1991, p. 108).

For this, one stands to argue that innovation performance of a firm may not after all be automatic of its innovation intent and R&D budget but may depend on how best they can be pursued to create economic value given the firms internal resource capabilities (RBV). Significantly, there is currently very little understanding in developing economies on how innovation affects performance in firms.

Nonetheless, Thomas (2007) discusses how technology in the UK continues to develop at an unprecedented rate and calls on manufacturing firms particularly small to medium size ones to introduce advance manufacturing technologies (AMT) to improve and cope with current changes and market demands. Thomas (2007) goes further to propose a generic framework for firms to adopt for which one could argue that most firms in such advanced economies do have the capabilities to do so for easy introduction of AMT in their organisational operations for growth and competitive advantage in the market. Conversely, most firms, particularly small to mediums size ones in developing economies do not have the needed technical capabilities as they in the UK and cannot therefore easily adapt and systematically follow frameworks that are highly characterised with advanced technicalities (January and Thomas, 2013, Sleuwaegen and Goedhuys, 2002). Moreover, AMT or frameworks with such potential to increase firms’ efficiencies are virtually absent in the literature for less capable economies and desperately required to be developed (Nichter, 2009, Srholec, 2011). In addition to that, the lack of understanding on how or whether innovation really affect firms’ performance in developing economies in the existing body of knowledge is due to lack of bespoke framework to help determine that.

For some time now, many organisational strategies are emphasising on resources that are internal to firms as the most important drivers of their profitability and strategic advantage (Garud and Nayyar, 1994, Markman et al., 2005). This strategic shift has since drawn the attention of management scholars and economic development policy makers towards a resource-based view
(RBV) strategy to achieve economic advantage at firm, regional and national levels. On the whole, the fundamental question of RBV addresses the issue of why firms are different in deploying their resources and how they achieve and sustain competitive advantage (Grant, 1999, Vega-Jurado et al., 2008). The next section looks at the concept of innovation performance in firms and attempt to capture significant innovation activities in the relevant literature.

2.4. Innovation measurement

Until recently, definitions of innovation stereotypically put less emphasis on the soft and less tangible elements of innovation, focusing largely on technology-based innovation (Edquist, 2001, OECD, 2005b). A clear case is the criticism levelled against this traditional innovation metric by Murphy (2011) who states that even available innovation policies concentrate on technological innovation at the expense of, for example, hidden innovation. Regrettably, this study is not an exception; the study also measures innovation to include, among other things, typically, traditional indicators such as R&D expenditure, nonetheless, incorporating a wider range of innovation activities and behaviours of firms; thus, the ‘subject’ approach to innovation data collection. Others are technological improvements of products and processes (Bradley et al., 2013, OECD, 2013).

Inherently, there are very few studies in the academic literature that employ the ‘subject’ approach even with advantages associated with it and the recommendation by the OECD. Arguably, the subject approach has the potential to cover all input and output activities in an economy, even in small and micro enterprises alike as against the ‘object’ approach. Comparatively, the ‘object’ approach of assessing innovation in a survey measures the numbers and features of individual innovation which thereby reduces the measurement of innovation to just specific significant innovations and only what a firm considers as its priority for innovation (Neely and Hii, 1998, OECD, 2005b). Actually, it is the reduction in the spectrum of coverage in the object approach that remains its major drawback and is therefore less encouraged by OECD. However, the two when combined offer a superior analytical advantage that underpins the validity of a study and therefore is highly recommended. In this study henceforth, the two are in fact used jointly for which the object approach is used as a backup to the subject approach to take the collective advantage of both approaches (OECD, 2005b).
On the whole, despite innovation measurement captures its activities and features; it is not just done arbitrary, but systematically undertaken a careful looks at the activities at the fundamental structures of the innovation system chosen for the study.

Researchers of innovation face a lot of challenges from the start of their studies due to the number of phases and levels of analysis they will have to carefully select in order to achieve their study aim. Accordingly, researchers will have to pre-define their units of analysis in advance of their studies and it could be firm, regions or an entire nation as a starting point (Procter and Allan, 2006, Sarstedt and Mooi, 2014, Saunders et al., 2012, Thomas, 2013). It is not uncommon for researchers, particularly first timers, to miss or mix their research units of analysis and eventually face structural problems and validity issues. Cooper (1995) notes that there is a high tendency for researchers to collect data that are easily obtainable and free rather than data that is important to their study. Although, most researchers agree that innovation data analysis is important for local and international comparison (OECD, 2005b), studies on its measurement and analysis in developing economies have since received very little attention in the literature (Driver and Oughton, 2008, OECD, 2005a, van der Have and Rubalcaba, 2016).

Certainly, there are theories developed to analyse innovation data but not really suitable for developing economies and even most theories are well designed for firms level but may not be good for sector, industry and national levels therefore continue to pose consistent challenges to researchers and practitioners (Crossan and Apaydin, 2010, Léger and Swaminathan, 2007, Meyer-Krahmer and Schmoch, 1998). Examples are the five generational models extensively discussed in the literature and also reviewed in the second part of Chapter 2 in this thesis (Damanpour, 1991, Léger and Swaminathan, 2007, İzadi et al., 2013, Kotsemir and Meissner, 2013, Meissner and Kotsemir, 2016). The measurement of the concept of innovation in a survey in general precedes its analysis as a phenomenon that is fundamental for economic development analysis. The two are conducted at different levels in studies in an attempt to determine the progress of innovation and innovativeness in an economy (Byosiere et al., 2010, OECD, 2005a). It is clear that each level of analysis deals with the same phenomenon but differs in terms of the spectrum of coverage, the type of research questions and the dependent variables employed. Several levels recognised in the literature are, thus; team, network, cluster, project, firm level,
industry level, regional level and national level. By design, this study focuses on innovation at firm level as its conceptual unit of analysis and therefore discusses it, the rest are beyond the scope of this thesis.

Actually, innovation analysis at firm level has been at the centre of attention among analysts and policy makers alike for decades due to its importance in determining the progress and levels of firms’ performances and economic growth and development (Cohn, 2013, Cooper, 1995, Per and Johan, 2001, OECD, 2005a, OECD, 2005b). It is also significant for international comparison of world economies and of profound interest to bodies and associations like, the Organisation for Economic Cooperation and Development (OECD), the United Nations (UN), the International Monitory Fund (IMF) and even the International Labour Organisation (ILO). However, due to the level of complexities in defining innovation and the inability to capture all the necessary objects and activities in its measurement in any study, scholars have over the years conveniently picked and chosen among firm level innovation models to meet given research question. For example, the chain-link model of innovation that guides firm-level innovation data collection and analysis with market potential follows a feedback loop in a series of interconnected activities and back to the market, and represents one of the foundational models for innovation analysis. On the other hand, a more open analysis adopted by other researchers (e.g. Chiaroni et al., 2011, de Wit et al., 2007, Helfat and Quinn, 2006, Huizingh, 2011, Chesbrough, 2006) is the theory of open innovation which makes efficient use of rich ideas outside firms. Surely, the lack of definitive analytical framework for firm-level innovation data analysis invites a consistent contention among researchers resulting in conflicting research findings and academic debates over which trajectories are more representative, valid and reliable in what circumstance in the literature. Of course, given the limitation of linearity with available foundational models, the open innovation approaches is also limited with a one size-fits-all scenarios since it does not actually specify how small scale firms and developing economies can adapt it and apply to their situation (Borrás and Edquist, 2013, Chesbrough, 2003b, Dubickisa and Gaile-Sarkanea, 2015). Anyway, for the current study, the integrated approach to firm-level innovation analysis has been adopted and adapted, thus; where a lot of modification have been made to factor in conditions only suitable for less income countries. This is purposely to address the associated limitations of the foundational firm-level innovation analysis approaches and to make it effective and purposeful.
Nonetheless, the focus of the adapted framework only on firms at the sector levels also constitutes a limitation primarily to itself and to the entire study. The study therefore argues further that the framework needs further conceptual refinement to allow for the analysis of a whole industry and regional data.

Added to the above, and irrespective of the differences in trajectories, on the whole, the measurement and analysis of firm level innovation data looks at organisational innovativeness and hinges on any changes that a firm makes on its factors of production, production process, products and services. This also includes factors that influence directly and indicate the willingness of a firm to respond quickly and appropriately to changes in the market with improved and better products and services (Janz et al., 2004, Tetteh and Essegbey, 2014). It also involves data on firm’s tendency to coordinate internal and external resources available to the firm to meet the changing needs of the knowledge economy (Driver and Oughton, 2008, OECD, 2005a). At firm’s level, it captures predominantly any substantial increase in research and development budget and other investments in patent, licensing and spin-offs companies achieved from university academics (OECD, 2005a, van der Have and Rubalcaba, 2016). It may be argued that theoretically, innovation analysis concerns how innovating firms implement innovation in their production process.

However, researchers like van de Vrande et al. (2008) complain of difficulties and deficiencies in collecting and inclusively capturing enough records at firm level to contain reliable insights about their motives and challenges on changes firms make in their effort to innovate. A major frustration recorded in the literature is the subjective nature of what change actually is to different firms. What is change in one firm may not even be recorded or remembered as such during data collection. While efforts are made to further develop definitions to factor in innovation data collection and analysis in weak and less developed economies and how to measure innovation (OECD, 2005a), the issue of vague definition and lack of a widely accepted framework remains a big problem in the literature. For this study, the data collection could not in fact escape this challenge entirely especially since the body of literature has failed to offer a coherent platform for firms’ level innovation data collection and analysis for developing economies (Janz et al., 2004, Neely and Hii, 1998). Further issues on data collection are
Chapter 2: Literature review

addressed in Chapter 3 but now it is apt to discuss the system within which innovation takes place and this come next. However, the parts of the literature selected to measure innovation performance in firms in the research instrument are presented in Table 2.1.

Table 2:1 Observable indicators and their theoretical bases

<table>
<thead>
<tr>
<th>Innovation performance</th>
<th>Theoretical basis</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In our organisation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We have made changes to our process and/or products in the last 12 months.</td>
<td>Organisational Change Management</td>
<td>(OECD, 2003a, Etzkowitz, 2003, OECD, 2005a)</td>
</tr>
<tr>
<td>We consider our R&amp;D to be of benefit to our business.</td>
<td>R&amp;D and Organisational Learning</td>
<td>(Giuliani and Rabellotti, 2012, Krupnik et al., 2015, Min et al., 2015)</td>
</tr>
<tr>
<td>Our management style is influenced by new knowledge in from universities.</td>
<td>Organisational Management</td>
<td>(Landry et al., 2006, Hughes and Kitson, 2012)</td>
</tr>
<tr>
<td>Our staff are efficient in undertaking new business process.</td>
<td>Innovation management</td>
<td>(Deiaco et al., 2012, Min et al., 2015)</td>
</tr>
<tr>
<td>Our annual budget for research and development is comparatively substantial.</td>
<td>Organisational Change Management</td>
<td>(Clancy and Moschini, 2013, Mowery and Oxley, 1995)</td>
</tr>
</tbody>
</table>

2.5. Systems of innovation

To start with, it is widely accepted in the network systems literature that innovation happens in a complex network of interconnected actors, structures and institutions interacting in feedback loops to affect relevant changes for social growth and economic development (Edquist, 2001, Iddris, 2014). Arguably, this system is not just mainly pursued for the sake of it but to develop it to manifest the needed changes in products and services at firms’ level. Notably, the concept of
systems of innovation (SI) is just about three decades old in academic circles and has attracted a lot of attention from scholars and practitioners in their attempt to understand its functionality and how it really affects society (Lundvall, 2004, Nelson, 1996, OECD, 1997). However, there is still vast uncharted areas of research as researchers have yet to study and analyse, and according to Patarapong and Cristina (2007, p. 1) ‘the specific policy dilemma arising from weak and fragmented innovation systems that characterise developing countries’. Systems of innovation actually came on to the scene in 1987 after the seminal work of Freeman (1987), and then became popular after the work of Lundvall (1992) and Nelson (1993). Today, SI is widely used as a framework in the academic context and innovation policy designs. By way of interventions, Patarapong and Cristina (2007) explain how Thai government adopted innovation systems policies as a five-year (2001-2006) S&T plan but the practice hardly addressed the profound systemic problems it sought to solve. Kruss et al. (2012) add that governments in the West African sub-region have also over the years borrowed innovation systems policies which have failed. In a specific case of Ghana in the same region, science and technology policies, also borrowed as a system, have not been productive either and are arguably attributable to weaker and more fragmented systems compared to those of the forerunner countries in the developed regions of the world. It may be logical to imply that conscious efforts by practitioners and researchers to not only strengthen the weak and fragmented innovation systems of developing economies is not only desirable, but also adequate in attempts by researchers to systematically analyse and development innovation systems policy framework capable of addressing such conditions is equally necessary.

Accordingly, Edquist (1997, p. 14) defines SI as ‘all important economic, social, political, organisational and other factors that influence development, diffusion, and use of innovation’. Almost at the same period as SI was introduced and published by Freeman (1987) came the idea of national innovation system (NIS) to explain factors within an innovation system that determines the process in the pursuit of national development. In a broader context, a national innovation system is said to include economics, political, social, institutional, organisational, and all factors that directly affect the development, diffusion and application of innovation in a national context (Edquist and Hommen, 2008, McCann and Ortega-Argiles, 2013).
Also, the literature explains national innovation system to include the generation and transmission of knowledge and technology that take place within a complex network of institutions, universities, enterprises and government agencies (IHERD, 2013, Mosey et al., 2012). Researchers agree that within the machinery of national innovation system lie; 1) effective interactions that take place among firms for the purpose of research projects within a close co-operation, 2) another aspect is interactions with other components of the system like universities, other enterprises, and public research institutes aimed at gaining commercialisation; patent and co-publications. These could also emanate from informal linkages, 3) technology and information diffusion is another type recognised as one of the ways they flow to enterprises and finally, 4) through personnel mobility, technical staff move between public and private sector firms and departments thereby diffusing technical and technological expertise between them (Dooley and Kirk, 2007, Edquist, 2006). Other systems, for instance, regional innovation system (RIS), sectoral innovation system and even technology innovation system are well recognised in the literature and worth mentioning but their discussions are not within the scope of this study (Edquist, 2006, Freeman, 2002).

Conversely, innovation systems have the tendency to make or unmake innovation in some circumstances depending on how they are set up and used. For instance, when some of the components begin to underrate the capacity of universities that operate in that domain as predominantly is happening in developing economies. The research on system of innovation has found evidence of this mishap in both lagging and advanced regions of the larger systems (Goddard et al., 2012, Bellamy et al., 2014).

Additionally, critics of nation-state, notably a researcher like Ohmae (1990), insists that sub-national units like cities, districts and provinces sometimes assume a more competitive position in commercialising innovation for growth and development. Eventually, these sub-units succeed in eroding the relevance of national innovation systems. The immediate example is Silicon Valley in California that has demonstrated a very high level of innovative capabilities almost over the entire national system of the US. To illustrate, the innovation performance of Silicon Valley is outstanding and outweighs the national innovation system of the US as a whole which researchers believe has masked the achievements of the national system to some extent or even
dwarfed activities of other networks in the country (Freeman, 2002, Thomas et al., 2011). Clusters or network systems of that calibre are not common in developing nations and therefore needs research contribution in that area. Interpersonal relation is said to play a significant role in every social system according to network systems theory so the next section tries to look at social capital in the perspective of innovation system.

2.6. **Innovation policy in developing nations**

The significance of the role of innovation policy in university knowledge transfer can never be over emphasised and will always feature in knowledge transfer literature detailing its place at local and international levels (Singh et al., 2015, Hobday et al., 2012). It is established in theory that globalisation has called for extensive investment in R&D. Paradoxically; firms who are at the receiving end of R&D may not really commit enough resources into it because of its ‘social good’ attribute (Bourelos et al., 2012, Cabrera et al., 2006). Indeed, developed economies of today have gone through several economic transformations to gain industrial status and now at knowledge-based economic level. However, for developing economies, which certainly are in stiff and constant competition for market with already advanced economies will need effective economic policies that will successfully address issues of knowledge generation through R&D and technology transfer to achieve transformation to the status of industrialisation (Fu et al., 2014, NDPC, 2010, Pietrobelli and Puppato, 2016).

In the first place, innovation system policy researchers such as Thomas et al. (2006) believe that economic policies and frameworks formulated to address economic conditions are also perfectly ideal for science, technology and innovation (STI) to strive. In general, it is a consensus that a careful, purposive and bespoke policy for market and for system failures is equally desirable for innovation. Indeed, policies made to achieve general economic primary objectives are only a necessary but not a sufficient condition for innovation to strive (OECD, 2010). There is generally lack of innovation systems policy in the literature purposely formulated through careful studies for developing economies and that has resulted in wrong policy adoption and misapplication imported ones from advanced nations without proper understanding of their specific requirements. Countries in the West African sub-region perfectly fit in well in this scenario. Meanwhile, economies differ in terms of sizes, policy orientation, capabilities and institutional
features. Organisation for Economic Co-operation and Development members; for example; UK, France, US and Germany have a wide variety of system policies in the literature offering enough information on STI trajectories. One may suggest that it is for this reason that governments in the West African sub-region believe that importation of such policies will perform to expectation because they represent successful cases to emulate. Nonetheless, there is very little evidence in the literature to prove their direct links to economic development (Mowery and Sampat, 2005). For example, innovation policy researchers like Mowery and Sampat (2005) have strongly questioned the effectiveness of such policies and the success of their resulting technology transfer and innovation using the US 1980 Bayh-Dole Act as a test case. Given the emulation of the act as a policy template in some OECD nations for university engagement, Mowery and Sampat (2005) examine the effects of the act on university–industry interactions and technology transfer in the US in their study in an objective manner. Primarily, the study considered the history of technology transfer before 1980 and also looked at the level of incentives put into the policy afterwards. By comparing the effect in OECD countries that had emulated the US example of the policy with countries in Western Europe and Japan, they found that there was just a modest effect of the policy without the much highlighted effect as claimed in some academic literature. The study however did not consider the structural differences among the systems higher education in these nations.

Furthermore, one of the principal rationales for public involvement in R&D by way of policy is to fix market failures which are usually expensive for the productive sector to bear in the areas of knowledge production. Buy this, researchers contend that public policies also induce investment in R&D (Mensah-Bonsu and Jell, 2011, Hobday et al., 2012). However, all systems also differ in the area of vision for the future and the rationale for intervention needed to alter prevailing situations for better (Clancy and Moschini, 2013, OECD, 2010a). Hence, achieving the intended technological advancement for a specific country requires the use of a policy instrument that pursues the countries own objectives to achieve efficient innovation system (Hobday et al., 2012, Hughes and Kitson, 2012). Bessant (2011) warns that innovation policies are by far easy to prescribe, adopt or emulate and the difficult part of it is the successful implementation which equally needs to take care of issues like trust, risk and gain-sharing as he termed it. This means that imported innovation policies do not work because they are not fit for less income countries
and will not work either because they need to be formulated with indigenous conditions well catered for.

2.7. Social capital

Among social capital researchers, there is a metaphor that ‘...people who do better are somehow better connected’ (Burt, 2001, p. 202); even though in social network literature in particular, there is still no theoretical clarity as to what is meant by better connected. Even there is no clear indications of which network structures really generate new knowledge either to bring better performance (Pickernell et al., 2006, Pittaway et al., 2004a). Nevertheless, this statement may be supported in a study by Gonzalez-Brambila (2014) which indicates that one of the major direct benefits of social capital is quick and easy access to information; which are vital ingredients for doing better. Indeed, social capital is considered to be a form of wealth or benefit that is generated as a result of relationship that exist between at least two people (Lesser, 2000, Murphy et al., 2015). Literally, researchers have agreed that unlike other capitals, social capital needs maintenance without which it will not be effective or productive (Chenhall et al., 2010). There is also a consensus that social capital is generally a public good and though inherently embedded not within the beneficiaries but in their relations with others (Noran, 2005, Adler and Kwon, 2002, Bourelos et al., 2012). Notably, within the literature, the concept is highly polarised and definitions fall within two main categories. For the first category, social capital is argued to be a form of relation that an individual has with other elements of society, it is considered an external phenomenon in network theory and inclined to the egocentric perspective of social network (Chenhall et al., 2010). For the second category, researchers focus on the internal structural characteristics of an organisation, and social capital is then defined from the internal stand point of an organisation. In a broader perspective and in line with the second category and from which this study draws its foundations;

‘Social capital is defined by its function. It is not a single entity, but a variety of different entities having two characteristics in common: They all consist of some aspect of social structure, and they facilitate certain actions of individuals who are within the structure. Like other forms of capital, social capital is predictive, making possible the achievement of certain ends that would not be attainable in its absence’ (Coleman, 1990, p. 302).
Others with the same stand point see it as; ‘a resource that actors derive from specific social structure and then use to pursue their interest; it is created by chances in the relationships among actors’ (Baker, 1990, p. 619).

To those who define social capital from an institutional stand point, emphasis is placed on the relations of actors in regards to structural characteristics of their organisations like Brehm and Rahn (1997, p. 999) who see it as ‘the web of cooperative relationships between citizens that facilitate resolution of collective action problems’. Fukuyama (1995, p. 10) puts it as ‘the ability of people to work together for common in groups and organisations’, he goes further to state again that ‘social capital can be defined simply as the exercise of a certain set of informal values or norms shared among them’ (Fukuyama, 1997). For Putnam (1995, p. 67) it constitutes the ‘features of social organisation such as networks, norms and social trust that facilitate coordination and cooperation for mutual benefit’. Nonetheless, there are some who think that it is a combination of the two perspectives and one of them is, Pennar (1997, p. 154), who thinks it is ‘the web of social relationships that influences individual behaviour and thereby affects economic growth’. Above all, Dasgupta (2005) sees social capital as being ‘interpersonal networks, nothing more’. Importantly, this definition takes it roots from a trust that members of an interpersonal network maintain as a foundation for their collective benefit and built on ‘mutual enforcement of agreements’.

Notwithstanding, the debate on the conceptual differences and disparities in the definitions of social capital among researchers continues and is inherently subjected to misunderstanding in the literature (Adler and Kwon, 2002, Cohen and Fields, 2000, Murphy et al., 2015). Of course, that has opened the nature of firm to misconceptions and several interpretations to different school of thoughts. For example, researchers in organisational theory continue to argue for a more socialised perspective of firms, insisting that organisations are social communities, the results of which goods and services are direct translations of people and expertise for economic benefit. They accuse critics of under-socialising the firm based on theoretical assumptions (Williamson 1975, Kogut and Zander 1992). Cleary, the other side of the debates persists on their view of firms, based on the concept of opportunism and market failures which is widely informed by traditional models of the firm. In this sense, there is a suggestion for a more acceptable
framework that incorporates all facets of the community as an aggregate capital that is critical for both scholars and policy makers (Eldeman et al. 2004). Although, the benefits of social capital abound in the literature; like low transaction costs and structural social capital in particular known to facilitate innovation by allowing efficient stream of information among members of a community (Cadger et al., 2016, Huggins et al., 2012b), the negatives are often overlooked. To illustrate by example, in a quantitative study conducted between mid-2008 and 2009 in seven Sub-Saharan African countries and designed to capture diversity in the Sub-region, Van Rijn et al. (2012) found a significant correlation between aggregate social capital and innovation adoption across seven countries (Nigeria, Niger, Rwanda, Uganda, Democratic Republic of Congo (DRC), Mozambique and Malawi). With a total of 2,518 households in a cross-sectional survey, a negative association was equally found in intra-community norms in the area of cooperation and trust. Van Rijn et al. (2012) conclude with what they call ‘a dark side’ of social capital. They explain that a high intensity of cognitive social capital could have the tendency to breed selfishness in attitude in communities. Largely, researchers also categorise social capital in two different forms which are bonding and bridging social capital.

To start with, research on the bridging aspect of social capital has generally built on the quantum of ties in relation to the structure of the set-up of relations in a social system. With this, researchers place emphasis on a number of connections achieved between different and often diverse social groups (Chenhall et al., 2010). Specifically, bridging social capital is defined around the network of social relations in total and the impersonal properties of a social system. Arguably, bridging social capital inclusively entails relations that social elements have or establish with distant associates, friends, and colleagues (Larsen et al., 2004, ONS, 2001). Just like other aspects of social capita, bridging social capital has been conceptualised and defined to show how social ties are diverse but tends to be weaker, but also more important in ‘getting ahead’ in Putnam's idea. For example, ‘weak ties’ are an important resource according to Granovetter (1973) in making mobility opportunities possible and more likely to produce positive outcomes, thus; access to resources like, skills/knowledge and valuable information. It is widely accepted that bridging social capital ensures secure benefits for members of a community or firms (Portes, 1998, Dasgupta, 2005) and re-enforces authority by brokering connections for leadership and power. However, bridging social capital could potentially be costly to maintain.
(Hansen, 1998) and equally nurture some forms of parochial interest and set in social inertia (Gargiulo and Bernassi, 1999). As a result, when excessively brokered, bridging social capital could also restrict opportunities and innovative ideas coming into a social network (Gabbay and Zuckerman, 1998).

Comparatively, while bridging social capital is about the network structure and number of social ties, the theory of bonding social capital tends to concern itself with the quality of social ties and the level at which social values are shared among social elements (Larsen et al., 2004, ONS, 2001). It is argued that bonding social capital exists within and between organisations (Adler and Kwon, 2002, Nahapiet and Ghoshal, 1998). In addition to that, it is found that bonding social capital is exclusive relations amongst homogenous groups and entails members of one’s family and other close friends with strong ties. Typical examples of bonding social capital in the literature are the existence of social norms, shared values by members of a particular group that insist on absolute cooperation in their network. Although it is known for its potential to discourage entrepreneurial activities by standing in the way to prevent a break away from community tradition and culture (Portes, 1998), it is a result of the numerous strong connections established among individuals of the same social setting. Meanwhile, with bonding social capital there is cooperation, generalised reciprocity and trust that are usually an outcome of the existence of shared values (Fukuyama, 1995, Putnam, 2000). Research has shown that the immediate benefits are faster resolution of disputes among members and also fosters early identification and prevention of sectarian grievances (Nelson, 1989).

Still, with all the benefits, research on social capital has completely neglected studies on how industrial sectors benefit from universities through all forms of social capital. It is equally silent about how knowledge networks born out of social capital influence knowledge transfer in developing economies. Even how social capital can pool knowledge generators and consumers together in various forms for mutual benefit in commercial circles is an interesting area of research but sadly ignored or still underdeveloped in less income countries in the body of knowledge.
2.8. Absorptive capacity

Of late, the term ‘absorptive capacity’ has become increasingly popular in knowledge generation, innovation and the global economic growth and development literature (Singh et al., 2015, Srholec, 2011). Absorptive capacity is used to describe the ability of a firm or at the general level and economy, particularly developing countries, to absorb new knowledge (technology) to be specific or new investment to be more general for competitive advantage (Adler, 1965, Theodorakopoulos et al., 2014). In his view, Rostow (1980) concludes that;

‘economic growth depends on the rate of absorption of the existing and unfolding stock of relevant knowledge; the rate of absorption depends on the availability of both trained men and capital; the reason for the accelerated growth among (...) middle-income countries in that they have built up the stock of trained man-power (including entrepreneurs) to a position where they can accelerate the rate of absorption of the stock of knowledge’ (Rostow, 1980, pp. 267-277).

In the context of a firm’s absorptive capacity which is of a fundamental interest to this current study, Cohen and Levinthal (1990, p. 128) also define it as; ‘the ability of a firm to recognise and value new, external information, assimilate it and apply it to commercial ends’. To development economists, absorptive capacity of a firm is significant in its interactions with external and foreign firms through which spill-overs and foreign direct investment (FDI) are channeled to aid innovation in local firms in developing economies (Osabutey and Jin, 2016, Ponds et al., 2010). Largely, the international community of applied researchers use it as one of the tools in analysing knowledge generation and transfer (technology) processes and the rate at which it is achieved between local and external knowledge players (Perkmann et al., 2013, UNU, 2009). Researchers have agreed that the potential of a country to exploit and absorb new knowledge depends on the technological and social capabilities of the country both of which offer clues to the level of its absorptive capacity (Sparrow et al., 2009, Svetlik and Lin, 2007). These include characteristics like access to large and homogenous markets, and issues concerning honesty and trust, markets capable to mobilise capital on a large scale from financial institutions, the stability of government machinery and their effectiveness in supporting economic growth with enforcement of defined rules (Nahapiet and Ghoshal, 1998, Osabutey and Jin, 2016). Other capabilities that have gained consensus among researchers to be relevant in supporting absorptive capacity are
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technical competence (level of education) and experience in management and organisation of large scale enterprises (OECD, 2005b, OECD, 2010a).

In contrast to this development, with the exception of few studies (e.g. Astrid et al., 2008, Borrás and Edquist, 2013, Keller, 1996), the literature has paid very little attention on how firms in developing economies accumulate absorptive capacity to be able to gain knowledge through intermediaries such as technology transfer offices, knowledge networks or even to participate successfully in collaborative research project with universities. This neglect of such crucial concepts of university knowledge transfer infrastructure therefore needs a second look in the academia in the opinion of the current study. Perhaps, development of a coherent strategy to guide practitioners and policy makers on firms’ capability building or a whole framework to offer direction on how intermediaries can support capability building could contribute to part of the solution.

Recent studies however show that university interactions does not automatically lead to successful transfer of knowledge unless firms amass adequate capabilities by strengthening their human and organisational capabilities to be able to absorb knowledge (Astrid et al., 2008, Boateng and Narteh, 2015, Eisenhardt and Santos, 2000). To illustrate this, research shows the German effort to catch up with UK more than a century ago and discusses how institutional instruments were set up to overcome internal obstacles particularly in the financial sector in order to make the needed progress. However, it may be argued that technical capability is a necessary but not a sufficient condition for innovation and wealth creation (Abramovitz, 1986, Cohen and Levinthal, 1990). For instance, evidence in the literature suggests instances of companies accumulating massive amount of knowledge repositories but unable to create wealth with them or survive competition in the market. The case of IBM, Kodak and GM are still fresh in our minds and Bessant (2003) concludes that companies with competitive advantage are able to exhibit ‘timely responsiveness and rapid product innovation, coupled with management capability to effectively co-ordinate and re-deploy internal and external competencies’.

As a matter of fact, the concept of absorptive capacity is not limited to just the ability to obtain knowledge or technology in theory as it may be narrowly thought in some aspects of the
litigation but extends to include the processes of searching, assimilation (or absorption) of whatever is found and the eventual commercial application. Without doubt, this is in consonance with Kim (1980) proposition of ‘technological capabilities’ as a tool used to illustrate Korean economic growth and development. One may also suggest that facilitating access to knowledge from external sources in developing countries will have limited effect on economic growth and development if prior absorptive capacity building is not adequately carried out (Astrid et al., 2008, Cooke and Leydesdorff, 2006, Liao et al., 2012). Again, the literature is limited on how firms’ absorptive capacities facilitate industrial sector innovation performance to collectively support economic development in developing countries. Therefore, understanding all these is crucial, especially for developing economies since their innovation systems are generally weak. Due to these, indigenous firms face hefty challenges building sufficient levels of absorptive capacities to support economic growth and development. To understand how absorptive capacity related to industry’s ability to innovation with university knowledge the next section unpacks the concept of university industry interaction.

2.9. University-industry interactions

‘In the current condition of the global knowledge economy, knowledge production and technological innovation become the most important productive forces. So, without at least some level of a national research system, which is composed of universities, the private sector, public research centres and external funding, no country, even the smallest country, can really participate in the global knowledge economy’ (Castells, 2009).

Typically, university-industry interactions have been a topical issue in knowledge generation literature and academic researchers have debated among themselves on the relative impact of the interactions on innovation and subsequent influence on economic growth and development (Islam et al., 2013, Thomas et al., 2004). For instance, some part of the literature (e.g., AAU, 2012, Boubakar and Sawyerr, 2008, Cloete et al., 2011) tends to cast doubt on the influence of universities, particularly in Africa on firms’ innovation, claiming that very little information is documented on universities’ engagement with firms to help analyse its impact on development. More so, the literature (e.g. Hart et al., 2009, January and Thomas, 2013) on the conditions of universities and industry with regards to their readiness to engage is very little and researchers
have yet to agree on whether there is enough evidence to suggest that current innovation manifested in industry is the result of interactions between universities and firms.

As noted earlier on, industry readiness for university knowledge also depends on firms’ knowledge and internal capabilities as they are embedded within firms organisational resources (Kogut and Zander, 1993). Significantly, external knowledge acquired by firms from external sources; university discoveries and experts, has attracted the attention of economic policy makers as they scour for solutions for global economic development challenges (D’Este and Patel, 2007, Lam, 1998). For that reason, interaction between universities and industry is considered a strategic source for knowledge creation and sustained competitive advantage in firms. In effect, scholars of knowledge generation (e.g. January and Thomas, 2013, Rutherford and Holmes, 2008) and management (e.g. Smith, 2001, Lam, 1998) typically believe that organisational learning and new knowledge creation are embedded in the complex network of social structures. These systems they contend harness both explicit and tacit knowledge for consequential innovative activities within firms (Byosiere et al., 2010, Wynn and Rezaeian, 2015).

In a broader context, internal knowledge development of a firm emphasises on organisational learning, routines and knowledge generation, which are shaped largely by the external environment and dynamics of social institutions (Deiaco et al., 2012, Edquist, 2001). In the notion of national innovation systems, the success of innovation is said to rest on a sustained relationships and continuous contact between academia and industry (Bradley et al., 2013, Lundvall et al., 2002). Formally, universities; their researchers, research teams and TTOs form an element of the complex network of external knowledge agents and also considered to play a role as some of the major societal establishments that influence the internal dynamic of firms as learning organisations (Rorwana and Tengeh, 2015, Singh et al., 2015). It has been stated that one of the most prominent ways universities as knowledge sources influence innovation in firms is through collaboration often with legally binding agreements, contracts research or joint projects in the pursuit for patent and IP (Lam, 1997, Boldrin and Levine, 2012). Collaborative organisations are instrumental nowadays in establishing the links mostly through the internet. Such organisations create and maintain databases of academic researchers, technology transfer offices (TTOs) and centres in readiness for university discoveries (Bradley et al., 2013). In the
collaborative review model, modern technology transfer offices create the platform and collaborative organisations catalogue information on various universities’ research interests, expertise and specialisations in anticipation for operational problems from industries and joint projects from firms (Hobday et al., 2012, Lee, 2011). In particular, the database also contains information on tacit knowledge available in both universities and industry including intellectual properties, patents, copy rights and license structure (Polani, 1966, Su et al., 2015). Arguably, all of these have been purported to yield innovative outcomes and customarily impact on industry performance (Cohen et al., 2002, Cooke and Leydesdorff, 2006).

Essentially, universities’ interactions with industry arguably may be vital for the mutual good of both parties and ultimately for innovation and economic growth and development of the larger society (Rossi and Rosli, 2013, Guimon, 2013). In particular, globalisation of economic activities and competition in the market have been part of the dynamics compelling firms to look for new knowledge from university interactions to gain competitive advantage and maintain profitability (de Wit et al., 2007, Bessant et al., 2012). For this, Kruss et al. (2012) call for new framework that takes global changes into account in knowledge generation and diffusion in relation to developing countries since there is still not a great deal of information on the participation of universities in innovation and economic development to inform innovation policies. Critically, scholars such as Kaymaz and Eryiğit (2011) argue that the traditional core mandate of educating skilled labour force and conducting research could be lost though, to the pursuit of industry’s commercial goals if universities engaged with industry.

One may argue that, university-industry interactions offer the potential to sustain the pursuit of technology and innovation in developing economies and the decades of 1950s and 1970s, even up to the 1980s saw newly independent African countries established new universities to educate and conduct research to reap the potential (Bailey et al., 2011, Barry and Sawyerr, 2008). Knowingly, in the last two decades, universities in African nations have been encouraged to engage the private sector to earn more income through knowledge exploitation (Bessant et al., 2012, Deiaco et al., 2012).
Generally, universities interactions with industry are typically expected to produce innovative outcomes by creating new knowledge for industry and business opportunities (Dooley and Kirk, 2007, Abdulai et al., 2015). For this purpose, university-industry interaction literature recommends interactions of this type to take a form that conforms to best practice to yield productive outcomes (Pertuze et al., 2010, Munyoki et al., 2011, Guimon, 2013, January and Thomas, 2013). Research projects of this sort involve commercial interest of both universities and participating firms (Cohen and Walsh, 2000, Clancy and Moschini, 2013). Barnes et al. (2002) insist that the selection of project partners is primarily the fundamental element of university-industry interaction. Indeed, it may be stated that, stakeholders need to be cautious when it comes to choosing research partners prior to the start of a project because it may be the foundation for future long term relationship. A successful initial partnership has the tendency to bind project parties together for years if managed productively (Hagedoorn et al., 2000, Johnston and Huggins, 2016).

For instance, in some cases, industry has direct contact with universities in many forms to obtain knowledge for innovation and this takes several channels as stated before, like contract research, joint research projects or consultancy services (Bozeman, 2000, Enders and De Weert, 2004, Lee, 1996). Sometimes too there are informal contacts, student project sponsorship by firms, joint R&D between industry research teams and university faculty members (Bekkers and Freitas, 2008, D’Este and Perkmann, 2010). These mechanisms of transfer have different significant relevance to diverse industries and discipline areas (Thomas, 2013, ECA, 2013). Interestingly, even with abundant literature on the benefits of all these mechanisms of contacts with universities, Howells et al. (2012) in their study into the paradox and complexities within the knowledge ecosystem have noted that firms in the UK have rated their direct contacts with universities incredibly low among their sources for information.

Sometimes too other bodies come in between research institutions including universities and industry to facilitate research processes in universities and subsequent transfer to industry and society using many means to achieve this. Effectively, this stems from local authorities, national and multilateral organisations that are active or have considerable interest in research for varying reasons. For example, the United Nations (UN), European Union (EU), the Organisation for
Economic Co-operation and Development (OECD), Department for International Development (DFID) and Economic and Social Research Council (ESRC) fund or partner universities to conduct research in areas of their interest or that of the larger society (Bourelos et al., 2012, Bozeman, 2000). Sometimes, alumni, charity organisations and professional bodies support research processes to advance technology in areas or disciplines that need research support or fall within their advocacy campaign interest (Nurse, 2014, Pérez and Sánchez, 2003).

Also, innovative opportunities open up to particularly smaller firms when they join cartels. It also offers them the advantage of being part of joint R&D ventures with larger firms (Azzone and Maccarrone, 1997, Bessant et al., 2012). Incidentally, as more firms recognise partnerships as being fundamental for new ideas, these co-operations and research joint ventures (RJV) projects have accordingly become popular, serving the knowledge needs of firms and stand as a premise for economically advantageous avenues to participating firms (Kaiser and Kuhn, 2012, Kamien and Zang, 2000). Most of all, joint ventures in R&D are now common these days in the US, Japan and Europe as alternative means to stimulate innovation within and among firms (Mothe and Quelin, 2000). In such schemes, participating institutions and firms harness resources jointly in a consortia or cartels and set on R&D partnership journeys with universities for their own business prospects and benefits. Among the benefits includes; low transaction cost for R&D, risk and cost sharing (Prokop, 2014, Grabowska, 2015). To point out, knowledge externalities (spill-overs) in RJVs are purposely internalised, usually controlled and patent applications by participating firms are evident in the literature. Although Ponds et al., (2010) dismiss this and contend that spill-overs are by their nature involuntarily dispersed far and wide as open knowledge from universities. Hitt et al. (2002) also warn of complacency among members in RJVs in the long run and that what is considered an advantage could easily turn to a liability and set in competition among members for resources. A typical example of a RJV is the Danish Innovation Consortia (DIC) that has operated in Denmark, spanning from 1995 and has recorded successful patent applications to their credit. Actually, this project has been under the Danish Ministry of Science, Technology and Innovation and managed by the Danish Agency for Science, Technology and Innovation (DASTI). With a total project budget sum of DKK 766M or 100M euro, consisting of 274 different firms up to the year 2002, the research project has demonstrated that the involvement of public subsidies in such projects has a positive effect on
innovation and employment. However, the economic impact of the project on large firms has no strong empirical evidence yet (Kaiser and Kuhn, 2012).

In particular, it is acknowledged that sometimes collaborative research projects with universities are not easy to come by and other alternatives like consortia formation can provide firms with the needed innovative objectives (NDPC, 2010, ECA, 2013). Nonetheless, Mothe and Quelin (2000) argue that consortia have not really lived up to the expectation of their proponents either. Notwithstanding, a project sponsored by the European Commission in 2014 demonstrates how universities in Europe have embarked on implementing a modernisation of their collaborative research agendas through the evolution of university-business based knowledge transfer structures and have reported positive results. Successful case studies include New Castle University in the UK, Chalmers University of Technology in Sweden and Norwegian University of Science and Technology in Norway (Trueman et al., 2014). In these projects, the universities described as entrepreneurial universities have developed long standing research relationship with companies and have benefited from proceeds of projects co-funded for commercial gains. Nevertheless, these types of co-operation do not go without high cost and risk to participants (Hughes and Kitson, 2012).

Also, in a grounded theory method of investigation, Autio et al., (2004) found that at an international level, big-science centres (for Physics, engineering, thermonuclear fusion and others) have immense knowledge spill-over effect on industry. In this case study, they concluded that big-science centres, which are public-private co-operations, were confirmed to have effect on learning outcomes and can be demonstrated in the good of industry. Similar conclusions were obtained in other studies in different geographic areas (Burns and Squires, 2011, Thomas et al., 2009). According to the triple helix principle, government have an equally important role to play in knowledge generation to affect innovation, improve industry performance and will have to support universities and industry to realise this objective (Etzkowitz, 2002).

Universities have for centuries been the source of knowledge through teaching and research as their traditional role but hitherto with limited interaction with the larger society. It is evident nowadays in developed countries that national development agenda are tied to the work of
universities (Mowery and Sampat, 2005) and knowledge generation has gone through an evolutionary process, thus: from mode 1 (a newtonain notion of knowledge production) through to mode 2 model of innovation (which is transdisciplinary). Knowledge generation has moved further on and is now at a point where several actors play pivotal roles in its creation for the good of the larger society.

To emphasise, universities’ functions have changed since the 1970s and institutions of higher learning have become important players in national and regional economic development through the production and diffusion of knowledge that is relevant to industry. This is happening at a time when governments are struggling with scarce resources as claimed by Roosevelt (1994) and Drurey (2010) in the wake of successive economic recessions that have affected public funding of higher education the world over. This has called for universities to rise up to justify their direct contribution to society and as well begin to look at other sources to fund and to effectively live up to the new responsibilities. The combination of these presents a big challenge to higher education and research process in universities indicating that universities cannot continue to be ‘ivory towers’, producing research results without direct benefit of the public that funds them (Mowery and Sampat, 2005).

Indeed, the challenges of globalisation have compelled higher education institutions to respond to the growing needs of the information society and called for a paradigm shift from the traditional function of universities to encompass closer relation with industry and governments (Subotzky 1999). This move over stretches the boundaries of universities to meet social needs and become entrepreneurial institutions that are accountable to the public. This new paradigm is at variant with the current basic developmental capacities of universities and their governments in developing countries. Thought, developing countries cannot afford to sit back and therefore have followed suit in this direction of science and technology and are urging universities and industry to collaborate with each other in a social contract made of a network of relevant actors to play the new roles and take proactive measure to achieve expected results.

Saad et al. (2010) contend, as they call it, the ‘new mission’ of higher education has changed the role of universities in national economic development and society can now participate (bottom-
up learning process) on how research result should affect their lives or how innovation should be tackled. This is also supported by Sorenson and Fleming (2001) who suggests that there is a great benefit to society and the economy at large when firms participate directly in science and innovation and further conclude that employees involved in such networks of actors who are talented are free to research, invent and diffuse knowledge even to rival firms.

Regrettably, the principle of triple helix and other models like open innovation framework are seen as borrowed concepts that do not yet fit well into the weak innovation systems of developing economies and a generic model for less income nations will offer a platform for firms in all sectors and the majority of the small scale enterprises to engage with universities for knowledge and innovation. In support of that, Singer and Peterka (2009) argue that a lack of structural flexibility within university research and knowledge transfer process in less endowed countries seriously inhibits universities interactions with firms. Also, resistance to change and novel initiatives have posed a massive challenge to innovation in such nations (Bailey et al., 2011, Mensah-Bonsu and Jell, 2011). Therefore, Amankwah-Amoah (2016) recommends an effective configuration between government policy and resource distribution in other to support firm level innovation in the Ghanaian situation. What is also obvious is the seemingly non-existence of shared trust and confidence between universities and business communities (Adler and Kwon, 2000, Hitt et al., 2002). Obviously, these challenges are comparatively much alleviated in advanced economies and the link between universities and industry is therefore much improved and highly productive in many sectors (Mothe and Quelin, 2000, Etzkowitz, 2002). In the light of these, it is the case of this study to advocate for a suitable framework for the use of developing economies, particularly those in the West African sub-region, for better understanding and a better guide in university-industry interaction studies. As part of the better understanding of university-industry interactions, the modes of interactions considered crucial in innovation performance are formal and informal modes of interaction which are discussed next.

### 2.10. Formal mode of university knowledge transfer

Formal mechanisms of university knowledge transfer have been tools for university channel of knowledge transfer in advanced economies for decades but have yet to attract massive patronage in developing economies in the West African Sub-region (Freitas et al., 2013a, Kaymaz and
Eryiğit, 2011). Known for its extensive codification prominence, studies show that formal mode of university knowledge transfer typically encompasses a legal contract between a university and a firm. For example, on patents or long-standing contracts, this may include R&D projects and also noted for its prominence with high intensity of relationships required (Grimpe and Hussinger, 2013, Perkmann et al., 2013). Available research is however on IP and patent in developed economies without due recognition to how formal modes of university knowledge transfer influence innovation performance in developing economies. The literature is not clear either of how such interactions lead to innovation or even whether the effect of any at all is different or the same for all sectors in the same economy. This leaves a gap in the literature with compelling reasons to investigate to increase understanding on university interactions in less income nations

The definition of formal mechanisms of university knowledge transfer remains ambiguous leading to controversies among scholars of knowledge transfer (Siegel et al., 2003b, Thomas et al., 2009). However, in most formal university knowledge transfer mechanisms there is specific target knowledge to be generated and transferred or a stated research outcome (Macho-Stadler et al., 2007, Muscio et al., 2013). Sometimes too formal university knowledge generation and transfer contracts are driven by intellectual property (IP) regulations (Rogers et al., 2001, Steffensen et al., 1999). Research studies available on both formal and informal modes of university knowledge transfers have described the two differently and while some papers categorise consultancies and conferences, even workshops as formal (Barnes et al., 2006, Grimpe and Hussinger, 2013, Perkmann et al., 2013) other papers group them among informal modes of knowledge transfer (Xiao and Tsui, 2007, Zahra and George, 2002). These by no means make the definitions very subjective and explanations given are therefore informed by authors own judgements without any definitive framework to guide researchers.

Notably, firms have different ways to learn and innovate as well as industries as a whole and the way each of these obtains knowledge also depends on type of knowledge or technology and absorptive capacity of participating firms (Thomas et al., 2006, Sparrow et al., 2009). To clarify, the size of a firm and type of knowledge or industry being dealt with at each time are influential factors when it comes to knowledge transfer. Even the discipline or business activity of a firm
guides the mode of transfer of university knowledge from the source to the learning structures of firms (Lam, 1997, Rogers et al., 2001). For example, firms that are in high technology areas or knowledge intense industries will turn to use formal agreements and long standing research projects to generate knowledge and to improve on quality of their products and services or bring effective incremental changes in their business activities (Landry et al., 2006, Laursen and Salter, 2004). To further illustrate this, in Chile, Giuliani and Rabellotti (2012) report of formal mode of arrangement between wine industry and two main national universities for wine research. These were the Pontificia Universidad Catolica and the Universidad of Chile both of which are based in the national capital Santiago and employs the largest number of wine research scientists in the country. The research was supplemented from other public research institutes in the country as well.

Nevertheless, as an external knowledge source, this form of university knowledge transfer is highly criticised though, for its high management cost, a higher chance of failing to offer the needed core competence to buyers or satisfy market needs (Kraijjenbrink et al., 2007, Mowery and Oxley, 1995). Another criticism for this form of transfer is that, there is a high chance of a large gap between innovation/invention and commercialisation in the market and may even turn out a completely different product in the long-run; an attribute of university research that entrepreneurs do not really like (Goldhor and Lund, 1983, Bradley et al., 2013). That is not all, transfer of technology through this means may trigger future competition between supplier and receiver of the knowledge or even organisational culture could stand between them and make it difficult to succeed (Mateso, 2014). In both situations capital investments made in such formal arrangements are not usually worthwhile for firms and industry (Amessea and Cohendet, 2001, Sainsbury, 2007).

In short, formal links with universities and university academics remains a critical factor in determining the competitiveness of firms, regions and nations’ innovation systems. Further understanding in this area is actually required in the context of developing economies. The part of the literature selected to measure formal mechanisms of university knowledge transfer in the research instrument are presented in Table 2.2.
Table 2:2 Observable indicators for formal mechanisms

<table>
<thead>
<tr>
<th>Formal mechanisms of knowledge transfer</th>
<th>Theoretical basis</th>
<th>Author(s)</th>
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<tbody>
<tr>
<td><strong>In our organisation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract research with universities is part of our university knowledge search</td>
<td>Knowledge generation and research management</td>
<td>(Kneller et al., 2014, Enders and De Weert, 2004)</td>
</tr>
<tr>
<td>We have a long-term standing contract with a university researcher.</td>
<td>Knowledge Management</td>
<td>(Abdulai et al., 2015, Amessea and Cohendet, 2001)</td>
</tr>
<tr>
<td>We receive regular consultancy services from a university.</td>
<td>Knowledge Management</td>
<td>(Bourellos et al., 2012, Bessant and Rush, 1995)</td>
</tr>
<tr>
<td>We are guided by ideas from the work of academics.</td>
<td>Community engagement</td>
<td>(D’Este and Perkmann, 2010)</td>
</tr>
<tr>
<td>We share training facilities with a university for some of our training needs.</td>
<td>Knowledge production</td>
<td>(Abdulai et al., 2015, Burns and Squires, 2011, Ndonzuau et al., 2002)</td>
</tr>
</tbody>
</table>

2.11. Informal mode of university knowledge transfer

Informal mode of university knowledge transfer on the other hand is the transfer through personal contacts or relations between university researchers and individual entrepreneurs mostly facilitated by interactions within social networks. Informal mode of university knowledge transfer is known for its extensive tacit characteristics in its mode of diffusion and high intensity of relationships. It is defined as; ‘facilitating the flow of technological knowledge through informal communication process’ (Link et al., 2007, Bekkers and Freitas, 2008). For instance, informal communication agreement to offer advice or technical assistance, or a form of arrangement between a researcher and a firm that leads to a single stage or a continuous share of knowledge could be termed informal. Additionally, any form of knowledge dissemination
through to the firm freely and without stringent conditions is considered informal (Castro-Martínez et al., 2010, Winkelbach and Walter, 2015).

Arguably, informal mechanisms of university knowledge transfer remain the genesis of almost all forms of university interactions and strive better when there are intensive human interactions thereby making knowledge flow from its origin to recipients. This statement is supported by the network system theory (Brenner et al., 2011, Burt, 2001, Nelson, 1989) and social capital literature (Chenhall et al., 2010, Cohen and Fields, 2000, Gonzalez-Brambila, 2014) which have both explained how informal mode of knowledge transfer work. Notwithstanding, the literature is limited or silent on how they manifest on innovation performance or their significance on various industrial sectors of developing economies.

Actually, sometimes the difference between formal and informal mechanisms is blur and difficult to tel. In special circumstances some personal agreements may call for contractual relationships and therefore becomes legally binding on both researchers and firms. In this case, the mechanism then becomes a formal mode and covers the duties and responsibilities of both parties including remunerations for academics.

Invariably, informal mechanisms of university knowledge transfer are sometimes referred to as the ‘grey market’ of knowledge transfer and used by university scientists to outsmart normal university bureaucratic protocols to profit from their inventions (Bradley et al., 2013). To bring to light, in their study into open innovation, which is a recent development in innovation and knowledge transfer circles, de Wit et al. (2007) also concur that this grey market is not widely researched and warn that firms cannot rely totally on external knowledge sources though, particularly informal mechanisms, for competence. They suggest that other ways such as internal R&D will have to be supported to increase firms’ absorptive capacities in readiness for external knowledge inflow. Surely, this is the position of Kamien and Zang (2000) too. Following this, Mowery and Sampat (2005b) report that firms consider the use of informal interactions as very helpful to their knowledge capability enhancement. Conversely, Hagedoorn et al. (2000) are concerned that informal means of knowledge transfer cannot be tracked for any detailed study to add to the body of knowledge generation literature (Link et al., 2007). To add to the above,
evidence from the US manufacturing sector shows that, 90% of formal research partnerships within firms that are active in corporate research are created initially through informal contacts (Hagedoorn et al., 2000).

However, Rossi and Rosli (2013) also elucidate that open disseminated sources of knowledge have no evidence of impact on firms’ intellectual property nor economic growth and development. Comparatively, medium, small and particularly micro enterprises tend to depend on informal modes of university knowledge transfer to upgrade their knowledge of the market and affect changes in business operations (Thomas et al., 2006, Abreu et al., 2008). This may be the case because of a relatively lack of strong absorptive capacity and inability to fund research or engage in long-term projects (Sparrow et al., 2009, Fu et al., 2014). For this reason, the usual tactics for small firms happen to be acquisition of university knowledge from meetings they hold with researchers at either informal or semiformal levels, sometimes through conferences and from refereed journal publications (Bekkers and Freitas, 2008). In particular, there is a wide variety of knowledge transfer activities and firms strategically pick and choose those which suit their area of discipline, industry and even interest to take advantage of the market in which they operate (Samantha et al., 2013).

To reiterate, small and micro-enterprises, even start-ups, particularly in low income countries, mostly rely on their casual contacts, the benefits of social capital accruing from interactions with university researchers, which are considered informal form of university knowledge transfer (Link et al., 2007, Bailey et al., 2011). It is worth noting that the electronic media from the last part of the 20th century offered to firms a wealth of free and valuable informal means to university knowledge (e.g. software designed and distributed for free by academia) in advanced economies. On the contrary, most firms in less developed economies even up to now rely mostly on the very basic forms of informal means to university knowledge such was personal relations. Other recognised informal sources available in the literature are\textsuperscript{1}; student placements, text books, knowledge spill-overs, conferences, workshops and labour mobility where they acquire knowledge or absorb new ideas to improve on their business prospects or achieve incremental changes (Pittaway et al., 2004b). In most cases, chiefly, start-ups, obtain knowledge from their

\textsuperscript{1} For exhaustive list see Bekkers and Frietas, 2013
industry networks, publicly sponsored research, openly disseminated research outcomes, largely in the social sciences and humanities. For example, in the UK, the UK Department for Business, Innovation and Skills, the Royal Society and British Academy, and sometimes EU governments are the public funding sources that make much innovative ideas available for firms to strengthen their local and international competitiveness (Castro-Martínez et al., 2010, Mateso, 2014).

Given these points, there is a growing debate in the literature on whether research outcomes that are mostly sourced from these open disseminations are substantive and do actually impact on firms’ innovation. In fact, critics consider such sources as junk and superfluous to innovative intensions of firms. Similarly, others like Castro-Martínez et al. (2010) conclude that the so-called ‘productive’ use of informal modes of knowledge transfer mainly in the humanities and social sciences has no tangible reward. Namely, Edelman et al. (2004) also add that despite interpersonal connections emanating from social capital and being a catalyst to aid knowledge and information flow within a social setup, it is at the same time a disincentive for comprehensive search for information. Contrary to this though, Mowery and Sampat (2005b) have considered these forms of knowledge transfer as some of the most important mechanisms of accessing business ideas from the academia, universities and other institutions that generate knowledge. Other supporters of such a view are Bruneel et al. (2009), Abreu et al. (2008) and D’Este and Patel (2007).

Irrespective of the considerable interest in informal mechanisms of university knowledge transfer, research on it is quite scanty and relatively neglected by researchers despite it is used widely by all firms across the globe, particularly in developing economies as recounted here. This spell out a significant literature deficiency and this study takes the opportunity to fill it. The parts of the literature selected to measure informal mechanisms of university knowledge transfer in the research instrument are presented in Table 2.3.
Table 2:3 Observable indicators for informal mechanisms

<table>
<thead>
<tr>
<th>Informal mechanisms of knowledge transfer</th>
<th>Theoretical basis</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In our organisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>We have a working relationship with at least one university academic</td>
<td>Triple Helix</td>
<td>(D’Este and Patel, 2007, Power and Malmberg, 2008)</td>
</tr>
<tr>
<td>We work closely with at least one university department for guidelines on our operations.</td>
<td>Triple Helix and Open Innovation</td>
<td>(Bekkers and Freitas, 2008, Etzkowitz, 2000)</td>
</tr>
<tr>
<td>We follow the work of some academics for improvement in our process/services.</td>
<td>Triple Helix and Open Innovation</td>
<td>(Bourelos et al., 2012, D’Este and Perkmann, 2010)</td>
</tr>
<tr>
<td>We make use of research findings in our business area.</td>
<td>Knowledge dissemination</td>
<td>(Keller, 1996, Kremer and Williams, 2010, Meissner and Kotsemir, 2016)</td>
</tr>
<tr>
<td>We take keen interest in published academic literature.</td>
<td>Knowledge dissemination</td>
<td>(Pickernell et al., 2008)</td>
</tr>
</tbody>
</table>

2.12. Collaborative research

Collaboration between universities and industry has been an area of academic research focus for many years (Abreu et al., 2008, Freitas et al., 2013b). Accordingly, research on the concept has generated extensive literature and theories around how firms can benefit from the much talked about ‘third mission’ of today’s universities (Hughes and Kitson, 2012, Singh et al., 2015). There has equally been a worldwide policy discourse on the concept as an intervention for innovation for regional and national competitiveness and also takes the centre stage in the economic growth and development of nations. Notably, under the conditions of the third mission, universities are expected to produce relevant research outcomes; thus, provide ground breaking guidance for firms, research results that create business opportunities or new ways for development of new
technology for industry (Dooley and Kirk, 2007, Lundvall, 2007). Put in context, university-industry collaboration is documented in the literature to be critical in skills development and technology diffusion. It is arguably a platform for long-standing R&D, patent, spin-offs and start-ups and now a phenomenon recognised in both developed and developing economies (Anderson et al., 2007, Barnes et al., 2006). However, there have been very few studies on collaborative research that deals with how it comes about and influence innovation in developing economies at the sector levels. The link between collaborative research and other modes of university knowledge transfers in less endowed countries have not been thoroughly discussed in the body of literature either. Therefore the absence of literature on how industrial sectors respond to collaborative research provides no framework for policy makers to frame policies to reflect the needs of various industrial sectors.

Broadly, collaboration is also usually categorised into short-term and long-term again depending on the objective. In the short term, it may be on-demand or to solve corporate problems that are pre-defined and set as a target for the research project that is specific and close-ended. In the long-run it may be said that collaboration has general objectives, open-ended and very strategic in its definition of the research target objective (Cui et al., 2006, Dooley and Kirk, 2007).

However, Abreu et al. (2008) in their report on university, business and knowledge exchange states that in collaborative research, obtaining a productive outcome is not just about prescribing the objective of the project but the challenges of delivery even after a successful outcome are crucial. Accordingly, it is tedious and difficult as businesses want direct access to possessors of tacit knowledge and also the challenge of transforming tacit knowledge to explicit or codified knowledge to be used by clients is generally frustrating to both possessors and the beneficiaries. This is particularly worse if the absorptive capacity of recipients is low. What also features prominently, they warn, is tension on knowledge transfer and IP issues including the question of whether the knowledge created is commercially viable and valuable or even worth the effort and expense.

Researchers such as Barnes et al. (2002), state that the selection of project partners is primarily the fundamental element of collaborative research. Moreover, the success or failure of university-industry collaboration depends on which university is engaged for research project
(Sendogdu and Diken, 2013). Effectively, experience of prospective university, their knowledge transfer mechanisms with industry, the university researchers’ entrepreneurial characteristics and knowledge of industry are also essential (D’Este and Perkmann, 2010, Etzkowitz and Gebhardt, 2000). In fact, the nature of universities’ internal operational structures is also fundamental to collaborative success. Also, the overall university mission, the commercial orientation, research income and those of the departments and faculties are all clues to potential success or otherwise of a collaborative research project (D’Este and Patel, 2007, Huggins et al., 2012a). In addition to that, institutional factors and social embeddedness of tacit knowledge in both universities and firms may pose considerable hindrance to collaborative research and eventual knowledge transfer process, in particular across international frontiers (Smith, 2001, Kaymaz and Eryiğit, 2011). Above all, beyond this, organisational cultures, individual abilities and absorptive capacity of receiving organisations are all influential if collaboration is to make an impact (Sparrow et al., 2009, Singer and Peterka, 2009).

Likewise, in a quantitative analysis of data collected from 2,157 managers of higher education institutions in 33 European countries, universities were assessed on how they sustain collaborations with firms. There was clear evidence indicating effective support from two levels; one was strategic and the other was operational for all collaborations. In this study in question, communication was, though, not a factor that influenced the dynamics to a very large extent, it proved to be significant (Pertuze et al., 2010, Victoria et al., 2015). Scholars like Huggins et al. (2008) have however disputed this, stating that not all collaborative research results in capitalisation, licensing or bringing in financial reward, they further lament that despite the effort to co-operate and innovate, only a few of the supposedly cutting edge innovations have yielded intended impact for universities and firms. The same view is expressed by Sendogdu and Diken (2013).

In earnest, research has shown various instances where industry-university collaborations have proved successful; yielding patents, licences, IPRs and spin-off companies (Clancy and Moschini, 2013, Meyer-Krahmer and Schmoch, 1998). An example is the case of the Massachusetts Institute of Technology (MIT) in the US, spinning out up to 25,600 companies with a 3.3 million work force or the Silicon Valley project in California. Another example is the
Cambridge phenomenon in Cambridgeshire, UK or Canada's High-Technology City (Christopherson et al., 2008). These collaborations have been sponsored or co-funded by industries with various objectives. Through these collaborations, knowledge has also been transferred from region to region and across the globe (Huggins et al., 2008, January and Thomas, 2013).

Evidently, the examples given in the literature are clear illustrations from advanced economies and comparatively different on the continent of Africa and other developing economies which further highlight the literature limitations. This is supported by the suggestion that universities in developing economies are saddled in several areas and therefore are not apt in their set ups to productively collaborate due to years of financial neglect, leaving many universities with defunct research infrastructure (Atuahene, 2011, Mohamedbhai, 2008). That is not all, there is very little investment made in science and technology with unsupported economic development strategies (Mouton et al, 2008). For example, African economies and other developing nations around the world spend less than 1% of their GDP on R&D; this of course includes Ghana in the West African sub-region (Mouton, 2008). Arguably, there has been some evidence of university collaboration in developing economies even in the wake of scare resources. However there is very little literature discussing it at the sector level in developing economies and the current study seeks to add knowledge to that body of the literature by examining university industry collaboration in Ghanaian context. The parts of the literature selected to measure collaborative research in the research instrument are presented in Table 2.4.
Table 2:4 Observable indicators for collaborative research

<table>
<thead>
<tr>
<th>Collaborative research</th>
<th>Theoretical basis</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>In our organisation</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most of our collaborative project outcomes have been perceived as successful.</td>
<td>Organisational Learning</td>
<td>(Abreu et al., 2009, Kneller et al., 2014)</td>
</tr>
<tr>
<td>Our collaborative research team was able to publish at least one academic journal article.</td>
<td>Knowledge Acquisition and Dissemination</td>
<td>(Anderson et al., 2007, Bessant et al., 2012)</td>
</tr>
<tr>
<td>At least one of our collaborative project outcomes was filed for a patent.</td>
<td>The Knowledge of the Firms</td>
<td>(Bellamy et al., 2014, Dornbusch and Neuhäusler, 2013)</td>
</tr>
<tr>
<td>Some of our collaborative project outcomes have yielded new business practices/products</td>
<td>Organisational Knowledge and Practice</td>
<td>(Furmana et al., 2002, Meissner and Kotsemir, 2016)</td>
</tr>
<tr>
<td>We see collaboration as a way forward in building and maintaining our competitive advantage.</td>
<td>External Knowledge Acquisition</td>
<td>(Azzone and Maccarrone, 1997, Borrás and Edquist, 2013)</td>
</tr>
</tbody>
</table>

2.13. Technology transfer offices

Commercialisation of university research through technology transfer offices (TTOs) has been given a lot of attention in practice and in the literature lately (Landry and Amara, 2012, Guimon, 2013). For this reason, much has now been seen of such bureaus at local and international levels (Junior et al., 2014) where among other things, they take the role of assessing market potential of research findings from universities (Autio et al., 2004). Essentially, administrators of TTOs search for prospective investors for all sorts of agreements and licensing for university research outputs (Siegel et al., 2003a, Siegel et al., 2004).
While most of the literature acknowledges the significance of TTOs in university knowledge transfer (e.g. Lockett et al., 2005, Padilla-Pérez and Gaudin, 2014, Powers and McDougall, 2005, Singh et al., 2015), the literature is virtually silent on how they influence innovation in developing countries. This henceforth becomes imperative for scholars to expand understanding on TTO activities in those countries and even extend to how different sectors are affected by their work. A more specified study of how interpersonal relations affect TTOs and their role on innovation still needs to be considered for our understanding and extending the existing body of knowledge.

Within the research society, there is currently a debate with regards to the use of the terms Knowledge Transfer and Knowledge Exchange and while some thinks knowledge exchange represents the process better, due to its multi-directional transmissions of knowledge, the term knowledge transfer continues to dominate in the literature (Abreu et al., 2009, Bozeman, 2000, Goddard et al., 2012, Markman et al., 2005). Others even prefer knowledge sharing because of the ‘public good’ characteristics of knowledge, innovation and technology (Evstigneeva, 2015, Jacob and Meister, 2005, Lee, 1996). However, one could argue that there bear some similarities with some slight differences. Notable, while all knowledge transfer terms explain dissemination of knowledge, knowledge transfer can take a unidirectional transmission from its source to the recipient which is the line of inquiry in this study. It is considered to be the transfer of useful know-how or information across company lines. Breznitz and Etzkowitz (2016) define technology transfer as ‘the movement of particular inventions, entire technological systems or knowledge of how to construct them across national or organisational boundaries’. They note that technology occurs across time and space and while researchers debate over what it is to offer a widely accepted definition, they have not yet considered how the transfer happens at industrial sector levels. Research has not looked into TTOs activities in economies that cannot provide all the needed facilities for that to happen and our understanding is still limited in that area.

Technology transfer offices in some countries, for example: the US and France, where the concept has promoted successful research projects and yielded a lot of income for both universities and investors, breakthroughs and inventions in university settings are by law mandatory to be disclosed to a university TTO. Principally, this applies to research funded by the
governments (Bradley et al., 2013, Mowery and Sampat, 2005a). All of these have been efforts towards encouraging universities’ effective involvement in innovative activities with industry to influence firm’s competence and boost regional and national innovation systems (Lundvall, 1992, Bradley et al., 2013).

Alas, the literature on TTOs suggests that these attempts by policy makers have however since suffered some frustrations for years in the sense that some faculty members still circumvent the necessary guidelines and find their inventions in the market through informal routes due to deficiencies in TTOs’ administrative set ups (Siegel and Phan, 2005, Bekkers and Freitas, 2008). Mostly, some of these are because of lack of proper structures to streamline or supervise the work of university scientists. Typical examples are in developing economies (Padilla-Pérez and Gaudin, 2014, Rogers et al., 2001). In developing nations for instance, such rules have not been articulated and aligned to the general administrative objectives of universities and therefore difficult to check and take advantage of (Necoechea-Mondragon et al., 2013). A test case is the failure of the Technology Consultancy Centre (TTC) in Kwame Nkrumah University of Science and Technology in Kumasi, Ghana. Even with that, activities of TTOs in developing economies are vague in the literature (Islam et al., 2013, Mensah-Bonsu and Jell, 2011, Narteh, 2008) and development of a framework to guide the set-up, its activities and even training needs are highly recommended in the literature. The parts of the literature selected to measure TTOs influence in the research instrument are presented in Table 2.5.
Table 2.5 Observable indicators for TTOs

<table>
<thead>
<tr>
<th>Technology transfer offices</th>
<th>Theoretical basis</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In our organisation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We know of a technology transfer office (TTO) that mediates with the academics for us.</td>
<td>Technology transfer and Management</td>
<td>(Anderson et al., 2007, Macho-Stadler et al., 2007, Singh et al., 2015)</td>
</tr>
<tr>
<td>The technology transfer office available to us is useful in getting us the help we need.</td>
<td>Technology Management and Management</td>
<td>(Siegel et al., 2003a, Thomas, 2013)</td>
</tr>
<tr>
<td>Technology transfer offices are important for our core competence.</td>
<td>Technology Management and Management</td>
<td>(Rogers et al., 2001, Thomas et al., 2009)</td>
</tr>
<tr>
<td>We sometimes get useful information from technology transfer office(s) on new technologies.</td>
<td>Technology Management and Management</td>
<td>(Macho-Stadler et al., 2007, Mosey et al., 2012)</td>
</tr>
<tr>
<td>Technology transfer offices are essential for our business activities.</td>
<td>Technology Management and Management</td>
<td>(Hoppe and Ozdenoren, 2005, Singh et al., 2015)</td>
</tr>
</tbody>
</table>

2.14. Social network and knowledge networks

Although there is a growing body of literature on close association between innovation performance in firms and knowledge networks, there is still very little knowledge about how the networks influence innovation in less income countries. There is equally no knowledge on how networks influence sector specific innovation performance in such countries for our reference. There is a current shift of innovation process from a phenomenon that is closed and takes place within internal systems of firms to a more open system that relies on ideas of the vast majority of world researchers. This is a system that offers limitless opportunities in the knowledge value chain from actors for new products and services (Chesbrough, 2003). Certainly, the development of network theory has contributed to enrich further understanding on the relevance of knowledge
networks in university knowledge transfer process. Nonetheless, definitions of knowledge networks, their formations and relevance to firms’ innovations in weak economies still remain largely under researched.

Without doubt, knowledge management researchers have some differences in the way they view knowledge networks. Whilst some view them as a third form of organisation, others conceptualise them as hybrid forms of organisations that tend to fill the gap between markets and hierarchy. One could support the latter view on the basis that both market and organisational hierarchies could be seen to contain elements of an organisation. Also, differences continue to linger around in the way knowledge networks are viewed; thus, depending on the specific purposes of a network. For instance, Thomas et al. (2006, p. 434) define networks as ‘associations of companies and employees committed to innovation’ and the micro-view of the definition here can be obvious. Stated differently with a macroscale of knowledge gathering, Smith (2007, p. 3) explains that: ‘...Networking directly determines the innovative potential of firms – and entire economies. In turn, this drives our prospects for sustainable development and wealth...’ Obviously, some regions tend to be more competitive than others in terms of levels of intensity of university research, economic activities, available human capital, presence of innovation-intensive universities and other research institutions which are pretext for knowledge networks (Huggins et al., 2012a, Johnston and Huggins, 2016). This may imply that organisations will have the propensity to network if they are located in regions where there are opportunities available and attractive to other groups, experts and organisations (Kim and Lui, 2015, Perez and Sanchez, 2002).

In any case, knowledge networks are crucial for knowledge transfer, organisational competence and sustainability (Bozeman, 2000, Huggins et al., 2012a). However, the tendency to network to a large extent is influenced by certain characteristics of firms too and therefore varies between organisations as the reasons and benefits of networking are not uniform (Pickernell et al., 2006, Perez and Sanchez, 2002). This also includes the technical capabilities which are internal to firms. In most cases, small organisations concentrate on networks to help them gain access to knowledge within their regions that will help them solve some technical problems bordering their business operations whiles large organisations target issues of core-operations and
competence when joining networks (Lee, 2011, Pickernell et al., 2006). In another context, it is clear that small organisations will want to join knowledge networks because they cannot commission projects and unilaterally bear the cost compared to larger firms (Huggins et al., 2012a).

Low transaction costs and risk sharing have been consistently reported as primary benefits of knowledge networks and clusters locally or internationally in the network literature (Murphy, 2011, Christopherson et al., 2008, Hitt et al., 2002). Researchers have agreed that interactions among firms and universities within networks offer an exhaustive exploitation of the benefits of social capital to the advantage of all members (Lundvall, 2004, Lin and Si, 2010). In principle, it also suggests that social capital constitutes gains that accrue for being in a particular set-up. Put in another context, firms stand to gain access to knowledge resources for innovation they would otherwise not get, for belonging to certain social networks (Burt, 1992, Cohen and Fields, 2000). Additionally, relational theorists (Hitt et al., 2002, Moran, 2005), consider relationships in a social setting as a fundamental aspect of social capital. For this, Walker et al. (2000) investigates social capital, structural holes, and the formation of industry networks and elucidates the significant role interconnectedness plays in closing structural holes (linking disconnected individuals) in networks for the benefit of larger societies. As matter of fact, the theory is in consonance with the work of Xiao and Tsui (2007) who express that, for example, in a social network there is bound to be easy access to vital information for innovation for all members, solidarity among parties and sometimes power to influence decisions and for advocacy campaigns among other things.

In another development, firms in geographical areas and disciplines are encouraged to cluster or form networks and re-enforce innovation processes for the benefit of members and good of larger societies (Huggins et al., 2012a, Pittaway et al., 2004b). However, it is shown in the literature that human variables, environment, economic conditions and culture or even organisational routines sometimes hinder knowledge transfer processes in networks (Keeble and Nachum, 2001, OECD, 2005b).
Of late, governments have taken it upon themselves to create and facilitate networking between universities and businesses to boost innovation performance in all areas of businesses and disciplines through loyalty and mutual interest, though not sufficient for success as advocated by Pickernell et al. (2006). An example again is the UK government that has set up the UK Knowledge Transfer Network (KTN) for this purpose in about twenty different fields (Abdulai et al., 2015, Sainsbury, 2007). In like manner, with the launch of ‘Open Innovation’ model in recent years, organisations have opportunities to access knowledge they hitherto would not have had without opportunities that underlie networking (Chesbrough, 2003b, de Wit et al., 2007, Huizingh, 2011, van de Vrande et al., 2009). On this premise, it could be argued that the open innovation framework could be modified and used by countries with special circumstances that are different from the original place of birth of the framework.

However, studies of network systems suggest that social capital may not be useful for innovation if there is no general consensus and shared understanding, beliefs and common set goals within groups (Adler and Kwon, 2000, Nahapiet and Ghoshal, 2000). In like manner, researchers have also reported that social capital does not help when there are stronger links within smaller groups or sub-units with unique sub-cultures; for example, within departments than links within larger groups as in a whole firm. Most of all, Edelman et al. (2004) explains how, social capital in larger organisations or knowledge networks can be worse for innovation if institutional structures are unreliable, not trustworthy and may present some devastating setbacks. In situations of social meltdown for instance, where networks lose trust among members, an entire firm or state could become chaotic, dysfunctional and innovation performance will not be achieved.

On a stronger note, it is widely agreed among researchers that, no individual organisation holds the credit of having all expertise and resources to exclusively develop successful innovation, given the diverse nature of skills and knowledge required to achieve all organisational innovation targets (Chesbrough, 2003b). That was why Chesbrough (2006) concluded in his public lecture on ‘Open innovation and open business models: A new approach to industrial innovation’ in 2006 under the theme ‘Globalisation and open innovation’ stating that;
‘Good ideas are widely distributed today. No one has a monopoly on useful knowledge anymore; innovation is now done within networks of firms, rather than within a single firm. Not all of the smart people in the world work for us’ (Chesbrough, 2006).

Clearly, this is seen to be in concordance with Wilson’s (2012) report on business-university interactions that emphasises that no university has all the expertise in all the domains to deliver the needs of industry. Indeed, firms need to join with knowledge networks to access appropriate knowledge for innovation, business development and core competence that will lead to wealth creation and economic development.

To further support this, in a review of evidence of networking for innovation, Pittaway et al. (2004b) indicate that organisations that do not network externally either formally or informally stand no chance of accumulating organisational knowledge base thereby restricting their ability to further engage with other important individuals and organisations. In this review, they find proof of major paybacks of networking as primarily, a direct and fast route to external market, a reservoir of external knowledge and skills, access to sometimes free new technology and market, and above all risk sharing (Amessea and Cohendet, 2001, Grabowska, 2015). Notwithstanding, knowledge networks sometimes may not offer competitiveness because competitors will also have access to the knowledge in the open market since it becomes a social good and free for all (Michels, 2015, O’Connor et al., 2011).

Focusing on knowledge networks as a new organisational form in emerging economies and South African in particular, Kruss (2006) investigates knowledge networks, of course, made of universities, industry and intermediary partners in seven cases and finds some complexities in research partners in networks in terms of structures and dynamics of interactions. The complexities are found to render networks dysfunctional across board in reference to the cases looked at. The study also finds neither contextualised analysis nor cross-sectoral coordination framework for informing any interventions for networks within a national system of innovation in developing countries.

The study therefore calls on governments to enshrine network formation in national innovation and economic policies as a desirable element in the knowledge and innovation infrastructure in
all industrial sub-sectors. However, the lack of a framework that identifies knowledge actors and their roles in networks constitutes a big challenge and disincentive to firms even though industries know the potential advantages they present in terms of research knowledge. This could mean that developing economies require a strategic guidance in the area of network formation. As of now, issues relating to knowledge network formations, their benefits, outcomes, future possibilities and limitations remain largely under researched in developing economies and therefore require thorough studies. The subject matter for this study is on university knowledge and its transfer to firms so after discussing knowledge networks it will be apt to delve into discussion on what the concept of knowledge and what it is to firms, and the next section deals with that. However, the parts of the literature selected to measure knowledge networks influence on innovation in the research instrument are presented in Table 2.6.

**Table 2:6 Observable indicators for knowledge networks**

<table>
<thead>
<tr>
<th>Knowledge networks</th>
<th>Theoretical basis</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Our organisation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is part of an association that aims for improvement in our business practices through knowledge sharing or products?</td>
<td>Network theory</td>
<td>(Bessant et al., 2012, Brown-Luthango, 2012)</td>
</tr>
<tr>
<td>Is active in connecting with other bodies to share ideas on our business prospects.</td>
<td>National and Regional Innovation System</td>
<td>(Grabowska, 2015, Huggins et al., 2008)</td>
</tr>
<tr>
<td>Is in a region where there is a university that has connected us with other important bodies that are crucial to our organisation’s access to new ideas.</td>
<td>Proximity Theory</td>
<td>(Huggins et al., 2008, Huggins et al., 2012a)</td>
</tr>
<tr>
<td>Gives attention to established systems that aim at disseminating a wealth of knowledge in our business interest area.</td>
<td>The theory of Social Capital</td>
<td>(Ponds et al., 2010, Theodorakopoulos et al., 2014)</td>
</tr>
<tr>
<td>Sometimes works with agents that open opportunities for us to gain skills that we need for our business success.</td>
<td>The Theory of the Law of Agency</td>
<td>(Rutherford and Holmes, 2008, Shinn, 2002)</td>
</tr>
</tbody>
</table>
2.15. **Concept of knowledge of the firm**

The significance of this section is to provide a brief discussion on the concept of knowledge in general and knowledge of the firm as a repository and a framework from which the current study obtains its data for empirical analysis. Since innovation measurement at firms' level emanates from knowledge and experiences of its human elements, discussion of human knowledge could provide a good springboard for understanding how the data ties up with the subject matter of the study.

To start with, just as the field of philosophy continues to generate great controversies in the effort to understand the real world, so is the discipline of epistemology tries to explain human nature in the wave of conceptual debates and disagreements over what is logical or ethical in terms of methodologies and approaches in understanding the real world. Amidst these, epistemologists have tried to answer one of the first, oldest and most important epistemological questions; ‘*What is knowledge?*’ Over years but still locked up in discrepancies over what is it (Audi, 2011). However, the knowledge management literature on the theory of knowledge has come to embrace the different perspectives from which knowledge researchers have tried to explain knowledge (Alavi and Leidner, 2001, Gourlay, 2006). On the one hand, epistemological researchers view knowledge as an object or an entity that can be directly observed and studied and it is from this strand that it is believed can be stored and successfully transferred to be reused again (Alavi and Leidner, 2001, Garaveill et al., 2002). On the other hand, some researchers view knowledge as a process which takes an interactive mode to manifest changes among individuals involved in the forms of skills and capabilities (Garaveill et al., 2002). For this study, both perspectives have relevance; first because as an entity or object knowledge is created, stored and transferred, and as process, it employs individual capabilities and skills as mechanisms to move organisational activities from one stage to the other in a more effective and efficient way.

Actually, understanding knowledge becomes more ambiguous when it is defined from other field of studies. For instance, information technology (IT) literature tends to explain the theory of knowledge along the lines of data and information to distinguish between them (Alavi and Leidner, 2001). Most definitions are vague and do not capture it as either an object or process. Nonetheless, a more generally cited definition of knowledge in the management literature that is...
based on personal beliefs and values that are accumulated through experiences, reflection, or inferences (D’Este and Patel, 2007, Lahti and Beyerlein, 2000, McCann and Ortega-Argiles, 2013) states it as a ‘justified true belief that increases an entity’s capacity for effective action’ (Audi, 2011, Nonaka, 1994). This definition will be the basis for our further discussions of knowledge and its transmissions.

To put it into the context of how knowledge is gained and transmitted, it can be seen in three perspectives; thus; through motor skills, experience and research, and explained in details in Table 2.7.

Table 2:7 Knowledge in perspectives

<table>
<thead>
<tr>
<th>Motor skills</th>
<th>Through experience</th>
<th>Through research</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Abilities of various kinds; this is the human cognitive abilities that are manifested as a result of learning processes. It encompasses the ability to remember, recollect, identify and a way to a place. This even determines the motor skills and abilities to learning at the early period of infancy.</td>
<td>• Another type of knowledge involves acquaintance and familiarity. It also covers personal experience and corresponding recognitional abilities. A person can know fear and love, have personal experience and also able to appreciate disappointments or even know a particular location.</td>
<td>• The last is about facts gathered through a study, an observation, or by experience. With this type of knowledge one makes a vivid conclusion that is inferred from a fact.</td>
</tr>
</tbody>
</table>

Source: Bruce (1990)

Based on the above premise, the management literature recognises that people within firms are deemed to be indispensable players in knowledge development and its subsequent transmission
as noted by Lam (1998) and D’Este and Patel (2007). Similarly, Kogut and Zander (1992) contend that firms exist to facilitate the generation of knowledge and to transfer knowledge created among key players themselves within organisations. Ideally, it is established in the extant literature that knowledge after generation is also exchanged with external partners in knowledge networks for mutual benefit in terms of innovation, profit generation, firms’ competence and competitive advantage (Bradley et al., 2013, Kogut and Zander, 1993, Su et al., 2015).

Following this, firms as social entities also generate knowledge of their own internally, exchange with other firms, universities and institutions through several mechanisms in a complex network within which they all form part (Kogut and Zander, 1992, Kogut and Zander, 1993). Such mechanisms remain as unique strategic resources to firms with superior knowledge (Su et al., 2015, Parayil, 1991).

Researchers differentiate explicit knowledge from tacit knowledge by the fact that explicit knowledge can be expressed, codified and presented (Zack and Street, 2007). Codified knowledge can be emulated through social contact, education and training (Bessant et al., 2012, Byosiere et al., Kraaijenbrink et al., 2007). This latter type of knowledge of the firms (tacit) is subconsciously mastered and needs intense personal interactions to transfer and also flows as externalities or spill-overs to other firms sometimes not primarily intended. The two constitute important facets of a firm’s knowledge and work hand-in-hand, shape the knowledge body of firms and create combinative capabilities for firms’ technology and market opportunities (Reber, 1989, Smith, 2001, Wynn and Rezaeian, 2015, Jensen et al., 2007).

Other forms of knowledge that researchers have identified and categorised are human, social, and structured knowledge, which reflect levels of learning involving individual, group, and organisational respectively (Borrás and Edquist, 2013, Byosiere et al., 2010). All of these collectively form part of organisational knowledge repository that the current study has relied on for data. However, the discussion of these types of knowledge in details is outside the scope of this study.
Researchers like Einsehardt and Martin (2000) have argued that the resource-based view theory underscores the dynamic capabilities of firms which they term as a set of specific and identifiable processes. They define it along the lines of product development, strategic decision making and alliances. Whilst this argument suggests that firm’s internal resources form a model for the firm’s growth, another perspective supported by Lechner and Dowling (2003) suggests that inter-firms networks also constitute firms’ knowledge resources for growth and wealth creation based on network systems theory. Based on the two perspectives, it stands to suggest that firms grow as a result of a combination of both internal and external resources available to it (Zack and Street, 2007). It is even a consensus among economists that economic growth is a function of both tangible and intangible resources and therefore supports the knowledge management strategic theory that, for superior knowledge and competitive advantage, firms must combine all resources (Zack and Street, 2007). Implicitly, it is clear that firms that extensively exploit knowledge repository know more than their competitors and stand a very good chance of enjoying competitive advantage from their knowledge.

In contrast to this view, Zack and Street (2007) warn that merely holding or controlling a resource, be it internal or external, does not guarantee its effective exploitation to create value for a firm. They argue that creating new knowledge that will be unique to a firm requires some level of combinatorial capability; thus, the ability to combine previously held knowledge somewhat perfectly with new knowledge. Not just that, in new ways they claim. Both knowledge and strategic management literature hold it that innovative firms with strategic knowledge must have the ability to close the ‘knowing–doing gap’ (Pfeffer and Sutton, 2000). This means that, firms need to deliver products and services that are valued by the market through the exploitation of knowledge they possess. Generally, it can be postulated that knowledge management (KM) capabilities are crucial for firms to effectively and efficiently source and apply knowledge in their activities (Yusof and Bakar, 2012).

Eisenhardt and Santos (2000) also draw attention to the fact that market boundaries turn blurr sometimes and successful business models also become unclear making market players ambiguous and in constant shifting mood. To demonstrate the significance of research on human subjects as respondents and justifying the choice from an epistemological point of view, we note
that individuals are essentially the primary agents of the knowledge of firms (Smith, 2001, Audi, 2011). However, individuals are constantly moving within their social network due to labour mobility but firms do not really change much because of that (Kogut and Zander, 1992). This indicates that firms are the custodians of their own knowledge. Firms preserve knowledge, thus; norms, beliefs, behaviours, cultures and values, maintaining organisational innovative momentum for sustainable advantage (Hitt et al., 2002, Edelman et al., 2004, Murphy, 2011).

To demonstrate further, in an investigation to understand modes of human learning in social networks and for innovation in organisations, Jensen et al. (2007) whose findings parallel with existing literature and that of Smith (2001) also uncover two major and similar forms of knowledge explain that; human agents in some firms in their area of production, learn through codified knowledge that is scientific and very technical in content – this is, the Science, Technology and Innovation (STI) mode of learning. In other firms, they continue, learning in an organisation is through the experienced-based mode of learning; thus, Doing, Using and Interacting (DUI-mode). Also, depending on the context, academic literature shows that the two have been effective both at firm’s competence building level, and to a larger extent, at regional and national economic development levels (Reber, 1989, Smith, 2001). Even with either modes of innovation in firms, evidence further suggests that firms can no longer survive in isolation (Pittaway et al., 2004b, Bessant et al., 2012). Largely, this is because the growing demand of the complex knowledge-based economies of today requires firms to take full advantage of the knowledge stockpile of networks within which they are a part (Singh et al., 2015, RSA, 2007, Wang and Lu, 2007, Ylinenpää, 2009). As Chesbrough (2003b) rightly put in his public lecture that ‘...Not all of the smart people in the world work for us’. By this, he draws the attention of corporate bodies that effective interaction with universities and other institutions is vital for firm-level innovation and for industrial sectors (Tetteh and Essegbey, 2014, Chesbrough, 2006, Chiaioni et al., 2011, Christopherson et al., 2008, Cohn, 2013). However, Pittaway et al. (2004) warn of network failures and limitations to innovating firms, indicating that inter-firm conflicts could arise among firms during interactions. Added to that, available literature shows that external disruptions and lack of system infrastructure could also pose serious problems for firms in any interactions which are typical cases in developing nations (Cloete et al., 2011, Fu et al., 2014, Kaymaz and Eryiğit, 2011).
The literature relating to knowledge of the firm discussed above is predominantly dealing with cases prevalent in developed countries. For knowledge generation and management in developing countries in general, the challenges are more complex to develop new competencies in firms through dynamic learning. Some of the reasons for the challenges are attributed to political and economic complexities (Kale and Little, 2005). Above all, the lack of existing theoretical frameworks is limiting the studies and analysis of the process of knowledge generation thereby providing no template for firms to learn and generate knowledge to increase their technical capabilities. Therefore, firms’ knowledge continues to remain low and technical capabilities are described as weak in developing countries. The above claim is also clearly stated by Kale and Little (2005) in a study into ‘knowledge generation in developing countries that tries to develop a theoretical framework to help explore dynamic learning in high–technology firms’.

The broader analysis of firm-level knowledge generation, learning and innovation performance in developing countries actually requires theoretical frameworks to guide the exploration and analysis of institutional environments which largely play significant role in creating ideal atmosphere for firm based learning. Generic firm-level innovation frameworks, clearly showing stages, processes and mechanisms on how university knowledge is transferred to firms in developing economies are definitively required in the literature.

### 2.16. Conceptual framework

Evidence from the review of the literature (e.g. Brown-Luthango, 2012, Decter et al., 2007, Dubickisa and Gaile-Sarkanea, 2015) in the previous chapter shows that university interactions with businesses, where knowledge is transferred to firms, is significant for innovation and wealth creation. It also shows that firm’s competitive advantage emanates from knowledge resources and not necessarily physical resources as claimed by the traditional economic growth principle of superior land, labour and capital. Moreover, Street (2007) claims that firms that do more in knowledge acquisition will definitely do better than their competitors in the market. With this established, innovation and university knowledge literature has since ignored knowledge transfer links between universities and innovation performance at industrial sector level. Neither has the literature concerned itself with how universities interact with firms and transfer knowledge for
innovation in developing economies. Also, very little is known about formal and informal mechanisms of university knowledge transfer in low income countries, therefore compelling the need for the development of a university-industry interaction-innovation framework to care of that.

Notably, the process of building a conceptual framework is ‘tricky’ and requires a precise body of knowledge, which should also be drawn from a large volume of literature. However, the construction of a framework, or its selection, is generally purposive and guided by the objectives of the study. Thus, the dimensions of the research problem are important together with data needed to be collected for eventual analysis. In that sense, the study draws evidence from existing body of knowledge, discusses several generational innovation models and proposes a research framework in this section to examine university knowledge transfer at industrial sector level in Ghana. It goes further to find out how formal and informal mechanisms of university knowledge transfer influence innovation in firms in the country. Research hypotheses are formulated from the framework to help address the study main purpose and can be used in other developing economies.

To begin with, the proliferation of innovation models and specifically firm-level innovation frameworks dates back to the 1950s when researchers tried to explain the process of innovation in industrial firms (Rothwell, 1994, Hobday et al., 2012). During the post-war years, scientists depicted the process of technology transfer and innovation as a smooth, sequential and linear process from start to finish. Namely, the so-called ‘technology push’ models (Goddard et al., 2012, Meissner and Kotsemir, 2016), seen in Figure 2.1, offered simple and discrete procedural steps to explain how technology is transferred to firms in the industrial world.
In this model, to explain, a university researcher makes a discovery and discloses to TTO, which then evaluates and determines the market potential for patent or licence with entrepreneurs (Siegel et al., 2003b). Next, the result could be licensed to an existing firm for the market or a spin-off company could be a possibility if deemed appropriate in the market for the new technology (Macho-Stadler et al., 2007, OECD, 2005a). Eventually, in this sort of deal, the researcher may still be needed to monitor the progress of work and how the product is doing in the market or where the university is still a party to the proprietary, both the entrepreneur and the university will co-own and share royalties (Hobday, 2005). Further development in the innovation literature makes it clear that the linear model was too simple to capture the complexities of knowledge transfer in such a straight forward process. As Kline and Rosenberg (1986b, p. 285) rightly put is, ‘innovation is neither smooth nor linear, nor often well behaved’. They were found to be seriously flawed and did not represent the process. For instance, they did not take into consideration the needs of the market. Also the concentration was on just investment in science depicting only ‘technology-push innovation’ (Borrás and Edquist, 2014, Caraça et al., 2007).

The second generation innovation models came in the 1960s and began to address issues that were found in the previous models and those that limited the explanatory powers of the models (Caraça et al., 2009). They also incorporated the components that underestimated the intricacies
of knowledge transfer to firms. To illustrate, a diagrammatic representation of the process is presented in the model in Figure 2.2. Although these, were still linear, they adopted a market need strategy into the process to respond to the needs of customers and other stakeholders. In effect, this changed R&D focus to ‘demand-pull’ technology (Hughes and Kitson, 2012, Lundvall, 2007). However, once again, a lot of intricacies were missing, for example, the feedback loops between sages were not given attention and there were no interactions between actors catered for in the models. They were still linear and therefore just did not show the constant interdependencies between the stages and actors in the models and failed to solve the problem (Borrás and Edquist, 2014, Caraça et al., 2007).

Figure 2.2 Generic second generation innovation model

![Figure 2.2 Generic second generation innovation model](image)

The models of the 1970s adopted a further pragmatic look at firm-level innovation and technology from external sources and universities. On this occasion, innovation was then seen in these models as integration between science and technology (S&T) and market demands (Mowery and Rosenberg, 1979). As presented in Figure 2.3, they were characterised by feedback loops and R&D was more of a customer oriented activity, more representative of the intricacies of innovation and started to see the entire process with linkages to other institutions with multiple interdependent stages. Rothwell (1994) explains that, this was the stage where the models started to become interactive and there was a link between decision makers in firms and S&T. Yet still, they presented the process as sequential and lack some element of fundamentalism in the interactions (Hobday et al., 2012, İzadi et al., 2013, Kotsemir and Meissner, 2013).
However, just as definitions of innovation over the years have failed to capture the process exhaustively from inception in the literature, so have the models of university knowledge transfer/innovation failed to offer a robust framework for the process. In fact, further development in the literature found a lot of inaccuracies with the linear models; primarily with the belief that knowledge/technology is transferred in a unidirectional causality and flow from science invention to technology and from technology to the market for economic gains, which has been widely criticised (Rothwell, 1994). This strict linearity and oversimplification of innovation process actually distort the factual innovation practice as it is now understood to be a complex system with intricacies and feedback loops from the start to commercialisation and economic development. Critics believe that, many facets are overlooked in the linear models and that for these models, knowledge is solely R&D-driven or supply-driven. One major limitation levied against these models is the claim that what is in the market is a product of R&D outcome with little element of market or customer centralism (Goddard et al., 2012, Hobday et al., 2012).

Above all, the traditional models are also blamed for their composition and the systematic arrangement of the components of the process of innovation. In reality, researchers now believe that the process is not rigid; it is nonprocedural as some of the stages can be preceded by others at different times and in different circumstances. Crucially, the linear models also assume a ‘one-size-fits-all’ status and a standard phenomenon is prescribed in the model for all forms and categories of knowledge transfer and innovation processes. Today, there is a consensus among
researchers that it is a serious violation of contemporary innovation principles. Indeed, each transfer process is different and all innovation processes vary in accordance with the purpose and target of commercialisation (Groenewegen and van der Steen, 2006, Michels, 2015). Lastly, their fixed expectation on patents is also strongly accused in the literature (Caniels, 2005, Mensah-Bonsu and Jell, 2011). To avoid these limitations, further development led to another set of generational models.

Quite apart from that, the first generation models also failed to incorporate industrial sectors of economies of nations for innovation analysis. Not just that, knowledge transfer along the line of formal and informal relations between universities and firms were not considered and totally neglected. To add to the above as a flaw on the part of the linear models, they did not explain how universities’ knowledge could be transferred to firms in less developed economies where a majority of small to medium size owners and entrepreneurs have very low education, low technical capabilities, no research infrastructure and where very few people have access to credit (Murphy et al., 2018). Again, a further work was undertaken for improvement which brought in another set of generation models also discussed next.

Next, the 1980s also saw the influx of the fourth generation models that brought in higher order of models with overlapping activities of departments and cross functional amalgamation of activities of firms and other institutions including local and international universities (İzadi et al., 2013, Rothwell, 1994). These models represented in Figure 2.4 recognise the role of suppliers, customers and government agencies alike. An example of this is the innovation model in Japanese automobile firms that used such integrated models in the 1980s with overlapping department activities (Rothwell, 1994).

Furthermore, Figure 2.4 shows how companies concentrate on core business activities like marketing and R&D on core technologies. These models focus on knowledge accumulation with increasing awareness of their strategic importance. Emphasis thereby is placed on manufacturing strategies achieved through alliances between companies. Increasingly, the immediate advantage is the enhancement of product life cycles as a result of inherent time-based strategies and parallel development of technology in the integrated model (Hobday et al., 2012, İzadi et al., 2013,
Kotsemir and Meissner, 2013). Upon all these effort, less capable firms and the environment of less developing economies have not been recognised. Other mechanisms like knowledge networks, collaborative research and even social interactions among actors were not factored in the models therefore action needed further development.

**Figure 2:4 Example of the integrated fourth generation innovation model**

![Diagram](Source: Graves 1987)

Subsequently, the post 1990 fifth generation models of innovation introduced a further integrated system with a network of interconnected institutions and overlapping departments and activities. As an upgrade of the fourth generation models, these models came with corporate alliances, vertical and horizontal relationships among partners, suppliers, customers, joint ventures of all sorts and offered much more flexibility to firms (Hobday et al., 2012, Rothwell, 1994). The models were a result of external pressure from inventors, global demands for better products, turbulent economic environment, more competition and pressure from funders of R&D. Largely, in response to today’s knowledge-based economies of the world, the post 1990 fifth generation models could not have come at a better time.

Accordingly and prominent among the post 1990 innovation models were the features of national innovation system (NIS) framework. This framework puts firms and innovation activities within it at the centre of interconnected spheres of universities and institutional structures of the larger economic system. For this concept, firms do not innovate unilaterally but collaborate as part of the larger economic system that collectively influences the development of innovation and
subsequent diffusion for the good of the entire society. Again, this framework is traced to the original work of Christopher Freeman and Bengt-Ake Lundvall and was used to analyse the rise of Japan in the 1980s (Goransson and Brundenius, 2011, Mathew, 2016). Despite the effort, the framework has no empirical evidence of success in reality, particularly in developing economies and could only be described as a theoretical fact, drawn from abstraction and conceptualisation of intellectuals for testing data and further theory development (Mowery and Sampat, 2005a, Singh et al., 2015).

Another widely important model in innovation circles, which can be traced to the pioneering work Etzkowitz and Leydesdorff in the 1990s, is the Triple Helix model of University-Government-Industry interaction. This calls for an interface between three knowledge generation actors to relate with one another in an overlapping interface where actors take up the traditional role of each other in an ‘innovation space’ (Etzkowitz, 2003, Jauhiainen and Suorsa, 2008). However, it is widely acknowledged in the literature that innovation models lack realism, are seriously flawed and vague, as they appear without substance, and may be considered arguably deterministic and simplistic with usually ‘a single best way’ as suggested for innovation across all industrial sectors (Danermark et al., 2002, Pratschke, 2003).

Specifically, during almost the same period, Michael Gibbons (1994) and his colleagues introduced mode 2 knowledge production as against mode 1 where they looked at the dynamics of science and research in contemporary societies, published in 1994 (Fujigaki and Leydesdorff, 2000, Gibbons et al., 1994). In their view, innovation is in the context of application in social and economic problem solving, it is transdisciplinary with skills mix from all relevant disciplines. As a result, innovation is also considered to emerge from a heterogeneous group of many different institutions and organisations which are in turn accountable to the larger social world (Abreu et al., 2008, Bessant and Rush, 1995). Basically, it is also seen as novel quality control where the diversity of players and expertise help to ensure a better approach and more proactive project outcomes are obtained. Nonetheless, Gibbons et al. (1994) have in reality admitted that the mode 2 model is not intended to replace the mode 1 model but the two will co-exist and that their co-existence will depend on how institutions already using the mode 1 will respond to it. In any case, fifth generation modelling had accordingly brought in a more pragmatic and flexible way
of looking at transfer of university research knowledge for firm-level innovation stretching to the emerging sixth generation models (Bradley et al., 2013).

Nevertheless, the framework does not cater for informal mechanisms of university knowledge transfer or factor in organisational cultures and attitude of both universities and firms. More so, very little is mentioned of the soft (hidden innovation) aspect or non-technical innovation (marketing and advertising), not even macroeconomic conditions and their effects are well explained (Hobday, 2005, Léger and Swaminathan, 2007).

Lastly, even with that, the relatively sixth generation models were introduced in the 2000s by Chesbrough (2003a) in an attempt to factor the entrepreneurial university concept into knowledge transfer. The Chesbrough (2003a) concept captures mainly the knowledge search framework adopted by multinational corporations like IBM and Proctor, and Gamble in the later part of the twentieth century when labour mobility became another channel for technology diffusion (Bradley et al., 2013). Researchers have agreed that there are a lot of useful ideas nowadays found in the open, among experts dotted around the globe and this needs to be tapped. In his words, Chesbrough (2003a, p. 41) rightly articulated that ‘useful knowledge has become widespread and ideas must be used with alacrity. If not, they will be lost’. Actually, the open innovation model encourages firms to look outside for state-of-the-art ideas to tap for competitive advantage. The concept is applied to all sorts of firms, institutions and universities around the world. In this framework, firms now open up to external partners to jointly generate knowledge to meet market needs. As opposed to closed innovation, firms can enhance their internal R&D effort with knowledge from outside and university spin-offs can be licensed to other firms for commercialisation (Chesbrough, 2006, Chiaroni et al., 2011).

One may argue that there is no perfect system out there yet, one that can capture the significant components of technology transfer and innovation happening in firms (Michels, 2015). Additionally, the process is complex and the intricacies cannot therefore be captured in a single framework. Another reason is that industries differ vastly and firms are petty limited in their knowledge search as they struggle for market advantage to make profits to satisfy their customers, shareholders and owners at the same time (Tetteh and Essegbey, 2014, Thomas,
In fact, incentives offered to scientists for their hard work play an important role in the success of university-industry interactions but innovation models do ignore them and need to feature them prominently in any attempt to mimic the real innovation process (Kremer and Williams, 2010, Sainsbury, 2007).

2.17. Conceptual model and hypotheses

The alternative view of university technology transfer model in Figure 2.5 is dynamic, flexible and typical of modern day innovation features as stated above. It incorporates all possible components of innovation process and caters for smooth flow of technology (Bradley et al., 2013, Perkmann et al., 2013). One other element in the model is that it overcomes the majority of the limitations of the previous models, particularly those of the first generation models of innovation (Hughes and Kitson, 2012). Perhaps, as one of the latest alternative, the model places greater emphasis on open innovation from university technology/knowledge transferred to firms as opposed to closed innovation (Chesbrough, 2006, Gassmann et al., 2010). This is where entrepreneurial universities are placed higher up on the agenda for effective national innovation system and even goes beyond the famous framework by Bayh-Dole; a policy framework that encourages a network of active university involvement in a transparent and cooperative manner for commercial research and economic development (Christopherson et al., 2008, Mowery and Sampat, 2005a).

More so, what is unique and practical about the alternative model is that it works with both soft and hard influencing factors of university technology transfer, taking into consideration the effective research activities and practices, the funding structures, institutional settings and legal environment (Murphy, 2011, Edquist, 2006). In addition, it incorporates a reward system that influences academic involvement, proximity to high-tech firms and TTOs, the role of joint facility co-ownership and laboratory facilities, the position of spin-offs in the technology transfer path, joint publications and IP (D’Este and Perkmann, 2010, Su et al., 2015).
To illustrate, in the framework, the solid black arrows represent typical technology transfer processes and grey dashes represent factors that underlie the processes. Just like the linear model, the alternative model also starts with a discovery but here different inventors are identified; university scientists, research teams or graduate students. Significantly, funding source is also indicated as to whether it is government sources, private funds, venture capital, corporate contracts or donations. At this point two options are opened to inventors as seen in the model.

- **Disclosure:**

The first option is that, the researchers can disclose their inventions to their university’s TTO per the framework of Bayh-Dole Act (1980) in the US and the like in other parts of the world if it is funded by central government (Decter et al., 2007, Mowery and Sampat, 2005a). In fact, the
choice of this route is very much informed by university culture, attitude on research
commercialisation and reward system as can be seen in grey in Figure 2.5. To emphasise, this
path is highly common with ‘formal mechanisms’ of technology transfer where official
arrangements are made with legal protections for all parties (Lockett et al., 2005, Macho-Stadler
et al., 2007). If a breakthrough is commercially viable and goes into the market, the government
can hold onto the title of ownership if it is publicly funded (Process 3) and negotiate the license
(process 7) with potential investors (Bradley et al., 2013). If it is a private funded or donations
universities can hold on to the proprietary (process 4). Universities can also claim the proprietary
with the approval of a government agent involved in any discovery. In this case, any
participating university will apply for IP or patent (Clancy and Moschini, 2013, Cohen and
Walsh, 2000). In other instances, universities may avail the opportunity to the inventor to claim propriety (Bradley et al., 2013).

- **No disclosure:**
The second option is that, researchers sometimes use ‘informal mechanisms’ (process 2) or
bypass university authorities or TTOs (process 10) and make their way to market with their
discoveries (Link et al., 2007, Mensah-Bonsu and Jell, 2011). In much the same way, this can
also end up with start-ups, spin-offs or can be co-opted in an existing firm as a new product line
(process 9). Some of these routes build on pre-existing social contact between university
researchers and industry players and out of consultancies and conferences or regular meetings
between them. From these, some of these ideas or technologies are being taken and adapted
(Perkmann et al., 2013). Superficially, barriers and red tape are always blamed for why scientists
go for the informal route with their inventions to the market (Kaymaz and Eryiğit, 2011). Also,
unfair university reward systems, negative attitude to entrepreneurial culture and sometimes
proximity to a research intense university determines individual engagements and personal
contracts between academics and firms for research (Bailey et al., 2011, Fu et al., 2014).

On the whole, more complex and integrated models that represent and capture the realistic
description of firm-level innovation began making their entries into the system in the early part
of the twenty-first century. Primarily, earlier models however provided foundation for further
development in the academic literature and paved way for current developments. In any case,
there is arguably no definite innovation model that can claim to have all the answers on how the process works for all innovation projects and for all industries but as Rothwell (1994) concludes; all the models co-exist and some show overlapping features with each other. Table 2.8 contains the generational models and shows the gaps that have been identified and summarised.

**Table 2.8 Innovation models evolution in historical perspective**

<table>
<thead>
<tr>
<th>Generation</th>
<th>Innovation model</th>
<th>Period</th>
<th>Authors of fundamental ideas</th>
<th>Essence of the model</th>
<th>Model Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Technology push</td>
<td>1950s- late 1960s</td>
<td>Myers and Marquis, 1969</td>
<td>Linear process</td>
<td>Limited to one fixed process</td>
</tr>
<tr>
<td>2</td>
<td>Market(need) pull</td>
<td>Late 1960s– first half of 1970s</td>
<td>Rothwell and Zegveld, 1985</td>
<td>Interaction of different functions</td>
<td>Sequential and still linear and still did not consider measure and analyse at the sector levels</td>
</tr>
<tr>
<td>3</td>
<td>Coupling model</td>
<td>Second half of 1970 – end of 1980s</td>
<td>Kline and Rosenberg, 1986</td>
<td>simultaneous process with feedback loops; ‘Chain-</td>
<td>Limited to R&amp;D and patent without non-technical</td>
</tr>
</tbody>
</table>
Chapter 2: Literature review

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Year</th>
<th>Author(s)</th>
<th>Linked Model” Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Networking model</td>
<td>1990s</td>
<td>Rothwell, 1992</td>
<td>System integration and networks (SIN)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Recognises no sectoral and interpersonal involvements</td>
</tr>
<tr>
<td>6</td>
<td>Open innovation</td>
<td>2000s</td>
<td>Chesbrough, 2003</td>
<td>Innovation collaboration and multiple exploitation paths</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No consideration for less endowed economies</td>
</tr>
</tbody>
</table>


2.18. Mapping university knowledge transfer framework

Earlier in Chapter 1, the study set out to also map out a university knowledge transfer model for Ghana and to do that, various generational models have been discussed to reveal their limitations and to pick on that to develop a suitable one. Other academic literature has also been reviewed including analysis of the alternative view framework by Bradley et al. (2013) which has been adopted and equally adapted to map out an ideal model for Ghana. This model has since been used to test empirical data collected from Ghana to achieve the research purpose. In fact, the model worked well and the results are discussed in subsequent chapters.

In essence, all generational models discussed above have their features integrated into the conceptual model in Figure 2.6 since every model depends on previous ones to make improvement for better. Also, considering the lack of literature, limitations of the models and the many avenues to develop one for developing economies as indicated in the review of literature, the conceptual model presents a simple and basic system of university knowledge transfer that befits the conditions of such economies. Nonetheless, it still captures the complexities of university knowledge transfer and firms’ innovation to offer opportunities to understand
relationships between the significant components of the models. For instance, the features of the linear models of the 1950 to 1960s are incorporated in the framework with disclosures going to TTOs, the coupling model with the feedback loop bringing information back to universities and scientists and the fifth generational model features with parallel and integrated development which is supported by advanced information technology. In any case, Gibbons et al. (1994) argues that all generational models exists side-by-side and that none exclusively replaces the other at any point in time, therefore earlier model are still being used. It is worth noting that the conceptual model is a development broadly from the framework of Bradley et al. (2013) for this study purpose. Ones again, the objective has been to integrate the features of the models available as has been attempted by Bradley et al. (2013) and adapted for further development for one that suits conditions in developing economies. For this reason, Figure 2.6 remains our adapted model, without the advanced features, for analytical point of departures for the current study.

Largely, the main components of the models are: university discoveries, disclosures, TTOs, knowledge networks, collaborations, and commercialisation in the market as innovations resulting in: spin-off, start-up, existing firms, licenses and patents. However, all these are either the product of industry’s formal or informal relations with universities and have also been consistent with the literature on universities’ engagements with industry.

To put to context as knowledge transfer situation maybe in Ghana in case of a discovery in the university;

- **Disclosures:**

As usual, from the conceptual model in Figure 2.6, the first option is that, a researcher can disclose a discovery to a university’s TTO ($H_4$) which depends on the university’s attitude to commercialisation and reward system. This channel is actual ‘formal’ ($H_2$) with technology transfer official arrangements and legal protections for all parties. Certainly, this is consistent with the usual procedures in principles (Lockett et al., 2005, Macho-Stadler et al., 2007). If the product is commercially viable and has the potential to go into the market, entrepreneurs have the chance to capitalise on it with investment for profit. If it is public funded or any form of
collaboration then the university concerned could apply for IP, patent or spin-out a firm ($H_8$) (Clancy and Moschini, 2013, Cohen and Walsh, 2000). In other instances, TTOs may avail the opportunity to inventors ($H_6$) to claim proprietary (Bradley et al., 2013). Also, formally, entrepreneurs walk into universities to access technological breakthroughs as existing ($H_6$) firms and negotiate terms with universities and researchers.

- **No disclosures:**

  The second option is that, researchers sometimes use ‘informal mechanisms’, bypass university authorities or TTOs ($H_{10}$) and make their ways to the market with their discoveries through exiting firms (Link et al., 2007, Mensah-Bonsu and Jell, 2011). In much the same way, this can also end up with start-ups, spin-offs or can be co-opted into existing firms as new product lines ($H_7$). Some of these routes build on pre-existing social contact between university researchers and industry players through their knowledge networks ($H_5$). Knowledge networks are known to help firms gain knowledge to gain commercial benefits in the market. Lastly, most collaborative projects initially start with interpersonal relations between knowledge players ($H_1$) and are actually productive when they start on the basis of social links ($H_3$) and existing relations.

By and large, the significance of the model development is central to the objective of the study and largely to the overall aim. Put into perspective, the clear lack of literature on how universities in developing economies relate with industry has presented a compelling need to add the findings of an investigation of this nature to existing body of knowledge.
Based on the links established between the significant components of the framework (Figure 2.6), underpinned by previous generational models discussed and the extant literature reviewed in the first part of this chapter, ten hypotheses as labelled in the framework are formulated for further evaluation. The evaluation is done with respect to aggregate and sub-data considered in the study. In line with the objective stated in Chapter 1, the research model is framed into a structural model (Figure 4.1) to conform to the requirement of the statistical technique proposed to test the hypotheses formulated below:

- **Formal mechanisms of university knowledge transfer**

  \[ H_1: \text{Formal mechanisms of university knowledge transfer between universities and firms in Ghana directly influence innovation performance in firms.} \]
H2: Formal mechanisms of university knowledge transfer between universities and firms directly influence collaborative research between them in Ghana.

H9: Formal mechanisms of university knowledge transfer between universities and firms in Ghana directly influence innovation performance in firms.

- Informal mechanisms of university knowledge transfer
  
  H3: Informal mechanisms of university knowledge transfer between universities and firms directly influence collaborative research between them in Ghana.

  H5: Informal mechanisms of university knowledge transfer between universities and firms directly influence the formation of knowledge networks in Ghana.

  H10: Informal mechanisms of university knowledge transfer between universities and firms in Ghana directly influence innovation performance in firms.

- Mediators

  Actually, the study anticipates mediators in the process of transfer to influence the effect as indicated in the review of the literature. These mediators eventually offer the potential for innovation to be manifested when delivered through either of these two major components of transfer. To examine the effects of the mediators identified, we make propositions to empirically test their roles in the examination, thus;

- Collaborative research

  H8: Collaborative research between universities and firms in Ghana directly lead to innovation performance in firms.

- Technology transfer office

  H6: Technology transfer offices in Ghana directly influence innovation performance in firms.


**H₁**: Firms in Ghana benefits directly from their formal links with technology transfer offices.

- Knowledge networks
  
  **H₇**: Knowledge networks in Ghana directly influence innovation performance in firms.

### 2.19. Research gap in university-industry engagement theory

The extensive theory on universities interactions with businesses in the literature attests to the fact that there is a lot of work done in the areas by researchers over the years (e.g., Dooley and Kirk, 2007, Drurey, 2010, Guimon, 2013, Rossi and Rosli, 2013, Johnston and Huggins, 2016). However, from the review if literature in Chapter 2, evidence suggests that researchers have concentrated more on university engagement with industry in advanced economies. For example, Johnston and Huggins (2016) looked at drivers of university-industry links in the case of knowledge intense business service firms in rural locations in the UK and Mowery and Sampat (2005) previously looked at the Bayh-Dole Act of 1980, which is a piece of legislation made in the US to stimulate significant growth in university–industry knowledge transfer and research collaboration. Another research by Thomas (2007) in the UK is on manufacturing companies, dealing with how they can meet the current pressure of modern manufacturing environment with the right technological innovation. Admittedly a few studies have come up trying to address the concept in developing economies: studies by the Association of African Universities (2012), which investigates how to strengthen university-industry linkages in Africa, looking at institutional capacities and potential gaps. Another one known to the current study is by Guimon (2013) who looks at how to promote university-industry collaboration in developing countries. Even though they have conducted high quality research and provided meaningful findings, they failed to explain how formal and informal mechanisms of university knowledge transfer influence innovation in firms. Most of all, none of them has offered an explanation on how university research affects innovation in firms at sector levels in developing economies.

More so, researchers seem to have neglected the concept and its significance to firms, industry progress and wealth creation in developing economies. Due to that, there is no appropriate model
or framework to adequately examine universities interactions with businesses and how formal and informal mechanisms of university knowledge transfer fit in, in less income countries. In fact, there is just one known to the current study and conducted by Grimpe and Hussinger (2013) who examined both formal and informal knowledge transfer from academia to industry, yet again, in Germany; a high income country which bears no resemblance to any less income economy, which is expressed clearly to be a concern for the current study.

Having identified the gaps in the literature, the current study aims to empirically investigate the influence of formal and informal mechanisms of knowledge transfer on innovation performance in firms, guided and directed by the proposed conceptual framework with the formulated hypotheses. With the objective to examine the available data at sector levels, the study further intends to generalise the findings to all developing economies with similar characteristics as Ghana in the West African Sub-region. In particular, the study aims to extend knowledge on formal and informal interactions between academia and businesses in developing economies.

### 2.20. Summary

This chapter reviews the literature in the area of university’s interactions with businesses with a critical look at various university knowledge transfer mechanisms and how they influence innovation performance in firms. Firstly, the review defines and critically discusses innovation to reveal the origin and different areas of concentrations of innovation definitions. The pioneering work of Joseph Schumpeter is highlighted and other contributions made over the years are also discussed. Various flaws that have necessitated the continuous development of the definitions are also explained leading to recent one by Organisation for Economic Co-operation and Development (OECD), which is still considered not comprehensive enough. This ends with a review on innovation measurement at the firm’s level and points out here that the study concentration is at firm-level, which is the analytical unit of the study.

The second major section of the chapter reviews available systems of innovation where the concepts of regional and national systems of innovation are also discussed. It is argued here that the level of involvement of firms and industry is informed by the intensity of research and development taking place in a region giving examples of regions that have been affected by the
calibre of universities within the regions. Thirdly, social capital is also reviewed at this stage taking into consideration the main branches that are respectively discussed in the literature to affect innovation in firms. Next to that in the review is absorptive capacity where a firm’s ability and capacity are expressed as a crucial element for acquiring external knowledge for productive use. These are followed by university relations with industry which give details of transfer mechanisms such as formal and informal relationships, collaborative research, the use of technology transfer offices, social and knowledge networks, ending with other knowledge transfer means. The reviewed literature suggests that business engagement is very crucial for competitive advantage in today’s knowledge-based economies of the world and firms have no option but to continuously seek appropriate knowledge to innovate. More so, it is obvious from the review that universities will also have to engage given the current economic crisis that leaves government budgets allocation for R&D in a constant decline.

Lastly, the concept of knowledge of the firm is thoroughly reviewed placing the human agent at the centre of firm’s knowledge resources and as a reliable source for innovation data measurement and collection. Eventually, the types of knowledge in the literature and their significance to firms and the study are well established to underpin the objective of the study. In all sections, the lack of literature is demonstrated and the need for further development is equally vividly expressed.

This final section of the literature looks at the conceptual framework of the study by tracing the historical development of university knowledge transfer and firm-level innovation models from innovation pioneers up to current times. It reviews them by critically looking at the generational models, their flaws and limitations thereby exposing gaps which remain a big challenge to innovation researchers. Actually, the section delves into how researchers tried to address lapses of each generational model to cope with changing time and to incorporate new modes of knowledge generation and transfer tools into new and updated models to stand the test of time in each generation. In the section, one of the most latest generational model, considered to be robust and all-inclusive, is selected and modified to guide and direct the study as the conceptual model. Further down the section, the two main research variables are highlighted together with propositions made on them in regard to their effect on the ultimate dependent variable for further
testing in the next chapter. Mediators are also identified with a proposition as well for further testing. Finally, the research gaps that the current study seeks to fill in universities interactions with businesses literature are pointed out.
Chapter 3. Research methodology
3.1. Introduction

This chapter starts with an overview of the philosophy of the study, giving the ontological/epistemological stance. It expatiates on what Grix (2010) explains as, “‘what’ is out there we need to know’, ‘the ‘what’ and the ‘how’ we can learn about it’. It also gives the methodology adopted for the study through to the sampling techniques and data collected for the study. Reliability and validity issues are explained progressing to ethical considerations and generalisation of the results.

Driven the by the research purpose and with the aim of understanding university-industry interactions in developing economies, the objective here is to adopt a robust means to critically investigate the influence of formal and informal mechanisms of university knowledge transfer on innovation performance in Ghana. To unpack ‘the what’ of the study through ‘the how’, two methodological approaches are employed. Primarily, a cross-sectional survey was conducted to collect data from firms of all shapes and sizes in Ghana and analysed through statistical technique in a quantitative approach for preliminary results. The second part was by interviews with a purposeful sample of universities and firms in Ghana in the qualitative approach, where the data was also analysed thematically to explain preliminary quantitative results. The two approaches were conducted sequentially to achieve a mixed method approach for the research to according to Creswell (2014) ‘provide the best understanding of the research problem’.

3.2. Philosophical approach to the research

Social researchers have agreed that (e.g. Morgan, 2007, Saunders et al., 2012, Thomas, 2013, Topping, 2006) there is no one rigid structure for social research and while a research structure depends on many parameters; thus; the research problem, the researcher experience and the audience of the research as Creswell (2014) puts it, a lot of research designs have been published in the social science literature. However, Crotty (1998) identifies four designs along the lines of epistemological and theoretical perspectives, methodology and methods. Saunders et al., (2012) presents the popular research ‘onion’ encompassing six layers of research philosophies through to methodologies and down to the specific techniques used. However, the current study has
adapted the framework for research by Creswell (2016); see Figure 3.1, for its simplicity and clarity for the current research.

**Figure 3:1 Research philosophy**

By far, there is a general consensus among social science researchers (e.g. Morgan, 2007, Saunders et al., 2012, Thomas, 2013, Topping, 2006) on how research philosophy largely affects the practice and in turn affected by the research problem. Implicitly, a researcher’s views of the world - the ontological/philosophical stance - is based on their past experience of the world, knowledge and their discipline orientation which pretty much influence the worldviews they bring to their study. The literature has expounded on many philosophical worldviews over the years but the most common ones widely recognised in social science are: positivism, constructivism, transformative and pragmatism as seen in Table 3.1. In principle, researchers need to decide on a philosophical standpoint and methodology that will guide their research to achieve their research objectives.
Table 3.1 Four philosophical worldviews

<table>
<thead>
<tr>
<th>Positivism</th>
<th>Constructivism</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Determination</td>
<td>• Understanding</td>
</tr>
<tr>
<td>• Reductionism</td>
<td>• Multiple participant meanings</td>
</tr>
<tr>
<td>• Measurement</td>
<td>• Social and historical construction</td>
</tr>
<tr>
<td>• Theory</td>
<td>• Theory generation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transformative</th>
<th>Pragmatism</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Political</td>
<td>• Consequences of action</td>
</tr>
<tr>
<td>• Power and justice oriented</td>
<td>• Problem oriented</td>
</tr>
<tr>
<td>• Collaborative</td>
<td>• Pluralistic</td>
</tr>
<tr>
<td>• Change oriented</td>
<td>• Real-world practice oriented</td>
</tr>
</tbody>
</table>

Source: Creswell (2016)

For a long time, probably until late 19th century, research was mainly characterised by the philosophy of objectivity (Positivism) and was seen as the only way research should be conducted (Creswell, 2014, Morgan, 2007, Saunders et al., 2012). Popularly known for its scientific method of research, positivism is equally known for its claim to positive knowledge about human behaviour, thus; the belief that ‘a single reality can be measured reliably and validly using scientific principles’. Positivist researchers base all their research argument on widely accepted principles which they also believe are conventionally expressed through deductive reasoning guided by rules and laws. This Creswell and Plano Clark (2007) describe a ‘top-down’ approach to research. Soiferman (2010) adds that positivism, using deductive inquiry moves from ‘general to specific’ implying that positivists start with theory, develop hypotheses and then generate mainly quantitative data to reject or fail to reject the theory. Basically, as seen in Table 3.1, the principle in this view is that, in order to study reality, ideas must be reduced to discrete variables determined to test cause and effect in hypotheses that are generated through theory. Researchers like Soiferman (2010) contend that the positivists’ approach to research could be termed as ‘confirmatory’ since the philosophy is to test and confirm knowledge which they think is ‘found’ through deductive reasoning.
Holistically, a research approach is an embodiment of the philosophical worldview, the design and the specific methods employed to carry out a research. Creswell (2014) based on his framework also advises researchers to inform audience on how their philosophical worldview shapes their research design. For the positivists, as already mentioned, the quantitative design of research is the dominant approach characterised among other designs like experimental designs and non-experimental designs which include surveys. These types of designs according to Soiferman (2010) usually end in statistical analyses that tend to establish relationships between variables in a research, mostly with descriptive and inferential statistics. Eventually, inferences are made to a larger population of interest and primarily from which a sample would have been drawn from the start of the research.

Finally, underneath every philosophical stance are specific methods employed for data collection, analysis and further interpretations before the inference can be made. In the positivistic paradigm for example, Creswell (2014) talks of causal-comparative research which compares two groups based on independent variables. Another example is structural equation modelling which is one of the choices of this study that will be discussed later in this chapter.

An equally major world view common in the literature is constructivism which is usually referred to as interpretivism in certain areas of the literature. Social constructivists believe that individuals in a social system always tend to gain a subjective sense of the environment in which they live. According to Creswell (2014), the meaning they create of their environments vary extensively and in multiples which an inquirer will need a broader understanding of in order to appreciate the complexities rather than reduce them to simple and small ideas as in the positivists’ sense of reality. In the ontological/epistemological stance of research, participants of a research are the drivers of the research and the view and experience of participants of the situation being studied are significant. To Trochim (2006, p. 1) the constructivists’ approach to research is ‘moving from specific to general’ using inductive reasoning. He further contends that in inductive reason, observation and experience remain the basis for any argument. Creswell and Plano Clark (2007) also add that in this world view, research is ‘bottom-up’ and the view of participants are the building blocks for theory generation. Understanding multiple participants
meanings in social and historical constructions collectively underpin the principle as seen in Table 3.1.

The research design for this worldview is largely qualitative and could take several structures including narrative research, phenomenological, grounded theory, ethnographic or case study. The research design for constructivists is largely qualitative research conducted in natural settings where the investigator is the instrument of data collection which is done through, observation, interviews or document gathering. Data analysis starts at the time of collection and investigators look for patterns in their data which are mostly words, text, statements and even images as a standard method of analysis. Eventually, the data is organised into categories or themes for interpretation. Creswell (1994) discusses six stages for this and the details of these are used and explained in the qualitative analysis section 3.12.2 of this chapter.

Transformative view is another philosophical tradition which is influenced by the critical theorists’ view who tend to blame post positivists’ assumptions, which they think impose theories, laws and structures that do not cater for the interest of marginalised people of the real world. Actually, the transformative view believes the positivists do not address issues like power and social justice, issues bordering ethnic minority, discrimination and disabilities. Creswell (2014) admits that there is no extensive literature explaining in detail what the ontological/epistemological stance of the transformativists precisely is, however, he adds that there are participatory action researchers who advocate and advance this course. Similar, they do not think the constructivist philosophy is in any way better, although it opposes the positivists as well, it does not cover enough to look after the marginalised in society. In his view, Mertens (2010) explains that, an inquiry into the real world should set an agenda to change politics at whatever level to confront operations and injustice in the real world. The research design proposition here is grassroots participatory research where participants are made to take part in the design, data gathering and analysis to be able to claim the benefit of the research at the individual and societal level.

The philosophy of pragmatism comes last, which is the philosophical worldview adapted (highlighted in Figure 3.1) for the current study, Creswell (2014) explains, is an
ontological/epistemological view that arises out of action rather than antecedent conditions. Thus, the principle here is that situations arise independent of the other and not sequential in the real world. In disputes with the postpositivism notion of the real world, pragmatism concerns itself with application of what Patton (2015) calls, ‘what works’ well at what particular time. With the notion of pragmatism, no method is fixed or better but any can be useful if the situation calls for it and is suitable to understand the social problem at stake.

For its nature and philosophy, pragmatism is underpinned by a mixed method approach to research where multiple designs and methods are used to achieve research objectives. Implicitly, pragmatists believe in all designs, thus, quantitative and qualitative approaches can both be used concurrently and justifiably which is what the current study has adopted to tackle the problem of the research (Creswell, 2014, Creswell and Plano Clark, 2007). Qualitative and quantitative approaches have been touched on but not exhaustively in the previous sections and is looked at in practical detail in subsequent sections.

As indicated in the preceding section, ‘pragmatism’ is the philosophical position of the current study since it presents the ideal framework, as Creswell (2014) argues to:

1. understand the best drivers of university-industry interaction for innovation performance in developing economies, and at the same time,
2. offer detailed explanation of issues of complex intricacies as typical of the concept of university-industry interaction and innovation.
3. be the best approach to use for theory testing and explanation in a single research design.

It is a general consensus among social science researchers that, the purpose of research to a large extent dictates the philosophy, the methodology and techniques of data collection and analysis. Also, it may be noted in Chapters 1 and 2 that the purpose of the current research is to fill a gaps in the literature for:

1. Lack of analytical frameworks for university-industry interaction for developing economies.
2. Lack of knowledge on the influence of formal and informal mechanisms of university knowledge transfer on firms’ innovation performance in Ghana.

3. Lack of knowledge on how university interaction with businesses actually influences innovation at industrial sector levels.

Primarily, these are the main problems for the study which inform the decision for multiple methods. Inherently, the nature of the research problem and the type of research purpose (see Chapter 1) call for a more all-inclusive approach to achieve the ontological/epistemological objective. To recap, the background literature in Chapter 2 reveals a lot of lapses in the literature in the areas listed above. However, the conceptual framework also reveals a robust framework that has been adopted and modified, in Chapter 3, as a theoretical basis to be tested empirically to answer the research problem. It is also significant to note here that, the complexities of the university knowledge transfer framework adopted and the links established between the research independent variables and innovation performance (the dependent variable) in the literature have jointly necessitated a hypothesis based type research. Additionally, there are areas of innovation performance, especially at industrial sector levels, that need not just generalised conclusions, as will be obtained from the deductive reasoning aspect of the study (Soiferman, 2010), but also specific and in-depth explanations required to effectively and efficiently achieve the research purpose. Naturally, the extent of the neglect of literature on university business interaction in developing economies, coupled with the non-availability of a framework on the concept in developed countries requires a philosophical assumption that will allow for:

1. Theories testing to deductively search for evidence to either support or refute the research hypotheses.
2. Elaborate information to be gathered from research participants to identify themes to inductively explain underlying issues in innovation performance (Creswell and Plano Clark, 2007).

3.3. Methodological choice

Similarly, just as there are reasons for the choice of philosophy for a research, the choice of a methodology in any research is also informed by the philosophy adopted to guide and direct the
research (Mertens, 2010, Zachariadis et al., 2010). Whilst there are many reasons for both quantitative and qualitative approaches, their merits are widely contested in the literature. Whereas a quantitative method is known for its wider coverage of research subjects and generalisability, it is criticised for its imposition of theory, rules and laws in its practical application. Qualitative method on the other hand is also criticised for its subjectivity, low in coverage and problem of replicability, it is also known and appreciated for its in-depth examination of research problems, explorative capabilities, openness and not being limited to variables. Nonetheless, researchers have concluded that both qualitative and quantitative approaches are set to address the same essential social problems. The differences, they go on to add, arise due to how each view nature and reality and how they are implemented. For Creswell and Plano Clark (2007), the differences are rather a continuum. Others consider the difference as an issue of philosophy and not methodological (Creswell, 1994, Morgan, 2007, Zachariadis et al., 2010). That is not to take it for granted; Bazeley (2004) warns of many issues including complexities when mixing methods of quantitative and qualitative approaches in a single study. He raises this and argues that definitional, methodological and paradigmatic questions continue to crop in among social researchers who write about mixed methods. For instance, the problem of research design, the question of sampling, methodological integration, the subject of analysis, reporting and skills, time and financial demands on researchers all have their toll in a mixed methods study.

Consequently, writers and researchers using mixed methods (e.g. Brannen, 2005, Creswell, 2014, Morgan, 2007) have always claimed among other benefits, triangulation and greater validity of results eventually, for their methodological choices. In any case, without adequate consideration of issues inherent in such a mix, Bazeley (2004, p.1) concludes that ‘such validity may be more imagined than real’. Based on this, one may argue that there is no one study that is purely quantitative or qualitative in nature but a complement of the two in an attempt to understand reality, therefore an equally same positive reasons has informed the choice in the current study.
3.4. Explanatory sequential mixed methods

As a philosophy, pragmatism, which is the ontological/epistemological position for the current study, is generally agreed among researchers (e.g. Creswell, 2014, Morgan, 2007, Patton, 2015, Soiferman, 2010) to underpin mixed methods in research. Greene (227) defines mixed methods as:

‘that actively invites us to participate in a dialogue about multiple ways of seeing and hearing, multiple ways of making sense of the social world and multiple standpoint on what is important and to be valued and cherished’ (Greene, 2007, p. 20).

Creswell (2014) claims that mixed method study is new (as late as 1980s) explaining that its significance rests on both quantitative and qualitative studies being highly flawed on their own and weak in many respects. Mixed methods approach, he believes makes up for the flaws and offers a kind of methodological triangulation where the two start from different traditions and converge to solve a research problem. Naturally, mixed methods approach has several dimensions but the current study adopted an explanatory sequential mixed methods which best suits the needs of the study. With this choice, quantitative research from the positivist’s philosophy is conducted first and sequentially followed by a qualitative research from the interpretivists’ philosophy, seeking to offer an in-depth explanation to preliminary quantitative results. Nevertheless, Bazeley (2004) further questions the concept of mixing in this manner if one method is conducted after the other, sequentially and separately. He calls for an integrated method of research suggesting that perhaps the technology for managing such integrated analyses will still be under development in social science. Other known types of mixed methods are convergent and exploratory mixed methods, which are beyond the scope of this study.

To emphasise as indicated above, the current study adopts an explanatory sequential mixed method (highlighted in Figure 3.1); a combination of quantitative and qualitative research in one study. This is preferred, as Creswell (2014, p. 20) claims, because both quantitative and qualitative approaches ‘each itself is inadequate to best understand’ the research problem. Notably, other reasons for the choice of mixed methods (Soiferman, 2010, Creswell, 2014) include primarily, the research purpose, the research audience; thus, the examiner, the
investigator’s previous experience, which is quantitative background and innovation researchers, policy makers and practitioners who want hard evidence with further empirical reasoning and explanation to justify their positions and decisions. More especially, to understand the complex nature of university knowledge transfer mechanisms in Ghana, their subsequent influence on innovation in firms and how they may be related using the structural model adopted, mixing these two methods was deemed suitable. To achieve this, the investigation aimed to design a survey questionnaire to conduct a hypothesis base test to achieve a broad understanding of university knowledge transfer and firm-level innovation situation in the Ghana. The approach also provided a deeper explanation on issues that may be peculiar to the Ghanaian innovation system.

Further to this, methodological integration was achieved by building on the statistical results of the hypothesis test. The statistical test results informed the generation of a semi-structured interview to be designed to further understand, for example, the weakness of the primary sector in their ability to absorb new knowledge as reflected in the results. It also sought for reasons that may explain why both formal and informal mechanisms of university knowledge transfer do not lead directly to innovation performance in firms in Ghana except in the manufacturing sector. Other in-depth information also sought had to do with why knowledge networks in Ghana were effectively used in the service sector and why TTOs do not manifest direct influence in the primary sector in Ghana (Details in Appendix A-4).

Figure 3.2 illustrates the entire integration process constituted in 6 phases from design, methods, merger of results and interpretation stages through 6 integration processes (I₁-I₆). To start with, I₁ process integrated the qualitative data source in Activity 2 with the same source in Activity 1, which built on the concepts of the previous survey-items for the qualitative data to ensure total data quality, reliability and consistency (Fetter et al, 2013). The link here also offered the opportunity in the design of the methods of sampling and data collection process in the qualitative research. This tailored the interview guide to look for specific significant information for thematic analysis, which actually worked well as required. In I₂ integration process, the hypothesis test results in Phase 1 created a platform for assessment of various relationships and statistical conclusions to be made and discussed to proceed to merge with the qualitative data in Phase 5 through process I₅. Quantitative results from thematic analysis in Phase 3 were marched
and merged in Phase 5 with the quantitative results through process I₄ to ensure a data fit to develop a single complementary narrative. Leading to Phase 6 through process I₆, the merger of quantitative and qualitative results for interpretation provided a comprehensive insight into factors that underlie the insignificant effects of formal and informal mechanisms of university knowledge transfer in Ghana and other relevant understanding that sought to provide the needed answers to the study aim (Fetter et al, 2013). The interpretation and discussion of the findings is provided in Chapter 5.
Figure 3:2 Integration of explanatory sequential mixed methods

- **Phase 1: Method**
  - Formulated hypothesis from the literature
  - Adopted and modified to map up a university knowledge transfer and innovation model for Ghana
  - The data and the conceptual framework were tied together by the literature, guided the data needed and process of collection
  - Collected numeric data from 533 firms
  - Conducted hypothesis tests

- **Phase 2: Method**
  - The hypothesis test results suggested a semi-structured interview
  - The hypothesis test results prescribed the qualitative data and collection
  - The test results determined the sampling method
  - Some respondents in the sample were purposefully sampled to obtain 20 participants for face-to-face interview

- **Phase 3: Method**
  - Interview data/transcripts unveiled the characteristic of management types in primary sector through thematic analysis
  - Further understanding was provided on challenges and abilities of TTOs in Ghana
  - Characteristics of the service sector management was revealed
  - Specific problems and requirement of the manufacturing sector is probed into and expressed clearly
  - The qualitative data exposed environmental, mistrust, social meltdown cultural and institutional factors in the knowledge transfer and innovation ecosystem
  - Knowledge transfer policy need to facilitate industry engagement was highlighted in the qualitative data

- **Phase 4: Method**
  - Quantitative results showed a positive relationship between formal mechanisms and innovation only in manufacturing sector
  - Quantitative aspect indicated a strong intermediary influence of knowledge networks and collaborative research
  - The hypothesis test revealed a strong relationship between formal and informal mechanisms of knowledge transfer and required further understanding

- **Phase 5: Merger and data fit**
  - Merge both quantitative and qualitative findings to explain issues affecting both formal and informal mechanisms of university knowledge transfer
  - Through waving narrative, the weaknesses of primary sector in absorptive capacity is confirmed and expansion throws more light on effective use of both knowledge networks and collaborative research as mediators in the service sector in complementary fashions
  - Divergence in the manufacturing sector benefiting from formal mechanisms obtains explanation on the mature of knowledge required and why

- **Phase 6: Interpretation and reporting**
  - Ineffective formal and informal mechanisms of university knowledge transfer due to external factors
  - Weak primary sector in Ghana mainly due to less educational attainment and family inheritance
  - No direct influence of TTOs for university discoveries in primary sector except mediation when formal mechanisms fail
  - Highly qualifies management/staff/directors in the service sector due to easy and low initial capital investment at the initial stages particularly small enterprises
  - All sector have effective use of knowledge networks for the advantage of easy and cheap access to new knowledge and risk sharing
  - Collaborative research is only effective in the service sector as an indication of high technical abilities
  - All calling for policy on establish research universities with well equipped TTOs and skilful staff

Adopted and modified from Fetter et al., (2013)
Before the research process and methods of the study are discussed, the next section presents a pilot survey to show how it was conducted as a pre-test to the main one for both theoretical and practical reasons. Where and how the pilot was conducted and lessons learnt are all present in the section.

### 3.5. Pilot study and lessons learnt

This section presents a pilot study conducted as a pre-test of the survey instruments in advance of the main study, prominently to gain some familiarity with the instrument beforehand. Largely, every research needs a pre-test mainly for two reasons: 1) to test the instrument to be used for data collection in the main study and 2) as a rehearsal for the major research process and particularly for first time researchers for their major project. Whether a project is a quantitative or a qualitative research, a pre-test of the instrument is extremely vital for a smooth process of the main project (Gorard, 2003, Braun and Clarke, 2013). In this case, the questionnaire was piloted in Ghana in April 2015 before the main survey in October 2016. Effectively, with a total sample size of 245 firms, the pilot study was considered a success.

The theoretical objective of the study was to find out whether firms contacts with universities bring about innovation performance in Ghana and the hypothesis ($H_p$) therein was: *Firms’ formal links with universities directly influence innovation in firms.*

Actually, this was to learn lessons that will be used to reduce problems and bring improvements to the main study. From the start, the data was collected using the instrument designed (de Vaus, 1996, Gorard, 2003) seeking information on knowledge, perception and experience of respondents on their firms’ approaches to knowledge acquisition from outside and particularly universities (Kraaijenbrink et al., 2007). In essence, PLS-SEM technique was used as a better alternative to Ordinary Least Squares (OLS) given the nature of the design. This was deemed effective and a lot of advantages were achieved in this study due to the unique features of the technique (Kock, 2014, Kock and Chatelain-Jardón, 2011).
3.5.1. Sample and data collection

The data was obtained from all sorts of firms and mainly from their representatives who were in senior management roles. The sample of firms used for the survey was acquired through stratified random sampling (Punch, 2005, Teresa and Procter, 2006) and were drawn from two business groups in Ghana. Accordingly, industry sectors were put in strata and sampled randomly from each stratum for a balanced distribution based on their characteristics. The questionnaires were hand delivered and self-administered across the country in April 2015 with two follow-ups made by a team of data collectors. Furthermore, there were phone calls made to remind respondents and to emphasise on the importance of the survey for business development and Ghana. Eventually, a total of 800 questionnaires were distributed but 245 usable questionnaires were completed and returned and the response rate was 30.63%. There were missing values for all the observable indicator variables but were very negligible percentagewise to affect the results. Missing data were replaced with multiple regression imputation algorithms in WarpPLS v5.0 statistical package used for the analysis (Kock, 2014).

3.6. Findings of pilot study

The main findings can be summarised as:

- Formal mechanisms of university knowledge transfer do not directly affect innovation performance in Ghana.
- Formal mechanisms of university knowledge transfer lead to collaboration between firms and universities.
- Formal mechanisms of university knowledge transfer lead to knowledge networks.
- Collaborative research leads to innovation performance in firms in Ghana.
- Knowledge networks lead to innovation performance in firms.

3.7. Lessons learnt in pilot survey

From the start of the pilot survey to the end, some lessons were learnt for improvement in the main survey and are found in two parts as stated earlier. The firstly was about the survey
instrument designed, and the data collection process. The second, it was about general conduct particularly in the data analysis and the presentation of the results.

The philosophical position adopted in this study calls for a research designs that direct all efforts to solve the research problems with whatever effective and appropriate tools available and not be restricted to a specific methodology which may be only ideological (Fletcher, 2016, Wikgren, 2005, Zachariadis et al., 2010). Owing to this, a mixed methods approach was chosen to allow flexibility and practical engagement with the research purpose. One other problem the study identified in the literature is that little academic research has used the approach to either explain universities interactions with businesses or tried to understand how informal and formal mechanisms of knowledge transfers influence innovation performance in developing economies.

Due to a lack of such empirical studies with that design, the current study seizes the opportunity as a methodological point of departure to achieve the purpose of the study. Given this opportunity, the coming section presents the choice of specific research techniques and discusses the research process for the study.

### 3.8. Research process

The process started with the definition of the unit of analysis and sampling which were followed by data collection in the research field. The next stage started with the quantitative research aspect of the study where a cross-sectional survey process was used to collect data. Data analysis was by structural equation modelling with hypothesis testing based on propositions made in a modified conceptual model in Figure 4.1. At this stage, there was dual-hypothesis testing where the first one tested 10 hypotheses with the aggregate data set (a country wide data set) considering the role of formal and informal mechanisms of university knowledge transfer on innovation performance. The second hypothesis tested the data which was split into primary, manufacturing and service sectors in a comparative fashion.

With exploratory sequential mixed method chosen for the study, the next stage involved the qualitative research aspect of the study using thematic analysis, which started with interviews
and documentary evidence analysis after data transcription, coding, categorising and summarising.

Finally, the results from the two traditions are linked together and the results of the qualitative research are used to further understand the quantitative results. A summarized version of the research process is shown in Figure 3.3.
Figure 3:3 The research process flow chart

- Defining the research unit of analysis, sampling and data collection
- Quantitative analysis with hypothesis testing
- Qualitative analysis with traditional approach
- Findings
- Discussion of findings
- Empirical findings
- Chapter 6: Conclusion, policy implications, critical evaluation, limitations and recommendations for future studies
- Summaries

Investigators on design
3.9. Sampling and methods

The validity and reliability of research results depend on the quality of the instrument of data collection and how it is conducted is equally crucial. In other words, a carefully designed instrument that is badly administered is as bad as a carelessly designed one (de Vaus, 1996, McKenna et al., 2006). Furthermore, every study needs careful design, purpose and direction to obtain a representative sample of the population of interest (Bagozzi et al., 1991, Golafshani, 2003b, Kimberlin and Winterstein, 2008). Therefore in this study, a cross-sectional survey was used for quantitative data collection due to the fact that the objective was to take a snapshot of innovation activities in firms across the ten regions of Ghana guided by a research framework designed to direct the research process. Secondly, it was also the case of this study to investigate the population of interest and make a generalisation for the total Ghanaian economy and other developing economies, particularly in the West African sub-region.

To achieve the mixed methods design and also obtain high quality data it was the responsibility of the investigator to recruit data collectors who knew the Ghanaian industry terrain, had understanding, the need and significance of data and the collection process. The data collectors were therefore taken through the survey items in the questionnaire by way of orientation and training for them to understand what the exercise was all about. The training was also to enable them to support respondents in case of any problems or difficulties in understanding any part of the questionnaire. The data collectors also had the opportunity to discuss petty problems respondents encountered and were able to resolve them before moving on. The qualitative aspect of data collection was conducted by the investigator himself.

For the quantitative data, which was the first to be collected, the study used two databases from the National Board for Small Scale Industries (NBSSI) and the Association of Ghana Industries (AGI), both of which are made up of small, medium-sized and large firms in Ghana and across all sectors. To achieve a representative sample in quantitative studies, several techniques are recorded in the literature and Saunders et al. (2012) encourages the use of a good strategy and techniques. Punch (2005) and Nulty (2008) differentiate between probability and non-probability sampling and Cohen and Manion (1985) also discuss cluster, stratify, simple random sampling and stratified random sampling of which the last was used. By that, firms of all sorts were
sampled in two stages; the first was to stratify firms according to sectors, thus; primary, manufacturing and service sectors, which was sorted in MS excel and randomly sampled with random numbers each sector (Nulty 2008, Punch, 2005). Logically, the technique was suitable and used because it offered the opportunity to categorise all firms in the population into all the three sectors under consideration in the study and also gave at least equal chance to every firm to be included in the study. Another advantage was that, the firms were randomly sampled within each stratum to theoretically correct for sampling errors (Podsakoff et al., 2012, Podsakoff et al., 2003). Without doubt, stratified random sampling is time consuming, tedious and comes with many other challenges and setbacks, some of which the study could not totally meet. By that, the investigator needed to identify and list every member of the population exclusively and exhaustive and to empanel a definitive list of each stratum in the entire population, thus; accurately sorted (Sarstedt and Mooi, 2014, Saunders et al., 2012, Teresa and Procter, 2006, Wolf et al., 2013). Alas, a situation that could not be possibly handled in reality. Indeed, the study empirically faced this as a setback but the closest to meeting such requirement was a comprehensive official database of firms provided by the two organisations was sorted in MS Excel for the study. Of course, this did not encompass all firms in the population of interest, leaving unregistered firms without any chance of participation and therefore could be a recipe for bias in the study.

For the qualitative data collection, purposeful sampling and snowballing were concurrently used which are consistent with the methodological framework of thematic interview approach (Miller and Glassner, 2016) and participants were earmarked purposefully, contacted formally and informal interviews were conducted. Purposeful sampling offers the chance for investigators to select the right informants with the experience to deliver accurate account of events and snowballing avails the next suitable candidate for more data by way of introduction. The combine use of the two was found suitable because of the opportunity they offered to not just get research participants but significantly, suitable subjects who could really provide the right information (Christopher Westland, 2010, Teresa and Procter, 2006, Wolf et al., 2013). By this, the investigator selected more established traditional universities, the right senior researchers and top management staff in universities and firms in Ghana for the interviews. Since participants were directly affected by the purpose of the study, they were happy to point to and even gave
details of other participants who were equally suitable to give information. Some even made the contact themselves. However, some issues the study had with these selections using these techniques have been the inability to control sampling errors, particularly response bias which could be a problem because some of the participants might have understated or over exaggerated in their submissions depending on their personal feelings and not what the situation really was. Also, since data analysis with qualitative research starts with collection, the subjective selection could have contaminated the judgement of the investigator in the observations and interpretations of some behaviours and gestures visibly noted in the process. The study therefore recognises all these for its own vulnerability to errors in judgment and that they could affect the reliability of the findings to support any form of generalisation (Golafshani, 2003a, Patton, 2015, Saunders et al., 2012).

Furthermore, previous academic research on innovation performance at firms’ level (Tetteh and Essegbey, 2014, Thomas et al., 2011) has not particularly considered sector specific factors and have always broadly made conclusions without due recognition to that. Though they may be assessing firms in the same economy, there is a great deal of difference at sector levels. Truly, the analytical point of departure the current study makes is the effort to recognise that firms by their nature, shapes and sizes respond to their environment, networks and cultures of their sectors and societies differently. Actually, the firms sampled for the study fitted well into the wider definition of innovating firms in the context of current available literature on innovation performance at firms’ level (Janz et al., 2004, Liao et al., 2012) and also fitted in well with the conceptual framework adopted and modified to examine innovation performance in firms in the study. Differences in cultures, environments and even geographic regions account for differences in definitions and categorisation of firms. Apart from that, geographic regions use different criteria to classify their firms in order to create and maintain a standard record of firms for many purposes including local and international comparisons. Besides, while some regions and countries use volume of investment, turnover, legal status and sometimes method of production to classify firms, the categorisation of a firm in Ghana is strictly by the number of employees in a firm which is widely used (Tetteh and Essegbey, 2014). Similarly, Ghana Statistical Service (GSS) and the Oslo Manual, which are guidelines, recommended for collecting and interpreting innovation survey data by the OECD both support firms categorisation based on the number of
employees in principle for cross-country comparison (OECD, 2005b). On this foundation, this study firms’ classification is as shown in Table 3.2. The study accordingly considered these on the basis of firms’ demographic attributes and needed to add a little more information to gain great understanding on innovating firms in Ghana.

Table 3:2 Classifications of firms by sizes

<table>
<thead>
<tr>
<th>Firms size</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1—9</td>
<td>Micro enterprises</td>
</tr>
<tr>
<td>10—49</td>
<td>Medium size firms</td>
</tr>
<tr>
<td>50—249</td>
<td>Large firms</td>
</tr>
<tr>
<td>250+</td>
<td>Very large firms</td>
</tr>
</tbody>
</table>


Apart from the classification above with standard definitions of firms in terms of size, the study further categorised the firms according to geographic areas which was aimed at assisting the extent of coverage, identification and were coded based on regions of Ghana. Thus, firms were coded as; UE, NR, VR, AS, CR and GR for Upper East, Northern Region, Volter Region, Ashanti, Central Region, and Greater Accra Region respectively. Numbers (1, 2, etc.) were also assigned to firms to differentiate them within the same region. Table 3.3 shows selected firms that were particularly contacted for interviews for qualitative data. In essence, firms in the sample were considered as innovating firms by the definition adopted to guide the survey. This means they made at least the minimum level of changes in their production process, products and services, even in the areas of marketing, new to market or new market identification (Bessant, 2003, OECD, 2005b, Schumpeter, 1934). Notwithstanding that, the minimum innovation achieved could neither be easily explain nor understood between the investigator and some of the less educated management or particularly very small firms and the inability to consensually agree to innovation achieved by some firms could also pose a potential bias.

Large or small, the survey considered firms covering sole proprietorship to firms employing up to more than 250 staff provided they were within the country of Ghana, however, subsidiary organisation of foreign companies were not enlisted. It is worth noting that family firms were
listed and may not have been considered to be employing others despite the fact that many family members could be working within them. There were no firms enlisted from the rural areas of Ghana as they are usually not suited for innovation surveys which may generally be prejudicial on the part of researchers including this and vital information could be lost because there could be massive potential innovating firms in the countryside with indigenous technological innovation going on. However, Firm from semi-urban, urban townships and cities were considered appropriate for innovation studies based on both experience and the academic literature (Abor and Biekpe, 2006, Makanyeza and Dzvuke, 2015, Robson et al., 2009). It will be noticed that in Table 3.3 the primary, manufacturing and service sectors are mainly the concern of the study since there are no studies comparing innovation performance based on them particularly in the context of developing economies. To fill the knowledge gap, the sample included innovating firms from these significant sectors of the Ghanaian economy.

Although the OECD (2005a) recognises that choosing the most suitable respondents in firms in innovation surveys may prove difficult in practice, it is argued to be particularly significant because questions are mostly highly specialised and only a few people are in positions to answer them in firms. Therefore by their recommendation, respondents for the survey and for later interviews were senior managers of the firms; chief executives and directors responsible for operations, innovation and technology issues (see Table 3.3). Special efforts were actually made in advance to identify respondents before the start of data collection. This in fact contributed greatly to the success of the survey and achievement of data saturation (Saunders et al., 2012) with rich and quality data in the interviews, and adequate knowledge was obtained for analysis.
Table 3:3 Interviewees from firms

<table>
<thead>
<tr>
<th>I.D.</th>
<th>Innovating organisation</th>
<th>Interviewees</th>
<th>Years of Service</th>
<th>Number of employees</th>
<th>Location</th>
<th>Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NR1</td>
<td>Managing Director</td>
<td>7</td>
<td>23</td>
<td>Tamale</td>
<td>Service</td>
</tr>
<tr>
<td>2</td>
<td>NR2</td>
<td>Managing Director</td>
<td>6</td>
<td>4</td>
<td>Tamale</td>
<td>Primary</td>
</tr>
<tr>
<td>3</td>
<td>VR1</td>
<td>Managing Director</td>
<td>15</td>
<td>8</td>
<td>Ho</td>
<td>Primary</td>
</tr>
<tr>
<td>4</td>
<td>AS1</td>
<td>Managing Director</td>
<td>4</td>
<td>30</td>
<td>Kumasi</td>
<td>Primary</td>
</tr>
<tr>
<td>5</td>
<td>AS2</td>
<td>Assistant Manager</td>
<td>5</td>
<td>328</td>
<td>Kumasi</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>6</td>
<td>UE1</td>
<td>Director</td>
<td>5</td>
<td>5</td>
<td>Bolgatanga</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>7</td>
<td>CR1</td>
<td>Director for technology</td>
<td>5</td>
<td>2</td>
<td>Cape Coast</td>
<td>Service</td>
</tr>
<tr>
<td>8</td>
<td>CR2</td>
<td>Director</td>
<td>7</td>
<td>18</td>
<td>Cape Coast</td>
<td>Service</td>
</tr>
<tr>
<td>9</td>
<td>GR2</td>
<td>Chief Executive</td>
<td>8</td>
<td>230</td>
<td>Accra</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>10</td>
<td>GR3</td>
<td>Chief Executive</td>
<td>3</td>
<td>342</td>
<td>Tema</td>
<td>Service</td>
</tr>
</tbody>
</table>

Source: Own

Universities were also later contacted for their part and only for qualitative data. Data triangulation is well established in the academic literature and the benefit the study intended to derive for that includes information verification and support for accuracy and validity in the findings (Golafshani, 2003a). It was also to counterbalance the potential weakness of preceding data collected and to strengthen the overall study results (Saunders et al., 2012, Silverman,
2016). To maximise the benefit, arrangements were again made to have informal interviews with suitable participants in the universities. Snowballing and lobbying were also used at some point to gain access to researchers and administrators who were recognised as appropriate people to deliver the right information on universities business engagements. The reason behind the choices here was to avoid being directed to interview any available researchers or administrators which would have resulted in poor data collection. Considerably, innovation data collection is sensitive and specialists are the right people to obtain information from for a study (OECD, 2010b, OECD, 2005b). Notably, triangulation is complex, particular for first time researchers as in this case, and surely mixing data from different sources and traditions inflicted a major disadvantage on the study taking a lot of time, recourse and energy which actually dragged the study process and drained the enduring capabilities of the investigator to the limit. This indeed affected the concentration of the investigator to capture and put together the full details of the analysis and could bias the findings of the study. Nonetheless, observation was not suitable because it would not have been offered adequate information since innovation is not a one-day event to be captured through observing. Focus groups would not have been useful since innovation is not a linear process and as Bessant (2003) argues, thus; ‘it is a mutating and shifting puzzles - and firms have to try and find their own particular ways of solving them and continue to be able to do so as the puzzles shift and change’. Bringing different people from different firms and universities will only unleash chaos and confusion in focus group interviews.

To understand the nature and process of university knowledge transfer in Ghana, it is actually significant to include not just a truly representative sample, as claimed in most academic literature (Christopher Westland, 2010, Teresa and Procter, 2006, Wolf et al., 2013), but suitable subjects who can really provide the right information. This is significant for understanding the phenomenon of interest to the study. Accordingly, universities recruited to participate in the in-depth interviews were mainly traditional public universities set up within the last six decades. Seemingly, these choices were informed by the strategic nature of their establishment and government intention to stimulate its innovation and industrialisation agenda within the time period. Also, they are those that are at the forefront of all government education and science strategies and receive support in the form of grants for research. These universities were suitable for this study because they house the most effective research centres in the country constituting
the research hub of the country at the very moment. As a result of the purposeful sampling strategy and snowballing, interviewees were researchers and administrators who were really in contact with businesses in many directions. Most of them had industry experience and were either working with businesses at the time or came from industries into academia and were ideal to give sufficient information (see Table 3.4 for details on participants, research centres and students populations). In order to obtain rich and sufficient data, out of the 10 universities, 5 were full time university researchers and 5 were administrators out of which two were from technology department and transfer centre officers respectively. Each university has at least an active research centre with KUNST having up to 8 research centres as one of the oldest university in the country and was specifically structured to conduct research in science and technology.

Table 3:4 Interviewees from universities

<table>
<thead>
<tr>
<th>I.D</th>
<th>University</th>
<th>Interviewees N=20</th>
<th>No of research centres</th>
<th>No of research staff</th>
<th>Student population</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>University for Development Studies</td>
<td>Deputy Director of Research/Head of Registry</td>
<td>1</td>
<td>542</td>
<td>18000</td>
<td>Tamale</td>
</tr>
<tr>
<td>2</td>
<td>University of Ghana</td>
<td>Research Development Officer/Head of Department</td>
<td>6</td>
<td>1179</td>
<td>37940</td>
<td>Accra</td>
</tr>
<tr>
<td>3</td>
<td>Cape Coast University</td>
<td>Assistant Registrar/Head of Department</td>
<td>5</td>
<td>652</td>
<td>15835</td>
<td>Cape Coast</td>
</tr>
<tr>
<td>4</td>
<td>Kwame Nkrumah University of Science and Technology</td>
<td>Research Fellow/Researcher</td>
<td>8</td>
<td>823</td>
<td>23591</td>
<td>Kumasi</td>
</tr>
<tr>
<td>5</td>
<td>University of Professional Studies</td>
<td>Head of Industrial Relations</td>
<td>4</td>
<td>462</td>
<td>11300</td>
<td>Accra</td>
</tr>
</tbody>
</table>
To obtain the quantitative data, a 5-point Likert-scale type questionnaire was found appropriate to measure experiences and perceptions of respondents which were latent variable and could not therefore be measured directly. It is also generally recommended for measuring respondents’ attitudes and opinions in survey (Groenland and Stalpers, 2012, Norman, 2010). Mainly respondents from the firms were asked to rate their experiences and perceptions on university knowledge transfer activities they were involved in or knew about as corporate bodies. Largely, this involvement covered personal and social interactions, involvement with knowledge networks up to formal collaborations. Even all internal knowledge generation activities made with the intention to achieve innovation were comprehensively presented for rating. Eventually, large volume of data was generated through that. However, it was difficult to tell if respondents could accurately rate or scale their experiences, levels of activities and participations in knowledge and innovation and therefore was given to chance. The investigator could only work with what was obtained from the field and was limited by design since he was not present to offer guidance. Some degree of inconsistency could set in as it is in almost all measurement procedures (Hoe, 2008, Jarvis et al., 2003, Kimberlin and Winterstein, 2008). Therefore variability between the actual scores of their experiences and their chosen scores could introduce some errors thereby unleash a problem of reliability in the findings. Significantly; Likert scale type questionnaires are known for their susceptibility to asymmetric verbal anchor, unwarranted length of scale, unevenly-spaced verbal anchor and unwarranted interpretation of their calculated mean (Pornel and Saldaña, 2012). These could not have been achieved in the study and could have affected the validity and reliability of the results though measures were taken to minimise their effects. Thus, to contain these, the questionnaire for the survey was designed with enough items and with evenly-spaced verbal anchors.

The appropriateness of Likert scale types approach to measure latent constructs in a quantitative study is well documented as a psychometric scale commonly used in surveys to rate responses on social phenomena that in reality cannot be easily observed and measured discretely (Bishop and Herron, 2015). The study admits that researchers continue to debate over its use in statistical tests requiring normal distribution assumptions drawing user’s attention to issue of reliability of results from analysis conducted with Likert scale type data. Nonetheless, it is deemed in the
literature to yield accurate results without such perceived reliability problems (Clason and Dormody, 2009, Norman, 2010).

As stated earlier, the credibility of study findings depends on the validity and reliability of the measurement instrument used for data collection. Therefore, it is recommended that existing instruments that have been tried and proven to work well could be of great use to current research (Kimberlin and Winterstein, 2008, Punch, 2005). The fact that a particular research instrument is used many times in research facilitates comparison and integration of findings across different studies. More so, significant facts on such a measurement instrument could be known beforehand (Kimberlin and Winterstein, 2008, Murphy-Black, 2006). Examples are the Cronbach’s alpha values (Cronbach, 1951) of construct can easily be assessed and adopted for current studies. However, construct validity issue comes in when an existing instrument is to be used. Thus, if the operational definitions of the variables of the previous study do not fit well with the current study as in this case, a freshly constructed instrument tailored to current needs is recommended in principle (Punch, 2005).

For reasons of lack of a suitable existing instrument to use for this survey, the instrument in this instance therefore has been designed freshly and purposely for this study. The design was undertaken through a careful scrutiny of the extant literature on knowledge generation and transfer from universities to firms. Surely, this is something that is emphasised in the critical realist’s view of the role of theory in empirical research. To support the above, it is equally stressed that every hypothesis in structural equation modelling (SEM) (chosen for this study) should be theoretically generated (Gefen et al., 2000b, Hair Jr et al., 2014, Jarvis et al., 2003). On this account, all observable indicators (constructs) in this study were accordingly constructed from theory. However, it will be admitted that designing a new instrument for the survey has not been an easy task and chances of systematic errors in the construct due to the investigators inexperience were eminent. This could distort the research findings by introducing common method variance which is a common occurrence in measurement theory (Hair et al., 2014b, Lewis et al., 2013). For this, ‘procedural remedies’ were adhered to during the design process to reduce the effect (Armstrong and Overton, 1977, Podsakoff et al., 2012). Other measure adopted of course, was a pilot survey and lessons learnt for improvements have been discussed.
Empirical observations, in other words, information obtained as data for inquiry in social science are scientific facts that are occasionally objective or somewhat neutral in principle to the scientist. They are facts that are theory-laden therefore are generated with the aid of theories and concepts that an investigator uses in the research process. As Lancaster (2005, p. 65) describes data as ‘the raw material for problem solving and decision making’, and can mainly be categorised in two types as primary and secondary which were both used in this study. Either of them presents an enormous amount of benefit and challenges, particularly in social scientists attempt to capture both ontological and epistemological concepts of reality in a study. At the same time, in their own right they do so as in any research process. Other categories of data, again, of interest and broadly recognised in social science research are quantitative and qualitative data (Ragin, 1987, Topping, 2006). To achieve the research purpose, the two categories were gathered sequentially through survey and face-to-face interviews respectively to benefit from the combined advantages therein.

Specifically, to obtain the right information, both survey respondents and interview participants were asked to respond to issues on innovation in firms and how it is achieved through university research. For example, firms in the survey (See Appendix A-1, showing the questionnaire) were asked to rate their extent of agreement or disagreement on whether there have been any forms of research contracts (either department or personal level) with a university had a consultancy services from a university for any form of changes in their work. The potential knowledge to be gained here was about either product or any form of process innovation. Also, it was meant to source information on formal or informal links with universities for knowledge. Another statement was about whether they have had at least a new marketing strategy or identified a new one or even if they have been able to introduce something new to the market with the potential to gain information on their level on innovativeness over the years. To obtain a deeper knowledge of the level of firms’ links with universities and level of innovation, the same topics were discussed in far more details in face-to-face interviews with participants. In another instance, propositions were made to respondents on collaborative projects they may have with universities to gain new knowledge; for instance to what extent had they agreed that their collaborations had been successful to gain insight into whether universities collaborating with firms in the country really produce any innovation for participating firms and industry. A lot of relevant issues on
knowledge transfer channels such as knowledge networks, and technology transfer offices and departments were tackled. To illustrate, respondents were also asked to rate the possibilities and level of knowledge they may have gained from technology transfer offices and knowledge networks. The relevance of these were to assess the extent of support firms get from these knowledge transfer structures that are claimed to play significant roles in innovation systems of economies (Abreu et al., 2008, Evstigneeva, 2015). Significantly, there were items and questions on R&D investment and patent that were rated and further discussed during interviews with the potential to gain insight into firms’ commitment to innovation. These are common and relevant topics discussed in innovation surveys for the same reason. Nonetheless, the limitation with this is that, R&D is just an input to innovation. More so, it is only a part of the effort and does not measure innovation. The same is true for patent which is used as an indicator of firm’s innovativeness. Actually, this has the potential to send wrong messages and make respondents feel that without patent means no innovation and that could also set in serious response errors to mislead the study (OECD, 2005a). Researchers therefore have yet to agree on the connections between the two and innovation in firms and may require further conceptual development for that.

Primary data is usually generated from research field originally and purposely for the research at stake and does not usually exit until it is meticulously planned and generated (Lancaster, 2005). This is where primary data has advantages over secondary data which has to be reformatted and re-adjusted to suit the needs of secondary research (Beverley et al., 2006). In secondary research, a lot of information tends to be lost and could derail the authenticity of the findings in many directions. Other advantages of undertaking primary data in this study were to tailor the research design, the data collection strategy and the theoretical constructs primarily to the research objective and eventually to achieve the research purpose. However, the downside of going through primary data collection in the study was that, it was very expensive to the investigator and also took too long to collect, involved travelling and finally far more distant places could not be covered which could lead to loss of vital information (Hox and Boeije, 2005). Eventually, with patient and perseverance it was all successful.
To gain more knowledge on issues discussed above and to explain the preliminary quantitative data, thematic interviews were conducted shortly after the survey in a qualitative research (Appendix A-4 gives the interview guide). With this, the understanding gained was profound and the innovation ecosystem was becoming clearer to the investigation. More so, some of the issues raised in the quantitative research were taking shape in an attempt to fix the innovation puzzle surrounding industrial sector innovation performance in Ghana, perhaps for the first time in the body of knowledge.

Qualitative researchers argue that interviews are better for social science studies adding that they provide a greater depth to understand social reality and process. Other advantages attributed to interviews are opportunities to probe for more, to motivate, to ask more questions and for participants to openly and freely demonstrate their knowledge and experiences in a narrative, which in contrast surveys do not offer (Lethlean, 2006, Miles et al., 2014). It has been for the reasons above that the study considered using qualitative research for this part. Social scientists face the problem of the form of interview to use for data collection. However, depending on how formalised an interview is, they have to choose structured, semi-structured or unstructured interviews (Patton, 2015, Saunders et al., 2012). For this study, structured interview was not suitable because participants were volunteers who willingly offered to participate, were not to defend their knowledge and could easily refuse without prior notice (this was made clear to them in a letter). Also, unstructured interviews could not be used because the meeting could go without a direction and may end with little meaningful information, hence thematic interview was used with semi-structured guide eventually in the current study. Nevertheless, even with the carefully chosen method here, the honesty of the participants and genuineness of their narratives could not be guaranteed. Also, although there was a guide, it was too loose to regulate the discussions which also would have affected the reliability of the data collected.

With that, participants in the interviews were given the opportunity to express themselves on the same issues as mentioned in the survey questionnaire content discussion above. With a particular focus on specific cases at a time, the face-to-face interview generated primary data with each interviewee at their respective offices and places of work (Miller and Glassner, 2016). It was made convenient to the interviewees and the investigator was in a position to invoke active
interview processes to elicit and probe for details and could observe their emotions and facial expressions which are not usually noticed during telephone interviews for example (Tod, 2006, Holstein and Gubrium, 2016). Also, the body language of interviewees has been of vital importance to the interpretation of the data too (Creswell, 2014). Interview locations and times were purposefully chosen and agreed between the investigator and interviewees to avoid unnecessary interferences (Punch, 2005, Thomas, 2013). It was therefore meant to be descriptive, inductive, heuristic, experiential and particularistic in the context of university knowledge transfer and innovation performance in firms in Ghana (Lancaster, 2005, Silverman, 2016).

Put into context, participants were asked if they could explain why the primary sector firms in Ghana are not collaborating with universities for knowledge and not achieving innovation through technology transfer offices. Another was why despite the primary sector engaging the majority of the Ghanaian work force; it remains the least innovating sector in the economy. All these gave clues on some hidden characteristics of the primary sector as against the characteristics of the other sectors. Knowledge on the inception of technology transfer offices became obvious and explanation on why their performances are still slow. What is lacking, who are engaged for the job and what their skills levels are also became new knowledge to the investigation. Also, the relevance of knowledge networks, their existence, what sort of firms benefit from them, how they benefit from them, soon became further information to be reported in the body of knowledge. The investigation at this point was able to learn more about the innovation landscape of the country and hidden challenges faced by each sector, particularly the primary sector firms in Ghana. Another issue also largely discussed with interviewees centred on why both formal and informal mechanisms of university knowledge transfer do not generally lead to innovation in the country according to the quantitative results. All of these produced very significant knowledge about the kinds of entrepreneurs that dominate which sectors and why those sectors function and perform in a particular manner, which have since advanced the research process to reach meaningful generalisations (Danermark et al., 2002, Thomas, 2013). To gain insight on the county’s specific innovation challenges, both university researchers and directors of firms were asked to offer suggestions on what Ghana government could do to
facilitate innovation in firms. To this, participants were again unanimous in their quest for government involvement in many ways to ease financial pressure on research and development.

Eventually, adequate samples were obtained for both quantitative and the qualitative research. For quantitative data, a sample frame of 600 firms was obtained (Steele et al., 2001, Burns, 2000, OECD, 2005b). Actually, the questionnaires were self-administered in October 2016 and were physically handed over to potential respondents to complete, to be collected on later days after completion and two follow-ups were made after two weeks. Convincingly, this was convenient in the sense that respondents completed them in their own times and spaces without any pressure. Admittedly, this method has not been rated as the best and the disadvantage here is that any other person could complete it in the investigators’ absence (Cohen and Manion, 1985, Krippendorff, 2004). However, online and postal surveys come with more challenges and were not suitable for this study. Considerably, self-administering was the most suitable for this study for lack of logistics to use other methods. On the positive side for which it was chosen, it was found to be less costly to administer as compared to postal survey which would have cost a lot and taken too long to retrieve due to unreliable postal system in the country. In contrast, online survey could not be used either because of poor internet system. Lastly, one other motivating factor for the personal contact survey was the cost element which was of concern to the study interest. Generally, surveys are known for their convenience in facilitating the generalisation of research results, in which sense Danermark et al. (2002) describe it as ‘an extrapolated to, and is assumed to be valid for, a larger population’ if they are conducted carefully and effectively. The results are usually extrapolated from the representative sample to the target population. Without doubt though, the major setback for employing this was the investigator’s inability to help interpret items to be rated in the questionnaires or answer questions about what the items meant and other issues which would have arisen as a result of differences in meanings of terms due to cultural disparity and cross-border language barriers. This would have forced respondents into making inappropriate choices for cultural reasons (Allred and Ross-Davis, 2010, Podsakoff et al., 2012). Most of all, the investigator could not be sure if respondents who were selected to receive questionnaires were the actual persons who filled them out and that could have also seriously affected the validity and reliability though all measure were taken to eliminate that.
By and large, formal applications were made for access to the databases and were then granted. To emphasise, all the 10 administrative regions in the country were included with all sorts of firms and their respective sectors defined in reference to the International Standard Industry Classification (ISIC) revision 3.1, which is mostly relied on by surveys conducted in Ghana (GSS, 2013). For minimum sample size required to avoid a type I error in the significance tests, Hair et al. (2016) recommend the often-cited rule of thumb for PLS-SEM sample data required which uses the 10 times rule for studies of this nature. Generally, this rule requires that the sample size for a structural model should be more than 10 times the largest number of structural paths directed at any endogenous latent variable in the structural equation model. It this study the largest number of paths directed at an endogenous latent variable was 5 and therefore would need \(10 \times 5 = 50\) or more cases in the sample (Henseler et al., 2009). Missing data were replaced with multiple regression imputation algorithms in WarpPLS v5.0 statistical package used for the analysis (Kock, 2014) and appendix A-3 shows the percentage in each case. Consequently, in all the structural models implicitly evaluated in this study, the sample sizes were more than 50 and the sample size eventually obtained the aggregate data set was 533 firms in total from all strata.

Each sector had 300 in the sample frame (Gorard, 2003, Punch, 2005). Eventually, two follow-ups were made to increase the response rate within a period of four weeks; and one call within a fortnight. Effectively, during the first follow-up 359 representing 59.83% usable questionnaires were collected and subsequently, 174 were again collected during the second follow-up (Podsakoff et al., 2012, Podsakoff et al., 2003). With all efforts, the response rate was increased to 88.83% giving an overall total of 533 usable questionnaires out of 600 selected firms in the initial sample frame.

To ensure generalisability of the study results, the quantitative aspect of the study was designed to collect enough data in the sample using the right statistical tools available to obtain adequate sample for analysis. On account of this, knowledge obtained from the sample considered in this study can be assertively inferred on the broader context of the entire corporate body in Ghana, and not only that, it can be assumed actually to be valid for all firms and sectors.
Actually, in the course of this study, a few documentary data were collected to integrate with other primary data. The benefits of using documentary data are documented in scholarly work (Mogalakwe, 2006) and this study took advantage of that to enhance its credibility. Truly, it was quicker and free to collect and for this reason the study relied on available official documentary sources. In retrospect, the use of documentary data for research in social science dates back to the seventh century when the ‘statists’ used it to carry out research in order to understand and improve the lives of poor people (Prior, 2016, Jacobsson, 2016). Even today, scholars use secondary data extensively particularly in the form of numerical text in health or official statistics (Gorard, 2003). Nonetheless, because the documents gathered were not originally meant for research purpose most of them carried scanty information therefore not useful, some were incomplete and further used would have invited a role conflict if the investigator was to complete them with his opinion and interpretations. Also, some were found outdated and further use would have resulted in wrong findings.

Examples of some of the records obtained from firms were business reports on R&D, internal training facilities and external relations with networks and correspondence (Mogalakwe, 2006). On the part of the universities, annual reports and correspondence on universities’ dealings with the business sector were obtained. Others were leaflets, in-house newsletters and catalogues of projects undertaken to generate knowledge for innovation in industry. Another set of documents retrieved were research projects sponsored by external agents involving universities and the business sector with photographic evidence. They were ministerial reports and government policies particularly on science and technology. Others were the Ghana government budget statements on research and expenditure on university research units and centres, and finally the acts of parliament on science and technology improvement in the country. Evidence also included were documents on the introduction of polytechnic education in the country and their contributions to industry. Moreover, the United Nation (UN) will usually rely on central government economic development figures, their local agents and country representatives to report on the state of the country’s economic development and those were also useful to this study. Lastly, the Ghanaian media houses tend to cover issues concerning science, technology and activities between universities and businesses in the country and are always covered by newspaper reports, some of which were collected and analysed in the current study. Additionally,
this study used such reports in the qualitative analysis to support the preliminary findings. Nonetheless, minutes and consultancy reports of both universities and businesses were not made accessible to this investigation due to institutional policies and confidentiality.

Although, a documentary research method is not very popular in social science research and very little is heard about it, it is not new and has proved to be a source that holds rich data for mainstream research (Mogalakwe, 2006). Ultimately, on this basis, the current research made an extensive use of documentary data to supplement the mainstream qualitative research aspect of the study.

After elaborating on sampling and methods employed in the study research design, the next section discusses the quantitative research aspect of the study. As stated earlier in the objective section of Chapter 1, the explanatory sequential mixed method here starts with quantitative research, which is designed to drive the study with explanatory support from qualitative research to achieve the study aim.

### 3.10. Quantitative research

The coming section deals with quantitative research and begins with exploratory data analysis where the structures of the data are explored in details and presented graphically, giving a ‘snapshot’ of the sample to reveal the percentage compositions of the industrial sectors of the economy. Generally, in quantitative research, the data usually involves few variables and many cases which are summarised to support generalisations to a population about a phenomenon under study. Equally, it is known for its prescriptive procedures for validity and reliability, and its deductive approach to research (Creswell, 2014, Saunders et al., 2012, Thomas, 2013). Basic statistics in quantitative research is recommended in social science and said to give an overview of the nature of the population of interest to a study (Rowntree, 2004). However, the approach is criticised for viewing the world ‘in a single reality that can be measured reliably and validly using scientific principles’ and assumption of knowledge being relatively objective, measurable and experimental (Golafshani, 2003a, Soifer, 2010). For several reasons including validity, reliability and generalisability of the results, the current study employs the quantitative approach
for the first part, to support the objective of testing hypotheses to achieve the overall aim of the study.

Even though the entire study is designed to use mixed methods to achieve the aim, the core of its approach is rooted in the quantitative research and largely influenced by its philosophy. The coming section therefore presents an exploratory analysis which picks up some underlying features that are equally significant to the study.

3.10.1. Basic statistics

Figure 3.4 presents the proportions of the major sectors of the Ghanaian economy in the sample of 533 firms captured for the study. From the figure, it can be seen visibly that the service sector is the largest (69.42%) in the economy and therefore may be employing the majority of the workforce thereby being the leading contributor to gross domestic product (GDP) as reported in the literature (Oppong et al., 2014). The manufacturing sector is the second in size, and it represents 17.07% of the target population of firms and takes almost one-quarter of the service sector while the primary sector is 13.51% and almost one-fifth of the largest sector. Note: these sectors could suggest possible heterogeneity in the data for further analysis in the inferential statistics. Though this information has offered a good description of the nature of the data, the figures presented theoretically lack scientific judgments and validation and therefore the study goes on to concentrate on inferential statistical to make inferences to more general conditions.
Another characteristic of the economy as a whole that was of interest to the study was the longevity of firms in the system. Significantly, the age of firms may have an immense effect on their innovation capabilities and as firms exist for a longer time they may develop networks and
become involved in knowledge generation activities to gain competitive advantage. Figure 3.5, which shows which age groups of firms are prevalent in the economy, gives companies aged from 10 to 25 years being more than any other firm’s age groups in the sample. They are presumably those that were set up within the last two decades when technology changed and shaped businesses and economies around the world possibly in the dotcom era. Firms from 25 years to 50 and above were found to represent those which have lived through these times. In reality, this group would have established links within and outside the country over the years in many attempts to stay on top of the market or to outsmart the aggressive marketing and innovative strategies of new firms. Hence, they will use their experience and longevity in the market to access external knowledge to support internal R&D for core competence. The next group is from 1 to 9 year old firms which is also about 30% of the firms’ population in the country and again formed within the last decade. Such calibre of firms might be active in taking advantage of current knowledge search to stay on top of the market because their formation from the start might have been influenced by technology adoptions in the country. Obviously, they may have faced technological challenges from the start since their growth was in the era of information technology boom around the world market. Of course, there were some respondents who did not state their firm’s age groups but completed the questionnaire and their responses were captured in the analysis in the study. In any case, they represented less than 5% of the total sample.

Figure 3:6 Industry sub-sectors captured in the survey
The Ghanaian economy is dominated by so many units and sub-units under the primary, manufacturing and the service categories of the productive sector as discussed in the literature. Figure 3.6 shows those covered in this study and presented again in accordance with which is the largest to the smallest as a proportion of the total population. From the figure, it is visibly clear from the survey conducted that the financial service sector is the dominant sub-sector of the economy and represents about 25% of the population of firms in the country. This includes high street banking institutions, insurance companies, local and city rural banks and micro-finances institutions. Also worth mentioning are the ‘susu’ collectors and traditional money lenders who according to a later face-to-face interview, move from door-to-door and render financial services to local people. Next is the health care service, which represents about 21%, where firms offer a wide variety of health care to local people. This covers physical to mental health services and such services are rendered to children and elderly as interviews with local businesses revealed.

Another important service and of course very paramount for this study is the knowledge and business support services. To elaborate, this kind of service encompasses the private educational institutions right from kindergarten stage to tertiary level of education. Also, all forms of training institutions and consultancy services come under this service and make up about 18% of the total captured in this study. In an interview with a local petroleum business consultant, it became clear accordingly that Ghana in 2001 discovered petroleum ore, and started extracting in 2004, and has since seen many businesses emerging to join the newly discovered lucrative business of the day. Though it has not yet really become a very common business to attract the interest of many people, a good number of businesses have emerged to take the challenge and so much knowledge is needed in this area for the sector to grow.

Again, there were a lot of questionnaire that came back without the firms’ areas of business operation indicated and that alone was up to about 18%, however other areas completed in the questionnaire were included in further analysis. Most businesses are in the area of wholesale and retail services as reflected in the interviews with local wholesalers and retailers, simply because there is not much being manufactured locally, in other words there are not many incentives in the manufacturing sector in the country. Nonetheless, about 8% percent of the population indicated

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2 Susu is a local financial arrangement where small business owners deposit money daily, weekly or monthly with the susu collecting agent for a lump sum withdrawal at a specified time.
they were in this sector and of course need so much knowledge and technology in the supply chain to facilitate their commerce.

The next significant category is the agricultural sector, which someone said in an interview, ‘*is the backbone of the Ghanaian economy*’, and represents about 6% of the total firms that responded to the survey. In fact, this sector employs the majority of the local people across the country and constitutes the informal sector as well and businesses in the area are unnoticed and unrecorded to be captured in the formal sector. One feature of this sector in the country, according to, particularly farmers, is the uneasy access to knowledge on farming techniques or latest technology. One farmer stated that ‘*it is unfortunate up to this time we are still relying on traditional farming methods in this part of the world in this era of technology*’ and called for more research in the sector. Lastly, food processing, mining and quarrying and transport services all represented between 2 to 5% of the total sample while automobile, textile, wood, chemical and metal sectors represented less than 2% of the total sample. These areas are where development is needed to entice business people to venture into and take advantage of the opportunities of the sector.

**Figure 3:7 Proportions of the respondents’ designations in the sample**
Officers in various firms who personally responded to the survey and the face-to-face interviews were those in responsible positions in their respective firms or were senior managers and were apt to provide useful and credible information for the study. Figure 3.7 exhibits their designations and the proportions of various designations that featured in the survey. From the figure, it can be seen that managers of firms completed 56.66% of the total questionnaire distributed representing the largest responsible operational officers in the survey. Surely, from this caliber of officers, a lot of useful and credible pieces of information were gathered in the face-to-face interviews as well for analysis. Directors of firms occupy high offices and hold vital information about their firms and represent them in their relations with the outside world. Owing to this, 19.32% of the respondents were directors, and managing directors were 9.19% of the sample. Next officers in terms of percentage were secretaries who represented 8.44% and also serve as a link or the first point of call for firms. The least were designated personnel responsible for technology needs by firms or available for firms from outside. Largely, these are officers who described themselves as technology experts in the firms and are trained to facilitate the technology needs.

In the universities, there were two categories of participants conveniently sampled for interview (Krippendorff, 2004). The first category was made of university administrators in responsible administrative positions. Some of them were technology or research administrators while others were liaison officers and industrial relations officers actively involved in linking their universities to the business communities and the rest of the world. The other set of respondents were university researchers who had immense and varying experiences over the years in their posts. The respondents from firms for the interviews were again in responsible administrative positions and could give information regarding innovative activities and external knowledge search by their firms, their links with other organisations and universities in and around the firms’ local areas.
Figure 3.8 Bar charts comparing the three sectors in firm’s age groups

The ages of firms were considered under three identified sectors of the economy and compared visually as can be seen in Figure 3.8 below. It is noted in the previous section that there were 91 firms from the primary sector, 72 firms in the manufacturing sector and 370 firms in the service sector. Respectively, each age group (represented as a bar) is a percentage of the total number of firms in that sector presented in the figure. Visibly, it is seen that firms in the age group 10—25 years are more in the primary sector (51%) than in the manufacturing and service sectors. Clearly, this same age group is higher in both the manufacturing and service sectors as well. Firms between 26 and 50 years are next in the percentage of representation in the primary sector but the least in the manufacturing and services sectors. Meaning, very old firms; thus, 50 years and above were least in the primary sector. Most of all, very young firms in the country with ages from 1 to 9 years have very high representation in the services sector. Notably, there were some questionnaires that could not be identified with any of the three sectors due to non-responses.
Figure 3:9 Comparisons of the sub-sectors

Under each sector are other sub-sectors that were also captured for detail study and presented in Figure 3.9 below. In the first part representing the primary sector, which has only three sub-sectors, the petroleum products (PP) sub-sector seems to be dominating the sector and engages about 42% of the total firms in the sector. Next are agricultural products (AG), which follow with 38% and trails by mining and quarrying with 18% of the sector. In the manufacturing sector which is next in the diagram there are 5 sub-sectors looked at and the food processing (FP) sub-sector takes the biggest proportion of the sector with 36%, the chemical and metal sub-sector takes a 16% share of the sector while textile and wood processing takes a 12% share of the sector. Last in the sector is the automobile sub-sector, which trails with just 8% indicating a less patronised sub-sector in the manufacturing sector. Finally, in the service sector there are 5 sub-units captured and the highest is financial services, as seen in Figure 3.9, that are very common and also doing well in the economy. The least is the transport services (TS) which is not well organised according participants in the interview and the benefit of business in that area is not much due to dwindling fuel prices.
Figure 3.10 Comparing firm’s sizes with respect to workforce

Figure 3.10 shows the percentage representations of the total sample population and is ordered from the highest to the lowest. Again, the y-axis is cut for the figure to fit well and be properly visible. Visibly, the figure shows that firms with a workforce of 10 to 49 are the highest in the sample and represent about 36% of the total. Those very large ones are next with about 28%. The least in terms of number of employees are firms that are very small with less than 10 employees representing about 15% of the total and firms that have 50 and over employees and up to 249 represent about 20% of the sample population.
Figure 3:11 Comparing firm’s sizes with respect to workforce in the sectors

In Figure 3.11, there are once again three diagrams and each represents a sector of the Ghanaian economy discussed here. The first is the primary sector of the economy, followed by the manufacturing and the service sector. Relatively, firms employing 10 people up to 49 remain the highest in all the sectors with about 33% in the primary sector, 42% in the manufacturing sector but less than 10% in the service sector. Comparatively, it can be seen that firms with 250 and above employees are the next highest. In any case, those employing from 0 up to 9 remain the least even at the sector. Significantly, all three sectors have exhibited the same features in terms of the order of the workforce groupings. Meaning, firms employing from 50 up to 249 become the second highest at the sector levels putting those employing 250 and above in third place at that level with respect to their percentage representation in the sample.

Figure 3:12 Comparisons of the designations of respondents across the three sectors
Representatives of all firms who responded to the questionnaire indicated their designations and responsibilities to qualify as potential informants in the study. In Figure 3.12, it can be seen that different types of senior level management in different operational responsibilities were contacted for the survey. In the figure, it can be noticed visibly that there are 4 categories who responded in the primary sector. Also, there are 4 in the manufacturing sector and 5 in the service sector. There were some who did not indicate their positions. The first part of the diagram therefore offers an insight into the caliber of officers and their share of representation in the primary sector. Similarly, as seen in the figure, respondents in managerial (MG) positions responded to the largest number of the questionnaires in all the sectors in the survey and up specifically to 48% of the total in the primary sector. It seems to reflect the same pattern in all the sectors as managers also responded up to 51.49% in the manufacturing sector and 60% in the service sector, respectively. Directors of the firms comes next in terms of proportions of the total respondents also in all of the sectors and represents 22%, 20% and 18% respectively for the primary, manufacturing and service sectors.

Explicitly, the managing directors come next to directors in both primary (5%) and service (8%) sectors in proportionate terms as can be seen the figure. Next, company secretaries (CS) to the firms are seen to take (10%) in both the primary and service sectors and about 5% in the manufacturing sector. Lastly, in the service sector, a unique type of respondents can be noted to be technology transfer officers who responded on behalf of the managers and directors because they had the responsibilities of looking for the technology requirement and dealt with departments in the sector. To look into the inferential statistics, the next section looks at the response rate and common raster errors and possible biases and checks to ensure reliability of the outcome.

3.10.2. Non-response bias

Survey response rate theory clearly states that a low rate of response does not necessarily mean unreliable research results (Delecki et al., 1993) and that reliable result can be obtained if adequate measures are taken. To elaborate, systematic error in construct measurement is widely known in behavioural science research as a problem and essential in all surveys including those with a high response rate (Hair et al., 2014b, Lewis et al., 2013). Crucially, there is therefore
always the need to estimate its extent in all surveys before further analysis of the data (Bagozzi et al., 1991). For the sake of this, it was deemed necessary to test for non-response bias between early and late respondents in the study as best practice to detect any possible bias in the data (Armstrong and Overton, 1977). Of great concern to the study therefore is, that the ‘interest hypothesis test’ was used as a basis to test a non-directional hypothesis (2-tailed) that early and late respondents were statistically different in their responses to the survey questionnaire. To do that, an independent *t*-test was conducted on all the three latent variables in the study as elements of great interest to the respondents. In Table 3.5, the results of the tests show that there is no significant difference between early and late respondents in their responses to all the variables under investigation, thus; $t(531) = -1.718$, $p = 0.086$ for formal mechanisms of university knowledge transfer (FORM). The associated Levene’s test for equal variance is $F(531) = 3.343$, $p = 0.068$. For informal mechanisms (INFO), $t(531) = -1.482$, $p = 0.139$. Levene’s test for equality of variance was not significant either; $F(531) = 3.276$, $p = 0.071$. Collaborative research (COLL), $t(531) = -0.471$, $p = 0.638$ and Levene’s test for equality of variance is not significant; $F(531) = 1.799$, $p = 0.181$. Innovation performance (INNO) is; $t(531) = 0.504$, $p = 0.615$ and Levene’s test is $F(531) = 0.467$, $p = 0.494$. Also, TTOs and NET have $p$-values of 0.836 and 0.101 respectively for the *t*-test and Levene’s tests are also not significant. Appendix B-1 gives a visual comparison of early and late waves showing the similarities of their medians. Also, Appendix B-2 compares them at the sector levels and again reinforces the similarities with their median responses with boxplots. Normality assessment with Shapiro-Wilk test results (Hair, Black, and Anderson, 2010) are also fine except for collaborative research which is not disturbing on graphical inspection and supposedly will not affect the results.
Table 3:5 Non-response bias in the sample

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<th>Variables</th>
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<th>SD</th>
<th>t</th>
<th>Sig. (2-tailed)</th>
<th>F</th>
<th>Sig.</th>
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<td>3.276</td>
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<tr>
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<tr>
<td></td>
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<td>3.139</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INNO</td>
<td>Early</td>
<td>359</td>
<td>3.542</td>
<td>0.04</td>
<td>0.504</td>
<td>0.615</td>
<td>0.467</td>
<td>0.494</td>
</tr>
<tr>
<td></td>
<td>Late</td>
<td>174</td>
<td>3.505</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NET</td>
<td>Early</td>
<td>359</td>
<td>3.555</td>
<td>0.04</td>
<td>1.645</td>
<td>0.101</td>
<td>2.686</td>
<td>0.102</td>
</tr>
<tr>
<td></td>
<td>Late</td>
<td>174</td>
<td>3.441</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COLL</td>
<td>Early</td>
<td>359</td>
<td>2.971</td>
<td>0.05</td>
<td>-0.471</td>
<td>0.638</td>
<td>1.799</td>
<td>0.181</td>
</tr>
<tr>
<td></td>
<td>Late</td>
<td>174</td>
<td>3.014</td>
<td>0.07</td>
<td></td>
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</tr>
</tbody>
</table>

Evidently, in most research conducted in social science, there are various other inherent problems highlighted in the measurement literature that usually distort research findings, one of which is common method variance and of course was of great concern to this study as well (Lewis et al., 2013). On account of this, ‘procedural remedies’ were adhered to during the instrument design process actually to reduce the effect or eliminate its occurrence. Namely, these included counterbalancing the instrument items; the scale was also improved by eliminating all ambiguities to facilitate understanding of the instrument. Further to this, identities of respondents were even protected (Podsakoff et al., 2012, Podsakoff et al., 2003). Nonetheless, effort to measure the predictor and the response variables at different places and times to eliminate common rater bias was not possible in the study. Henceforth, a statistical remedy was considered, thus; Herman’s single-factor test was used to test for any trace of response error (Aulakh and Gencturk, 2000, Greene and Organ, 1973 ). Generally, this test uses Exploratory Factor Analysis (EFA) to test for common method variance and was conducted with unrotated loadings with Principal Axis Factoring with R statistical package (free software). Conclusively, there was no evidence of common method bias because no single factor accounted for all the
variances. Instead, as can be seen in Figure 3.13 that all the variables accounted for all this despite the fact that the first variables accounted for a lot of it. Based on the results of the non-response bias and the Herman’s common method variance, further statistical analyses were conducted with confidence in the results.

Figure 3:13 The Herman’s single factor test

The next section delves into the root of the study purpose starting with inferential statistics and dealing with hypothesis testing as required in the research design and underpinned by the theoretical background and conceptual framework adopted by the study.

3.11. Qualitative research

Qualitative researcher is the type of research that relies on the view of it research subjects with broad and general questions to collect data consisting large amount of words, pictures, documents, audios and videos to analyse for themes to understand a social phenomenon. This type of inquiry is subjective and highly biased and for which it has been heavily criticised by quantitative researchers in the social sciences (Lancaster, 2005, Patton, 2015). Qualitative research conducts inquiries with inductive thinking in natural setting and with a subjective view of the world within which the investigator immerses himself to collect the data and generate theory (Saunders et al., 2012, Soiferman, 2010). Above all, qualitative researchers assume that
individuals in social settings have different views of the world and how it works and findings from such background cannot therefore be generalised to a population as claimed in quantitative research. It is also accused of limited scope without replicability of its findings (Creswell, 2014, Thomas, 2013).

Qualitative and quantitative research methods may come from different traditions; however they often address the same question with different approaches and therefore are not mutually exclusive in approach (Soiferman, 2010, Thomas, 2013). Actually, researchers seem to have some disagreement as to which one is better, but the question is mostly not being better but appropriateness to address real life and social problems at different times with certainties (Creswell, 2014, Punch, 2005). Therefore, the main concern of the study is to contribute to the body of knowledge on university knowledge transfer to firms in developing economies through formal and informal mechanisms using appropriate approach without necessarily sticking to a particular method. For this reason, the chosen approach to achieve the research aim is to use explanatory sequential mixed methods, however, largely driven by quantitative research. Henceforth, the purpose of the qualitative research is to offer and explanatory support to the quantitative results which are already discussed. To do so therefore, several sources have been used to gather data and evidence on issues pertaining to knowledge transfer from universities to firms and guided by what was already found in the quantitative research.

With an interview guide, issues discussed in the interviews centred on for example, why firms would choose to collaborate instead of using technology transfer offices? Why are some sectors more engaging with universities than other sectors? Also, university researchers were asked how they could engage better with all sectors and why some sectors are reluctant to engage. A lot of unsolicited but valuable pieces of information were revealed and all fed into the objectives of the study. Now, to analyse the data and to specifically explain the previous preliminary findings from the quantitative research, several authors have come up with brilliant methods to use (Lancaster, 2005, Patton, 2015, Soiferman, 2010). The popular research ‘onion’ by Saunders et al., (2012) comes to mind but appears too complex to engage for explanatory purposes. Thomas (2013) recommends construct mapping and discourse among others. Nevertheless, most methods that are common in qualitative analysis generally bear resemblances to iterative coding processes
in Figure 3.14 which was used for the analysis and started with; gathering of large data (texts, pictures, documents, videos, audios etc), reading through, observing participants’ behaviours while gathering further data, doing initial coding of the properties; coding 3 transcripts initially, negotiating and revising, leading to coding 5 transcripts, continued negotiating and revising again, and ended creating the final coding structure then applying to all transcripts. The method was considered simple but robust enough to offer the explanations required at this stage.

### 3.11.1. Data processing

With multiple sources of data to collect from, the investigator managed the data as Thomas (2013) advises by creating a database for both hard and soft copies such as audios and videos with a security password. The hard copies were also stored and locked up for security reasons. Traditional methods of qualitative data management and analysis were used; after all, the investigator would still have to do the analysis even if any software was to be used (Miles et al., 2014). Admittedly, the traditional method was needlessly cumbersome and definitely time consuming, better still; it produced a more succinct analysis. The benefits of recently developed software like NVIVO, MAX QDA and Atals Ti used for effectiveness, efficiency and perhaps accuracy of qualitative analysis are acknowledged, however inherent limitations of inflexibility and imposition of particular structures on data by the software have been found inappropriate for the study (Krippendorff, 2004, Braun and Clarke, 2013). Also, it takes so much time to learn these software too, particularly first time researchers (Lathlean, 2006). Soiferman (2010) argues that unlike quantitative studies, in qualitative research, data analysis starts at the time of collection. Therefore in this study, the processing of data also included the start of the analysis where note taking and memos were used to document issues that were captured at the peripheries of the data collection process.

### 3.11.2. Qualitative data analysis

Obviously, the method of analysis could be termed as an integrated (deductive/inductive) approach where the starting point involved an existing theory to explain with the inductive approach in the study. To achieve the purpose after transcription the rest of the analysis took the steps below:
1. Gathering of large data (texts, pictures, documents, notes, and memos, diaries); some of these included newspapers, in-house letters, leaflets, university annual research reports, websites and catalogues explaining business engagements.

2. Reading and reflecting on participants’ behaviours while data was gathered.

3. Coding of initial codes and properties, coding 3 transcripts, negotiating and revising; categorising according to themes, operational words, checking on frequencies of statements and words.

4. Coding of 5 transcripts, negotiating and revising; merging similar terms and statements that implied the same and creating new holistic themes.

5. Creating final codes structure, apply to all; matching emerging themes with existing ones to develop permanent structures and conclusions. (See Figure 3.14).

With the benefits of both deductive and inductive approaches, since the study was designed to use both quantitative and qualitative approaches (a mixed methods approach), the entire data was gathered after transcription and reorganised into groups according to physical attributes; thus transcripts from universities, firms, newspapers, catalogues and those printed from websites. The investigator first read through the transcripts freely, thoroughly and deeply also as advised by Curry (2015) and Braun and Clarke (2013) without any preconceived mind at this time to scrutinise the detailed meaning and implications of all phrases and sentences. Phrases giving pieces of more interesting information and mini stories interviewees wanted to convey were first conceptualised and noted, and quotations and potential themes were also noted and highlighted. A process Thomas (2013) also advises researchers to do in a quiet and serene environment deliberately selected to create an uninterrupted and ideal atmosphere for good results.

To obtain the best possible results, a comprehensive coding process was adopted. At the second stage more transcripts were read through just to have a broader clue on what was going on in the data. Coding data is very helpful and is defined by Miles et al. (2014, p. 71) as; ‘labels that assign symbolic meaning to the descriptive and inferential information compiled during a study’.
Therefore the initial coding process started afterwards to put the data into the context of the firm’s position on knowledge and learning processes and sources available from the first reading. These were further developed through a further systematic and broad coding of the interview transcripts which was guided by the initial codes and more were added. Over the process, other sub-codes were then added to the already existing code structure by adding and reading more transcripts in the second stage. Increasingly, the process became cyclical, pragmatic, meticulous, systematic, daunting and iterative as described by Thomas (2013).

By the time five transcripts were read thoroughly at the fourth stage, over 80 codes emerged and were further merged through a hierarchical arrangement of ideas and construct mapping. This was in a sequential order from the transcription stage into theme mapping (Thomas, 2009, Thomas, 2013). At this stage, issues concerning levels of education, disparities in access to universities, knowledge networks to market and facilities like loans and financial assistance came in as themes. To be specific, this coding process was mechanical, traditionally with the use of namely; hand, A4 paper and different colour highlighters. The markers were used to highlight emerging codes, short phrases and sentences that captured key characteristics of interview conversations. Typically, some were highlighted based on emphasis observed to have been placed on them by interviewees at the time of the interviews. Evidently, this outlined almost all properties and critical features of the verbal information which were further looked at and noted through constant comparison of ideas and concepts to make sense of the texts.

Lastly, the final code structure was created and applied to the rest of the transcripts. From here, a list of results, conclusions, relationships and generalisations that came through the quantitative analyses was matched to some codes to offer explanation and answers. For example, the issue of why both formal and informal mechanisms of university knowledge transfer do not by nature lead to innovation in firms were matched with the general perception of lack of trust and competence. Also issues of collaborations tallied well with size, capabilities and access to facilities. Some issues sprung out as surprise themes to note, for instance, themes like lack of information about TTOs and their work in business society was also seen to explain perhaps a lack of qualified staff and resources for technology transfer offices. At this stage, more major
themes featured to explain all of the issues that were raised in the quantitative research results and needed further insight. Figure 3.14 illustrates the transcription process.

**Figure 3:14. Integrated approach –Deductive/Inductive method**

![Diagram of integrated approach](image)

Adopted from (Curry, 2015): YouTube Modified

### 3.11.3. Reliability and validity

Reliability and validity are described as psychometric characteristics of an instrument used to assess the final product of a study (Kimberlin and Winterstein, 2008). To explain, validity is determined by how well a research has been designed to measure and capture what it was primarily anticipated to capture in a study (Murphy-Black, 2006). Although, Goodman and Evan (2006) argue that the instrument for a research may be reliable, yet not produce any valid results in a research or ensure generlisability of research results. Also validity is highly subjective according to Saunders et al. (2012); therefore triangulation has been used in several methods; data and data collection, data analysis and approaches to increase chances of validity and reliability.

Also, in the measurement literature, reliability of instruments used are central to the process and to the overall results and social science researchers consider it as one of the fundamental requirements of every research (Punch, 2005, Hagan, 2014). In this study, the reliability of the instruments was taken seriously right from the beginning and several measures were taken to
eliminate all potential sources of mistakes to avoid all forms of errors. For example, sentences were rephrased in the process of developing and validating the instrument. According to Crocker and Algina (1986, p. 106), ‘a test developer has a responsibility to identify the sources of measurement error that would be most detrimental to useful score interpretation and design a reliability study that permits such errors to occur so that their effects can be assessed’.

The issue of validity was therefore tackled with proper design of all constructs to really measure issues of concern to the study to ensure construct validity. At each stage, all types of validities in the literature and relevant to this study were dealt with independently to include construct and content validities which ensured true representation of the concepts under discussion in the study (Kimberlin and Winterstein, 2008). Notwithstanding the need for reliability and validity checks in research, another section of the body of knowledge claims that due to differences in quantitative and qualitative research and differences in the purposes of evaluating their quality of studies, the concept of reliability is deemed irrelevant in qualitative research. According to Stenbacka (2001, p. 552) Stenbacka (2001, p. 552), ‘the concept of reliability is even misleading in qualitative research. If a qualitative study is discussed with reliability as a criterion, the consequence is rather that the study is no good’.

3.11.4. Ethical considerations

Ethical issues in research have attracted the attention of social science researchers of late and require researchers to properly and adequately take necessary measures to respect, minimize harm, duly inform and seek the consent of all participants in any form of research that involves human subjects (Bond and Gerrish, 2006, Johnson and Long, 2006, Creswell, 2014). Without doubt, another school of thought within the body of literature such as that of Gerald (2002) casts doubt as to whether traditional theories on ethical issues actually meets challenges of other traditions like environmentalism, multiculturalism and feminism. In all traditions, confidentiality of information extracted from participants is essentially required to be maintained and assurance of anonymity in principle also needs to be made clear to them. Notwithstanding the risks and benefits (HSCIC, 2013, Lancaster, 2005).
With this letters, were delivered to firms per the university research protocol providing adequate information with regards to the essence, the objectives and final implications of the findings of the study to the firms. It is recommended that the consent of respondents in a study needs to be made very clear and unambiguous to them or to their advocates right from the start (Goodman and Evan, 2006, Johnson and Closs, 2006, Johnson and Long, 2006). Respondents in this study therefore were accordingly contacted. Confidentiality and anonymity were observed and all copies of transcripts and other related data documents were locked away and stored with a password electronically.

3.11.5. Generalisability

The purpose of a rigorous method of sampling is to obtain a representative sample from a sample frame to confidently generalise the results of the study to the population of interest (Danermark et al., 2002, Punch, 2005). This was at the heart of the current study and generalising the results to make conclusions about the general Ghanaian context was paramount. However, there is still the general consensus among researchers that research findings can be totally valid in one population and not valid in another location for lack of generalisability (Danermark et al., 2002, Thomas, 2013). In this context therefore, it describes the level at which research findings may be useful to another area outside the area it was primarily intended for. To ensure the generalisability of the study results, the study was designed and enough data was collected in the samples using the right methods available to obtain adequate sample for analysis. On account of this, the knowledge and understanding obtained from the sample considered in this study can be assertively generalised to the broader context of the entire corporate body in Ghana, and not only that, it has the potential to be valid for all firms and sectors. Table 3.6 summarises the entire methodology employed for the study.
3.12. Research hypotheses

By far, extensive background literature on university knowledge transfer mechanisms is reviewed leading to formulation of a conceptual framework based on available knowledge transfer/innovation models. These models address the extent to which various mechanisms are used significantly to transfer knowledge generated in universities and by university researchers, and end up commercialised or affect firm-level innovation performance. By unpacking the frameworks used in the literature to explain how knowledge from universities get to market, the study develops hypotheses as to how those various channels empirically influence innovation
performance in firms. With that, a comprehensive structural model is adopted by modifying an existing one that has been used as conceptual framework for the study. Since the purpose of the study is to determine how innovation at firm level is influenced in Ghana mainly by formal and informal mechanisms of university knowledge transfer using a knowledge-transfer framework to guide the study, a hypothesis based study is deemed appropriate to help to understand the concept (Gefen et al., 2000b, Groenland and Stalpers, 2012, Kock, 2011). Also, based on the objective of investigating primarily, the influence of both formal and informal mechanisms of university knowledge transfer, the entire test hinges on two main hypotheses, thus;

**Hypotheses: H₉**

*Formal mechanisms of knowledge transfer between universities and firms in Ghana directly influence innovation performance in firms.*

and

**Hypotheses: H₁₀**

*Informal mechanisms of knowledge transfer between universities and firms in Ghana directly influence innovation performance in firms.*

Other hypotheses involving mediators in the framework are listed in Table 3.7. The mediators in the framework represent key influencing components in university knowledge transfer theory for innovation performance in firms. For this reason, they are also examined for their mediating role with empirical data collected in Ghana in multi-stage mixed-methods. The theories behind the development of the hypotheses are captured in Chapter 2. This is to set the stage for inferential statistics in the next chapter.
Table 3.7 Summary of hypotheses

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_1$</td>
<td>Informal mechanisms of university knowledge transfer directly influence formal mechanisms of knowledge transfer in Ghana.</td>
</tr>
<tr>
<td>$H_2$</td>
<td>Formal mechanisms of university knowledge transfer between universities and firms directly influence collaborative research between them in Ghana.</td>
</tr>
<tr>
<td>$H_3$</td>
<td>Informal mechanisms of university knowledge transfer between universities and firms directly influence collaborative research between them in Ghana.</td>
</tr>
<tr>
<td>$H_4$</td>
<td>Firms in Ghana benefit directly from their formal links with technology transfer offices.</td>
</tr>
<tr>
<td>$H_5$</td>
<td>Informal mechanisms of university knowledge transfer between universities and firms directly influence the formation of knowledge networks in Ghana.</td>
</tr>
<tr>
<td>$H_6$</td>
<td>Technology transfer offices in Ghana directly influence innovation performance in firms.</td>
</tr>
<tr>
<td>$H_7$</td>
<td>Knowledge networks in Ghana directly influence innovation performance in firms.</td>
</tr>
<tr>
<td>$H_8$</td>
<td>Collaborative research between universities and firms in Ghana directly lead to innovation performance in firms.</td>
</tr>
<tr>
<td>$H_9$</td>
<td>Formal mechanisms of university knowledge transfer between universities and firms in Ghana directly influence innovation performance in firms.</td>
</tr>
<tr>
<td>$H_{10}$</td>
<td>Informal mechanisms of university knowledge transfer between universities and firms in Ghana directly influence innovation performance in firms.</td>
</tr>
</tbody>
</table>

### 3.13. Summary

The chapter presents the philosophical stance of the study and narrows to the methodological choice with theoretical and practical justification for the choice. Then a pilot study conducted to test the survey instrument and the outcomes of the pilot are both presented in details. The methods of sampling, data collection and analysis successfully conducted for both quantitative and qualitative research approaches are clearly explained. To be clearer, the section presents the basic statistics in the quantitative research aspect, data management on the part of the qualitative research. It also gives details on the methods of data analysis in the qualitative research used to
provide the needed explanation to the previous quantitative research results. In particular, the data analysis offers in-depth knowledge through a systematic and rigorous process recommended in qualitative approach to research. The entire research process is evaluated along acceptable checks and monitoring tools available in the literature. The last part discusses the reliability, validity and ethical issues generally surrounding social science research and concerns that have been raised over the years about safety and security of social science research participants. How the study dealt with these is discussed in the section. Finally, generalisability of the research results is presented to put into context how the potential of the study is challenged to meet the conditions of generalisability in the study. The chapter actually ends with a presentation of the research hypotheses which is intended to rusher in the primary propositions of the research thesis. This introduces the main concern of the purpose of the study.
Chapter 4. Findings
4.1. Introduction

The purpose of the study is to contribute to existing body of knowledge by examining how formal and informal mechanisms of university knowledge transfer influence innovation performance in firms in Ghana at sector levels. The findings are evidence from analysis of data collected through a cross-sectional survey conducted on 533 firms and thematic interviews with directors and managers of 5 universities and 10 firms in semi-urban and urban areas in Ghana. In the process, explanatory sequential mixed methods have been used to understand how formal and informal mechanisms of university knowledge transfer influence innovation in firms in Ghana. The findings encompass the role played by collaborative research, knowledge networks and technology transfer offices on innovation performance. It also shows how they mediate the effect of formal and informal mechanisms of university knowledge transfer on innovation at sector levels. Quantitative and interview data have been used. Other sources relied on for data to corroborate evidence from interviews were documents which also included government reports, leaflets, in-house letters, prospectus and university research annual reports. Eventually, a research model developed in Chapter 2 was used to fit the data at national and industry sector levels with the help of hypotheses formulated from the model to help achieve the research aim. The model offered a platform to understand universities' engagement with industry in Ghana and how industry sectors' innovation performances are affected. Structural equation modelling was used as a statistical technique in the hypothesis based test and supported with thematic analysis. For clarity, the findings are presented here according to the mechanisms of university knowledge transfer which represent the main themes of the study and the components of the conceptual framework. The rest of the sections give the findings in accordance with significant themes as found in the discussions.

4.2. Exploratory findings

By far, the service sector appears to be the largest in the country, which is close to two-thirds of the population of firms in the sample. This leaves the primary sector as the smallest and far less than one-quarter of the population of firms in the sample. In terms of years of business operation and experiences, the data structure shows that at national level, there are more 10—25 year old firms than any other category in the country which could suggest that the last 25 years has seen a
lot of firms starting-up in the system than ever before. The situation is seen to be a little different over fifty years ago as it shows very few firms operating in the system aged fifty years and above. Again at the sector levels, it presents the same picture, thus; 10—25 year-old firms dominate in all the sectors. This group takes a little over half of the total firms in the primary sector too and less than half of the total firms in the manufacturing sector.

A similar case is seen in the manufacturing sector, where the same age group is seen to take about one-third but parallels the early stage firms (1—9) as the highest age groups. Implicitly, this age group demonstrates that the services sector and has lately seen an increase in the number of micro-enterprises coming into the system. Ostensibly, this observation is unveiled due to the fact that the whole survey data set has been explored at sector levels, therefore revealing these sector characteristics. More so, a look at the sub-units within sectors again reveals that the financial and health services, which are both in the service sector, appear to be dominating the sub-units with each of the two representing nearly one-quarter of the total population in the sector. In fact, this points to an economic system that has weak primary and manufacturing sectors. However, petroleum and agriculture products, which are clearly indicated, can also be seen to dominate the primary sector while food processing seems to be the most prominent sub-unit in the manufacturing sector. Further analysis with the sector comes next, giving more insight into the behaviours of firms in various formal university knowledge transfer mechanisms and innovation performances.

4.3. Inferential statistics

In this section, the study tries to reach conclusions beyond the description of the data; thus, make scientific judgments with probability that an observed difference between categories or groups of objects might not have happened by chance in this study. However, inferential statistics comes with a lot of challenging conditions to meet and the conditions are discussed at various stages in the coming sections.

To deal with the propositions of whether formal and informal mechanisms of university knowledge transfer actually influence innovation performance in firms in Ghana, the conceptual research model in Figure 2.5 is adopted and modified from ‘technology transfer framework’ by
Bradley et al. (2013) to suit the context and purpose of the study. The structural presentation for modelling with the empirical data is in Figure 4.1. The aim here is to examine available empirical data from Ghana with the framework to find out if formal and informal mechanisms of university knowledge transfer actually influence innovation performance as suggested in the framework. Based on the framework, the hypotheses formulated are tested and the results analysed for inference on the total Ghanaian corporate sector and other developing economies with similar characteristics. By the way, the ovals in the model represent latent variables, rectangles are indicators and the arrows show the direction of relationships between variables.

**Figure 4:1 Research model**
Variable definitions in the research model

Exogenous latent variables:

- Formal mechanisms of university knowledge transfer (FORM)
- Informal mechanisms of university knowledge transfer (INFO)

Mediating variable

- Knowledge network (NET)
- Technology transfer offices (TTOs)
- Collaborative research (COLL)

Endogenous latent variable

- Innovation performance in firms (INNO)

Therefore, the examination of the data is by hypothesis testing with the modified framework to determine if they can be supported empirically. Significantly, the relevance here is to understand the Ghanaian innovation ecosystem and learn the role of these mechanisms on the productive sector of the economy. Essentially, the conceptual model is used as a lens to statistically examine and investigate how the hypothesised model in this study fits the empirical data collected from Ghanaian firms. After this stage of the investigation, the model is further used in turn as a lens or a frame of reference to compare the three sub-sectors identified within the productive sector data sets. Crucially, these three sub-datasets are characterised according to observable heterogeneous subcategories inherent in the whole population from which the data set was collected. The research model is therefore first statistically examined with the aggregate data set, and then the sub-datasets are also examined with the same research model in succession and compared between each other to understand how different or similar these heterogeneous sub-categories are. Predominantly, the comparison is therefore undertaken both vertically (between the subcategories and the main model) and horizontally (between the sub-categories themselves). As hypothesised in the research model to underpin the thesis of the study, the conceptual model is expected to help demonstrate that formal and informal mechanisms of university knowledge
transfer directly influence innovation performance in firms in Ghana. Partial least squares structural equation modelling was the chosen technique. To do this, the next stage of the quantitative research follows these phases:

First model (Aggregate data)

1. Justification of choice of technique
2. Presentation and hypotheses test results of the whole data set and presentation of statistical results
3. Mediation analysis, findings, discussion of results and summary

Sub-models (Sector levels)

1. Presentation and hypotheses test results of the whole data set, evaluation of the three models and presentation of results
2. Mediation analysis, findings, discussion of results, comparison of sector results and summary

4.4. Partial least squares modelling

The choice of Partial Least Squares Structural Equation Modelling (PLS-SEM) for this study has been strategic, timely and of course, appropriate in the sense that theoretically the technique is purposely designed to help researchers identify key drivers of concepts in social science studies involving multiple variables as in the current study (Gefen et al., 2000b, Hair Jr et al., 2014). Significantly, PLS-SEM offers researchers intricate causal networks made of dependent and independent latent constructs to be able to characterise real-world situation in a single study. This therefore makes it suited for mathematical modelling of complex social realities. In fact, the question of the influence of formal and informal mechanisms of university knowledge transfer on firms’ performance in developing economies presents a complex social reality. Moreover, the absence of existing frameworks in such circumstances at sector level makes it more complex to deal with, and so to achieve the research purpose stated in Chapter 1, comprehensively and in a systematic manner, PLS-SEM becomes the obvious choice.
However, SEM in general has a problem of specification errors when a significant construct in the model is missing or there are no enough observable indicators measured for each construct (Gefen et al., 2000a, Gefen et al., 2000b, Hair Jr et al., 2014, Kock, 2015). This could introduce bias in the results leading to wrong interpretations of the results. For this, the study has made enough arrangement to control it by gathering sufficient data and observable indicators. In fact, the associated merits of SEM for which the study employs it is that, it can be used to demonstrate that a proposed association in a structural model or predicted correlations in a set of data are in harmony with the causation truly predicted with an established theory-base (Gefen and Straub, 2005, Gefen et al., 2000b, Groenland and Stalpers, 2012). Among other advantages for the choice also mainly include: 1) PLS has the advantage of working with small sample sizes with its non-parametric features (Henseler et al., 2009); 2) another is the flexibility in distributional assumptions and also 3) it is used to predict social behaviours in research among other things. Other analytical techniques such as regression and covariance-based equation modelling (CBSEM) techniques comes with a lot of limitations that affect generalisability of their results (Gefen and Straub, 2005, Gefen et al., 2000a, Gefen et al., 2000b). Since in this study the objective is to examine and identify key university knowledge transfer mechanisms to firms in Ghana on the basis of merits, PLS-SEM has been adopted to use the research framework to explore the conceptual relationship between university knowledge transfer mechanisms and innovation performance at the firms’ level.

Notably, structural equation modelling (SEM) as an aspect of path analysis is an embodiment of sub-models; thus, the measurement and structural models, that come together to constitute (SEM-PLS) path analysis (Urbach and Ahlemann, 2010). Crucially, it is deemed a second generation modelling technique to multivariate data analysis accredited to the positivistic research tradition (Hair et al., 2016). As a component-based data modelling approach, it is a technique that efficiently combines several exogenous and endogenous latent variables in a multi-step path analysis (Gefen et al., 2000b). Justifiably, for the analysis in this study, WarpPLS v5.0 statistical package was used for its added ability to model nonlinear relationships between latent variables (Kock, 2015).
Structural equation modelling with WarpPLS in general provides statistical tests for both linear and non-linear relationship with which researchers can test complicated research hypotheses using SEM as in this study to establish relationships between variables of interest to the study. However, a good hypothesis in SEM-PLS has conditional characteristics that must be met for it to produce the required result. Significantly, hypothesis has to be simple, specific and generally, as in this case has exogenous (independent) and endogenous (dependent) latent variables, and of course, must be stated in advance, which the current study has met. Even with that, the conclusion of a test may still be wrong and that presents a limitation to research process of which this study is also affected. For example, a type I error can occur if an investigator accidentally rejects a null hypothesis when indeed it is true or a Type II error when he/she fails to reject it when indeed it is false. For instance, when a sample is not a representative of the population of interest to the study. Another limitation is the size of the association (Effect size) between the research variables, for instance, between formal mechanisms of university knowledge transfer and innovation performance (Appendices D3, D8, D13 and D18 contains the achieved values for various hypotheses). This was difficult for the investigator to estimate beforehand, but with the help of the pilot survey, the investigator was able to estimate it together with the expected power in the sample to ‘find a statistically significant difference when such a difference actually exists’ which are somewhat arbitrary (Banerjee et al., 2009). Also, the investigator had to establish the maximum chance of making a type I and type II errors discussed above (at 0.05) in advance of the study. Actually, the researcher could not eliminate uncertainties completely. At the very best, he was able to quantify it for sample size calculations. Most of all, the investigator could not ‘prove’ or ‘disprove’ anything by hypothesis in the process of statistical tests. Nevertheless, he could only reject the null hypothesis and by default accepted the alternative hypothesis in each case if a null hypothesis could not be accepted. The next section presents the first test results of the hypotheses of the main research model.

4.5. Research model hypothesis test with the whole data set

Figure 4.2 presents the visual display of the statistical outcome of the hypothesis test on the research model of the whole data set. This presents an explanation to the knowledge transfer situation in the broader perspective of the Ghanaian economy. In practice, before any sense can
be made with the PLS-SEM results, it has to be evaluated for the model fitness and adequacies and the coming section presents a thorough evaluation of the model.

**Figure 4:2. Research model for the Ghana**

![Diagram of the research model for Ghana with statistical results and significance levels.](image)

### 4.6. Research models evaluation for reliability and validity

For PLS-SEM, there are no global goodness of fit indices to assess the whole models at once, nonetheless fit measures for the outer and inner models apply for which Hair et al. (2016) contend rather gives it an added advantage over other covariance-based techniques. The measures primarily determine relationships between variables and whether the model fit the data as predicted (Urbach and Ahlemann, 2010, Lei and Wu, 2007). Thus, the research model is therefore assessed accordingly in the coming sections. In fact, bootstrapping algorithm has been used to estimate the model parameters and standard errors with 900 resamples in 5 iterations (Kock, 2015, Gefen et al., 2000b, Gefen and Straub, 2005, Urbach and Ahlemann, 2010). Appendix D-1 presents an assessment of all the outer models which appear good for all. For
internal reliability, composite reliability values are all well above 0.80 for the reflective construct (Hair et al., 2016). Also, Appendix D-2 shows strong correlations and Average Variance Extracted (AVEs) for all the constructs indicating substantial amount of the variances explained by the constructs of their indicator variables in the models. Fornell and Larcker (1981) suggest about 0.50 of the variances as a threshold. With the factor loadings, it can be seen that all the indicator item scores loaded high on their respective constructs other than different constructs for discriminant, convergent validities and unidimensionality (Urbach and Ahlemann, 2010). More so, the AVE of any variable is required to be greater than the greatest squared correlation coefficient with all other variables in the model (Chin, 1988, Fornell and Larcker, 1981). Appendix D-3 deals with all measures on explanatory powers, effect sizes and Q-squares which are also good.

After the satisfactory validation of the main research model with respect to the outer and inner models, the interpretation and reporting of the results come in the next section. Also, with the acceptable measures and statistics from the statistical output, all the parameter estimates produced from the PLS regressions are interpreted in the next section. Eventually, all the hypotheses expressed in the structural model in Figure 4.1 are assessed and either statistically supported as hypothesised or not supported.

### 4.7. Main research model results

Typically, in Table 4.1, the model results show a statistically highly significant relationship between FORM and INFO \((H_1; \beta = 0.628, p < 0.001)\) at 0.05 level of significance. Not only that but also positive in magnitude and noticeably the highest among all relationships hypothesised in the model. Nonetheless, the relationships between the two exogenous latent variables and the ultimate endogenous latent variable are both statistically not significant, thus; INFOR \((H_9; \beta = 0.078, p = 0.05)\) and FORM \((H_{10}; \beta = 0.033, p = 0.224)\) in the model at a 5% significant level. Even so, all the three mediating latent variables as seen in Table 4.1: \((H_6; \beta = 0.230, p < 0.001)\), \((H_7; \beta = 0.314, p < 0.001)\) and \((H_8; \beta = 0.317, p < 0.001)\) are found to also be highly significant in the model. Additionally, the two exogenous latent variables FORM and INFO are again found to be statistically influential on all the mediating latent variables; \((H_2; \beta = 0.317, p < 0.001)\), \((H_3; \beta =
0.351, \( p < 0.001 \)), \((H_4; \beta = 0.376, p < 0.001)\) and \((H_5; \beta = 0.357, p < 0.001)\). All of those are therefore confirmed in principle as hypothesised in the structural research model.

To support the above, the correlation coefficients in Appendix D-2 are among all the variables in the model and it can be seen that all the variables correlate well between each other and are statistically significant, offering authentic relationships between all the relationships established by the model path coefficients in Table 4.1.

Table 4:1. Path coefficients (\(\beta\)s) for the main models hypotheses

<table>
<thead>
<tr>
<th>constructs</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOs</th>
<th>NET</th>
<th>COLL</th>
<th>S.E.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM</td>
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<td>TTOs</td>
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<tr>
<td>INNO</td>
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<td>INNO</td>
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<td>INNO</td>
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<td>NET</td>
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</tbody>
</table>
Consequently, considering the path coefficients in Table 4.1 and the coefficients of determination for informal mechanism of university knowledge transfer (INFO), which is proposed to primarily be a driver of formal mechanisms of university knowledge transfer (FORM) in the model is obviously very fundamental in firms formal links with universities. In contrast, for the pair (in \( H_9 \) and \( H_{10} \)) as drivers of innovation performance in firms (INNO), the path coefficients for the two do not prove to directly result in innovation performance in firms and their coefficients of determinations do not have any explanatory powers either. Appendix D-4 illustrates the neutral effect on formal mechanisms of university knowledge transfer on innovation performance in firms showing the regression line being parallel to the x-axis (FORM). This implies that despite more formal links are established with universities by firms in the country, virtually no improvements are made in innovation performance in firms just because of that. The same is seen in Appendix D-5 where the regression line is also parallel to the a-axis (INFO) showing a non-proportionate increase innovation as informal mechanisms of university knowledge transfer increases.

In any case, the pair, thus; (INFO and FORM) has respectively, almost the same impact in bringing firms and universities together for collaborative research. Collaboration with universities (COLL) is also seen eventually to lead to innovation in firms (INNO). More so, FORM actually appears to generate a lot of benefit from the work of technology transfer offices (TTOs). Equally, it is found that INFO also has tremendous telling effect on the formation of knowledge networks which eventually leads to innovation performance in firms. Interestingly, both TTOs and NET accordingly have substantial impact on innovation taking place in firms. On the whole, it is illustrated in Table 3.6 that comparatively FORM has the next highest influential effect among all the components on TTOs after INFO on FORM, leaving TTOs with the least effect on INNO.

### 4.8. Mediation analysis

This section takes a look at the role of technology transfer offices, knowledge networks and collaborative research as mediators in transmitting knowledge from universities through either formal or informal means to firms in Ghana as a whole. It tries to explain whether they facilitate the process when they are incorporated in universities interactions with businesses. These types
of investigations are widely neglected in the academic literature and the current study seeks to remedy that.

In theory, it is widely expected that in any cause-effect relationship, independent variables will directly relate with dependent variables without interferences from other components (Hair et al., 2014a). Conversely, in reality, many influential variables come in between them and change the direction of influence or in some cases reduces or increases their degree of influence on the dependent variables (Kock, 2011). Largely, these components play very important role in exploring key drivers of a response variable in a model and when ignored could lead to wrong research conclusions (Hair et al., 2016). With the objective of investigating the degree and direction of influence of both formal (FORM) and informal mechanisms of university knowledge transfer (INFO) on innovation in firms (INNO) in Ghana, the research takes further interest in the mediators, which are important and theoretically relevant mechanisms of knowledge transfer from universities to firms in the literature (Bekkers and Freitas, 2008, Grimpe and Hussinger, 2013). These additional mechanisms also according to extant literature may also exert some influence on the direct effect that both formal and informal mechanisms of university knowledge transfer have on innovation taking place in firms (Abdulai et al., 2015, Abreu et al., 2009).

In fact, the purpose of the this analysis is to actually find and explain how TTOs, knowledge networks and collaborative research influence relationships between both formal and informal mechanisms of university knowledge transfer, and innovation in firms in Ghana. The essence of the analysis is largely because of the absence of literature on how the said mechanisms transmit knowledge for innovation in the context of developing economies. However, mediation analysis comes with some limitation in the forms of assumptions that are difficult to meet but are necessary condition. To start with: 1) There is the assumption that a correctly specified model has no misspecification of causal order. 2) There is no misspecification of causal direction. In other words, there is reciprocal causation between the mediators and the endogenous latent variable. 3) There is no misspecification as a result of unmeasured variables that influence the endogenous latent variable in the analysis, and finally. 4) That there is no misspecification resulting in imperfect measurement inherent in the measurement models. Regrettably, all of these could not be tested in this study simply because there are purely conceptual and mostly
impossible to meet. The only available possible solution for this is incorporation of additional information from exiting body of knowledge to achieve a tentative conclusion that the incidentce of mediation actually exists (MacKinnon et al., 2007).

From the analysis in Table 4.2, the direct relationships are examined and established, and both exogenous latent variables (FORM: \( \beta = 0.249, p < 0.001 \) and INFO: \( \beta = 0.291, p < 0.001 \)) have significant and positive total effect on innovation performance in firms (INNO) as expected when applied without these mediators in a model.

### Table 4.2. Significance analysis of path coefficient (\( \beta \))s without the mediators

<table>
<thead>
<tr>
<th>Ultimate endogenous latent variable</th>
<th>FORM</th>
<th>INFO</th>
<th>S.E.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>INNO</td>
<td>0.249</td>
<td></td>
<td>0.044</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.291</td>
<td>0.048</td>
<td>0.001</td>
</tr>
</tbody>
</table>

The research model on taking mediation theory into consideration proposes that the relationships between the two mechanisms individually, (FORM and INFO) and innovation performance in firms are mediated by the three components (TTOs, COLL and NET) identified in the extant literature (Bekkers and Freitas, 2008, Abdulai et al., 2015, Abreu et al., 2009). Incidentally, with all the mediating components, the main research model shows a statistically non-significant relationship between (FORM and INFO) individually, and innovation performance in firms; INNO: \( H_0: \beta = 0.033, p = 0.224 \) and \( H_{10:} \beta = 0.078, p = 0.05 \) respectively. Actually, these results provide an accurate and full explanation of a cause and effect in the relationships between the variables in question. In effect, the interpretation here is that the mediators, thus; Technology transfer offices (TTOs), Knowledge networks (NET) and Collaborative research (COLL) absorb the entire effects of the exogenous latent variables (FORM) and (INFO) on the endogenous latent variable (INNO) in the main model since they hold the key effect of their influence on innovation in firms (INNO).
Table 4.3. Variances accounted for by mediating variables for innovation in firms

<table>
<thead>
<tr>
<th>Effect</th>
<th>FORM</th>
<th>Latent variables</th>
<th>Effect value</th>
<th>S.E.</th>
<th>P value</th>
<th>VAF</th>
<th>INFO</th>
<th>Latent variables</th>
<th>Effect value</th>
<th>S.E.</th>
<th>P value</th>
<th>VAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect effect</td>
<td>FORM</td>
<td></td>
<td>0.09</td>
<td>0.03</td>
<td>0.00</td>
<td>0.75</td>
<td>INFO</td>
<td></td>
<td>0.11</td>
<td>0.03</td>
<td>0.00</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>TTO</td>
<td></td>
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<td></td>
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<tr>
<td>Total effect</td>
<td>Direct + Indirect</td>
<td></td>
<td>0.12</td>
<td>0.07</td>
<td>0.061</td>
<td></td>
<td>Direct + Indirect</td>
<td></td>
<td>0.18</td>
<td>0.08</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>Indirect effect</td>
<td>FORM</td>
<td></td>
<td>0.10</td>
<td>0.06</td>
<td>0.001</td>
<td>0.77</td>
<td>INFO</td>
<td></td>
<td>0.11</td>
<td>0.04</td>
<td>0.001</td>
<td>0.58</td>
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<tr>
<td>Total effect</td>
<td>Direct + Indirect</td>
<td></td>
<td>0.13</td>
<td>0.05</td>
<td>0.001</td>
<td></td>
<td>Direct + Indirect</td>
<td></td>
<td>0.19</td>
<td>0.05</td>
<td>0.001</td>
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</tr>
</tbody>
</table>

Note: VAF = Variance Accounted For

Note:
In arithmetic terms, Variance Accounted For in PLS-SEM mediation analysis can be calculated as:

\[
VAF = \frac{(\beta_a \times \beta_b)}{(\beta_a \times \beta_b) + \beta_c} \quad \ldots \quad 4.1
\]

Where \(\beta\) is the path coefficient, \(a\) and \(b\) are the effects of the mediating variable and \(c\) is the direct effect

Also note:
Endogenous Latent Variable (LV) means dependent LV
Exogenous LV means independent LV.

In Table 4.3, the indirect effect of formal mechanisms of university knowledge transfer (FORM) through technology transfer offices (TTOs) on innovation performance in firms (INNO) is 0.09
and statistically significant at $p < 0.001$. With the direct effect of FORM in the table being 0.03, the total effect is 0.12 and statistically significant at $p = 0.061$ at 10% significant level. The VAF is 0.75 indicating that 75% of FORM’s effect can be explained to affect INNO through TTOs. Accordingly, since the VAF is more than 20% but less than 80% as recommended by (Hair et al., 2014a) it can be said that there is a partial mediation between them. The same is true for INFO with a direct effect of 0.08 and indirect effect of 0.11, the total effect is 0.19 on INNO and statistically significant at $p < 0.001$. The VAF is 0.61 meaning that 61% of INFO’s effect on INNO is explained through the NET mediator. Again, since 61% is more than 20% but less than 80% it can be implied that there is equally a partial mediation between them. Finally, the VAF for FORM through COLL is calculated to be 77% while that of INFO through COLL is calculated to be 58%, both of which account for less than 80% of the variances in INNO but more than 20%, therefore can be concluded as being partial mediation. By extension, partial mediation means both the exogenous latent variable and the intervening variable jointly explain the endogenous latent variable at the same time. In effect, the mediator explains part of the endogenous latent variable and there is therefore a split between direct and indirect mediation in all the mediations which Zhao et al. (2010) describes as complementary mediation in such a situation.

4.9. Analysis of observed heterogeneous groups

As explained in the previous section on mediation variables in PLS models, the same is true for the moderation effect of heterogeneity in data with empirically recognisable categories. Observable categories in a population could also alter the cause of influence of variables or the results of hypothesis tests on heterogeneous groups’ perception and experiences (Bellamy et al., 2014). Situations of this nature, as in this current research, could yield significant differences among categories of respondents and needs to be considered in any PLS-SEM path modelling. Following that, heterogeneity in data could change the direction of influence or at worst, as Hair et al. (2016) put it ‘when heterogeneity is present significantly negative and positive group-specific effects can cancel each other out when analysed on the aggregate data level and suggest the absence of a significant difference’. Increasingly, heterogeneity in a data set therefore plays a very important role in investigating a research model with a cross-sectional data set. However,
researchers mostly overlook this and its significance and role are scantly reported in the literature. Therefore the current study has accordingly taken it into consideration to fill the gap.

Notably, as hinted in the previous section, the study explores the data set further along the lines of sub-sectors as a matter of theoretical significance. In this section, the study recognises three observable categories (sectors) and therefore employs a multi-group analysis to compare differences, if found at all, in innovation performance of firms in the three sectors. In particular, the goal at this point, is to explore the differences that can be traced back to the individual characteristics of the sectors. Also, it is intended to eventually reveal the effect of differences inherent in these sectors and try to unbundle the dilemma of whether both formal and informal mechanisms of university knowledge transfer directly influence innovation in firms differently in different sectors. After statistically examining the research model with the aggregate dataset in previous sections, the same model is then used to further investigate the same innovation performance in the subsequent of sections in all the sectors which eventually reveals more possible difference that exist as already established in the basic statistics. To reiterate, the research model is expected to demonstrate that formal (FORM) and informal mechanisms of university knowledge transfer (INFO) both influence innovation directly as the literature suggests (Grimpe and Hussinger, 2013). This will be considered in all the sectors and the mediating variables (TTOs, NET and COLL) will be assessed for the same reason as before. The next sections present the three sub-models fitted to the sub-data sets representing the three sectors of the Ghanaian economy.

**4.10. Hypothesis test for primary sector**

With the data split into sectors, the primary sector data is employed first with the same hypothesised research model. This is followed by the manufacturing and finally the service sector. The graphical presentation of the statistical outcomes of the primary sector model is given in Figure 4.3 below.
Figure 4.3. Research model for primary sector

For illustration, this section presents the model’s statistical results for the primary sector. It shows the analytical information from which inferences of the sample results can be generalised for the larger population. The null hypothesis here for all relationships is that ‘the relationship between the exogenous latent variable and the endogenous latent variable is non-existent’; \( H_0: \beta = 0 \) at 5% significant level. To explain, each relationship is designated by \( H \), numbered from 1 to 10 to differentiate them. Also, letters a, b and c are used to identify the hypotheses for the primary, manufacturing and service sectors, respectively. For example; \( H_{1a} \) represents hypothesis 1a in the primary sector. For all the sectors, the research model statistics are then discussed and eventually explained in the subsequent sections.

### 4.10.1. Research model statistics for primary sector

Table 4.4 contains path coefficients and \( p \)-values for all hypotheses only for the primary sector model and shows statistically a highly significant relationship between FORM and INFO (\( H_{1a}: \beta = 0.607, p < 0.001 \)) to begin with. The two exogenous latent variables are found to be not
significant, thus; FORM ($H_{9a}; \beta = 0.003, p = 0.491$) and INFO ($H_{10a}; \beta = 0.232, p = 0.088$) on innovation performance in firms (INNO). Incidentally, only one of the mediating variables; NET ($H_{7a}; \beta = 0.479, p < 0.001$) is found to be directly influential on INNO in this sub-model. Nonetheless, the two exogenous latent variables; FORM and INFO are hypothesised to be directly influential on the three mediating variables accordingly in the table. Co-incidentally, two of the mediating variables are not directly influential on INNO; ($H_{6a}; \beta = 0.055, p = 0.331$) and ($H_{8a}; \beta = 0.074, p = 0.314$). Finally, between the two exogenous latent variables, only INFO is found to be directly influential on COLL: ($H_{3a}; \beta = 0.558, p < 0.001$) but FORM is not ($H_{2a}; \beta = 0.093, p = 0.222$).

Table 4.4. Path coefficients ($\beta$s) for models hypotheses for primary sector

<table>
<thead>
<tr>
<th>Constructs</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOs</th>
<th>NET</th>
<th>COLL</th>
<th>S.E.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM</td>
<td></td>
<td>$H_{1a}$; 0.607</td>
<td></td>
<td></td>
<td></td>
<td>0.082</td>
<td>0.001</td>
</tr>
<tr>
<td>TTOs</td>
<td></td>
<td>$H_{4a}$; 0.484</td>
<td></td>
<td></td>
<td></td>
<td>0.107</td>
<td>0.001</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{6a}$; 0.055</td>
<td></td>
<td></td>
<td>0.125</td>
<td>0.331</td>
</tr>
<tr>
<td>INNO</td>
<td>$H_{9a}$; 0.003</td>
<td></td>
<td>$H_{10a}$; 0.232</td>
<td></td>
<td></td>
<td>0.124</td>
<td>0.491</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{7a}$; 0.479</td>
<td></td>
<td></td>
<td>0.171</td>
<td>0.088</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$H_{8a}$; 0.074</td>
<td></td>
<td>0.096</td>
<td>0.001</td>
</tr>
<tr>
<td>NET</td>
<td></td>
<td>$H_{5a}$; 0.458</td>
<td></td>
<td></td>
<td></td>
<td>0.084</td>
<td>0.001</td>
</tr>
<tr>
<td>COLL</td>
<td>$H_{2a}$; 0.093</td>
<td></td>
<td>$H_{3a}$; 0.558</td>
<td></td>
<td></td>
<td>0.119</td>
<td>0.222</td>
</tr>
</tbody>
</table>

195
4.10.2. Research model evaluation for reliability, validity and results

In this section, the primary sector sub-model is evaluated for model fitness and adequacy. Indeed, Appendix D-6 has all the fitness measures for the evaluation of the outer models which are all reliable and within acceptable continuums. Appendix D-7 also contains evidence of acceptable measures of correlation coefficients among the variables which is a precondition for PLS-SEM technique. Average Variance Extracted (AVEs) are also good. The same is true for the inner model measures in Appendix D-8 dealing with all measures on explanatory powers, effect sizes and Q-squares which are also good.

To this end, a path coefficient of 0.607 for FORM gives the greatest positive influencing variable in the model and confirms the first hypothesis \(H_{1a}\) for the model. It also happens to have the highest coefficient of determination in Appendix D-8 for informal mechanisms of university knowledge transfer (INFO), which is proposed to be a driver of formal mechanism of university knowledge transfer (FORM). Obviously, it is a fundamental component in firms’ formal links with universities. In contrast, for the pair as drivers of innovation performance in firms (INNO); \(H_{9a}\) and \(H_{10a}\) could not be supported statistically. Appendix D-9 shows non-influential formal mechanisms increasing on the horizontal axis without any corresponding increase in innovation performance on the vertical axis. Likewise in Appendix D-10, an increase in the informal mechanisms leads to a seemingly crooked result with little positive and negative changes around zero. These two graphical relationships are presented in the text here because the two predictor variables are the two main drivers of innovation performance mainly being investigated in this study. The same are presented in the manufacturing and service sectors.

Hypothesis \(H_{2a}\) could not be supported either, indicating that FORM does not influence collaboration in the primary sector. However, \(H_{3a}\) is statistically supported in the analysis and this means INFO is a true determinant of firms’ collaboration with universities for research projects in this sector. Hypotheses \(H_{4a}, H_{5a}\) and \(H_{7a}\) are all supported implying that technology transfer offices are beneficial to firms in their innovation performance when they use formal mechanisms with universities. In short, from above results, FORM and INFO do not prove to be directly supportive to innovation performance in firms in this sector. This is also verified by their
coefficients of determination which do not have any explanatory powers either. In any case, only INFO appears to have almost the same impact in bringing firms and universities together for collaborative research. Eventually, collaboration with universities (COLL) is also seen to not lead to innovation in firms (INNO). More so, it is found that informal mechanisms of university knowledge transfer have a telling effect on the formation of networks or clusters of firms. Remarkably, in the primary sector, knowledge networks greatly influence innovation but technology transfer offices do not on their own, likewise collaborative research. In all, informal mechanisms of university knowledge transfer are the most influential variable in the model for the primary sector. Furthermore; it is illustrated in the table that formal mechanisms have the next influential effect of all the components after informal mechanisms.

### 4.11. Hypothesis test for manufacturing sector

The same hypotheses are tested for the manufacturing sector model, and the graphical presentation of the statistical outcomes of the model is presented in Figures 4.4 below.

**Figure 4.4. Research model for manufacturing sector**

*; p<0.10
**; p<0.05
***; p<0.001
n.s.; not significant
Table 4.5 also shows path coefficients for all hypotheses in the model for the manufacturing sector once again with INFO having a highly significant relationship with FORM, thus; \( H_{1b}; \beta = 0.612, p < 0.001 \). Comparatively, between the two exogenous latent variables, FORM is found to be directly influential on INNO; \( H_{9b}; \beta = 0.345, p < 0.001 \). However, INFO is not directly influential on INNO as hypothesised \( H_{10b}; \beta = -0.032, p = 0.414 \). In the table, two of the mediating variables are found to be directly influential on INNO; \( H_{ab}; \beta = 0.343, p < 0.001 \) and \( H_{7b}; \beta = 0.362, p < 0.001 \) but not COLL \( H_{8b}; \beta = -0.031, p = 0.423 \). In this instance, both exogenous latent variables are directly influential on COLL, thus; \( H_{2b}; \beta = 0.291, p < 0.001 \) and \( H_{3b}; \beta = 0.513, p < 0.001 \), respectively. Finally, FORM is also found to be significantly related to TTOs; \( H_{4b}; \beta = 0.508, p < 0.001 \) and INFO is also directly influential on NET; \( H_{5b}; \beta = 0.384, p < 0.001 \).

Table 4.5. Path coefficients (βs) for models hypotheses for manufacturing sector

<table>
<thead>
<tr>
<th>Constructs</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOs</th>
<th>NET</th>
<th>COLL</th>
<th>S.E.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM</td>
<td>( H_{1b} ): 0.612</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.080</td>
<td>0.001</td>
</tr>
<tr>
<td>TTOs</td>
<td>( H_{4b} ): 0.508</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.088</td>
<td>0.001</td>
</tr>
<tr>
<td>INNO</td>
<td>( H_{5b} ): 0.345</td>
<td>( H_{6b} ): 0.362</td>
<td>( H_{7b} ): 0.343</td>
<td></td>
<td></td>
<td>0.104</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>( H_{10b} ): -0.032</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.073</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>( H_{8b} ): -0.031</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.147</td>
<td>0.414</td>
</tr>
<tr>
<td>NET</td>
<td>( H_{5b} ): 0.384</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.124</td>
<td>0.001</td>
</tr>
<tr>
<td>COLL</td>
<td>( H_{2b} ): 0.291</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.002</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>( H_{3b} ): 0.513</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.098</td>
<td>0.001</td>
</tr>
</tbody>
</table>
4.11.1. Research model evaluation for reliability, validity and results

In this section, the manufacturing sector sub-model is evaluated for model fitness and adequacy. Appendix D-11 has all fitness measures for the evaluation of the outer models which are all reliable and within acceptable continuums. Appendix D-12 also contains evidence of acceptable measures of correlation coefficients among the variables which is a precondition for the PLS-SEM technique and Average Variance Extracted (AVEs) are also good. The same is true for the inner models in Appendix D-13.

In the manufacturing sector, $H_{1b}$ is confirmed as seen in Table 4.5, and the interpretation is that informal mechanisms of university knowledge transfer brings about formal mechanisms of university knowledge transfer. Consequently, hypotheses $H_{2b}, H_{3b}, H_{4b}, H_{5b}, H_{6b}, H_{7b}$ and $H_{9b}$ are all supported in the research model for the manufacturing sector. That notwithstanding, hypotheses $H_{8b}$ and $H_{10b}$ have not been found to be supported either and between the two main drivers investigated in the study, only informal mechanisms of university knowledge transfer are not directly influential on innovation performance in Ghana. Appendix D-14 shows how in the manufacturing sector formal mechanisms of university knowledge transfer directly affects innovation performance in firms. Thus; as firms begin links with universities formally, (increase by value of the standard deviation), innovation performance in firms first remains at a steady level and eventually increases. In contrast, the reverse is the case when informal mechanisms of university knowledge transfer with universities decrease in firms in the sector; Appendix D-15 shows no corresponding increase in innovation performance in the firms.

To conclude from, this implies that both formal and informal mechanisms of university knowledge transfer directly influence collaborative research between firms and universities. Also, both directly influence the benefit that accrues to technology transfer offices and network formations respectively. In brief, for this model and between the two drivers, only formal mechanisms appear as drivers of innovation performance in firms in the manufacturing sector. Informal mechanisms are not in the case.
Lastly, hypotheses $H_{8b}$ and $H_{10b}$ could not be supported either in the model and this goes to suggest that informal mechanisms do not influence innovation performance in the sector; the same was as collaborative research does not support innovation. When it comes to knowledge networks, informal mechanisms of knowledge transfer are very important ($H_{5b}$) and firms also benefit when they use informal mechanisms of university knowledge transfer in their search for knowledge and innovation performance in firms. It can be seen that formal mechanisms of university knowledge transfer ($H_{4b}$) and technology transfer offices $H_{6b}$ have almost the same direction of influence on innovation performance in firms. Comparatively, the effect of informal mechanisms on knowledge network formation is synonymous to the effect of knowledge networks on innovation performance in firms. Finally, collaborative research and informal mechanisms are both found not to drive innovation performance in the manufacturing sector.

### 4.12. Hypothesis test for service sector

The last hypothesis tests is the service sector and Figure 4.5, gives the graphical presentation of the statistical outcomes of the model;

**Figure 4:5. Research model for service sector**

![Diagram of research model for service sector](image)

$\beta=0.33^{***}$

$\beta=0.66^{***}$

$\beta=0.38^{***}$

$\beta=0.38^{***}$

$\beta=0.00^{**}$

$\beta=0.20^{***}$

$\beta=0.23^{***}$

$\beta=0.37$

$\beta=0.44$

$\beta=0.15$

*: p<0.10, **: p<0.05, ***: p<0.001, n.s.; not significant
Table 4.6 also exhibits the mathematical relationship between the variables in the model for the service sector. In the table, it can again be seen that the influence of FORM on INNO is statistically highly significant ($H_{1c}: \beta = 0.660, p < 0.001$). However, the influence of the main two exogenous latent variables are statistically not significant on INNO, thus; FORM ($H_{9c}: \beta = 0.101, p = 0.138$) and INFO ($H_{10c}: \beta = 0.003, p = 0.481$). In any case, their influence on all the mediating latent variables; COLL, TTOs and NET are statistically significant, thus; FORM on COLL ($H_{2c}: \beta = 0.383, p < 0.001$), and FORM on TTOs ($H_{4c}: \beta = 0.329, p < 0.001$). Also, INFO on COLL ($H_{3c}: \beta = 0.294, p < 0.001$) and INFO on NET ($H_{5c}: \beta = 0.383, p < 0.001$). In all, it is also found that all the three mediating variables are statistically influential on INNO and can be seen in the table as; COLL ($H_{6c}: \beta = 0.376, p < 0.001$), TTOs ($H_{6c}: \beta = 0.202, p < 0.001$) and NET ($H_{7c}: \beta = 0.233, p < 0.001$).

Table 4.6 Path coefficients ($\beta$s) for models hypotheses for service sector

<table>
<thead>
<tr>
<th>Constructs</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOs</th>
<th>NET</th>
<th>COLL</th>
<th>S.E.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$H_{1c}$:</td>
<td>0.660</td>
<td></td>
<td></td>
<td></td>
<td>0.032</td>
<td>0.001</td>
</tr>
<tr>
<td>TTOs</td>
<td>$H_{4c}$:</td>
<td>0.329</td>
<td></td>
<td></td>
<td></td>
<td>0.051</td>
<td>0.001</td>
</tr>
<tr>
<td>INNO</td>
<td>$H_{6c}$:</td>
<td>0.202</td>
<td></td>
<td></td>
<td></td>
<td>0.053</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>$H_{7c}$:</td>
<td>0.233</td>
<td></td>
<td></td>
<td></td>
<td>0.070</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>$H_{8c}$:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.376</td>
<td>0.063</td>
</tr>
<tr>
<td></td>
<td>$H_{9c}$:</td>
<td>0.010</td>
<td></td>
<td></td>
<td></td>
<td>0.093</td>
<td>0.138</td>
</tr>
<tr>
<td></td>
<td>$H_{10c}$:</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
<td>0.069</td>
<td>0.481</td>
</tr>
<tr>
<td>NET</td>
<td>$H_{5c}$:</td>
<td>0.383</td>
<td></td>
<td></td>
<td></td>
<td>0.058</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>$H_{8c}$:</td>
<td>0.383</td>
<td></td>
<td></td>
<td></td>
<td>0.058</td>
<td>0.001</td>
</tr>
<tr>
<td>COLL</td>
<td>$H_{3c}$:</td>
<td>0.294</td>
<td></td>
<td></td>
<td></td>
<td>0.058</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>$H_{4c}$:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.12.1. Research model evaluation for reliability, validity and results

The service sector sub-model is also evaluated for fitness and adequacy. Appendix D-16 has measures for the evaluation of the outer models which are all fine and within theoretical range. Appendix D-17 also contains the measures for correlations among the variables which are also good including Average Variance Extracted (AVEs). The inner model values for assessment of adequacies are in Appendix D-18.

Eventually, in the service sector $H_{1c}$ is seen to be statistically supported, giving the implication that informal mechanisms of university knowledge transfer are good predictor of formal mechanisms of university knowledge transfer. Also, all other hypotheses, thus; $H_{2c}$, $H_{3c}$, $H_{4c}$, $H_{5c}$, $H_{6c}$, $H_{7c}$, and $H_{8c}$ are statistically supported with the exception of $H_{9c}$ and $H_{10c}$ in the model which is uniquely found to be similar to the results of the main model for the aggregate data. Appendix D-19 illustrates the zero effect of formal mechanisms of university knowledge transfer on innovation performance in firms and shows formal mechanisms that increase horizontally without a vertical corresponding increase in innovation performance in firms. This implies that even with more formal links being established with universities by firms in the sector, virtually no corresponding improvements are made in innovation performance in firms. Analogous to that, Appendix D-20 shows no increase in innovation performance in firms as more interpersonal relationships are built between firms and universities.

Consequently, this offers the basis to infer that in the service sector all the components have a relatively important relationship between themselves and their hypothesised outcome variables. Put in a better perspective; both formal and informal mechanisms of university knowledge transfer have immense effect on firms’ collaborative research with universities. Whereas technology transfer offices are beneficial to firms’ links with universities in formal arrangements, network formations are equally found to be highly influenced by informal interaction between firms and universities. Nonetheless, in the sector, formal and informal mechanisms of university knowledge transfer do not lead to innovation performance in firms as proposed in the model. More so, from the appearance of the mediator’s significance, they appear
to be catalysts for innovation performance in firms when these two mechanisms are used for innovation performance in firms.

**4.13. Mediation analysis for sectors**

As explained earlier on in the main model analysis, the role of other components in the relationship between both formal and informal mechanisms of university knowledge transfer and innovation performance in firms are already established and have not been directly effective. With the same objective of investigating the effects of the pair on innovation performance in firms, a further statistical investigation is conducted at this stage, this time with the other components introduced as mediators and separately for each sector. This is to understand whether the mediators are actually helping in transmitting knowledge from universities to firms in Ghana at the sector levels.

In principle, methodological researchers have within the last three decades found mediation analysis as an indispensable tool and in the same vein as a statistical challenge for investigating cause-effect relationships (Preacher and Kelley, 2011, Hair et al., 2016). Notwithstanding, mediation is not usually hypothesised in most empirical research, yet, extremely recommended. Besides, the true reality of cause-effect relationships in the literature is not explicit (Hair et al., 2016). Meanwhile, to exhaustively account for possible mediators in these cause-effect relationships and for full understanding of university knowledge transfer mechanisms, the identified mediating components are included in this study research model. There are associated limitations of the analysis though which are already discussed in section 4.8.

To start with, the independent variables and the dependent variables are first investigated without the mediators and it is established in Table 4.7 that both exogenous latent variables (FORM: $\beta = 0.36$, $p = 0.001$) and (INFO: $\beta = 0.54$, $p = 0.001$) indeed have significant and positive influence on INNO in the primary sector model as expected. Also, the same is true for the manufacturing sector model, thus; (FORM: $\beta = 0.57$, $p = 0.001$) and (INFO: $\beta = 0.65$, $p = 0.001$). Lastly, for the service sector also both are found to have significant positive effects on INNO, thus; (FORM: $\beta = 0.18$, $p = 0.001$) and (INFO: $\beta = 0.27$, $p = 0.001$).
Next, with both direct significant effects established in both independent variables on the ultimate dependent variable in the study, this section discusses the indirect and total effects of the main drivers through components introduced as mediators in the three sub-models. It concludes on the theoretical role of each component in each sector of the economy. Further on, comparisons are then made between these mechanisms in all the sectors with regards to their degree of influence on innovation performance in firms. Finally, a summary of the comparisons follows this before the qualitative aspect of the study is looked at in the next section to offer deeper insight as to what is happening in the sectors.

To continue with the rest, it is established in Table 4.7 above that FORM and INFO have statistically significant direct effects on INNO in all the three instances. However, it can be seen that in all the three sector models that both hypothesised direct effects ($H_9$ and $H_{10}$) turned out to be statistically not significant. Incidentally, the only exception is $H_{9b}$ in the manufacturing sector model, which is in any case drastically reduced from ($\beta = 0.57, p = 0.001$) to ($\beta = 0.35, p = 0.001$). These results of course demonstrate example of cause-effect relationships between the variables and signal that the mediating variables, TTOs, NET, and COLL have absorbed the effects of the supposed driving factors (FORM and INFO) on INNO in all three models. By

### Table 4.7: Significance analysis of path coefficients ($\beta$s) without mediators for sectors

<table>
<thead>
<tr>
<th>Ultimate endogenous latent variable</th>
<th>FORM</th>
<th>INFO</th>
<th>S.E.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>INNO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Primary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INNO</td>
<td>0.36</td>
<td>0.10</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.54</td>
<td>0.09</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INNO</td>
<td>0.57</td>
<td>0.07</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.65</td>
<td>0.06</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td><strong>Service</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INNO</td>
<td>0.18</td>
<td>0.08</td>
<td>0.012</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.27</td>
<td>0.09</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>
extension, the indirect and total effects of the models are shown in Table 4.8 and further investigated. For simplicity, both the indirect and total effects of all three models are put together in one table but separated accordingly and analysed to facilitate understanding.

Table 4.8. Variances accounted for by mediating variables for innovation in firms

<table>
<thead>
<tr>
<th>Effect</th>
<th>Latent variables</th>
<th>FORM</th>
<th>INFO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effect value</td>
<td>S.E.</td>
<td>P value</td>
</tr>
<tr>
<td><strong>Primary sector</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect effect</td>
<td>FORM TTOs</td>
<td>0.03</td>
<td>0.07</td>
</tr>
<tr>
<td>Total effect</td>
<td>Indirect + direct</td>
<td>0.03</td>
<td>0.05</td>
</tr>
<tr>
<td>Indirect effect</td>
<td>FORM COLL</td>
<td>0.02</td>
<td>0.07</td>
</tr>
<tr>
<td>Total effect</td>
<td>Indirect + Direct</td>
<td>0.02</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Manufacturing sector</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect effect</td>
<td>FORM TTOs</td>
<td>0.17</td>
<td>0.08</td>
</tr>
<tr>
<td>Total effect</td>
<td>Indirect + direct</td>
<td>0.51</td>
<td>0.04</td>
</tr>
<tr>
<td>Indirect effect</td>
<td>FORM COLL</td>
<td>-0.01</td>
<td>0.08</td>
</tr>
<tr>
<td>Total effect</td>
<td>Indirect + Direct</td>
<td>0.33</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Service sector</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect effect</td>
<td>FORM TTOs</td>
<td>0.07</td>
<td>0.02</td>
</tr>
<tr>
<td>Total effect</td>
<td>Indirect + direct</td>
<td>0.17</td>
<td>0.06</td>
</tr>
<tr>
<td>Indirect effect</td>
<td>FORM COLL</td>
<td>0.14</td>
<td>0.12</td>
</tr>
<tr>
<td>Total effect</td>
<td>Indirect + Direct</td>
<td>0.24</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Note: VAF = Variance Accounted For
With reference to equation 4.1 in section 4.8, the VAF of 0.100 for the primary sector in this analysis in Table 4.8 means 100% of the effect of FORM on INNO is accounted for by TTOs when COLL is controlled for in the sector. On the other hand, when TTOs are controlled for, again 100% of the effect of FORM on INNO is accounted for by COLL in the primary sector. In principle, this is a situation of full mediation in the concept of Baron and Kenney (1986). Also, in the same primary sector, it can be seen that a VAF of 0.49 indicates that 49% of the effect of INFO on INNO is accounted for by NET after controlling for the effect of COLL, while 0.37 or 37% of the effect of INFO on INNO is accounted for by the mediating variable COLL after controlling for the NET. By the standard threshold, since 37% is more than 20% but less than 80% (Hair et al., 2014a) it can be said that there is a partial mediation between INFO and INNO in this case per the notion of Baron and Kenney (1986). The fact that parts are accounted for by both the direct and indirect effects and most of all the two being positive and significant, Zhao et al. (2010) describe the occurrence as a complementary mediation.

In much the same way, and still in Table 4.8, it can be seen that 33% of the effect of FORM on INNO is accounted for by TTOs after controlling for COLL in the manufacturing sector but in proportionate terms only 3% of the effect of FORM is accounted for by COLL after controlling for the effect of TTOs in the manufacturing sector. This is considered to have no mediation effect since it is less than 20%. In fact, NET appears to account for 82% of the effect of INFO on INNO in this sector after controlling for COLL. Now, a full mediation may be thought of in this instance for the sector. On the other hand, COLL explains 40% after controlling for NET, of the effect of INFO for this sector.

Finally in the service sector, the effect of FORM on INNO after controlling for COLL is seen to be 41% while the effect is 58% after controlling for TTOs. On INFO effect on INNO in the service sector, both NET and COLL have a 100% mediation effect after controlling for either of them in the two circumstances presenting another situation of full mediation. Notably, there is no direct-only or competitive mediation in any of the mediations discussed in this study (Hair et al., 2016).
4.14. Comparative results

The question of comparative effect of formal and informal mechanisms of university knowledge transfer on firms’ innovation performance in different sectors of the Ghanaian economy is addressed in this section. The lack of literature on how university knowledge is transferred to different industrial sectors in developing economies and how formal and informal mechanisms influence them differently poses a big challenge to researchers and policymakers alike in low income countries like Ghana and those in the West African Sub-region. The effort to fill the gap has since compelled researchers such as Johnston and Huggins (2016) to investigate the ‘drivers of university–industry links in the case of knowledge-intensive business service sector firms’, however, that is still not the case for a developing economy but predominantly in rural districts of the UK; another case of advanced economies.

Obviously, for our understanding of how different or similar these sector firms are in gaining university knowledge in terms of their effect on innovation performance, a multi-group analysis (MGA) is employed. It is established that sub-categories in a data set will always manifest mathematical differences (Hair et al., 2014). Clearly, Figure 4.6 demonstrates the differences visually using the median estimates in boxplots. Nevertheless, the question to answer is; are the differences statistically significant?

To answer that, the results of the three sub-models are reported and compared with respect to the models’ parameter estimates; this is done with a mathematical formula in a multi-group analysis (MGA). Of all the comparisons made here, the estimates of the aggregate data (path coefficients of the main model) are included and used as a reference to understand how similar or different the sectors are in terms of the mechanisms.

First and foremost, the results of the model of the aggregate data set previously showed that formal and informal mechanisms of university knowledge transfer are proven to influence innovation performance in firms through mediation components. This implies that the thesis statement has not been confirmed with the main model and the sub-models. However, further investigations with mediating variables reveal that indeed their influences on the outcome variable are mediated indirectly through other components. In other words, formal and informal
mechanisms of university knowledge transfer lead not directly to innovation performance in firms but indirectly through technology transfer offices or collaborative research or through knowledge networks. Similar occurrences are noticed in all the three sub-sector models. It therefore follows that by comparing the path models across the three sub-sectors, statistically with different parameter estimates for the sub-sectors observed in the aggregate data, we may unveil some disparity previously not observed in the analysis (Hair et al., 2014a).

The thesis further recognises that all observable subcategories inherent in the aggregate data and determined a priori will most likely exhibit a different fit to the data and produce distinct results with the same model. Theoretically, there are always the possibilities of finding some unobserved traits of respondents with further investigation thereby unmasking different features or providing a sub-sector specific-effect and potentially yielding different findings altogether (Hair et al., 2014a, Hair et al., 2016).

Significantly, the difference between the service sector and the other two subsectors in that section is consistent with the difference revealed in Figure 4.6 below. Visually, there seem to be similarities between the primary and the manufacturing sectors both of which are higher than those of the main model and the service sector sub-model which are also similar.

**Figure 4:6 Comparison between the main model and the three sub-models for the sectors**
Obviously, as established in an earlier section, sub-categories in a data set will always manifest differences which are clearly demonstrated. Nevertheless, the issue at stake is to determine if the differences observed in the visual evidence are statistically significant. To be clear of the supposed difference, a multi-group analysis (MGA) is employed in the coming section for further investigation as;

On the occasion of MGA, the null hypothesis is that;

\[ H_0; \text{‘the differences in the path coefficients are not statistically significant’}, \]

thus;

\[ H_0: p^{(x)} = p^{(y)} \text{ or } H_0: |p^{(x)} - p^{(y)}| = 0 \]

The alternative hypothesis is that the path coefficients are different in the population,

thus;

\[ H_a: p^{(x)} \neq p^{(y)} \text{ or } H_a: |p^{(x)} - p^{(y)}| > 0 \]

In other words, the null hypothesis is;

thus;

\[ H_0: p_a = p_b = p_c \text{ Or } |p_a - p_b - p_c| = 0. \]

Where; \( p_a = \text{the primary sector} \), \( p_b = \text{the manufacturing sector} \) and \( p_c = \text{the service sector} \).
Actually, multi-group analysis (MGA) is a recent development and attempts have been made by methodological researchers to develop both parametric and nonparametric techniques to help compare groups in PLS-SEM.

Unfortunately, for now, conducting the analysis is limited to a modified version of parametric approach to two-independent sample $t$-test by Keil et al. (2000), which is not yet factored in any statistical software for the research society and uses the formula in equation 4.2 to compare path coefficients across sub-models. Just like $t$-test, this version also comes with conditions. Thus, it depends on standard errors obtained from bootstrapping and also on whether the population variances are assumed to be homoscedastic (equal) or heteroscedastic (unequal) (Sarstedt and Mooi, 2014). The issue of a distributional assumption also arises as its limitations at this stage. However, since the samples are large, the distributional problems is to some extent contained and the result can be relied on for further analysis (Kvanli et al., 2003, Anderson et al., 2003). Another limitation which the study could not control was the assumption of the analysis that different samples are independent and therefore do not correlates when indeed in survey data of this nature, correlation among different samples is a natural occurrence (Hair et al., 2014).

In the interim, there is a Microsoft Excel version of the formula that does the calculation automatically, gives the $t$ and $p$ values and can be found at http://www.pls-sem.com in the PLS-MGA_Parametric.xlsx file under the Coporate_Reputation_Moderation.zip folder (Hair et al., 2014a).

The MGA formulary is as;

$$
t = - \frac{|p^{(x)} - p^{(y)}|}{\sqrt{\frac{(n^{(x)} - 1)^2}{n^{(x)} + n^{(y)} - 2} \cdot se(p^{(x)})^2 + \frac{(n^{(y)} - 1)^2}{n^{(x)} + n^{(y)} - 2} \cdot se(p^{(y)})^2} \cdot \frac{1}{n^{(x)}} + \frac{1}{n^{(y)}}} \quad \ldots \ldots 4.2$$

where:

$n^{(x)} = $ the number of observations in category $x$.  

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Levene’s test results show equal variances for variables considered for comparisons for any two sectors.

To start with, Appendix E-1 presents a comparison of the path coefficients (the regression weights) between the main model and the primary sector sub-model. From the table, it is clear that only two path coefficients of two relationships, thus; that of $H_2$ and $H_8$ differ significantly between each other at 5% and 10% significance levels respectively. All other paired coefficients comparatively show no significant difference. With $H_2$ the absolute difference between the main model and the primary sector model is 0.224. The effect between formal mechanisms of university knowledge transfer (FORM) and the benefit from technology transfer offices (TTOs), $H_4$ is as high as 0.317 in the main model. However, it is higher (0.484) in the primary sector. The effect is virtually nonexistent in the primary sector. In much the same way, a significant difference in the effect of collaborative research (COLL) on innovation performance in firms (INNO) in the main model is 0.317 and that of the primary sector is again as low as 0.074 giving a difference of 0.243.

Appendix E-2 also presents comparison of path coefficients between the main model and the manufacturing sector model showing a statistically significant difference between the two models in hypotheses $H_8$ and $H_9$ at 5% level of significance. With the absolute difference of 0.286 and 0.312 respectively, the effect of collaborative research on innovation performance in firms in the main model is as high as 0.312 but that of the primary is negative in the first place and also very low (-0.031) in magnitude comparatively. Conversely, the effect of formal mechanisms of university knowledge transfer (FORM) on innovation performance in firms (INNO: $H_9$) in the main model is very low (0.033) as compared to its effect in the manufacturing sector (0.345) which is obviously higher.
Incidentally, Appendix E-3, compares the path coefficients of the service sector model against the main model and from $H_1$ through to $H_{10}$ there is no significant difference seen between any of the coefficients. The service sector conclusively seems to be a true reflection of the main model as may be expected in a situation where heterogeneity is not a discriminating moderator in a population.

In addition, Appendix E-4 compares the coefficients of two of the sub-models under discussion in the study, thus; the primary and the manufacturing sectors and shows a significant difference between two relationships hypothesised ($H_6$ and $H_9$) in the research model. With a difference of 0.287 for $H_6$, the path coefficient for the primary sector model is found to be lower (0.055) than the path coefficient for the manufacturing sector coefficient (0.342). Note that the significance here is at a 10% significance level. This implies that the contribution of technology transfer offices (TTOs) in the process of innovation in firms (INNO) is lower in the primary sector than in the manufacturing sector as seen in the table. In the other relationship, $H_9$, the primary sector has a lower effect (0.003), perhaps no effect at all, in the relationship but in the manufacturing sector model, the effect is 0.345 indicating that while formal mechanisms of university knowledge transfer (FORM) is not effective in the primary sector, it greatly and positively affects innovation (INNO) in firms in the manufacturing sector.

Also, in Appendix E-5, four of the hypotheses are tested statistically to have significant differences between them. The first difference is the path coefficients between TTOs and INNO in the models which reveal a difference of 0.289 in $H_2$ and a lower path coefficient of 0.093 for the primary sector. Clearly, the coefficient for the service sector is found to be higher at 0.382 in the relationship showing that formal mechanisms of university knowledge transfer (FORM) on innovation performance in firms (INNO) in the service sector is more effective than in the primary sector. The other relationships significantly different statistically in respect of $H_3$ can be seen in the table. With this, the path coefficient for the primary sector model is relatively higher (0.558) than that of the service sector with a difference of 0.294 in the table. In this instance, it reveals that informal mechanisms of university knowledge transfer (INFO) are more influential on innovation performance in firms (INNO) in the primary sector than in the service sector. Further significant differences are found in $H_7$ and $H_8$. While the path coefficients in $H_7$ are
significantly different at a 10% significance level, those of $H_8$ are significant at the 5% level. The higher coefficient in $H_7$ is 0.479 for the primary sector model and the lower one being for the service sector model at 0.233. In other words, it can be interpreted that knowledge networks (NET) contribute more to innovation performance in firms (INNO) in the primary sector than they do in the service sector. For $H_8$, the higher coefficient is for the service sector model at 0.376 while the lower one is 0.074 for the primary sector. In clear terms, it can be said that collaborative research (COLL) is more influential in innovation process in firms (INNO) in the service sector than it is in the primary sector.

Lastly, in Appendix E-6, only one significant difference is visible and for the relationship ($H_8$) which once again shows not only a lower path coefficient for the manufacturing sector model but also a negative effect of -0.031. Relatively, the service sector has the higher coefficient of 0.376 with an absolute difference of 0.407 between them implying that collaborative research (COLL) in the service sector is proved scientifically to be more than it is in the manufacturing sector.

### 4.15. Formal mechanisms of university knowledge transfer and innovation in firms

For a clear understanding of how formal mechanisms of university knowledge transfer influence innovation performance in firms, based on the techniques stated above, the findings are presented systematically according to the major sectors, thus; national, primary, manufacturing and service sectors.

By and large, it is evident in the examination of the research model that at national level, formal mechanisms of university knowledge transfer do not directly influence innovation performance in firms. In other words, firms in Ghana generally do not innovate through their direct formal links with universities. Implicitly, the hypotheses test results do not therefore provide enough evidence to support the proposition.

Evidence from interviews with senior management of both industry and universities in the country shows that most firms do not have required direct links with universities and their
researchers or do not trust universities to solve real business and operational problems. Accordingly, socio-cultural factors have been attributed to this disconnect and explained by power distance created between ordinary people and the elite. This actually separates university researchers from the rest of society. Another issue highlighted by industry directors is corruption among leadership of government departments, including universities, which is described as considerable by less educated business owners. This deters them away from the elite research society. Further to this, bribery within low-level and middle-level civil servants compounds the problem, which also does not encourage formal relationships. All these accordingly hinder entrepreneurial activities and innovation in small firms which constitute the majority of the economy together with micro enterprises. It is also found that entrepreneurs with little or no education in the country traditionally rely on family owned small enterprises for employment, which they operate and manage with little or no formal skills or any form of literacy. As a result, these categories of entrepreneurs do not have confidence, human and financial capacities to engage universities or researchers unilaterally with their operational or marketing problems. Moreover, family succession and inheritance system seriously affect innovativeness in firms where persons in executive positions are through inheritance but not through knowledge, experience or performance (Takyi-Asiedu, 1993). Not just that, universities in Ghana do not really profoundly demonstrate their research proficiency to firms either through their liaison officers, public relation offices. In this situation, most firms tend to resort to traditional means to innovate ostensibly with any available knowledge from friends, associates and family members.

At the sector level, analysis of hypothesis results has offered no evidence of formal mechanisms of university knowledge transfer resulting in innovation performance in the primary sector; \(H_{9a}\). The level of influence of formal mechanisms of university knowledge transfer in the sector is found to be similar to the national level, showing no difference in innovation achievement comparatively as can be seen in Appendix E1. Clearly, it is found that universities and researchers are actually not forthcoming, not proactive in terms of current events and are not practically oriented to address issues challenging the sector. Inherently, this is the sector that suffers heavily due to power distance as Takyi-Aseidu (1993) explains, meanwhile majority (two-thirds) of Ghana’s workforce are employed in the primary sector due to lack of education and skills (Diao, 2010, GLSS, 2014). A self-employed poultry farmer stated, ‘University
lecturers here do not even interact with us about what we do. How can they know the challenges we have? And if they do not know how can they research to get us solutions to our problems?’ Emphatically, this highlights a clear segregation between sub-cultures in Ghana (Edelman et al., 2004, Takyi-Asiedu, 1993). A real frustration demonstrated by almost all primary producers who participated in the interviews. Contrary to that, documents gathered as part of the study from universities show effort being made, according to 2015 annual research report of one of the more established universities in Ghana, to support primary producers with innovative ideas and business operational activities. To do this, accordingly, four centres of excellence have been established in the university, with 1 million Ghana cedis (Gh¢) to start with and to further develop many research areas including food production and processing (UG, 2015). From further documentary evidence from government sources, the study understood that the parliament of Ghana in 2014 passed a Bill to set up another state owned university to, among other things, provide higher education, undertake research and disseminate knowledge related to development in environment and agribusiness in the primary sector. As part of the technology transfer objective of the country, the university in question will foster relationships with persons and businesses internal and external to achieve the objective.

Contrary to the primary sectors, in the manufacturing sector, formal mechanisms of university knowledge transfer results in innovation performance in firms, and from analysis of hypothesis test results, it is found that the manufacturing sector achieves innovation performance through firm’s direct formal interactions with universities and researchers. In this case, analysis of hypothesis $H_{9b}$ is found to support the incident of innovation through formal mechanisms. Notably, the influence of formal mechanisms in this sector is comparatively higher than the national and primary sector as can be seen in Appendix E2 and E4 respectively. Evidence of innovation was elaborated extensively in the interviews by participants as being due to recent progress in product development with technology developed within the country. Particular reference was made to agro and food processing businesses that are starting up in the country. Besides, research is being conducted through formal mechanisms for firms to meet their market demands and remain competitive. The formally established link between Kwame Nkrumah University of Science and Technology in Kumasi with Integrated Technology Transfer Unit at the Swame Industrial Network is a typical case for reference.
Equally, in the service sector, similar to the national level and primary sector, formal mechanisms of university knowledge transfer is evidently shown to not influence innovation in firms from analysis of hypothesis test result ($H_{9c}$). Consequently, the service sector uses all other opportunities available for university knowledge. The service sector has been found to have had the highest level of innovation of 55.1% of total innovation in 2008 in a study conducted by Robson et al. (2009) in Ghana. This is evident in the descriptive statistics, which shows the service sector to be the largest sector in the country with 10 to 25 years firms dominating. Analysis of interview results and observations in this particular instance revealed that most business owners in the service sector are skilful, well-educated business directors and largely with qualifications up to tertiary level in attainment. It is herein found that the most common source of knowledge for this sector is not only formal as defined in this study but also through other agents and bodies like the chamber of commerce and relevant apex bodies in the country. One IT consultant concluded;

> ‘I have very good relation with my university in town here and Alma Mata but all is at the personal level and not formal. Valuable knowledge regarding my business usually flows rather through my university colleagues or the alumni than from the university as a research institution.’

To add to this, newsletters from two service sector firms as documentary evidence show a continued effort by the Bank of Ghana working with firms in the financial sector to increase their capacities with electronic and internet security. Significantly, very important software is sometimes reported to be offered to workshop attendants for free. Further evidence with photographic exhibits pointed to the involvement of universities in this effort.

On a wider note, university researchers and administrators alike complained of lack of incentives and research facilities on site for them to conduct research and blamed it on government reluctance to respond to their needs. Linked to that is the lack of promotion and financial reward to encourage research and entrepreneurship for knowledge exploitation. Summary of this analysis can be found in Table 4.9.
Table 4:9 Summary of findings on formal mechanisms of knowledge transfer and innovation in firms

<table>
<thead>
<tr>
<th>Approach</th>
<th>Descriptive statistics findings</th>
<th>Inferential statistics findings</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Size, Age</td>
<td>Main model (National)</td>
</tr>
<tr>
<td>Quantitative research</td>
<td>Most firms are (10-25) years</td>
<td>Innovation is not achieved with formal mechanisms</td>
</tr>
<tr>
<td>Qualitative research</td>
<td>Most interviewed were well educated</td>
<td>Recent firms</td>
</tr>
</tbody>
</table>

4.16. Technology transfer offices and innovation in firms

This section presents findings on investigation on direct influence of technology transfer offices (TTOs) on innovation performance in firms in Ghana. The findings are at primary, manufacturing and service sector level in Ghana.
From critical analysis of the hypothesis test result, the study found that through formal interactions with TTOs, firms in Ghana do exploit university knowledge. Truly, this finding primarily is from the analysis of the general outlook of the Ghanaian economy and the same is the case for all individual sectors. Surely, hypotheses $H_4$ and $H_6$ are both actually supported for the entire economic outlook. This implies that consequently, the existence of TTOs is shown to influence innovation performance in firms in Ghana.

It is also found that though there are few TTOs available, to the interview participants, quite relatively reasonable innovations are achieved through interactions with them. To emphasise, in Ghana they are called different names like industrial relation offices, liaison offices or even technology department in some universities with added responsibilities to attach students with firms in different industries to gain industrial experience. For instance, a senior university administrator said; ‘the reports sent in by students on industrial attachment at end of year are studied thoroughly by universities to learn what is needed in industry’. These he said, serve as starting points for research proposals and subsequent projects with respective industries.

Available evidence in newsletters and annual reports of Ghanaian universities confirm efforts they are making to increase efficiencies of TTOs through staff training and capacity building as evident-based requirement for effective performance. Most importantly, recently established state universities have also expressed plans to set up offices to encourage researchers, and as well advertise commercially viable breakthroughs from academia for firms and potential investors. Incubators are plan of universities in Ghana in the near future and captured in several documents including websites (KNUST, 2015).

Notwithstanding the help of TTOs shown at national level, the benefit does not extend directly to innovation performance in primary sector firms since analysis of $H_{6a}$ in Figure 3.15 does not indicate any innovation achievements. Comparatively, this is the only sector where TTOs do not directly influence innovation in firms. It can be stated here however that a critical look at hypothesis $H_{4a}$ reveals that primary sector firms are somewhat aware of TTOs operations and with about 51% of influence in the sector, it means formal mechanisms in the sector potentially leads to involvements of TTOs. It is just that the ultimate results do not take new knowledge or
discoveries to firms in the sector. To clarify, examination of the research model with hypothesis test signifies that available TTOs are not very useful or helpful directly for innovation performance in firms in primary production in Ghana.

From senior staff of both firms and universities in Ghana, the primary sector is not familiar with TTOs however, since inception and has yet to get to understand their role in research distribution. The sector is understood to be layback since traditionally majority of primary production techniques have been passed on from generation to generation; it is very difficult for them to transition. Also, many who find themselves in the sector do so based on the need to just feed their families and not for commercial purpose and will not go to the extent of seeking breakthrough from TTOs. Most of them therefore remain peasant, informal and small without the possibility of expansion.

Also for the manufacturing sector, analysis of hypotheses $H_{4b}$ and $H_{6b}$ accordingly revealed an ultimate influence of TTOs in the sector. Again, with, the finding endorses the proposition that TTOs are essential for business innovation performance in the manufacturing sector. It also indicates that such offices are relevant and offer important pieces of information and discoveries to improve innovation in the manufacturing sector in Ghana. The influence of TTOs is notably similar to national and service sector but comparatively different to the primary sector where TTOs have shown to have no direct influence after all on innovation.

The implication here is that the manufacturing sector is progressing with new knowledge from discoveries and interview participants validated this when they related breakthroughs in natural oil processing and local medicinal products from research that have been done and now in the market to the work of TTOs. One issue that dominated discussions around TTOs are the lack of enough qualified staff and resources to reach out to potential investors and skills to spin out more firms with discoveries. Funding issues also featured prominently and processing firms would be happy if more productive and viable discoveries are made and brought to their notice.

Also, analysis of test results of hypotheses $H_{4c}$ and $H_{6c}$ accordingly indicate that discoveries coming from TTOs are actually feeding into the sector’s innovation needs and demands for
better ways of doing business. From the results in Figure 4.2, the study found that TTOs available in the country are serving the purpose in the sector and are therefore crucial to innovation performance in recent days. For this sector, the influence of TTOs is largely similar to the national and manufacturing sector except the primary which shows no influence at all on innovation. Further probe from interview participants also indicated that the sector has had good, productive discoveries and successful introductions of new entrants into the market. This was confirmed by some industry directors, university researchers and others also showed interest for future investments into start-ups from such discoveries. Table 4.10 has the summary of the findings.

Table 4:10. Summary of findings on technology transfer officers and innovation in firms

<table>
<thead>
<tr>
<th>Approach</th>
<th>Descriptive statistics findings</th>
<th>Inferential statistics findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size</td>
<td>Age</td>
</tr>
<tr>
<td>Quantitative research</td>
<td>Primary sector firms are 51%</td>
<td>Aged between 10 and 25 years</td>
</tr>
<tr>
<td>Qualitative research</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Interview/observations/documentary findings

|                     |                  |                                |                  |
| Qualitative research | Although not massively popular, the few have registered some positive results | Not really popular to primary producers | Patronised and encourages more discoveries to improve innovation in the sector | Have worked well with TTOs in recent times and still look forward to do more |
4.17. Technology transfer offices as mediators for innovation in firms

This section presents findings on mediation analysis conducted on TTOs’ role as mediators of university discoveries, starting with national outlook. The section also looks at findings on subsectors such as primary, manufacturing and services sectors across the country based on both analysis of hypothesis tests and interviews with senior staff of universities and industry in Ghana.

At national level evidence reveals that TTOs are partial mediators of innovation and discoveries from universities to industry in Ghana in the area of formal mechanisms used. Accordingly, 75% of new knowledge and discoveries get through TTOs to industry in and the percentage may not be possible without their intermediary role. The study found that TTOs activities are fairly new but have since taken active role in transfer of university knowledge for commercialisation according to knowledge players. For instance, some university researchers have confessed to rely on TTOs for exploitation of their research and some investors to have talked on TTOs involvement in their business development with the conclusions that TTOs are essential for innovation in Ghana.

In the primary sector, examination of hypothesis test results from the research model and mediation analysis results offer enough evidence to suggest that the role of TTOs in primary sector firms is full mediation on formal mechanisms of university knowledge transfer. It is found that – when entered as mediators - TTOs deliver productive results and university knowledge may not get to primary producers directly without TTOs mediation. Perhaps, when engagements are pursued with particular set of agenda, subsection of the research or with certain arrangements, it could even be specific primary producers where innovation is achieved (further investigation will be needed to know). Interestingly, TTOs influence appeared to be the highest in primary sector firms, and lowest in the manufacturing sector. The national level ranks next to the primary in terms of TTOs influence and higher than it is in the manufacturing sector. Note that TTOs have been found to not directly influence innovation. It could be suggested that mediation here is when TTOs intercede in previously established formal relationship as specialist
Chapter 4. Findings

Institutions to facilitate formal transfer of ownership of IP on discoveries to primary producers. In this case, the role of TTOs offers full benefit to primary sector firms and investors. This signifies that TTOs use as mediators is one of the most productive mechanisms in university engagements in the primary sector in Ghana.

In the manufacturing sector, TTOs are found to be partial mediators or intervene to help transfer just 33% of knowledge or discoveries from universities to firms. Implicitly, there is direct transfer to firms too in the sector, as discovered, resulting in 67% of university knowledge from formal mechanisms. Conclusively, TTOs are still not performing at expected level in the manufacturing sector, as stated in the previous section, The sector remains the least in influence of TTOs mediations and will not be considered as the best for the sector for now. It became clear that at the sector level, the delivery is not much from TTOs because of the high technical requirement needed in the processing sector. The majority of the requirement cannot be obtained from universities in the country and can only be imported. A food processing company director said;

“For now our TTOs cannot meet most of our knowledge needs because they are constrained in terms of resources and even technological innovation which is what we need at this crucial time. So we rely on imports.”

In the service sector too, evidence from hypothesis tests shows that TTOs actually mediate formal mechanisms of university knowledge transfer partially and responsible for 41% of innovation in firms in the sector. This implies that 41% of discoveries in universities in Ghana will not get all the knowledge to industry without TTOs. However, by far, the influence is comparatively lower than national level and only higher than the manufacturing sector (See Tables 3.8 and 3.13). It is found that particularly small to medium size enterprises have very little interactions with TTOs in the sector because majority of them tend to prefer to remain small for fear of problems of large scale production. Officers from TTOs will have to reach out to them on behalf of universities and researchers to convince them to realise the need for new technology. The summary of the findings are in Table 4.11.
Table 4.11. Summary of findings on technology transfer office as mediators and innovation in firms

<table>
<thead>
<tr>
<th>Approach</th>
<th>Descriptive statistics findings</th>
<th>Inferential statistics findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size (Less than 50% primary sector)</td>
<td>Age (Aged between 10 and 25 years)</td>
</tr>
<tr>
<td>Quantitative research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative research</td>
<td>Both researchers and investors have unanimously agreed on the usefulness of TTOs in Ghana</td>
<td>Firms tend to benefit when TTOs intercede in formal engagement to offer security for firms and universities</td>
</tr>
</tbody>
</table>

### 4.18. Collaborative research and innovation in firms

This section presents findings on examination of collaborative research as a mechanism of university knowledge transfer in Ghana. It explains how collaborative research influences innovation, primarily at national level based on analysis of hypothesis test results and interviews conducted, and further at primary, secondary and finally the service sector levels.

Analysis of hypothesis tests results on countrywide data captured for this study shows that formal mechanisms of university knowledge transfer lead to collaborative research between firms and universities. This finding is evident empirically in the examination of hypothesis test result; $H_8$ presented. Crucially, within the larger Ghanaian economy, it seems to suggest that,
firms’ formal relationships with universities progress to collaborative research and eventually lead to innovation performance in firms. On the whole, collaborative research is common in the country and seems to be accepted as a tool for university knowledge and verification of this was made during interviews by most participants. It was even claimed without collaborative research industry will be stack with obsolete technology without progress. According to one computer repair service provider, he said;

\[
\text{‘We will have to be innovative this time because a lot is going on in the market in terms of competition, and who survives is determined by the rate at which they adopt innovate practices, increase productivity and remain in business. This can only be done through new knowledge from university research’}.\]

From examination of hypothesis results \((H_{8a})\), the study found no evidence of productive collaboration in primary sector firms. For clarification, further analysis of interviews transcripts found that primary producers, particularly in the agricultural sub-sector on the one hand feel that university collaboration is really not known to them and that is why the sector is accordingly not doing well, thus; employing about 44.7% of the labour force but contributes only about 30% to GDP (Diao, 2010, GLSS, 2014). On the other hand, university researchers are unable to collaborate with them to help the sector as they continue to complain about lack of resources and appropriate help from government. The study found that universities and industry players know about a gap between them but the meeting point eludes both parties and a solution will take a long time to come. A farmer complained;

\[
\text{‘We expect the researchers to do better as we struggle to understand what is going on. We do not make a head way, meanwhile they do research all the time. I do not engage with universities. I think there is a lot universities can learn from us but when they approach us for information they do not come to tell us their findings and the way forward’}.\]

In the manufacturing sector too, examination of hypothesis test results; \(H_{8b}\) also clearly indicates that collaborative research is not a productive mechanisms for university knowledge transfer. This gives an indication that the sector in Ghana does not rely on collaborative research for knowledge from universities and firms in the sector may be using different mechanisms for university knowledge. It is understood that collaborating with universities has not yielded much
and the sector needs are met by foreign partners, which include universities. What is gathered from universities is that, they are ready to deliver but firms in the processing sector do not task them or think local universities are ready to supply the needed knowledge for innovation performance. A university administrator honestly lamented and put it as;

‘Some businesses find it unusual to contact or work freely with university researchers simply because it is uncommon as researchers are isolated in the academic world of their own with little to do with the rest of the society. A tradition that needs to stop and see the two players work together for the good of industry and society’.

In fact, an academic in a university reluctantly admitted to the above assertion and stated their readiness and commitment to help. However, he put the blame on the innovation ecosystem, which he said lacks capability and technical competence for them to really engage. He also alluded to the fact that most businesses that are processing of primary goods are small and do not have the needed absorptive capacity for technical knowledge.

The service sector firms have been found in examination of hypothesis test result \(H_{8c}\) to collaborate and obtain university knowledge for innovation performance. The influence of collaborative research for the service sector, as can be seen in Appendix E3, is similar to the national level, whilst no influence is found in the primary and manufacturing sectors. From observation, the service sector is mostly made of technically inclined staff and technological innovations needed in most of their business operation are usually within the collaborative capabilities with universities. Also, collaborative research in the sector is not usually capital intensive and commercially viable research outcomes have been achieved while more are expected. The service sector remains the sector that is on average, actually satisfied with collaborative research outcome and has so far injected a lot of funding into it.

By and large, there are similarities in the findings in collaborative research influence between the service sector and the national perspective, and analytic evidence from multi-group comparison shows no significant difference in magnitude of the effect and direction. Put in perspective, at the sector level the primary and manufacturing sector firms appear not to use collaborative research for various reasons and therefore both differs from national perspective. However, the findings
show that collaborative research in service sector firms actually reflects the national innovation ecosystem. It is worth noting that in all sectors and at national level, the findings suggest that informal mechanisms lead to formal engagements which are potential starting point for collaborations in Ghana. This important revelation is masked when examination of this nature only looks at the general or just national perspective without due recognition of subsectors. This feature would not have been known without the sector analysis.

Firms in this sector have been found to be involved in joint research projects and use of training facilities co-owned by firms and universities for capacity building and skills development. Among others, this was narrated in the interviews by participants who saw that as positive developments for the sector. Observations during interviews revealed that most directors and managers in the service sector are highly qualified individuals and the study learnt that demand for services from the sector are equally high and they will have to keep innovating to maintain their competitive advantage and to meet expectations of customers. A business service manager stated;

‘We have to meet the demand all the time with high quality service and at right times to keep our jobs. There are foreign competitors at our door steps and innovation is our only way out, less, we will be defeated easily with their hi-tech facilities and technology’.

Table 4.12 has the summary of the findings.
Table 4.12. Summary of findings on collaborative research and innovation in firms

<table>
<thead>
<tr>
<th>Approach</th>
<th>Descriptive statistics findings</th>
<th>Inferential statistics findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size</td>
<td>Age</td>
</tr>
<tr>
<td>Quantitative research</td>
<td>Above 30% in service sector</td>
<td>Aged 10-25 years</td>
</tr>
<tr>
<td>Qualitative research</td>
<td>Industry can only move on with new knowledge from research</td>
<td>Firm in the sector feel local universities are not forthcoming to meet their knowledge needs</td>
</tr>
</tbody>
</table>

4.19. **Collaborative research as a mediator of innovation in firms**

This section presents findings on mediation analysis conducted on collaborative research as a mediator of university knowledge for innovation in firms, first at national level. The second part deals with findings on subsector; as primary, manufacturing and services sectors across the country based on both analysis of hypothesis test and interviews with senior staff of universities and industry in Ghana.

In this study, collaborative research was entered as a mediator for both formal and informal mechanisms of university knowledge transfer for innovation in firms. For these, the findings show partial mediations for both mechanisms in university knowledge transfer in Ghana. It is
found in the analysis of hypotheses; $H_2$, $H_3$ and $H_8$ that collaborative research as a mediator transfers up to 77% through formal and 58% from informal mechanisms of university knowledge transfer to industry nationwide, apart from the direct effect noted in section 4.6.1 at national level. It implies that collaborative research tends to leverage the effects of formal and informal mechanisms of university knowledge transfer to industry. It is found that sometimes for successful transfer projects; formal and informal engagements needs further arrangements to boost confidence, ensure security, bring long term benefits and therefore required stronger terms in the form of collaborative research accordingly.

According to analysis of hypotheses; $H_{2a}$, $H_{3a}$, $H_{8a}$, collaborative research mediates 37% (partial) of knowledge transfer from informal mechanisms and 100% from formal mechanisms to primary sector firms in Ghana. This explains the fact that collaboration with universities is vital for firms’ innovation performance in Ghana. Also, it means here that in the primary sector despite collaborative research does not influence innovation on its own as noted already, as a mediator of formal means of knowledge transfers, it supports innovation performance. However, less innovation is obtained with this mediation through informal engagements. Significantly, collaborative research as a mediator has the highest influence in the primary sector through formal mechanisms. The least influence is in the manufacturing sector also through formal mechanisms. Primary producers in Ghana use both means to obtain university knowledge and university researchers and business directors all agreed in the interviews that there are many productive informal and informal means to knowledge for the sector. For example, published literature and even simple discussions with university researchers. Some talked about how extended family members helped in bringing about their collaborative projects with researchers and particular situations were cited in the poultry and dairy production sector.

In the manufacturing sector, the effect of informal mechanisms of university knowledge transfer through collaborative research as a mediator covers 40% of innovation performance in firms. It means, it is the result of collaborative research that the 40% is achieved otherwise such percentage of innovation will not take place in the sector. However, the analysis further show a combined effect of -0.05 in magnitude and direction revealing a case of missing mediators in these mechanisms, where further investigation is required to find other intervening components.
of innovation through informal mechanisms of university knowledge transfer in the sector (Hair et al., 2016). Also, as a mediator through formal mechanisms, collaborative research manifest a negative influence in manufacturing firms signifying that it is not a productive tool in the sector.

The no-collaborative result is found to be blamed on bureaucracy which is noted to be an issue that predominantly prevents collaboration between manufacturers and universities in Ghana. Accordingly, this puts in so many impediments, needlessly frustrating the progress and success of any form of collaboration between firms and universities. One wood processing firm’s manager confessed in his statement that;

‘There are many unnecessary formalities to follow and so many worthless officers to talk to in order to get anything done for you and this is extremely frustrating. Not only that, it dampens our spirits because everyone wants something in this form or that form’.

In the interview, it became clear that firms are discouraged by the frustrations mentioned above and will only rely on research findings from other bodies within and outside the country for innovation. A training manual from a Ghana-UNDP collaboration project on knowledge transfer to Ghanaian manufacturing firms gathered as part of the documentary data showed proof of external reliance for knowledge in the sector.

Informal mechanisms of university knowledge transfer are found to have full mediation in the service sector whilst formal mechanisms have partial mediation and responsible for 58% of innovation in firms according to the analysis. Comparatively, the service sector has the highest influence with collaborative research as a mediator through informal mechanisms. Further examination of interview transcripts revealed that the service sector, which the Ghana Living Standard Survey (2014) report describes as the fastest growing sector in Ghana, has of late become very competitive and therefore sensitive to knowledge and innovation because of a rapid increase in foreign competition in the local market. Informal means in the sector needs higher and stronger commitment and collaborative research is used to leverage interpersonal relations and other means to achieve innovation. Accordingly, a lot of products and services produced in the country are coming into competition with foreign products in the sector and collaboration is
purposely identified to save local firms. Luckily, most of senior officers are highly educated and well informed to respond to changes in the market. According to one computer repair service provider, in his submission he said;

‘We will have to be innovative this time because a lot is going on in the market in terms of competition, and who survives is determined by the rate at which they adopt innovative practices, increase productivity and remain in business’.

Comparatively, collaborative research mediation through both mechanisms of university knowledge transfer to firms is almost similar for primary sectors and service sector firms in Ghana. Interestingly, the most productive mediation effect of collaboration through informal mechanisms is in the service sector. The service sector, in contrast to the manufacturing sectors and like the general outlook of the entire economy, have been found to achieve progress in innovation in firms through collaborative research. Firms in the service sector in Ghana therefore see collaboration with universities as a productive means for innovation and use it to achieve improvement in their business operational activities. A summary of the findings can be found in Table 4.13.
### Table 4:13. Summary of findings on collaborative research as a mediator and innovation in firms

<table>
<thead>
<tr>
<th>Approach</th>
<th>Size</th>
<th>Age</th>
<th>Main model (National)</th>
<th>Primary sector</th>
<th>Manufacturing sector</th>
<th>Service sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative research</td>
<td>Less than 50% in primary sector</td>
<td>Aged between 10 and 25 years</td>
<td>Partial mediator for both formal and informal mechanisms of knowledge transfer</td>
<td>Full mediation for formal and partial for informal mechanisms</td>
<td>No</td>
<td>Partial mediation for formal and full mediation for informal mechanisms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative research</td>
<td></td>
<td></td>
<td>Sometimes some formal and informal engagements need further security to succeed</td>
<td>Primary producers rely on both formal and informal through collaborative research</td>
<td>Bureaucracies discourage secondary producers sometimes with collaborative research</td>
<td>The sector is actively using almost all means to achieve innovation performance</td>
</tr>
</tbody>
</table>

#### 4.20. Informal mechanisms of knowledge transfer and innovation in firms

This section presents findings on investigations on the influence of informal mechanisms of university knowledge transfer on innovation performance in firms in Ghana. Explaining how the mechanisms lead to innovation, the section looks at national level findings, primary, manufacturing and services sectors based on examinations of hypothesis test results and interviews conducted in Ghana. For national level, examination of $H_{10}$ gives an indication that informal mechanisms of university knowledge transfer do not influence innovation performance.
Considerably, university researchers and business directors all agreed in the interviews that although there are many informal means to university knowledge for the productive sector, less is gain perhaps because closer supervisions by researchers are needed to realise results. For example, published literature and even simple discussions with university researchers will need follow-ups and more intense interaction to realise innovation performance. Some talked about how extended family members helped in bringing about information relating to university knowledge but still very little is usually obtained.

Hypothesis $H_{10a}$ seeks to propose that informal mechanisms of university knowledge transfer directly influence innovation performance in firms in Ghana. However, in examining the research model with the hypothesis, the test results show that informal engagements do not yield any innovation in primary sector firms. Mostly, firms do have informal relations though with universities and their researchers, and according to further discussions, however, that alone is not sufficient to produce results in any meaningful form in firms in the sector. For example, a dairy farmer retorted; ‘we know university researchers, we meet with them, we have social relationships with them but they have little to help us’.

Findings on the influence of informal mechanisms of university knowledge transfer in the manufacturing sector is generated from examination of hypothesis test results of $H_{10b}$, which indicate that university knowledge obtained from informal means in the sector does not support any form of innovation. Also, what was gathered was that, the greater percentage of their innovative needs are predominantly product development as accordingly noted in empirical studies (Unceta et al., 2016, UNU, 2009). This, they admitted cannot be accessed based on social ties but strictly on commercial terms and conditions where funding will be needed formally. Moreover, some business owners, in the sector expressed in the interviews that simple relationships that they have with university researchers do not help them with any innovative ideas either with the ‘free good’ characteristics of university research findings. They have admitted though that they do innovate anyway and are ready for better improvement all the time if university knowledge comes their way.
A critical look at the result of $H_{10c}$ explains the finding on the influence of informal mechanisms of university knowledge transfer on innovation performance in firms in the service sector. The study found that the sector represents almost three-quarters of the study sample and also discovered that informal mechanisms actually have no influence on innovation performance. One business consultant made it clear that in most cases if services are delivered based on relationships and friendships the actual benefit of innovation is hardly achieved. He added; ‘One other thing is, we earn our livelihood from consultancy and research projects so we do not give out commercially viable knowledge based on social relationships, neither do university researchers do so to the best of my knowledge’. This statement in a way explains practically why informal mechanisms of university knowledge transfer are not on their own direct catalysts of innovation performance in firms in the sector. Summary of these are presented in Table 4.14.
Chapter 4. Findings

Table 4.14. Summary of findings on informal mechanisms of knowledge transfer and innovation in firms

<table>
<thead>
<tr>
<th>Approach</th>
<th>Descriptive statistics findings</th>
<th>Inferential statistics findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size</td>
<td>Age</td>
</tr>
<tr>
<td>Quantitative research</td>
<td>Service is the largest 69%</td>
<td>Aged between 1 and 10 years is 30%</td>
</tr>
<tr>
<td>Qualitative research</td>
<td>Interview/observations/documentary findings</td>
<td>Knowledge that is obtained is not effective useful to primary producers</td>
</tr>
</tbody>
</table>

4.21. Knowledge networks and innovation in firms

This section presents findings on how knowledge networks influence innovation in firms with university knowledge by first looking at national level. The section also gives findings on the same mechanisms at subsector levels from primary, manufacturing to services sectors based on
examination of hypothesis tests results and interviews with senior staff of universities and industry in Ghana.

At national level, knowledge networks are found to influence innovation in firms when hypothesis tests results ($H_6$) and interviews conducted were closely examined to understand the result better. From these, it is gathered that knowledge shared among members of networks in Ghana is productive and actually improve innovativeness in firms. On the whole, the significance of knowledge networks in bringing innovation to firms is highlighted in the work of apex bodies and institutions like the chamber of commerce which have delivered research knowledge through workshops and seminars. These have been captured in documents accessed and analysed in the study. Knowledge networks are found to offer a lot of resources for firms’ innovations in Ghana. Prominently, informal mechanisms of knowledge transfer are found to influence knowledge networks in the country according to analysis of hypothesis $H_5$.

In the primary sector, knowledge networks have also been found to directly influence innovation performance in firms in a critical examination of hypothesis test ($H_{5a}$). From there, informal mechanisms of university knowledge transfer appear to also influence activities of knowledge networks among sector members. Notably, the influence of knowledge networks on innovation through informal mechanisms is highest in the primary sector (See Appendix E3), whilst the rest appear the same. Coupled with that, it is found also in a critical analysis of interviews with senior officers of knowledge actors in the sector that some of them associate themselves with groups and networks that offer a lot of help to members in terms of knowledge and skills development. It became clear that the activities organised by these networks within the country generate and disseminate knowledge and innovative ideas for business progress. Some firms in the primary production rely solely on community networks despite most gain very little knowledge. However, all firms appreciate ideas from knowledge networks for their knowledge capabilities. Farmers for instance would gain a lot of knowledge from extension officers invited for workshops and seminars by community networks and a lot of these are informally set up or negotiated through informal relationships. Some managers have confessed that they tend to shy away from some of these knowledge networks because they are not really familiar with their nature and how they are set up and run. The more formal ones look ‘sophisticated’ and
‘complex’ to them and they cannot even speak English Language used for communication within them. Few have admitted staying away rather than joining to embarrass themselves.

Knowledge networks have worked well among manufacturers in Ghana and investigation based on hypothesis test results \( H_{6b} \) and interviews conducted have validated this finding. This again explains the important role of knowledge networks in getting university knowledge to firms in Ghana. The influence is quite similar to all sectors except the primary which is higher (See Appendix E1–E6). On this, the study found that some directors in the manufacturing sector believe that proximity to universities makes knowledge networks effective and attractive due to easy access to research findings. Although, it is equally found that some networks are in existence and active because of peers’ interest in industry progress, some are influenced by former classmates and alumni. Surprisingly, some firms have been found to not belong to any networks at all and admitted that they face disadvantages like lack of information and knowledge on which networks to join to gain access to topical issues relating to their businesses.

Analysing both hypothesis test results \( H_{6c} \) and interview transcripts, the study found that firms in the service sector enjoy the benefit of knowledge networks and gain a lot of knowledge for innovation through them in Ghana. Notably, the sector has similar innovation through knowledge networks as the manufacturing sector and the national level except the primary sector which is higher than all sectors (See Appendix E1-E6). Majority of firms in the sector are members of at least one knowledge network, despite a few firms are still on their own without networks. Considerably, university researchers and administrators too claimed to directly participate in such knowledge oriented networks. ‘The benefits to us and firms are great’, said one university senior researcher and this he means that they serve as a platforms in multidisciplinary manner for different experts in knowledge generation to compare notes and forge common agendas for the good of industry. Specifically, a managing director of a microfinance firm in his appreciation to the work of knowledge networks in his areas of operation stated that;

‘If not because of the technological improvement in our operations, thanks to our network, we would not have had the current software that we use. We got it for free and it’s been very useful. In fact, we would have gone out of business like others’.
Other benefits also come from interpersonal contacts and many platforms are created for exchange of ideas and latest technologies. Social media (e.g. Acadamia.ac, LinkedIn and ResearchGate) has actively become major online platforms for this particular sector in Ghana. It is also gathered that most seminars and capacity building workshops organised by knowledge networks are usually on current issues and technologies in the business world which are mostly offered for free or at low fees to registered members. Summary of the findings are in Table 4.15.

### Table 4.15. Summary of findings on knowledge networks and innovation in firms

<table>
<thead>
<tr>
<th>Approach</th>
<th>Size</th>
<th>Age</th>
<th>Main model (National)</th>
<th>Primary sector</th>
<th>Manufacturing sector</th>
<th>Service sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative research</td>
<td>Service is the largest 69%</td>
<td>Aged between 1 and 10 years is 30%</td>
<td>Innovation is achieved directly with knowledge networks</td>
<td>Innovation is achieved directly with knowledge networks</td>
<td>Innovation is achieved directly with knowledge networks</td>
<td>Innovation is achieved directly with knowledge networks</td>
</tr>
<tr>
<td>Qualitative research</td>
<td>Apex bodies offer so much knowledge for innovation</td>
<td>Local community networks are helpful</td>
<td>Alumni are sources many rely on for knowledge and innovation</td>
<td>Capacity building workshops are dominant sources of knowledge</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**4.22. Knowledge networks as mediators for innovation in firms**

This section presents findings on how knowledge networks mediate the influence of informal mechanisms of university knowledge transfer for innovation in firms. It starts with the findings.
at national level analysis. After that, it gives findings on primary, manufacturing and services sector firms based on examination of hypothesis tests and interviews with senior officers of universities and industry in Ghana.

At national level, knowledge networks have been found in a critical analysis to influence innovation with university knowledge base on hypothesis test results \((H_6)\) and mediation analysis. Accordingly, knowledge networks have been found to mediate about 61% of university knowledge for innovation in firms in Ghana. With this, further analysis of interviews revealed that knowledge networks have been instrumental in mediating between universities and firms, particularly in engagements that are the results of interpersonal relations established at conferences and workshops. The involvement of knowledge networks are eventually introduced to strengthen and move university knowledge to firms with surety and guaranteed for success and benefit for participating parties.

Also, knowledge networks are found to be partial mediators in the primary sector in Ghana for innovation achieved in firms through informal mechanisms of university knowledge transfer. From the analysis, the sector has up to half (49%) of innovation from informal mechanisms of university knowledge transferred to firms through knowledge networks. Effectively, the sector has the least influence on innovation among all sectors comparatively through informal mechanisms. The study understood that most primary sector firms tend to be traditionally inclined and owners and senior officers in the sector are therefore laidback, have little to do with external sources, partly due to low level of education, illiteracy and lack of access to many opportunities. Most of the firms obtain university knowledge and valuable information on production through informal means and only those belonging to knowledge networks really get to gain from knowledge mediated by the networks.

In addition to that, the manufacturing sector is found from analysis to have full mediating role for innovation in firms from informal means of university knowledge transfer. This is found to be responsible for a little above three-quarters (82%) of total innovation from universities in the sector. The mediation influence in this sector almost parallels the service sector but higher than the primary sector including the national level. Found to be the second highest among the three
sectors where knowledge networks play mediating role, firms in the sector are understood to also belong to active knowledge networks as mediators for current information and technology from universities. Majority of mediations are again from social and personal links facilitated by community gatherings and usual gatherings popularly known in Ghanaian society. With the highest mediation recorded for knowledge networks for the service sector in this study for innovation through informal mechanisms, knowledge networks offer full mediation (100%) according to the analysis and offer the highest mediation among all the sectors. A critical look at interviews conducted also suggests great influence of such networks in transmitting university knowledge in the service sector. Also, it became obvious from the interviews that certainly, many firms are still left out without knowledge networks because of some disadvantages they face in terms of their literacy levels and confidence to feel that sense of belongingness. This situation cuts across all sectors of the economy based on observations. Nevertheless, those that belong to knowledge networks in this sector have been found to openly appreciate the benefits in the areas of knowledge transferred to members through seminars, newsletters, catalogues, business meetings, workshops and productive visits from external experts, researchers from universities and international partners. This was also found with the support of a critical look at documentary evidence from few catalogues and newsletters from some knowledge networks.

In a nutshell, knowledge networks have been found to be productive in innovation performance at firms’ level in Ghana. However, while firms do not gain directly from their informal relations with university knowledge resources, their knowledge networks serve as necessary links that intervene to make the needed knowledge transferred for innovation performance. A car spare part wholesaler and member of the Kumasi Swame Magazine network stated in his own words that:

‘Our network has grown over the years to be a powerful and knowledge source for businesses, bringing in innovation in many areas including; marketing, distribution, in the entire supply chain and productive business models that suits our local market’.

Table 4.16 has the summary of the findings.
### Table 4.16. Summary of findings on knowledge networks as mediators and innovation in firms

<table>
<thead>
<tr>
<th>Approach</th>
<th>Descriptive statistics findings</th>
<th>Inferential statistics findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantitative research</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>Service is the largest 69%</td>
<td>Partial mediators for innovation</td>
</tr>
<tr>
<td>Age</td>
<td>Aged between 1 and 10 years is 30%</td>
<td>Partial mediators for innovation</td>
</tr>
<tr>
<td>Main model (National)</td>
<td></td>
<td>Full mediation for innovation</td>
</tr>
<tr>
<td>Primary sector</td>
<td></td>
<td>Full mediation for innovation</td>
</tr>
<tr>
<td>Manufacturing sector</td>
<td></td>
<td>Full mediation for innovation</td>
</tr>
<tr>
<td>Service sector</td>
<td></td>
<td>Full mediation for innovation</td>
</tr>
<tr>
<td><strong>Interview/observations/documentary findings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative research</td>
<td>Knowledge networks are common and offer valuable knowledge for firms</td>
<td>Most firms have little access to external sources of knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Majority of mediations are from social and personal links</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge networks serve as transmitter of university knowledge for innovation</td>
</tr>
</tbody>
</table>

**4.23. Government support for innovation in firms**

The essence of the qualitative research part of the study was to obtain non-numerical data from researchers and top management in universities and firms from semi-urban and urban cities in Ghana. It was designed to use appropriate methods to achieve the aim of the study. Interviews were conducted after hypotheses test results needed further explanations. For this, 10 participants from 5 universities and 10 from industry were recruited for face-to-face interviews. Consequently, the interviews provided in-depth and high quality data for understanding of the results. Appendix A-4 contains the details of the questions and items discussed in the interviews. However, this section only deals with findings on government support and policies accordingly gathered from participants.

From the interviews, the study gathered that senior management in industry are not happy with the manner government sponsored research projects are handled. They feel there is no trust
between university administrators and their counterparts in industry. It is found that there are a lot of complaints about the competence of some researchers and universities research centres. There are calls for the Government of Ghana to do more to allocate research contracts to only competent universities and whilst some advocated for more sponsored projects, others encouraged direct participation or partnerships with local or foreign universities for research and development. To this, a computer software development firm’s director stated;

‘We need the government to do the heavy lifting by sponsoring research and development and we can innovate and move the economy forward. We are too small to commission research projects and if the government does it, we will grow, create jobs and pay taxes in return’.

Another significant component industry management also is found to worry about was macroeconomic indicators which to a large extent affect almost everything in the areas of costs and prices. Curriculum development in universities also featured and industry feel their participation in curriculum development could help prepare university graduates for industry needs.

4.24. Summary

In conclusion, the purpose of the study is to contribute to existing body of knowledge by exploring how formal and informal mechanisms of university knowledge transfer actually influence innovation performance in firms at sector levels in Ghana. To do this, a mixed methods approach was employed which facilitated a hypothesis tests based research using quantitative data collected. This was supported with thematic interviews and documentary data also collected. Such a combination was very useful and the two approaches effectively complemented each other to generate the research findings. For instance, quantitative data collection engaged stratified random sampling technique to achieve a probabilistic and representative sample. Interview participants were recruited with purposeful sampling to not just achieve a representative sample but also to engage with the right informants with appropriate knowledge and experience. Eventually, the multiple sources brought in ensured triangulation which tremendously strengthened the findings.
To sum up from the findings above, the study’s primary finding is that formal and informal mechanisms of university knowledge transfers are both largely not influencing innovation performance in firms in Ghana at both nation and sector levels, though it seems to be effective only in the manufacturing sector. What is also found is that various mediating variables have different effects in transmitting university knowledge for innovation performance through formal and informal mechanisms of knowledge transfer to firms. For instance, according to the findings, the primary sector is better off with technology transfer offices and collaborative research as mediators through formal mechanisms than acting as standalone drivers of innovation performance. It is also found that manufacturing sector firms in Ghana do not collaborate and collaborative research does not help either as a mediator through formal mechanisms of university knowledge transfer. Just like all sectors and as reflected in the national perspective, the service sector is found to be better off with knowledge networks as mediators apart from the fact that independently, knowledge networks generate a lot of innovation for all sectors.

One major finding that is also noticed is that primary sector firms in Ghana seem to face more challenges in accessing knowledge for innovation performance through many mechanisms than manufacturing and service sector firms. Unlike the other two sectors under discussion in this study, collaboration and use of TTOs in particular are not common in primary sector firms therefore found not to influence innovation performance in the sector directly. However, it came out in mediation analysis that when TTOs are used in the primary sector, which appears to be a rare occasion, productive outcomes are achieved in the form of knowledge and innovation in the sector. Nonetheless, it is the only one intervening mechanism of university knowledge transfer discussed here and commonly used by primary sectors firms productively is knowledge networks through informal means.

Generally, it has been established in the study that informal mechanisms of university knowledge transfer really lead to collaboration between universities and firms in the country. It is also found that knowledge networks emanate from social influences and gatherings of university researchers and directors of firms and other industry players in Ghana. Furthermore, since technology transfer offices are formal establishments in universities in the country, intended to make breakthroughs available to firms, all sector firms have been found to have used and benefited
from their services except as mentioned earlier in primary sector firms. Largely, differences are found in how these formal mechanisms are used to influence innovation performance in various firms. More exactly, analysis of hypothesis test results suggests that TTOs are of benefit to manufacturing and service sectors firms but not firms in primary sector. Interview discussions with industry management found that most firms and small enterprises in the primary sector are family owned, managed mostly by people who are comparatively uneducated or have no or few managerial skills and therefore have low or no absorptive capacity to assimilate new knowledge. With these, the easy option for this category of firms is through their networks, which is evident in the findings.

Also, in manufacturing and service sectors, the situation is found to be different because they are mostly managed by directors who have technical expertise in what they do and can seek appropriate knowledge from universities for innovation. This has been found from observations made during interviews with most senior staff of firms. These firms have all options open to them and they take the advantages from within the country and also from outside to support their innovation. Finally, the government has seen called on to do more than it is doing currently to commission more projects on research and development for support for local firms.
Chapter 5. Discussion
5.1. Introduction

From the outset, the study was designed to offer understanding on a wide range of mechanisms used for knowledge transfer in interactions between universities and industry in developing economies. Doing so, it intends to contribute in solving the problem of a comparative lack of literature in the existing body of knowledge on how formal and informal mechanisms of university knowledge transfer influence innovation performance in firms at sector levels in Ghana. Several generational knowledge transfer/innovation models have been critically discussed to show their shortcomings and modified version of one of the more integrated models has been proposed for the study and for future use in developing economies. This proposed framework has since guided the research process; starting from data choice, questionnaire design, interview guide, data collection, choice of methods and presentation of findings. The research objective has since guided the development and formulation of hypotheses and research variables which have all been products of the research problem highlighted Chapter 2.

In Chapter 2, the literature reveals a constant neglect of studies into university engagement with industry in developing economies leaving a literature gap in the body of knowledge (e.g. AAU, 2012, Islam et al., 2013). However, evidence of knowledge of university engagement with industry in high income countries abound in the extant literatures (e.g. Goddard et al., 2012, Huggins et al., 2012a), but very little with regards to low income countries, signifying a compelling need for a critical investigation into the concept in Ghana. For a critical investigation, a mixed methods approach (Creswell, 2014, Soiferman, 2010), which lends itself to multiple systems and lenses through which a research problem can be tackled, was adopted to employ the most appropriate research tools to achieve the research aim.

Largely, the main proposition of the study is that formal and informal mechanisms of university knowledge transfer from universities to firms are primary drivers of innovation performance in firms in Ghana (Grimpe and Hussinger, 2013, Krupnik et al., 2015). That is not all; other mechanisms of university knowledge transfer have been included in the investigation and also are proposed to perform mediating roles in the transfer process. These include; collaborative research, TTOs and knowledge networks. Individually, these have actually been found to, in the study in one way or the other; facilitate the achievement of innovation in firms in Ghana through
either formal or informal mechanisms (Kneller et al., 2014, Lackéus and Middleton, 2015). Generally, in the knowledge generation literature, both formal and informal mechanisms have been acknowledged to be used by universities and industry in multiple forms to foster innovation performance in firms. The significant role the two unleash on social progress through innovation in industry has been subjected to a rigorous scientific inquiry to understand how they actually affect innovation in Ghana and at different sector level. Profoundly, this is hoped will inform various decisions in developing economies with similar features as Ghana. To uncover the sector context of these mechanisms, the study then discusses and compares sector results on knowledge transfer phenomena identified here using a broader context of the economy as a reference frame to outline similarities and differences that exist between the sectors.

Effectively, this chapter does this by addressing the research purpose with emerging issues under significant themes and evidence from hypotheses test results and interviews conducted with university researchers and business directors in Ghana. The findings are compared and contrasted with available literature in this chapter.

5.2. Formal mechanisms and technology transfer offices in Ghana

This section discusses issues of formal mechanisms of university knowledge transfer that take their roots from the literature (e.g. Macho-Stadler et al., 2007, Singh et al., 2015) extracted to measure the construct in the survey questionnaire. Details of the construct concerns formal contracts and R&D partnerships firms obtain from universities. Also, measuring the construct are long-term standing R&D agreements and facilities available to both players. The discussion here offers an insight into how firms in Ghana gain knowledge formally from universities mainly from the perspective of industry senior staff together with verification from their university counterparts in Ghana. Discussions from face-to-face interviews have all been used to deeply understand the process.

Primarily, based on hypotheses tests results, the study reveals that formal mechanisms of university knowledge transfer do not influence innovation performance in firms in Ghana directly. This clearly contradicts the current literature claim of a positive influence when formal mechanisms of university knowledge transfer are employed in universities interactions with
industry. Evidently, from the interviews conducted in the qualitative research aspect of the study, the difference is explained by weak institutions and loss of trust between civil servants, thus; university researchers primarily at the social level and business owners in Ghana. This represents a new finding which is significant on university knowledge transfer in Ghana.

Comparatively, except for the manufacturing sector as indicated in the hypothesis test result, both primary and service sector firms do not gain innovation from any formal arrangement made with universities in Ghana. This means that the significance of contract research and long-standing R&D projects involving universities and firms is less in Ghana. Meanwhile, several studies have reported impressive progress in innovation performance of firms involved in contract research and long-standing R&D projects with universities (Pickernell et al., 2008, Pietrobelli and Puppato, 2016, Sainsbury, 2007). However, one could suggested that differences and complexities in definitions and understanding of innovation could shroud the occurrence of innovation in this case and firms then fail to recognise innovation performance when even indeed innovation occurs as may be implied in the qualitative data analysis. Another theory could be that different innovation, other than originally targeted knowledge is usually seen as unsuccessful in Ghana or no innovation at all in this case. Cohen et al. (2002) also suggests that sometimes the generation of knowledge and its transfer is blurred which makes it difficult to realise its manifestation in the performance of firms. Put in a different context, technical weaknesses in the primary sector in Ghana as noted in the qualitative data analysis have been found and explained to be responsible for why firms in the sector fail to achieve innovation through formal means and the work of Robson et al., (2009) and Obeng et al., (2014) support this with empirical evidence. In their studies, they describe the characteristics of most business owners, about whom they report to be less educated and less skilled, who manage by hereditary and not by qualification or based on skills and experience.

Also in the qualitative findings, it was apparent that in the service sector too, failure to achieve innovation through formal means has been put down to lack of trust and inability of universities to demonstrate their capabilities in business and industries problem solving. Takyi-Asiedu (1993) explains how power-distance affects relationships between elite and less privileged in society who are senior management of particularly small firms that dominate the Ghanaian economy.
Age of firms has not been noted to be associated with innovation achievement through any means since senior industry staff could not link innovativeness to age of firms in the interviews. Even with that, a study conducted by Johnston and Huggins (2016) reports on productive formal interaction between universities and business service firms in rural locations in the UK, however, one could understand that the UK is an advanced economy where business environment and firms’ capabilities, and most senior staff are more technically skilled than those in Ghana.

Actually, it was uncovered in the quantitative research findings that manufacturing sector firms achieve innovation directly through formal means of contact with universities; thus, through perhaps long-standing R&D and consultancy projects. To affirm this part of the findings in the literature, Grimpe and Hussei (2013) discuss how industry-science R&D projects have now dominated knowledge generation in US and Europe which are strongly supported by policies. This, accordingly, has led to an upsurge of joint ventures with universities. Nonetheless, in a twist to that, Fu et al. (2014) lament challenges R&D faces in low income countries such as Ghana, where departments allocated for R&D are not common in either universities or firms. Even large firms have difficulties and lack support in developing economies as opposed to high income countries as indicated earlier. By comparison, one could argue that strong policies in developed economies play significant role in the dynamics of university engagement. Perhaps the strength and size of economies create fertile ground for universities to engage businesses (Mowery and Sampat, 2005a, Nurse, 2014, Sainsbury, 2007). That is not all; previous studies also show that public R&D institutions, including universities in developing economies with particular reference to those in sub-Saharan African countries are found to lack facilities ranging from physical to human resources, and provision of adequate support for industry in the area of knowledge and innovation (Deraniyagala and Semboja, 1999, Wignaraja and Ikiara, 1999).

In reality, as agreed by industry directors and firm owners in the qualitative research findings, corruption in society is taking a significant toll on government science, technology and innovation agenda, consequently, negatively affecting firms’ innovation performance in Ghana. Accordingly, the effect of corruption is huge and less privileged business owners in society in terms of education and exposure to outside world remains largely disadvantaged with little access to knowledge sources and innovation. Arguably, where corruption is prominent in society,
bribery is within and low-level and middle-level civil servants are those that exacerbate the problems thereby ripping all formal mechanisms of university knowledge transfer off the benefit of innovation in the country. One food processing form owner lamented; ‘we cannot continue to patronise bribery and corruption in such a scale and expect our country to develop’. The qualitative aspect of the study elicited information on the role of the general social norms and culture in innovation activities in the country in the interviews and participants both from universities and firms affirmed the negative effects of that current social problem has on the innovation landscape of the country. All of these have also been validated in the literature (e.g. Fu et al., 2015, Fu et al., 2014, Mensah-Bonsu and Jell, 2011, Murphy et al., 2018) as contributory factors for non-effectiveness of all formal arrangements of any kind in Ghana.

Typically, disparities between university engagements with industry in advanced and less advanced countries are numerous and the lack of extant literature on the concept even makes it more difficult to assess and compare. Whatever the case may be, as the current study seeks to fill the literature gap, the non-productive formal mechanisms of university knowledge transfer found in the quantitative research and supported in the qualitative aspect leads one to suggest that on the basis of the evidence of the challenges, which include a lack of technical capabilities, a lack of trust and many more as stated above, formal mechanisms of university knowledge transfer indeed do not influence innovation performance in firms in Ghana. This therefore extends the existing body of knowledge in the area of university knowledge transfer mechanisms in all sectors in Ghana. Even though there may be isolated cases as in the case of firms in the manufacturing sector.

In another development, the benefit and influence of TTOs were measured latently in the survey questionnaire as a combination of observable indicators such as; the importance of TTOs to firms, awareness of the role, existence and availability for innovation purposes. Based on the perception of knowledge transfer players, the findings here are the results of a collective analysis of hypotheses testing and thematic analysis of interview data gathered from top management of universities and industry in Ghana.
To start with, TTOs by far are found to offer significant benefit to firms in Ghana by availing discoveries from universities to firms for commercialisation and of course stand in as mediators of formal means of accessing university knowledge (Cesaroni et al., 2005, Lackéus and Middleton, 2015, Rorwana and Tengeh, 2015, Siegel et al., 2003b). Comments from the quantitative data from the interviews confirm that at both national and sector levels the significance is evident despite there were indications in the hypothesis test results that primary sector firms do not reap full benefit when TTOs act as standalone facilitators of university knowledge. The findings from the two traditions sound contradictory; however, the quantitative aspect reinforces the current literature (e.g. Lackéus and Middleton, 2015, Mosey et al., 2012, Singh et al., 2015) on the significant role of TTOs to academia. For instance, in a study to assess the role of TTOs in university knowledge transfer, Bradley et al. (2013) found that TTOs play significant role, thus; encourage university scientists and create fertile ground for successful transfer of knowledge to industry to achieve commercialisation of discoveries.

To put this into context, since inception of the TTOs concept in Ghana, comments from interview participants, especially those directly involved with TTOs role, related in the interview that a lot of work has been undertaken with university researchers by TTOs staff in areas of training and co-operation to educate few active researchers to understand the role TTOs play in getting their discoveries to market. Further details from the interviews indicate that some investors have also been invited to meet researchers in research fields to abreast themselves of what is happening in the area of research and what potential investments are available. Seminars, workshops and exhibitions have been used to accordingly highlight the potential to innovative with university knowledge and over the years there have been quite a lot of remarkable achievements made and substantial amount of money raised in investments by universities and scientists to boost their internally generated funds (IGF). One TTO officer out; ‘we organise exhibitions yearly and invite potential investors and stakeholders to showcase our products from university research to give confidence to the public what we can do here in the university’ More evidence from documentary data suggested that there have been instances when researchers have made a lot of financial gains particularly with the involvement of the intermediate technology transfer unit (ITTU) which is an imitative facilitated by Kwame Nkrumah University of Science and Technology (KUNST). It has been considered as a success and therefore replicated
throughout the country. Data accessed from universities has shown a number of spin-offs and some students are now interested in producing ideas in research with very experienced researchers to gain access to investment for their ideas. Significantly, KUNST has an entrepreneurship programme that encourages their researchers to start up or spin out new businesses, a revelation made by one of the ITTU pioneers in the interview process. Incubation and effective programme for more successful spin outs are now the challenges of the university was another hint by the officer in the latter part of the interview.

To support this, Rogers et al. (2001) present lessons learned from effective technology transfer from university TTOs in New Mexico over several years. In one of his examples, he cites technology venture corporation (TVC) as one of the venture funding bodies set up to invest in spin-off from TTOs in the area. Remarkably, about 20% to 30% spin-offs from university TTOs accessed funding each year successfully from TVC. Evidently, within five years of its operation, it is estimated that TVC brought in $134 million in investment, created 32 spin-offs and 1270 jobs in the state of New Mexico as of 1998.

Actually, from the hypothesis test results, the significance of TTOs to primary sector firms in Ghana is higher as mediators than it is for manufacturing and service sectors firms since there seem to be mediating almost all discoveries from universities to primary sector firms. This means, primary producers do not have direct links with research. From the qualitative research, the study understands it is largely due to their inability to personally reach out to universities for help. Much of the qualitative research suggests that primary producers in Ghana have very little education and technical skills and tend to manage their businesses with little interaction with scientists. However, with TTOs in place the challenges are reduced since TTOs officers actually negotiate between them to get discoveries to them. Comparatively, the quantitative research findings from the hypothesis test results confirmed that TTOs mediate partially in the manufacturing and service sectors and at almost the same level from formal mechanisms of university knowledge transfer. Thus, despite TTOs act as intermediaries in the two sectors, some of the firms still approach universities faculties and researchers personally without having to pass through TTOs to access knowledge. Explanations to this from the thematic analysis in the qualitative research is that most manufacturing processes are more technical since transforming
raw materials from primary to final products needs technical expertise; therefore staff in the sector tend to be more skilful with relatively higher absorptive capacities for external knowledge. Also, from physical observations and even verbal confirmations during the interviews it was noted that senior staff of these firms are more enlightened and networked with experiences of new ideas, knowledge and innovation that is why they can contact universities and researchers to discuss and negotiate their needs and problems to be solved. The same is true for the service sector firms which are highly technical with high qualifications, delivering high level services to manufacturing and primary sector firms. For some service sector staff, apart from the services they get from TTOs most of them have direct contacts with universities and researchers, and are able to obtain knowledge using their own initiatives.

Technology transfer offices in theory are established institutions for technology diffusion and their function over the years is well documented (Breznitz and Etzkowitz, 2013). As intermediate organisations, TTOs have helped bridge the gap between universities and industrial regions in both lagging and advanced nations. A typical example is the adoption of TTOs in Italy which has helped to protect IP for university researchers (Cesaroni et al., 2005). Surely, on the basis of the significant function performed by TTOs in Ghana, as jointly confirmed in the qualitative and quantities aspects of the study, and largely for the primary producers and also for the processing and service sector firms, the issue of TTOs as mediators of formal mechanisms of knowledge transfer in Ghana can be conclusively affirmed thereby adding to the existing body of knowledge.

5.2.1. Collaborative research and innovation in firms

Collaborative research was latently measured as a knowledge transfer mechanism with observable variables seeking to assess firms collaborations with universities and their outcomes. In the questionnaire, the collaborative research construct also deals with items such as patents and successful publications of collaborative research findings. To correctly deal with the issue, a combined method of hypotheses testing and thematic face-to-face interviews were used and the results are critically discussed and reported below.
The literature on collaboration between university and industry is well developed and the influence it has on innovation performance of firms and regional competitiveness is equally established (Abdulai et al., 2015, D’Este and Patel, 2007, Freitas et al., 2013b, IHERD, 2015). In particular, collaboration is considered to be central to firms’ innovation and remains a source for knowledge repository of innovating firms (Johnston and Huggins, 2016, Kneller et al., 2014, Nurse, 2014). Largely, in this study, the general outlook of the results from the quantitative analysis shows a positive collaborative research outcome that eventually leads to innovation performance in firms either through firms’ formal or informal links with universities, reinforcing current theory on university engagement with industry. This finding appears the same only for the service sectors in the hypothesis test when considered at sector levels. Specifically, at the primary and manufacturing sector levels, collaborative research is not only uncommon but also non-productive for innovation if pursued through both formal and informal links. Comparatively, the resulting innovation found in the service sector for each hypotheses test conducted for collaborative research therefore replicates the exact case as in the general outlook and consistent with the literature evidence documented by January and Thomas (2013). Also, from the results, there is evidence of no difference in the quantum on innovation performance at national and the service sector levels.

The disparities in the findings between the sectors and also compared to the general economic outlook present a challenging case of inquiry in structural equation modelling (SEM) and require a further study. However, available theories on university and industry collaborations (e.g. Evstigneeva, 2015, Gordon et al., 2012) provides a valuable light to the concept, showing how successful economies have gained through such engagements. Notably, a section of the findings in the current study affirms this. To illustrate the positive elements, Barnes et al. (2006) highlight the significance of universities collaborations with industry for critical skills development, technology diffusion and for generating knowledge for specific industry problems. In another study, Abreu et al. (2008) report of how knowledge generated from university and industry collaborative research became embedded in operational processes of participating firms, in such agreements. Advocating for this, they place emphasis on the process by which the knowledge gained become part of the firm’s knowledge resource leading to innovation and high performance.
Considerably, empirical evidence shows that there is an apparent social gap between less educated and more educated people in the west African sub-continent as reported by Takyi-Asiedu (1993), which is found to exist due to socio-cultural factors; power-distance and educational status. This certainly suggests a lack of relationships between elite researchers and mostly low skilled business owners in primary sector firms as found in the quantitative analysis of this study and the absence of collaborations for any mutual benefit as described in the literature too. The situation of no collaborations is not different in manufacturing sector firms and account for a mismatch of agenda for the common good of industry. Actually, bureaucracies and all sorts of ill practices, such as power distance and corruption in public universities are all known social problems well established and all featured in the qualitative research. For these, significant institutions in the country have been openly criticised and strongly described by both business directors and university authorities as being weak and ill positioned to facilitate collaborations as prescribed in the triple helix framework (Etzkowitz, 2002, Ivanova and Leydesdorff, 2014, Singh et al., 2015). In fact, the general assessment the result of the face-to-face interview data showed is that there is lack of technical capabilities in most primary sector firms and some manufacturing firms in the country, mostly denying them opportunities to collaborate. Lastly, from the same assessment for the service sector firms, the effective collaboration found can be explained by influx of people with high technical competencies and qualifications into the sector and now known for its high rate of growth as observed in the study. Drawing conclusions from the results of the qualitative research, it is now known that products from the service sector are high on demand across the country, calling for quick responses on supply side with massive influx of qualified staff in the sector. Also by that, the study understands that the benefit of such calibre of workforce in the sector is therefore manifested in innovation through collaborations and university knowledge transfer for better services.

Arguably, university-industry collaboration is said to enhance regional and national competitive advantage as noted by Lundvall (1988), and Dooley and Kirk (2007). It is for this reason that policy makers and practitioners now encourage knowledge creators to engage in such connections to influence innovation performance in industry. Additionally, university-industry collaborations yield a number of patents, licences, IP and spin-off companies (Clancy and Moschini, 2013, Meyer-Krahmer and Schmoeh, 1998). As noted in Chapter 2, the famous
examples are the cases of Massachusetts Institute of Technology (MIT) in the US, which helped create up to 25,600 organisations with a 3.3 million work force in a year and Silicon Valley project in California with billions of dollars in investments. Of course, the cases of the Cambridge phenomenon in Cambridgeshire, UK and Canada's High-Technology City are also examples to mention (Christopherson et al., 2008). On this note, collaborative research can be said to be productive in Ghana and can be useful to all sectors of the economy.

Collaborative research has been found to be a full mediator in the mediation analysis in the quantitative research for primary sector firms for university knowledge from formal mechanisms of transfer. The same is noted from informal mechanisms in the analysis for service sector firms. However, in the manufacturing sector, collaborative research has been a partial mediator from both formal and informal mechanisms of university knowledge transfer. It is also noted that in the preliminary hypothesis test results, primarily, collaborative research does not directly lead to innovation performance in the primary sector but appeared as a mediator in the mediation analysis. A similar situation was again noted with TTOs as mediators in the same sector and further investigation has been suggested to understand why. Perhaps it is a case of the point of involvement where on its own it does not lead to innovation but when initiated from formal or informal mechanisms as suggested by Grimpe and Hussinger (2013) and need more concrete and higher level interventions, it eventually leads to innovation in firms. Nonetheless, empirical analysis of the quantitative data shows that it does not mediate in the manufacturing sector from formal mechanisms of university knowledge transfer but partially mediates from informal mechanisms of university knowledge transfer. To understand this deeper, evidence drawn from the thematic analysis of the interview data collected during interviews shows that collaborative research neither influences innovation directly nor mediate university knowledge transfer in the manufacturing sector because of the high technological needs of the sector. From that, the study found the reason to be a supply gap which is beyond the capabilities of universities in Ghana. For the service sector, the same interview results revealed a low technical skills requirement needed to deliver services for most firms. In addition to that, interview participants asserted that highly skilled management personnel in the sector explains why collaborative research usefully intermediate almost university knowledge from both formal and informal mechanisms in the sector. As expressed by one director; ‘the service sector in Ghana is a fast moving and growing
sector and you see highly qualified people come in and make it successfully with university collaborations’. This is in consonance with existing claims in the literature and Barnes et al. (2006) explain how collaborative research has become a significant tool for technological development, encouraged and supported by the UK government for innovation and wealth creation since 1980s.

As has been noted, with all facts and issues considered above from both quantitative and qualitative aspects of the study, even with few instances of non-productive collaborative research results in primary and manufacturing sectors firms, the decisive conclusion of the study is that collaborative research between universities and firms in Ghana influence innovation in firms. For the fact that collaborative research is productive and beneficial at the national level and at least in the service sector, mediates in the primary sector, and above all, evident in the literature (e.g. Barnes et al., 2006, Freitas et al., 2013b), the study considers the positive results found as an added knowledge to existing body of knowledge. Therefore, the issue of whether collaborative research between universities and firms in Ghana influence innovation performance may be affirmed.

5.3. Informal mechanisms and knowledge networks in Ghana

In order to effectively investigate the influence of informal mechanisms of university knowledge transfer on innovation in firms in Ghana, the survey questionnaire elicited information from industry senior staff about their firms and interpersonal relationships with universities and researchers. It also assessed the perception of business leaders on the usefulness of published literature and whether they appreciate and follow the work of researchers for guidance in their areas of operations. All aided to determine the influence of informal mechanisms of university knowledge transfer to firms in Ghana. With the help of hypothesis tests from quantitative analysis and thematic interviews analysis from qualitative research, the study came out with interesting findings in Chapter 4 which are discussed below.

To start with, several studies have documented the significance of informal mechanisms of university knowledge transfer for innovation in firms and stress on how interpersonal relations contribute to that (Grimpe and Hussinger, 2013, Xiao and Tsui, 2007, Zahra and George, 2002).
However, in this study, informal mechanisms of university knowledge transfer have been found with quantitative evidence to not influence innovation performance directly as proposed from the outset. This is actually in conflict with what may be claimed in the extant literature. The discoveries here pertain to both national and sector levels where hypotheses formulated claiming direct influence of informal mechanisms of university knowledge transfer on innovation in firms in Ghana could not be supported. To illustrate this, Xiao and Tsui (2007) explains how Chinese firms rely largely on informal relationships embedded in their social fabric for innovating firms, which managers consider as ‘guanxi’ (or relationships) in general to be an important organisational resource that cannot be ignored. On another positive note, Zahra and George (2002) add that informal mechanisms, which they consider as products of social integration, contribute to knowledge assimilation and free flow of information from its source to firms for innovation and high performance. They conclude that firms that use ‘social integration mechanism’ he calls it; stand the good chance of benefiting from the best of what every society has to offer and that includes the research society which is the world knowledge repository.

Ironically, thematic analysis of face-to-face interview data collected to understand the quantitative results preceding the interviews presented a non-productive case on informal mechanisms of university knowledge transfer. Notwithstanding these, one should not forget that in Chapter 2, the review of the extant literature on social capital, which may be taken as synonymously to ‘social integration mechanism’ by Zahra and George (2002) or guanxi from Xiao and Tsui (2007), reveals some pitfalls. Indeed, these could be associated with informal mechanisms of university knowledge transfer situation in Ghana. Detailed analysis of the transcript from the interview revealed how civil society today in Ghana has lost its proverbial cultural values and norms leading to social decay and selfishness. According to participants, involvement in every aspect of research investments is now self-centred and nobody thinks about the larger society as a whole. A poultry farmer concluded; ‘our society has become “a winner takes all” society and only those close to authority tend to gain all the time’. By way of illustration, in a survey of 2518 households across some countries in the West African sub-region, Van Rijn et al. (2012) found a negative association in intra-community norms in the area of cooperation and trust which they call ‘a dark side’ of social capital. They further explain that
high intensity of cognitive social capital has the tendency to breed selfishness in attitude in communities which includes firms and universities.

One may suggest on this basis that selfishness could find its way into Ghanaian society, corrupting both academia and perhaps the corporate society as well leading to loss of trust that prevents co-operation for knowledge flow to firms. It could also be argued that social capital or ‘social integration mechanism’ known for its potential to discourage entrepreneurial activities therefore inhibits community members’ access to knowledge. Portes (1998) calls it an ‘excessive extensions of the concept’ which in turns jeopardises its heuristic value. More so, drawing from the work of Locke (1999) and Huggins et al. (2012) the literature mentions loss of business objective when firms draw some advantages from social capital made of friends and family members; because knowledge generated may have to be passed onto friends and family members for free. It may also be logical therefore to insinuate that academia in Ghana is not actually prepared to sacrifice to give knowledge for free, leading to a lack of knowledge flow through informal mechanisms available. This is found in all the sectors of the Ghanaian economy.

All theories explaining various reasons for non-productivity of informal mechanisms of university knowledge transfer have largely been found to reflect in practice in the country as listed in the findings in Chapter 4. Other issues of major problems in informal mechanisms of university knowledge transfer are lack of enough active researchers, low numbers of research centres and total absence of incentives and policies which make potential entrepreneurship researchers rather concentrate on ‘publish or perish’ notion of academia.

On account of the above discussion, one will be right to assertively affirm that informal mechanisms of university knowledge transfer do not influence innovation performance in firms in Ghana, thereby extending existing body of knowledge in the area of knowledge transfer mechanisms in Ghana.

In another development, information elicited to effectively understand knowledge networks mediation centred explaining the experience and perception of senior staff of firms in Ghana on established systems and networks that aim to disseminate knowledge in their business interest
areas. The knowledge network construct tries to assess the presence and influence of knowledge networks on innovation in firms. Processed and examined in hypothesis based test and integrated with interview transcript analysis, the study is able to offer evidence-based assessment of mediating role of knowledge networks in university knowledge transfer to firms in Ghana.

In fact, knowledge networks are found to have fundamental role in innovation performance in firms (Huggins et al., 2008, Huggins et al., 2012a, Huggins et al., 2012b, Murphy, 2002). Empirically, hypothesis test results from the quantitative part of this study shows that at national level and in all sectors of the Ghanaian economy, when informal mechanisms of university knowledge transfer is used through knowledge networks, innovation is achieved in firms. In other words, networks underlie knowledge transfer process for innovation performance in firms in the overall outlook. In the primary sector to be specific, further quantitative analysis confirms that knowledge networks influence innovation performance in firms. This thereby reinforces current theory on knowledge networks as facilitators of knowledge flow and innovation in firms.

For example, in examining social dimensions of innovation within networks of manufacturers in Tanzania, Murphy (2002) notes the importance of trust, group openness and how to improve the quality of knowledge exchange in the country and subsequent innovation performance. Without taking this at face value, he found that weak formal institutions within networks adversely affects role play and eventually discourages members from extending potential benefit beyond the core of the networks. Documents as part of the qualitative inquiry added impetus to the study process and critical analysis of them suggests that knowledge networks are naturally common in Ghana, (e.g. Gubkatemali network, Ghana Information Network for Knowledge Sharing (GINKS) and the National ICT4D Network) among primary producers, manufacturers and service delivery firms. From this, the study understands from the analysis of the documents that activities of knowledge networks are visible and effective among members. Memberships are opened to all to join and many workshops, conferences, seminars and events where members attend and gain knowledge for their operations are evident. It could be inferred from the summaries of the interview transcripts and documentary data that knowledge networks are encouraged in the country and interpersonal contacts and many platforms are supportive of all sorts of exchange of ideas and latest technologies. It was also evident in the information gathered from the research
participants that mostly, capacity building workshops are organised at local levels even by
government agencies to present any agenda of interest of the state to knowledge networks. The
Bank of Ghana, the National Board for Small Scale Industries (NBSSI) and the Association of
Ghana Industries (AGI) were mentioned by firms directors and managers in the interviews as
examples of significant bodies that encourage and support knowledge networks in the country.
The significance of such unions in knowledge generation and transfer in Ghana was
acknowledged by many university researchers and administrators as well in the interviews. The
conclusion therefore was that to actually reach out to firm who need to innovate, knowledge
networks in Ghana tend to have representatives across the country for easy access and
information dissemination to members. Accordingly, this is how less capable and less educated
are catered for, particularly most primary producers in far distance locations who lack technical
capabilities as noted in the literature and observed during the qualitative data collection. A
wholesaler in farm produce added; ‘we cannot attend the big gatherings in the national capital
but we can also get together here in our region and talk among ourselves and solve our local
problems’.

It may be noted that the influence knowledge networks have on various sectors firms differs
slightly depending on the nature of the firms and technical capabilities. Just as Huggins et al.
(2012) warns, implying that belonging to knowledge network alone does not solve any
innovation problems. It is noticed from the mediation analysis in the quantitative part of the
study that primary sector firms have their knowledge networks helping to mediate about half of
their knowledge needs in the country from informal mechanisms of university knowledge
transfer. For an insight into why about half of university knowledge being transfer in the primary
sector, suggestions from the qualitative data analysis is that most primary producers tend to shy
away from some of these knowledge networks because of their level of ‘sophistication’ and
‘complexities’. Added to that, accordingly, most of them are not used to gatherings of that nature,
particularly when their level of knowledge in English Language, which is usually the official
medium of communication, is very little, which limit the level at which they can interact,
network and express themselves. Situations like these are observed, from the experience of the
investigator during the qualitative data collection stage, to be common among less enlightened
but economically active people in Ghana and one can argue that the primary sector has about
50% of firms gaining knowledge through networks. The partial mediation could therefore be attributed to the result of those that are enlightened and engaging enough to take advantage of such networks in the country.

Further understanding from analysis of interview transcripts unveiled that the manufacturing sector firms gain most of their knowledge with the help of knowledge networks through informal mechanisms of university knowledge transfer. It also showed that the technical nature of processing primary products calls for technically inclined expertise which means that a lot of firms in the sector are to some extent technical and obtaining the needed knowledge may be beyond individual firms. It could be asserted that knowledge networks as conglomerates can generate such knowledge with the help of all individual contributions put together to gain an aggregate that will be useful to a whole industry. Unlike the primary sector firms who are weak technically as noted in previous qualitative analysis sections of this chapter, directors and managers in this sector are active in knowledge networks and therefore capture the full advantages they have. Logically therefore, almost full mediation could reasonably be said to be the result of their abilities to take part in knowledge networks and confidently obtain the needed knowledge.

Lastly, and found in the mediation analysis in the quantitative research, the service sector firms and just like those in manufacturing sector are actually revealed to gain most of their knowledge from informal mechanisms through their knowledge networks as mediators. As established already in Chapter 4 and mainly from the qualitative aspect of the study, senior staff members in this sector are observed and verbally confirmed to be highly qualified professionals with at least, a diploma or college qualification. During the interviews participants highlighted that knowledge networks even initiated as school mates, alumni members and industry senior management are common among them and taking advantage of such opportunities is a way they do it to reduce cost and stay on top of their businesses. Based on the findings from both quantitative and qualitative aspects of the study, it will therefore not be wrong to suggest that full mediation of knowledge transfer through informal mechanisms by knowledge networks in the service sector is influenced by their capabilities and high level of knowledge and expertise.
To support the finding above, Huggins et al. (2012) discuss the concepts of network capital and network space in an attempt to contribute to existing body of knowledge on the notions of social capital spanning to geographic space which they use as explanatory factors that underpin the impact of knowledge networks. Significantly, they report that firms use several knowledge networks to actualise innovation. One other finding in the study is that firms’ innovation performance may be related to network capital investment made in specific type of knowledge networks design to offer specific knowledge. The caveat is that, being in a region with research intense universities and good research facilities alone may not guarantee innovation performance in firms. Also, drawing from Westlund and Bolton (2003), Huggins et al. (2012) argue that strong ties within interpersonal relation or subcultures embedded in firms have the potential to retard firms’ innovation performance. One more concern they express is about knowledge becoming eventually homogenous and therefore less useful to members in the face of daily competition in the market.

Pulling the evidence together, it will be logical to conclude that knowledge networks with their potential to influence innovation, given that the right networks are formed purposefully and dynamically with specific knowledge intended, firms innovative activity will be enhanced and that is what is likely to be taking place in Ghana as found in the current study.

Finally, given the evidence above, partial mediation of university knowledge from informal mechanisms of university knowledge transfer by knowledge networks in primary sector firms and the full mediation by the same networks in manufacturing and service sector constitute new knowledge in the current study. Based on the evidence, the issue of knowledge networks as mediators of informal mechanisms of university knowledge transfer to firms in Ghana can be affirmed in this study. However, knowledge generation and transfer for innovation can only gain momentum if government support is assured and policies designed to enhance the course. For this reason, the next sections present a discussion on the support of the Ghanaian government in innovation and innovation policies.
5.4. Government support for innovation performance

To effectively understand government support for innovation in Ghana, the questions asked and discussed thoroughly in the face-to-face thematic interviews in the qualitative inquiry were meant to uncover challenges faced on the ground that the government could step in to facilitate knowledge transfer and innovation for competitiveness for all firms in Ghana. The interview guide was designed to understand core issues pertaining to policies and frameworks that government could use to ensure successful implementations of science, technology and innovation agenda in Ghana. To thoroughly discuss issues that came out of the interviews with regards to government’s role, themes that emerged from the analysis are discussed. The first theme deals with government sponsored projects, followed by partnerships with private sector on research and development. Finally, after that comes government’s direct role in R&D.

5.4.1. Sponsored research projects

To start with, it is well established that firm’s university knowledge acquisition and interactions with other firms specifically for knowledge are to a large extent influenced by frameworks and policies designed to achieve innovation performance in firms (Borrás and Edquist, 2014, Hobday et al., 2012, Lundvall, 2007, McCann and Ortega-Argiles, 2013). For instance, research projects documents and further discussions during face-to-face interview with university research, administrators and industry directors points to the fact that science and technology policies and directives come in with seculars and some sponsorship packages for research and tend to encourage research in universities and other research institutes in a country. In fact, government involvement in R&D is significant as the study understands from the qualitative inquiry and that funding is provided to universities and research centres in the country to conduct research to improve on the lives of the people of Ghana. This is emphasised by the recent Minister for Finance (2015) in his budget report to Ghana’s parliament in 2015 and accessed as part of the study. Of course, this is accordingly appreciated by the corporate community in the country and development partners who are thereby urged to take keen interest in science and technology projects. Alas, interview participants noted agitations within the business community in Ghana for more to be done for commercial and public funded research to be carried out by competent research personnel of certain designated universities and research institutes. Some researchers of
sponsored projects, and entrepreneurs in Ghana think universities taking research contracts should have track records in commercial research and be certain to yield productive research projects. They added during the interviews that for any policy framework to work, researchers must qualify by a standard set to offer chances to those who are honest and have demonstrated their capabilities in their own projects and in their specialised fields. Effectively, industry directors insisted in the face-to-face interviews that government directives regulating such projects could be monitored and evaluated by a government committee of expert in research to ensure successful innovation projects and subsequent economic growth and development.

More so, Ghana government’s sponsorship of R&D, intended to encourage innovation is well recorded in documentary data obtained and successfully sponsored projects are also evident. In a similar case, the UK government is an example with the Research Excellence Framework (REF), which has since brought in substantial funding for some UK top universities in disciplines that yield research results for direct application in industry (Mosey et al., 2012, Nurse, 2014). This has resulted in the establishment of central research laboratories, technology parks, research centres and particularly for the fields of chemistry, bio-technology and pharmacology. Of course, the immediate effects have been the reduction in cost of research and development (R&D) for businesses, improved technological innovation for regions, increased in innovative momentum of local firms and augmentation of firms’ capacities in the nation to compete globally (Abreu et al., 2009, Fontana et al., 2006, Hobday et al., 2012). Such initiatives lead one to suggest that government sponsored R&D offers the chance for many firms, particularly small firms to enjoy free access to knowledge and innovation. This could be a potential avenue to improve the national innovation systems of developing countries such as Ghana and others in the West African sub-region. However, this is not to say they have not been negative consequences. Laws created by governments to regulate these processes, have turned out to be the biggest challenge retarding them. In Turkey for example, the taxable rolling capital system of 57% for academics erodes the take-home income, forcing knowledge actors into different alternative ventures. Eventually, both external and internal hindrances in many ways affect successful interaction between universities and the industries (Kaymaz and Eryiğit, 2011).
5.4.2. Public-private cooperation

Today’s knowledge base economy and globalisations have attracted attention of governments and other world bodies to participate in R&D projects for progress of international knowledge transfer and trade (Trajtenberg, 2002, Kaiser and Kuhn, 2012). Also, benefits that accrue in international knowledge transfer and trade have necessitated intermediation of other bodies in partnerships with governments to come in collaboration with universities and industry to facilitate research process in universities and subsequent transfer to industry (Barnes et al., 2006, Cloete et al., 2011, Deiaco et al., 2012). Apart from that, local partnerships are common these days in both advanced and less income countries. It is acknowledged that sometimes collaborative research is not easy to come by and other alternatives like consortia formation can offer firms the needed innovation requirements (NDPC, 2010, ECA, 2013). Nonetheless, Mothe and Quelin (2000) argue that consortia have not really lived up to the expectation of their proponents either. Notwithstanding these, the Exceptional, Unconventional Research Enabling Knowledge Acceleration (EUREKA) project in Europe, which is public-private funded research project and a typical consortium, is an example of such co-operation which has chalked some renowned successes over the years. As such, EUREKA brings together universities, research institutes, private firms and governments on co-funded projects for commercial research that advances technology in identified industries and disciplines for the good society (Kaiser and Kuhn, 2012). Nevertheless, these types of co-operations do not go without high cost and risk to funders and do not escape failures either (Hughes and Kitson, 2012).

A combination of analysis of documentary data and interview transcript to make sense of Ghana government university knowledge transfer and innovation policy reveals that the government contracts or partners with private corporate bodies within and outside the country to achieve this aims as well. It is also reveals that these partnerships engage with individuals, research institutes and organisations with specific expertise to help transfer knowledge local corporate sector firms boost innovation performance. This according to participant in most cases has political interest and implications such as the ruling party’s manifesto promises. Added to this, the understanding gathered during interview was that sometimes this happens in disciplines that seem to be lagging behind and needs support to function. To illustrate from one of the numerous examples cited in the interviews, as a new oil and gas producing nation, the government continues to engage
private firms, oil and gas experts and researchers who can really help push the government agenda to gain maximum benefit of the oil and gas for growth and development of the economy. Public-private joint project were reported during the interview to be relatively small in size in Ghana and short lived in time span therefore the long term good of such crucial initiatives are really not felt in Ghana and industry is always left stranded after the end of such projects. It will be logical to suggest that, may be, a West African version of EUREKA or something similar for countries to benefit in the sub-region could be a good idea to consider. Even a stronger one could be set up across Africa given the success and the scale of such project objectives.

To support the arguments with a similar but small project that could be scaled beyond the current continuum, the closest example in Ghana is a project co-funded by DFID and ESRC and in collaboration with Oxford University in the UK, Cape Coast University in Ghana, the United Nations University – Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT), the Ghana Science and Technology Policy Research Institute (STEPRI), Tshwane University of Technology, and the United Nations Conference on Trade and Development (UNCTAD). Significantly, this project was led by Professor Xiaolan Fu and conducted to investigate factors that affect mechanisms of dissemination of innovation in countries that have less resourceful institutions for innovation. This survey used more than 500 of both formal and informal firms in Ghana between 2011 and 2013. Eventually, the findings of the project was that, irrespective of sectors and regardless of all challenges, all firms in Ghana seem to engage in all forms of innovation including importation and imitation and sometimes through multinational companies (Fu et al., 2014). However, while the project investigates the formal and informal sectors of the Ghanaian economy, on the contrary this current study investigates the influence of formal and informal mechanisms of university knowledge transfer on innovation in primary, manufacturing and service sectors.

5.4.3. Government direct involvement in R&D

Firstly, governments traditionally have been direct and primary drivers of university research for centuries and still cater for a large percentage of current university research budgets (Sainsbury, 2007, Muscio et al., 2013). The need for government direct involvement is comparatively more in developing economies because of industry’s inability to unilaterally fund research (Hobday et
al., 2012, OECD, 2013). To illustrate, in South Africa, there was a steady and consistent rise in information communication technology (ICT) expenditure as part of the government direct support between 2002 and 2005, investing 0.11% of GDP in 2005 for ICT and 12.8% of the total expenditure on R&D for that year (DST, 2007). Additionally, governments’ direct support has accordingly been critical for innovation in firms and for social and economic development of nations. For instance, Cohen et al. (2002, p. 1) in their investigation into the influence of public research on industrial R&D in the US manufacturing sector, using Carnegie Mellon survey on industrial innovation found that the impact of direct public support is in their own words, ‘...disproportionately greater for large firms as well as start-ups’. As a result of direct public support, patents approved to universities increased significantly in the US from 589 in 1985 to 3,151 by 1998 (National Science Foundation, 2000).

Numerous documents from different stakeholders and discussions with university administrators and industry directors as direct beneficiaries during interviews have pointed to significant campaigns for science, technology and innovation launched by the Government of Ghana through a designated ministry to link up to sources of knowledge inside the country. The campaign is said to generate and transfer knowledge to help industry realise the needed innovation. However, further from the qualitative research, the study understands that, not enough resources and incentives have been forthcoming for universities in the country to deliver the right quality of commercial knowledge to empower the economy with adequate innovative tools for fast growth and development. Among other thing mentioned are government efforts within the country to include upgrading of polytechnics to technical universities (NDPC, 2010, NCTE, 2014), restructuring traditional and new public universities to address current science and technology needs of the country. Participants in the interviews did not mince their words and admitted that as a developing economy though, there are many setbacks identified even within government circles as red tape are the main impediments in carrying out directives. Crucially, it was also noted that many public reports on economic development have called for more government participation in all sectors’ development and was said to be highlighted in several symposia and workshops organised by civil societies. However, many firms are still left out, particularly primary and informal sectors. Consequently, as indicated earlier, the government has not been able to formally incorporate informal sector firms into the main stream for revenue
Generally, governments have since influenced the process of technology transfer from universities to firms with interventions to encourage entrepreneurial activities in universities and also step up universities’ capabilities to self-fund research projects (Etzkowitz et al., 2000; Hagedoorn et al., 2000). A test case is the Bayh-Dole Act of 1980 in the US where proprietorship of university research outcome was made explicitly clear in its conditions. The act made federal government funded research projects results universities’ bona fide (Deiaco et al., 2012, Mowery and Sampat, 2005a). Despite the fact that there is no clear and convincing evidence of any direct impact of this act, the policy framework has been seen as a model instrument for many governments. For instance, some governments in Organisation for Economic Co-operation and Development (OECD) countries such as Denmark and Germany (Geuna and Muscio, 2009) have replicated it to encourage universities to work together with industry to strengthen regional and national innovation systems and facilitate social and economic growth and development (OECD, 2013, ECA, 2013). Strictly speaking, if an innovation policy is tested and proven why should it not be tested in Ghana to also gain the benefits? Such initiative will need the Ghana Government to learn from past successful example perhaps from the US to adopt and adapt such policy to guide local innovation policies.
Chapter 6. Conclusion
6.1. Introduction

The focus on the role of universities in economic development and the influence they make on innovation in industry that leads to regional and national competitiveness has increased greatly. Also, the significance and process of knowledge transfer from universities to firms are widely discussed in the literature. However, up to now, the literature on how specifically formal and informal mechanisms of university knowledge transfer influence innovation in firms in developing economies has been neglected or at best, been given just a prescriptive view in scholarly literature.

Given the fact that university engagement with industry is important for advancement of less developed economies, our understanding on how formal and informal mechanisms of university knowledge transfer influence the process is necessary for innovation in firms and for competitiveness in such economies. Above all, precisely how they actually affect the process is equally crucial at industrial sector level which is equally neglected. On the basis of these, the study seeks to contribute to the current discourse on university-industry engagement and by that; ‘to design and evaluate a university-industry interaction and firm-level innovation framework that will inform productive interaction between academia and Ghanaian businesses to enhance firms’ innovation performance’. The study also looks at how other components of university knowledge transfer system, such as TTOs, collaborative research and knowledge networks, and how they mediate to the process.

The findings from this study therefore underscore the significance of university knowledge transfer mechanisms and how they influence innovation in firms in Ghana. The evidence here is gathered from a variety of analysis from different strands of research approaches at different stages in the research journey and several methods used from the start to this stage. The research’s conceptual framework proposed for the study guided the sampling technique, data types at all stages, data collection methods and the entire research process. Therefore, using both quantitative and qualitative data and methods, the study examines empirical data quantitatively in a hypothesis based research with further explanatory secondary qualitative research to broadly understand the influence of formal and informal mechanisms of university knowledge transfer between three Ghanaian industrial sectors. The study has led to significant findings and some
suggested recommendations in a number of areas for further research which the rest of the chapter gives in the final conclusion below.

6.2. Conclusion on findings

Primarily, the study concludes from the discussion that formal mechanisms of university knowledge transfer do not direct influence innovation in firms in Ghana. Significantly, this is now known to prevail in the general assessment of the whole country and also found in all sectors at industry levels, except for the manufacturing sector. Generally, in the primary sector for one, the study argues that firms lack of technical capabilities and low absorptive capacities remain as barriers to innovation through formal mechanisms available. In this sector accordingly, TTOs effectively mediate in this as specialist’s institutions and achieve full and successful innovation in firms. Effectively, TTOs are suggested to be one of the best routes to innovation for the sector from knowledge generated in universities in Ghana. From the discussion, another route that is of equal mediating results in the primary sector is collaborative research project firms in the sector arrange with universities, and despite formal mechanisms and collaborative research on their own do not lead to innovation in the sector, when collaborative research is employed as a mediator, innovation is achieved. As found from the theoretical and empirical perspectives of the study, a further investigation is recommended in the area of university knowledge transfer in developing economies to find out why as a mediator, collaborative research does support innovation but does not support it as a standalone mechanism in the primary sector.

Also from the discussion, the study learns that informal mechanisms of university knowledge transfer do not influence innovation in firms at the national level and in the primary sector either. Although, knowledge networks do mediate and lead to innovation from knowledge transferred from universities in the sector. For this sector, the study has gathered evidence from the discussion to assert that knowledge networks mediate almost half of university knowledge from informal mechanisms. Again, from a critical look at available evidence, collaborative research is another component that mediates university knowledge from informal mechanisms of university knowledge transfer and does so with almost the same in terms of percentage of mediation as knowledge networks in the sector.
In all, although both mediating components have influence in this situation, discussions of the findings suggest that TTOs are some of the best forms of intermediaries for firms in the primary sector for innovation with university knowledge through formal means of contacts with universities. Knowledge networks, which are rooted in the benefits of social capital, also do have intermediary roles through informal mechanisms of university knowledge transfer but not as much as TTOs used as intermediaries. Information gathered from the literature and empirically, and discussed in the study show that it is important for the primary sector firms to rather concentrate on the use of TTOs as intermediary specialists facilitators of formal mechanisms of knowledge transfer for their knowledge acquisition from universities in Ghana. Other developing countries could do the same if they are to exploit the full benefits of formal mechanisms of university knowledge transfer. Future efforts by primary producers to pursue innovation from university knowledge should be by the use of TTOs when the opportunity to use formal mechanisms of knowledge transfer arises. Also, when on the other hand there is the need or opportunity to use informal mechanisms of knowledge transfer for innovation in the primary sector, knowledge networks are better intermediaries and should be considered as a priority. Future efforts need to recognise these as well and developing economies must also take note of that.

Another suggestion that came from the discussion is that the Ghana government will need to help most firms in the primary sector that have low absorptive capacities and lack technical capabilities with capacity building training and regular visits by experts in various areas of business operations to communicate vital information in the language they understand. This will accordingly encourage them to adopt innovative ways of doing their businesses. On the other hand, researchers and universities need to realign their research projects to address local problems and learn to integrate with local communities using programmes and events that will bring trust between them and societies within which they operate. Particular reference is made and emphasis placed on primary producers who are not in any productive form of contact with the research community in the country. Of extreme importance to the primary sector, the study found that TTOs staff will need more training to be able to encourage and facilitate more mediation between primary sector firms and researchers. A more qualified and well trained staff will be apt to the task and can make a lot of difference to innovation performance of firms. That
is not all; the understanding also is that the government can facilitate the establishment of knowledge networks using agents and departments like the National Board for Small Scale Industries (NBSSI) and the Association of Ghana Industries as platforms to set up various types of knowledge networks and organised according to levels of capabilities and literacy. More so, technology transfer office staff can do that through the Intermediate Technology Transfer Unit all around the country.

In addition, evidence drawn from the discussion suggests that in the manufacturing sector, technical capabilities are a little better than the primary sector and firms in the sector have capabilities needed to, at least, contact the research community comfortably to gain the benefits of knowledge generated from universities directly with formal mechanisms. They also gain from TTOs as standalone departments and as intermediaries through which knowledge transfer is facilitated to firms for innovation performance. Comparatively, further evidence again from the discussion suggests that TTOs are more productive with primary sector firms as intermediaries than they are with the manufacturing sector firms but knowledge networks involvements in the primary sector firms are less than their involvement in the manufacturing sector firms. Between the two sectors, it may be suggested that whereas TTOs are better used in the primary sector firms for university knowledge transfer, knowledge networks are better used in the manufacturing sector firms for the same reason. Universities and investors can take advantage of this and direct their attention to areas of TTOs work that produce higher values for higher innovation performance.

Conversely, collaborative research is understood to not influence innovation in the manufacturing sector either as a standalone mechanism or an intermediary component when initiated from formal mechanisms of university knowledge transfer in the sector. In fact, the total effect is found to be negative, implying a missing component in this instance for which the study again recommends a further investigation in the area of university knowledge transfer in developing economies. The investigation could be set to find out which extra missing mediator is responsible for the negative total effect in this study. On the other hand, from informal mechanisms of university knowledge transfer, when collaborative research is used as an intermediary, innovation is achieved but not as much as it is with knowledge networks as stated
earlier on. What is noteworthy here too is that, there is a negative total effect which also calls for further investigation for a missing component as an intermediary.

Concluding from discussions around this issue, the government and stakeholders in the area of knowledge transfer could be encouraged to not only help set up and train more TTOs and qualified staff for the primary sector but also for the manufacturing sector to facilitate their benefit to industry. The same could be done for both sectors in terms of increasing knowledge network activities in the primary sector as suggested above with knowledge networks in the manufacturing sector firms to gain more knowledge. Definitely, future knowledge transfer could concentrate more on knowledge networks in the manufacturing sector since evidence suggests it is one of the best routes to transfer knowledge from universities in the country at the moment for the sector. This could be suggested as well for all less developed countries with similar economic characteristics as Ghana, more especially those in the West African sub-region.

The study also concludes from critical discussion of the findings that the service sector firms tend to have more technically skilled personnel with highly qualified senior staff having tertiary qualifications than the primary and the manufacturing sectors firms. In fact, the study understands that this is the sector that bears similarities with the entire Ghanaian university knowledge transfer ecosystem. The other sectors differ significantly from the national knowledge transfer outlook. However, whilst the service sector firms also benefit from TTOs as intermediary departments, the benefits are lower than the benefit in the primary sector and almost the same as the manufacturing sector. For knowledge networks as such, the service sector firms seem to reap the most from them than the primary and manufacturing sector firms, though the manufacturing sector gain more than the primary sector firms in this instance. With knowledge networks however, in the service sector, innovation gained with university knowledge from informal mechanisms is high and even higher in this instance than the manufacturing sector which also in turn is higher than the primary sector. Again with these conclusions from the discussions of the findings, stakeholders will need to put more knowledge transfer effort on knowledge networks to gain more knowledge to innovate in Ghana. Technology transfer offices, as already suggested, could also achieve more if stakeholders concentrate and offer more specialists training to staff and upgrade facilities to cope with modern
needs of firms. Government-pulled triple helix is seen as a possible contribution for fast and effective TTOs work and broader access to university knowledge.

Once more, collaborative research is another mechanism that influences innovation on its own and also as intermediary for university knowledge transferred from both formal and informal mechanisms in the service sector. Largely, the influence in the sector as a mediator is understood to be great and parallels the influence of knowledge networks as mediators. By this, the study suggests, based on discussion around the use of these mechanisms in and outside Ghana, that both collaborative research and knowledge networks should be given the required attention in the service sector in Ghana to gain maximum knowledge for innovation. One may also conclude on the same basis that whereas knowledge networks are very useful to the service sector in intermediary role for innovation through interpersonal relationship, collaborative research is not only equally useful through that but also through formal relationship between universities and firms. Finally, as compare to the primary and the manufacturing sector firms, the service sector firms tend to gain more innovation performance even through almost all the intermediaries considered in the current study.

From this point, the key questions emanating from the discussion for future concern for governments and practitioners in the areas of university knowledge transfer in developing economies perhaps could be on these differences in terms of influence of the intermediaries, which the current study argues may be attributed to differences in their specialisations. Thus, intermediaries such as TTOs, and knowledge networks, may tend to concentrate their operations on their areas of comfort leaving other areas without enough impact. May be if training offered to upgrade their skills, particularly TTOs staff, could touch on all sector’s needs, intermediation could do better for all sectors in terms of innovation performance. Quite apart from that, whilst all firms in all sectors gain university knowledge through the intermediaries in university knowledge transfer and innovation, the levels and quantum of innovation gained are found to vastly depend directly on the characteristics of the sectors in the country. For instance, discussions on the findings point to the fact that those firms that are in the service sector are more technically ready to absorb any knowledge generated from various sources, whereas those firms in the primary sector are lagging behind in many capabilities. Firms in the manufacturing
sector accordingly concluded from the discussion, are stranded in the middle and whilst some are somewhat good in technical expertise other are behind. Consequently, as university knowledge generation and transfer involvement gets more sophisticated and complex, the farther it gets from the primary and manufacturing sector firms, however the more close it gets to the comfort zone of the service sector firms, the study concludes. It is significant to take note of the fact that, primarily, there is a lack of analytical framework on how formal and informal mechanisms of university knowledge transfer influence innovation performance in firms in developing economies. Not just that, there is the general neglect of scholarly literature pertaining to developing economies in the discourse of which the current study concludes with evidence for future policy needs and directions from the discussions of the study findings.

In the first place, as part of the long-term development strategies therefore as discussed in the preceding chapter, the government should take the challenge to increase research funding in research sponsorship with the support of clear directives to specific specialist research universities to do more to conduct specifically, commercially profitable research for the productive sector in the coming years. In the second place, for policy framework to work in this instance, a well prepared programme of action to facilitate information and knowledge access to all forms of businesses and firms in all districts of the country will help realise the intended outcome of the science, technology and innovation agenda of the country. More so, discussions in the area of policy suggest that support from the government in the form of securals and policies which has since been found to tackle issues on education, curriculum development and research funding in all research centres need a better structure to work. Notwithstanding inadequacies of government funding, more and stronger partnership with private corporate bodies and external donors in R&D will do more good as have been noted over the years to have augmented the process of innovation in industry.

Lastly, senior management of businesses in Ghana have advised and called for a framework from the government of Ghana that will be designed to offer effective training and specific skills development for graduates by expert and may be foreign partners in Ghana in the areas of need in the service sectors to cover oil and gas sub-sectors. Discussions on policy implication in the preceding chapter suggest that for a policy framework of this nature to work, it should be
designed to mobilise local resources and experts on government sponsored R&D projects for development of industrial sectors and make the country take absolute ownership of its own economic growth and development. However, it is suggested that sufficient incentives must be given to universities in the country to deliver the right quality of commercial knowledge to empower the economy with adequate technology for fast growth and development. Namely, a strategic upgrade of polytechnics to technical universities and establishment of more centres of excellence could be the government further direct role to innovation. Essentially, evidence gathered in the discussions point to the fact that this is what is required for all areas of the economy for growth and development in the country without too much politics. The study also concludes that most frameworks do not work because there are too sophisticated for the local system and policies pertaining to the framework are made without clear instructions to guide their implementation. This study notes that no real checks are done to keep such programmes on course. Implicitly, these are due to the dysfunctional nature of the general innovation system and institutions that are supposed to make them work. Effectively, better economic and administrative machinery put in place could ensure adherence to government seculars and programmes guides. Actually, these have been understood from the discussion to be needed for future development of the Ghanaian innovation ecosystem and those of developing economies particularly those in the West African Sub-region.

Next to this come the implications of the findings suggested by the study for practitioners in the field of knowledge generation, innovation and technology transfer. Significantly, the implication to theory is also presented at this point intended to extend understanding of university knowledge transfer and innovation in developing economies. The implication of this study to economic policy, and science and technology in Ghana is also detailed here. Finally, there is a critical evaluation of the study which outlines empirical and methodological limitations encountered in the study, eventually culminating into practical justification of the process.

Emphatically, the significance of the Ghana Government role in the promotion of innovation culture and innovativeness in the country can never be over stated and suggestions on policy implication on university-industry interaction are paramount. In fact, in the study’s view, the following section tends to offer some policy suggestion.
6.3. Policy implication

In the first place, considering formal and informal mechanisms of university knowledge transfer from universities to firms in Ghana in a multi-stage analysis and methods of qualitative and quantitative data collected in Ghana to understand university interactions with industry in Ghana, the study found and discussed some sector characteristic similarities and differences. Also, the study understands that though both formal and informal mechanisms of university knowledge transfer do not directly influence innovation in firms in Ghana, they could influence innovation in firms through intermediaries. These certainly carry implications for policy makers in Ghana and other developing economies.

To add to that, formal mechanisms of university knowledge transfer are understood to be reliable systems of universities and industry engagements characterised by innovation performance (Gabbay and Zuckerman, 1998, Grimpe and Hussinger, 2013). These sorts of arrangement are also known for their results in the form of constant flow of new knowledge and reliability as sources for innovation. In fact, formal mechanisms of university knowledge transfer are documented to lead to spin-offs, licensing or patents (Borrás and Edquist, 2013, Clancy and Moschini, 2013, Cloete et al., 2011). In the light of the above, the issues the study raises for policymakers in Ghana is the need to first provide security for both universities and industry players in formal contracts arranged between them with state insurance policies to instil confidence and trust in such expensive engagements in the country. Without doubt the study understands that, even though such security may offer some confidence in formal arrangements, evidence suggest researchers and firms will still arrange knowledge transfers without due recognition of the consequences of the lack of security (Boldrin and Levine, 2012, González-Pernía et al., 2013, Groenewegen and van der Steen, 2006). One may argue that the absence of such security in Ghana at this time and clearly spelt out productive framework guiding formal means to knowledge transfer could be affecting involvement of primary producers in particular. It could also be said that the luck of such security exposes local firms to potential legal issues, loss of investments and inability to turn to something for cover and support.

Moreover, the theory on how informal mechanisms of university knowledge transfer occur have explains conceptually why and how they do so and whilst some look at its occurrence from spill-
overs, externalities and market instabilities others define it through social interactions, social
capital, human capital and network capital (Grimpe and Hussinger, 2013, Xiao and Tsui, 2007).
Certainly, the benefits of all these abound in the theory, among which includes the improvement
of innovation capabilities of firms (Chenhall et al., 2010, Murphy et al., 2015, Huggins et al.,
2012b), which presumably according to the current study is not the case in Ghana. The
prevalence of power distance in the West African sub-region is well established in the extant
literature and associated repercussions are equally evident in social gap created between the elite
university researchers and the masses including the vast majority of business owners and
directors of many firms (IMF, 2006, Takyi-Asiedu, 1993). If there is any intervention necessary
for interactions between these classes of people in Ghana, then policy makers will have no option
but to commission it for knowledge to be transferred for better Ghana. To realise the advantages
of informal mechanisms of university knowledge transfer embedded within the social fabric of
the Ghanaian community, policies to bridge the gap should encourage events to include
university community workshop, festivals, business and research exhibitions, fairs and joint
communal projects, which should be used as tools by stakeholders to foster university knowledge
transfer.

Also, the documentation of the literature on the significance of technology transfer offices
(TTOs) and their role and potential to help academia spin out companies is by far undisputed
(Cesaroni et al., 2005, González-Pernía et al., 2013, Lockett et al., 2005). Patent and licensing
are also some of the features recorded for TTOs operations and functions (McCann and Ortega-
Argiles, 2013, Mowery and Sampat, 2005a). Ironically, the current study reports of non-
productive standalone TTOs in the country and certainly sends a big challenge to policy makers
to rise up to meet the needs for which there are in existence. For instance, TTOs as standalone
departments in Ghana have been understood not to influence innovation only in the primary
sector of Ghana; however as intermediaries of knowledge transfer, they generate innovation in
the sector and also in the manufacturing and service sectors. Significantly, the primary sector
engages the majority of the Ghanaian workforce (GSS, 2015b, GSS, 2015) and debatably will
need all available facilities to help support the growing needs of the sector. Increasingly, the
crucial need to advocate for food security led development in Ghana is widely recognised and
policies to support the implementation of TTOs as knowledge transfer route to the sector in all
directions and functions could be a positive move in the country. Though the study recognises TTOs as a new concept in Ghana, they still have the potential to deliver university knowledge to all sectors of the economy. Even with the refusal of some researchers to disclose their discoveries, incentives in the form of cash reward for product development from government and its agents can encourage enormous amount of knowledge flow from university TTOs to industry (Abdulai et al., 2015, Bailey et al., 2011, Sainsbury, 2007).

Not all, the government of Ghana needs to team up with investors to set up investment seed capital fund to support spin-offs from university TTOs in the country to facilitate start-up and to ease early stage business challenges. In addition, student idea generations and development can be taken seriously and rewarded by the government and the ministry responsible for industry growth to encourage more students and researchers. This can be handled by university TTOs for further development and up scaling from investments from private investors. That is not all; the government needs to promote university innovation performance through entrepreneurship development framework that should establish commercial research universities and with competition among them for research grants. University ranking in commercial research could also be put in place by government in Ghana to challenge universities to the task. This can be tied to national and local level support for commercial research and TTOs spin-off creation to boost the creation of business development in all regions from universities for nation and growth and development. Most of all, university business and science parks must be part of the government STI policy to house well equipped and resourced business incubators and accelerators with experienced in-house entrepreneurs mentoring students and researchers in their start-ups. More so, the government of Ghana can send TTOs staff for training on business negotiations, employment laws, entrepreneurial skills and development, and further design a comprehensive compensation scheme for them as encouragement to get research breakthrough quickly and efficiently to market.

Actually, without efficient intellectual property laws, investors and inventors cannot be sure if their time, energy and investments spent can bring expected benefit without future problems and misunderstanding. The government therefore needs to properly design IP laws that will assure both parties of full benefit of their commitment to participate in university research.
commercialisations. Before this can be achieved, however, a national STI policy that incorporate university research commercialisation through university-industry interaction and entrepreneurial university concept is required. This indeed needs a holistic approach with involvement of local, regional and national development stakeholders talking responsibilities for successful implementation of the policy.

Additionally, the scholarly literature on collaborative research is quite extensive as the need for knowledge support for indigenous firms to grow into more dynamic industries also becomes increasingly important for economic growth and development (Barnes et al., 2006, Freitas et al., 2013b, Islam et al., 2013). Essentially, it is widely accepted that collaborative research should not just be the concern of universities and industry but also and most importantly a major concern for government (Jauhiainen and Suorsa, 2008, Michels, 2015, Singh et al., 2015). With no exception for the government of Ghana in this challenge, the current study finding of non-productive collaboration between universities only firms in the primary and manufacturing sectors raises worrying concern for development activists and practitioners in Ghana. Policy makers may serve the economy if they concentrate on taking steps by assuming an active role in bringing government owned cooperate bodies into collaborative research with universities to achieve results for the needs of industry (Drurey, 2010, Etzkowitz, 2002, Fleetham et al., 2015, Grabowska, 2015). This, the study believes, will certainly support the current agenda for science, technology and innovation for economic progress and set the stage for private investors to emulate. To achieve this, the current university structures will have to be adjusted to accommodate effective industry interactions and efficient knowledge transfer. It is acknowledged that successes recorded in the literature predominantly present the merits of collaborative research in advanced economies, however; a well-supported state collaboration with investment in a developing economy such as Ghana could equally present a good narrative in the literature for our records.

Above all, well informed economic policies and good governance undoubtedly incubate innovation across all sectors and industries in every economy and knowledge transfer mechanisms are not excluded (Freeman and Soete, 2009, Guimon, 2013, Hobday et al., 2012, Kaiser and Kuhn, 2012). Effectively, whatever happens at microeconomic level has a direct
impact on the innovation performance of macroeconomic environment within which firms operate. With instability in economic activities at the macro level, firm’s production performance do not allow them to achieve enough to engage in innovation since investments in research and technology are high. The effect of policy frameworks on universities’ knowledge creation and subsequent transfer to industry is fundamental to its success and potential benefits to the larger economies. For instance, cash rewards for initial development can be issued for disclosures to TTOs in universities to encourage researchers.

Also, entrepreneur financing programmes to support technology commercialisation in universities could draw in both new researcher and student to take advantage to break into the market with spin-offs and more involvements in business venture. The government can also establish research universities with adequate funding for commercially viable research to enhance innovation in Ghana. The findings on sector disparities in areas of university knowledge transfer mechanisms, innovation and use of intermediaries could be indications of macroeconomic policy neglect, particularly for the primary sector which is understood to be the weakest yet employs majority of the Ghanaian workforce.

The central government of Ghana is understood to have made several attempts to help industry activities with universities as trade and political support to science and technology strategic improvement. Nevertheless, the current state of affairs in university knowledge transfer and innovation in the primary and manufacturing sector firms in the country needs these policies attention to catch up with the service sector firms. Perhaps private sector and international co-operation with universities with a targeted agenda for low innovating sectors will be a move in the right direction. In fact, policies of this nature are hard to come by, the study admits, as Freeman and Soete (2009) reports on how private firms did not show any interest in funding R&D across EU for the so-called ‘Barcelona target’ of 3% of GDP to be invested by 2010. However, substantial increase from current budget of 0.005% of GDP on R&D in Ghana, a carefully planned and well-articulated objective that meet the primary needs of private sector firms is believed can do the work in Ghana. The study therefore strongly advocates for it to see knowledge generation, transfer and innovation succeed to bridge the sector gaps identified by the study.
6.4. Critical evaluation of the study

This study has delved into fundamental issues needing the attention of economic growth and development policies of Ghana with the aim of inferring on other economies of similar features in the West African Sub-region. Namely: knowledge generation, knowledge transfer and innovation performance in firms. To actually evaluate the subject in perspective, the study was conducted with a sample made of different firms from all sectors across Ghana. As a consequence of the study design and methods used, this section takes a critical stand point and highlights issues that challenged the process of the study from start to finish. Also, it covers all inadequacies and shortfalls that beset the researcher and the process, and presents limitations that were primarily envisaged and how they have been managed to reduce their negative impact on the validity and reliability of the findings. Equally, those that emerged unexpected have also been mentioned at this stage and how they have been dealt with to achieve high quality of outcomes in both quantitative and qualitative processes.

To start with, conducting a study in any single paradigm is a daunting challenge and mixing actually two paradigms is admittedly difficult as in this study and limitations have been encountered. More to that, the definition of a firm as a statistical unit of analysis and definitions of innovation in the context of developing economies were a sampling and data collection challenge as most firms in Ghana are generally informal and unregistered with neither local nor the central government as trading organisations. Crucially, the definition of a firm was resolved with the suggestion that company registration has not been the concern of the study therefore the definition was shaped to include any forms of firms that conduct any forms of trade with the aim of making profit for the owners and should be located within the country at the time of the survey. The definition of innovation performance was also formulated to include any basic changes and improvements undertaken by a firm to add value in the market. In any case, most of the firms obtained for the study were from a government database and it did not matter whether they were duly registered or not.

Added to that, the study faced the problems of sampling and data collection process used, and feared they could be systematic errors in the data collected. Although firms were randomly selected, the coverage was not exhaustive as expected, and in a way was limited to 7 out of 10
administrative regions of the country. The study therefore believes this has the potential to introduce biasness in the findings since all the 10 regions were not comprehensively covered. Considerably, a statistical significance test (independent t-test) was conducted with the data for a common error bias in the sample and was cleared of systematic error with no significance difference between early and late waves of respondents.

Moreover, the statistical software package (WarpPLS) used to empirically examine the models is relatively a recent development and requires further improvements to stand the test of time. For example, some test had to be conducted separately since it is not yet developed into the package. However, the package comes with so many advantages over traditional and commonly used statistical software packages for SEM analysis. Additionally, PLS-ESM is non-parametric statistical technique that parametric technique users cast doubt on and research conducted with that is considered unreliable due to lack of distributional normality of the data.

Also, a 5-point Likert scale was used to measure all the constructs for the study latently for analysis since that was considered an appropriate metric for measuring innovation activities of this nature for statistical analysis. Put in context, Likert scale type items in survey questionnaires are a psychometric scale commonly used in quantitative-survey research to rate responses on social objects that cannot be easily observed and measured discretely as in this study (Bishop and Herron, 2015). Emphatically, it is used when surveying respondents regarding their views on issues at stake and made of a series of statements or items that require respondents to select ratings on a scale that ranges from one extreme to another. For example as in the current study: ‘strongly agree “5”’ to ‘strongly disagree “1”’ with a middle value ‘3’, often labelled as neutral or undecided. As opposed to binary ‘yes or no’ statements, Likert scale offers a numeric assessment of what survey respondents think; experience, perceive or feel. Commonly used in the social sciences and humanities, it is an ordered scale from which respondents choose one option to measure the latent constructs (variables in quantitative studies) (Bishop and Herron, 2015). It was therefore used to measure for instance; innovation performance in firms in Ghana, formal and informal mechanisms of university knowledge transfer and collaborative research activities. Latent constructs are generally defined as unobservable unique characteristics without a concrete objective measurement. There are said to exist and manifest noticeable variations in
behaviour. To measure the constructs in the study, the items or observable indicators were phrased in a way that they measured only one characteristic per item and were clear on what the research subject was responding to (Hair et al. 2016). For example, ‘*In our organisation, we are guided by ideas from the work of academics*’. In the questionnaire, item that was rated high indicated a high view of the characteristic described in the item and vice versa.

Technically speaking, Likert scale type items are generally considered ordinal and tend to violate statistical assumptions. For example, ‘*distributional normality*’ assumption for parametric tests, which forms part of the statistical analysis in the quantitative aspect of the study, was actually violated (Clason and Dormody, 2009, Norman, 2010). This had the potential to increase the chance of a type I error in the results, particular in the MGA analysis conducted using a modified version of the parametric approach to two-independent sample *t-test* by Keil et al. (2000). To minimise possible misinterpretation of the results, care was taken in making judgement on the statistical results from the analysis. More so, respondents could have misinterpreted the mid-point (*neutral scale ’3’*) differently delivering a negative correlation effects between observable indicators and their latent constructs (variables).

Largely, due to its ordinal nature, Likert scale measurements are always susceptible to asymmetric verbal anchor and unwarranted interpretation of the mean calculated from the scale to use for further analysis (Pornel and Saldaña, 2012). These were potential flaws appreciated by the study and could have affected the reliability of the results though measures were taken to minimise their effects. Thus, to contain these, the questionnaire for the survey was designed with enough items for easy responses, which were evenly spaced with neutral scale to offer respondents the option to choose if they were unsure (Clason and Dormody, 2009, Norman, 2010). A choice of 5-point length of scale and not 7 or above was also intended to not confuse respondents with a needless wide range which the study believes eased estimation of perception on the scale. The study still recognises problems some respondents faced in trying to put quantitative value on their knowledge, perception and experience as in this case though. Lastly, to be sure of reliable results, evaluation of reliability of the Likert-scale in the quantitative research was conducted using Cronbach’s Alpha (internal consistency) to measure how well the
observable indicators functioned together for consistency and Alpha values of more than 0.7 were obtained.

Finally, this area of university knowledge transfer in a comparative fashion is uncharted in the context of developing economies and there had not been readymade template to start from. This therefore posed a difficult starting point. More so, definitions of university knowledge transfer terminologies were hard to outline to suit the needs of the study without conflicts and misinterpretations in the process due to cultural differences. Consequently, the study found it best to integrate and properly redefine them to allow for international comparisons of the research findings. Again, by virtue of the conceptual framework proposed for this study, the central and local governments were not contacted for interview as they did not fall within realm of the framework or the scope of the study. Other experts and knowledge generation and innovation interest groups outside firms and universities such as United Nations (UNESCO), Association of African Universities (AAU) and Economic Community of West African States (ECOWAS) were not directly contacted either for their opinions for the same reasons. Also, found to have had the potential to limit the study due to the conceptual design was the absence of inferential analysis of the structural model with ages, sizes of firms as control variable. Finally, the absence of analysis on other factors like the influence of the local environment, organisational cultural, socio-cultural factors and perhaps some inherent sector characteristics such as organisational norms and even traditions and customs of both firms and universities.

6.5. Justifying the study

It will be acknowledged at this point that the study findings have demonstrated in both theory and in practice that university knowledge transfer issues have become the topic for modern day economic growth and development activists and needs more attention than ever before. Remarkably, due to globalisation and systematic drift of markets towards knowledge economies, a further push for more knowledge and detailed understanding into how firms’ knowledge and innovation performance are achieved through formal and informal means can never be over emphasised. Moreover, this insight is particularly crucial at this earliest time of the 21st century. Following this, the study has delved deeply into significant facets of Ghanaian business environment, investigated how university knowledge is transfered through formal and informal
mechanisms to firms and for the progress of larger society. Likewise, the study has demonstrated that university research affects the progress of firms’ production performance and the growth and development of the entire nation of Ghana. Not only that, other discovery in the study is that other mechanisms such as collaborative research, knowledge networks and TTOs are useful in transmitting university knowledge in the transfer process to firms in Ghana. Surely, the investigation has shown where each is more effective than others and revealed where encouragement is needed to really to help to boost innovation performance in Ghana. Furthermore, the investigations uncovered where and why some of the mechanisms do not work well in certain sectors of the economy. By far, these findings serve as a starting point for further research and search for more answers.

By and large, the study has thrown more light on informal and officially structured arrangements made between firms and universities to create knowledge through research. The study again revealed that these mechanisms are after all fundamental in the innovation system of Ghana and therefore encourages knowledge players to work together using them in a systematic manner to attain knowledge for firms and the economy as a whole. As demonstrated in the study, it is clear that firms in Ghana will commit resources when universities in the country demonstrate to them that they can deliver results for innovation. Likewise, universities have shown they will also accordingly work hard if the needed support is offered from Ghana government. It is again evident in this study that even in developing economies formal and informal arrangements between firms and universities can yield productive innovation outcomes for firms to compete successfully in the market as it is in advanced economies. Markedly, the study has also exhaustively solicited, explored and presented the experiences, expectations and perceptions of firms and universities collectively, as vital individual players in the context of knowledge transfer and innovation performance in firms in developing economies. Most important of all, the study has opened a new chapter for stakeholders to reflect on problems, challenges, frustrations, struggles and developments that were not previously or were faintly known to governments of developing economies. Without questions, the understanding of all these in this study is expected to influence policies in industries, governments of developing economies, interested international bodies and donors in the coming years for better competitive firms and industries in many countries. Above all, the development of a university knowledge transfer framework opens a
door of opportunity for Ghana and other developing economies to use to study and understand the nature university knowledge transfer and innovation performance in firms.

6.6. Contribution to knowledge

Table 6.1 presents the contributions to the existing body of knowledge obtained from both quantitative and qualitative research conducted.

Table 6:1. Contribution to knowledge

<table>
<thead>
<tr>
<th>Contributions to knowledge</th>
<th>Empirical/analytical sources</th>
<th>Location in thesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The development of a new university knowledge transfer model for Ghana.</td>
<td>From generational models discussed</td>
<td>Section 2.16</td>
</tr>
<tr>
<td>• Formal mechanisms of university knowledge transfer do not directly influence innovation in Ghanaian firms, largely due lack of trust, security and proactive approach from universities and researchers.</td>
<td>Path coefficient analysis and face-to-face interviews</td>
<td>Sections 4.7, 4.10, 4.11, 4.12 and 3.11</td>
</tr>
</tbody>
</table>
technical and management skills of most staff.

- Collaborative research is uncommon in the manufacturing sector with some firms because of high technological input needed to meet the needs of the secondary producers, which universities in the country cannot meet.

- The primary, manufacturing and service sector firms exhibit significant differences in their knowledge acquisition from universities due to differences in educational levels characterised by each sector; low at primary, average at manufacturing and high at the service sector. This is noted in all mechanisms.

- Knowledge networks and collaborative research are better mediators in the service sector from both formal and informal mechanisms due to the speed of growth, high absorptive capacity and foreign competition.

- The service sector is a replica of the Ghanaian innovation ecosystem in terms of university knowledge transfer due to the size of the workforce employed in the sector.

<table>
<thead>
<tr>
<th>Recommendations for further study</th>
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<tbody>
<tr>
<td><strong>6.7.</strong> Recommendations for further study</td>
</tr>
<tr>
<td>Current discussions on the importance and usefulness of formal and informal means of knowledge transfer between firms and universities extends beyond just the borders of developing economies and therefore deserves further diverse investigations across board. Surely, for policymakers to achieve any fruitful targets in their policy strategies, the current study believes that more studies will be needed. Also, based on the limitation and revelations in the study a number of recommendations are hereby made for further studies:</td>
</tr>
</tbody>
</table>
• **Extensive countrywide coverage**

First, it is recommended that another study, this time an inclusive countrywide study into how both formal and informal mechanisms of university knowledge transfer influence innovation in firm directly or indirectly be conducted in the very near future. This will give a broader direction to stakeholders and for government of all straggling economies. This will have to cover all the 10 administrative regions of Ghana to enhance reproducibility and replicability of the study. In essence, the study started with a cross-sectional survey therefore, however to support the current study, a longitudinal survey will extend understanding of particularly the ultimate effect of knowledge networks among firms on knowledge transfer in the productive sector in the long-run.

• **A further look at collaboration in the primary and manufacturing sectors**

Second, it is a general consensus in the knowledge generation literature that collaboration between the productive sector and knowledge generators mostly directly result in improvement in product quality and operational efficiency. Nonetheless, this could not be empirically supported in this study in the primary and manufacturing sectors when the data was reduced to sector levels and analysed. This of course, is inconsistent with the extant literature. A supplementary research into the primary and manufacturing sectors that will employ more mediators in the literature and moderating variable like environmental factors, organisational cultures and some features identified with these sectors may provide a clearer perspective to the inconsistencies noted in the study.

• **Sector specific investigation**

Third, it will be prudent if exclusive data on specific sectors are collected and independently studied longitudinally and cross-sectionally and then compared to uncover a detailed nature of each sector characteristics at different times. Inherently, these sectors have subunits that were captured but could not be analysed with inferential intent and need to be factored into later studies to offer explanations on how the subunits gain and manage their knowledge resource.
• **Country comparisons**

Fourth, this is a single country study which of course challenges the potential of the results to be inferred on all countries in similar context. As a result, a cross-border comparison of economies of similar characteristics, maybe two or three West African economies, will offer more generalisable results than the results in a single study like this one.

• **Methodological triangulation**

Fifth, it is always a recommended practice to verify results of a study with different methods or triangulate a research technique or approach to ensure authenticity. This study approach was underpinned with a mixed methods approach but still lacked the use of different technique to investigate the models and hypotheses for the advantages of triangulation. It is therefore suggested that different techniques or approaches are used or even statistical software to augment the generalisability of the results.

• **Views of policy makers and independent experts**

Sixth, since by the design and scope of the study, the sample frame did not include policy makers, independent knowledge experts and think tanks, another investigation that will address these shortcomings. The study should particularly centre on policy effectiveness in creating the right environment for productive research outcomes in all sectors of the Ghanaian economy. This will add value to the body of knowledge in the area since they also have crucial roles to play in university knowledge and technology exchange infrastructure of the country.
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Appendices
Appendix A- 1. Survey questionnaire

University of South Wales
Prifysgol De Cymru

Innovation Survey Questionnaire

University-Industry Interactions: A comparative analysis of the influence of knowledge transfer mechanisms on firm-level innovation in Ghana

Please score all statements from the perspective of your organisation on the relationship you have with academics or higher education institutions

There are no wrong answers and you need to choose only one score for each statement ranging from 1 to 5. (1 is Strongly Disagree and 5 is Strongly Agree)

Confidentiality statement
We will like to assure you that information we collect from you today will be treated with the strictest confidentiality

<table>
<thead>
<tr>
<th>Thick any that apply</th>
<th>Products/Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>□ Products</td>
</tr>
<tr>
<td></td>
<td>□ Process</td>
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<td></td>
<td>□ Service</td>
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<th>Sector</th>
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<td>□ Primary</td>
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<tr>
<td>□ Manufacturing</td>
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<tr>
<td>□ Services</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Employees</th>
<th>Years in Business</th>
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<tbody>
<tr>
<td>□ 0-9</td>
<td>□ 1-9</td>
</tr>
<tr>
<td>□ 10-49</td>
<td>□ 10-25</td>
</tr>
<tr>
<td>□ 50-249</td>
<td>□ 26-50</td>
</tr>
<tr>
<td>□ 250+</td>
<td>□ 50+</td>
</tr>
</tbody>
</table>
1) **Formal mechanism of university knowledge transfer**

<table>
<thead>
<tr>
<th>In our organisation</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Not Sure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract research with universities is part of our knowledge search</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>We use long-standing contract with universities researchers.</td>
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<td></td>
<td></td>
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<tr>
<td>We receive regular consultancy services from a university</td>
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<td></td>
<td></td>
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<tr>
<td>We are guided by ideas from the work of academics</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>We share training facilities with a university for some of our training needs</td>
<td></td>
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</tbody>
</table>

2) **Informal mechanism of university knowledge transfer**

<table>
<thead>
<tr>
<th>In our organisation</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Not Sure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>We have a working relationship with at least a university academic.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>We work closely with at least one university department for guidelines on our operations.</td>
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<tr>
<td>We follow the work of some academics for improvement in our process/services.</td>
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<tr>
<td>We make use of research findings in our business area.</td>
<td></td>
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<tr>
<td>We take keen interest in published academic literature.</td>
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</tbody>
</table>

3) **Technology transfer offices**

<table>
<thead>
<tr>
<th>In our organisation</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Not Sure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>We know of a technology transfer office (TTO) that deals with the academics for us</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
The technology transfer office available to us is useful in getting us the help we need.

Technology transfer offices are important for our core competence.

We sometimes get useful information from technology transfer office(s) on new technologies.

Technology transfer offices are essential for our business activities.

### 4) Innovation performance

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Not Sure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

**In our organisation**

We have made changes to our process and/or products in the last 12 months.

We consider our R&D to be of benefit to our business.

Our management style is influenced by new knowledge in from universities.

Our staff are efficient in undertaking new business process.

Our annual budget for research and development is comparatively substantial.

### 5) Knowledge networks

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Not Sure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

**Our organisation**

Is part of an association that aims for improvement in our business practices through knowledge sharing or products.

Is active in connecting with other bodies to share ideas on our business prospects.

Is in a region where there is a university that has connected...
us with other important bodies that are crucial to our organisation’s access to new ideas.

Gives attention to established systems that aim at disseminating wealth of knowledge in our business interest area.

Sometimes works with agents that open opportunities for us to gain skills that we need for our business success.

6) Collaborative research

<table>
<thead>
<tr>
<th>In our organisation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most of our collaborative project outcomes have been perceived as successful.</td>
<td></td>
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<tr>
<td>Our collaborative research team was able to publish at least one academic journal article.</td>
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<tr>
<td>At least one of our collaborative project outcomes was filed for a patent</td>
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<tr>
<td>Some of our collaborative projects outcomes have yielded new business practices/products</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>We see collaboration as a way forward in building and maintaining our competitive advantage.</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Comments:

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

Thank you very much for your time
<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Description</th>
<th>Theory</th>
<th>Author(s)</th>
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<td>Informal mechanisms of knowledge transfer directly influence formal mechanisms of knowledge transfer in Ghana.</td>
<td>The Theory of Social Capital</td>
<td>(Grimpe and Hussinger, 2013)</td>
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<tr>
<td>$H_2$</td>
<td>Formal mechanisms of knowledge transfer between universities and firms directly influence collaborative research between them in Ghana.</td>
<td>Research Project Management Theory</td>
<td>(Grimpe and Hussinger, 2013)</td>
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<td>$H_3$</td>
<td>Informal mechanisms of knowledge transfer between universities and firms directly influence collaborative research between them in Ghana.</td>
<td>The Theory of Social Capital</td>
<td>(Barnes et al., 2006, Facer et al., 2012)</td>
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<td>$H_4$</td>
<td>Firms in Ghana benefits directly from their formal links with technology transfer offices.</td>
<td>Technology Development</td>
<td>(Mosey et al., 2012, Deiaco et al., 2012)</td>
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<tr>
<td>$H_5$</td>
<td>Informal mechanisms of knowledge transfer between universities and firms directly influence the formation knowledge networks in Ghana.</td>
<td>Network Theory</td>
<td>(Huggins et al., 2012a, Borrás and Edquist, 2013)</td>
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<td>$H_6$</td>
<td>Technology transfer offices in Ghana directly influence innovation performance in firms.</td>
<td>The Theory of Knowledge generation and Intermediation</td>
<td>(Goddard et al., 2012, Hoppe and Ozdenoren, 2005)</td>
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<tr>
<td>$H_7$</td>
<td>Knowledge networks in Ghana directly influence innovation performance in firms.</td>
<td>Network Theory and Innovation Management</td>
<td>(Kooij, 1990, Kneller et al., 2014)</td>
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<td>$H_8$</td>
<td>Collaborative research between universities and firms in Ghana directly lead to innovation performance in firms.</td>
<td>Research Project Management Theory</td>
<td>(Kneller et al., 2014)</td>
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<td>$H_9$</td>
<td>Formal mechanisms of knowledge transfer between universities and firms in Ghana directly influence innovation performance in firms.</td>
<td>Innovation Theory and Management (Grimpe and Hussinger, 2013, Kaymaz and Eryiğit, 2011)</td>
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<td>Informal mechanisms of knowledge transfer between universities and firms in Ghana directly influence innovation performance in firms.</td>
<td>The Theory of Social Capita; (Crescenzi et al., 2012, Giuliani and Rabelotti, 2012)</td>
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### Appendix A- 3. Frequencies of missing data

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<td>Coll30</td>
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</table>
Appendix A-4. Interview guide

University of South Wales
Prifysgol De Cymru
Interview with Senior Staff of Universities and Firms
Interview Procedure

The welcome:
The key policy maker should be informed about:
The nature of the research project
The background to the interview
The structure of the interview
How long the interview will last

Continuity:
The interviewer should be aware of:
Responsibility for particular areas of questioning
Change over strategies between the different areas of the interview instrument
The role of the interviewer in terms of control and co-ordination

Closing the interview:

Before closing
Let the key business executive ask questions and/or
Provide any additional information
An appropriate response should be made

In closing
Inform the key policy maker of the outcomes of the interview
Close the interview courteously
### Section One: Collaboration

**Question One:**

a) To start with, can you tell me your views on your formal arrangement between your firm and any university that you deal with to generate knowledge for innovation in your firm?

<table>
<thead>
<tr>
<th>Notes:--</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Why will a firm not a formal arrangement with a university?</td>
</tr>
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</table>

---

**Collaboration**

**Question one:**

b) How will you relate your view on the innovation in your organisation and technology transfer offices in the universities?

c) How will you also relate that with collaborative research you have had with universities?

<table>
<thead>
<tr>
<th>Notes:--</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) What will you say about sectors involvement in collaborations</td>
</tr>
</tbody>
</table>
### Networks of firms

**Question two:**

- **d)** May I know more involvement with knowledge networks and social relationship with universities?
- **e)** How will you say in general what improvement do firms gain within relationship of that nature?

| a) | Will you say universities are actively taking part in community activities/development? |

**Notes:**

### General interactions

**Question three:**

- **f)** What will you say are the better or the best ways firms acquire knowledge from universities in your opinion?
- **g)** What do you thinks are your motivations for having a university relationship/partnership?

| a) | Are there particular reasons why your organisation will partner with a university |

**Notes:**
Section Two:
Policy framework

Question four:

h) What do you think about policy framework on how universities-industry interaction and technology transfer into the industry?

i) How do you feel about the government support that it seeks to offer to these types of interactions

Notes:-

Advice and opinion

Question five

j) What advice will you give to university scientist and business owners?

k) What do have to say to the Government of Ghana
## Section Three: Final remarks

### Question six

1) Is there anything you will like to add to what we have discussed today?

m) Do you have anything to ask me about what we have discussed today?

### Notes:-
Thank you Very Much for Your Time
Appendix B-1. Early and late respondents (Whole data)

Comparison of early and late waves

Formal mechanism of knowledge transfer

Informal mechanism of knowledge transfer

Innovation in the firms

Technology transfer

Networks of firms

Collaborative research
Appendix B-2. Early and late respondents (Subsectors)

Comparison of early and late waves by sectors
Appendix C-1. Normal distribution curves (Whole data)

Visual examination for distributional normality for all mechanisms

[Diagrams of normal distribution curves for various mechanisms]
Appendix D-1. Combined loadings of measurement model and composite reliability values for main model

<table>
<thead>
<tr>
<th>Constructs</th>
<th>FORM</th>
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<td>0.130</td>
<td>-0.077</td>
<td>0.044</td>
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<td>0.028</td>
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<td>0.710</td>
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</table>

| Composite reliability coefficient | 0.863 | 0.844 | 0.866 | 0.826 | 0.828 | 0.879 |
| Cronbach’s alpha (α) coefficient  | 0.801 | 0.769 | 0.807 | 0.736 | 0.740 | 0.827 |

Notes: Loadings are unrotated and cross-loadings are oblique-rotated. SEs and P values are for loadings. P values < 0.05 are desirable for reflective indicators.
Appendix D-2. Correlations among latent variables with square roots of AVEs for main model

<table>
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<tr>
<th>Constructs</th>
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<th>TTOs</th>
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<th>COLL</th>
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<td>0.277*</td>
<td>0.507***</td>
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<td></td>
<td>0.262*</td>
<td>0.354**</td>
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<td>TTOs</td>
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<td>0.501***</td>
<td>0.538***</td>
<td>0.500***</td>
</tr>
<tr>
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<td>0.262*</td>
<td>0.501***</td>
<td>0.699</td>
<td>0.540***</td>
<td>0.528***</td>
</tr>
<tr>
<td>NET</td>
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<td>0.538***</td>
<td>0.540***</td>
<td>0.700</td>
<td>0.503***</td>
</tr>
<tr>
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<td>0.520***</td>
<td>0.500***</td>
<td>0.528***</td>
<td>0.503***</td>
<td>0.770</td>
</tr>
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<td>AVEs</td>
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<td>0.491</td>
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<td>1.717</td>
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</table>

Note: Square roots of average variances extracted (AVEs) shown on diagonal.
Sig. (0.05): *, p<0.01; **, p<0.05; ***, p<0.001.
## Appendix D-3. Structural model evaluation for main model

<table>
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<th>Description</th>
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<th>Path (Hypothesis)</th>
<th>Values achieved</th>
<th>Outcome</th>
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<td>$R^2$</td>
<td>This is a measure of the variance explained by the exogenous latent variable of the total variance in the endogenous; $0 \geq R^2 \leq 1$</td>
<td>Substantial = 0.670, Average = 0.333 and as Low = 0.190 (Chin, 1998)</td>
<td>$H_1$</td>
<td>0.39</td>
<td>Average</td>
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<tr>
<td></td>
<td></td>
<td>Substantial = 0.75, Moderate = 0.50, Weak = 0.25 (Hair et al., 2014b)</td>
<td>$H_2$</td>
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</tr>
<tr>
<td></td>
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<td></td>
<td>$H_3$</td>
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<td>$H_7$</td>
<td>0.18</td>
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</tr>
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<td>$H_8$</td>
<td>0.17</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_9$</td>
<td>0.01</td>
<td>Too low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10}$</td>
<td>0.02</td>
<td>Too low</td>
</tr>
<tr>
<td>$\beta$</td>
<td>This estimates the relationship between exogenous and endogenous latent variables in a model: $0 \geq \beta \leq 1$</td>
<td>It is important to consider algebraic sign, magnitude and statistical significance of path coefficient. $\beta &gt; 0.10$ (Urbach and Ahlemann, 2010)</td>
<td>$H_1$</td>
<td>0.63</td>
<td>Substantial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_2$</td>
<td>0.32</td>
<td>Average</td>
</tr>
<tr>
<td></td>
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<td>$H_3$</td>
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<td>$H_4$</td>
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<td>$H_5$</td>
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<td>Average</td>
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<tr>
<td></td>
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<td></td>
<td>$H_6$</td>
<td>0.23</td>
<td>Average</td>
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<td></td>
<td>$H_7$</td>
<td>0.31</td>
<td>Average</td>
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<td>Average</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$H_9$</td>
<td>0.03</td>
<td>Too weak</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>$H_{10}$</td>
<td>0.08</td>
<td>Too low</td>
</tr>
<tr>
<td>$f^2$</td>
<td>This measures the impact of the exogenous latent variable on the endogenous latent variable; $0 \geq f^2 \leq 1$</td>
<td>Low=0.020, Medium=0.150, Large=0.350 (Cohen, 1988)</td>
<td>$H_1$</td>
<td>0.39</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_2$</td>
<td>0.17</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_3$</td>
<td>0.19</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_4$</td>
<td>0.14</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
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<td>$H_5$</td>
<td>0.13</td>
<td>Medium</td>
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<td></td>
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<td>$H_6$</td>
<td>0.12</td>
<td>Medium</td>
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<td></td>
<td></td>
<td></td>
<td>$H_7$</td>
<td>0.18</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_8$</td>
<td>0.17</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_9$</td>
<td>0.01</td>
<td>Too low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10}$</td>
<td>0.02</td>
<td>Too low</td>
</tr>
<tr>
<td>$Q^2$</td>
<td>This measures the predictive relevance of the endogenous latent variable to the endogenous latent variable $Q^2&gt;0.00$ (Fornell and Cha, 1994)</td>
<td>$H_1$</td>
<td>0.40</td>
<td>Relevant</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td>$H_2$</td>
<td>0.34</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
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<td>$H_3$</td>
<td>0.14</td>
<td>Relevant</td>
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<td>$H_4$</td>
<td>0.13</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_5$</td>
<td>0.43</td>
<td>Relevant</td>
</tr>
</tbody>
</table>

Note: ($H_2$ and $H_3$): $R^2 = 0.34$, ($H_6$, $H_7$, $H_8$, $H_{10}$): $R^2 = 0.49$ in Figure 3.13
Appendix D-4. Effect of formal mechanism of knowledge transfer mechanism on innovation performance in firms

Appendix D-5. Effect of informal mechanism of knowledge transfer mechanism on innovation performance in firms
Appendix D-6. Combined loadings of measurement model and composite reliability values for primary sector model

<table>
<thead>
<tr>
<th>Indicators</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOs</th>
<th>INN</th>
<th>NETW</th>
<th>COLL</th>
<th>S.E.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fm1</td>
<td>0.810</td>
<td>-0.045</td>
<td>-0.114</td>
<td>0.267</td>
<td>-0.325</td>
<td>0.060</td>
<td>0.068</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm2</td>
<td>0.838</td>
<td>-0.194</td>
<td>-0.175</td>
<td>-0.158</td>
<td>0.213</td>
<td>0.051</td>
<td>0.060</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm3</td>
<td>0.791</td>
<td>-0.043</td>
<td>0.309</td>
<td>0.191</td>
<td>-0.211</td>
<td>-0.157</td>
<td>0.088</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm4</td>
<td>0.587</td>
<td>0.102</td>
<td>0.424</td>
<td>0.123</td>
<td>-0.306</td>
<td>0.035</td>
<td>0.112</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm5</td>
<td>0.716</td>
<td>0.241</td>
<td>-0.355</td>
<td>-0.428</td>
<td>0.602</td>
<td>0.017</td>
<td>0.094</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf6</td>
<td>0.276</td>
<td>0.767</td>
<td>-0.320</td>
<td>-0.110</td>
<td>0.041</td>
<td>0.403</td>
<td>0.071</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf7</td>
<td>0.213</td>
<td>0.713</td>
<td>-0.336</td>
<td>-0.067</td>
<td>-0.033</td>
<td>0.284</td>
<td>0.079</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf8</td>
<td>-0.119</td>
<td>0.725</td>
<td>0.073</td>
<td>-0.180</td>
<td>0.425</td>
<td>-0.218</td>
<td>0.112</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf9</td>
<td>-0.237</td>
<td>0.694</td>
<td>0.335</td>
<td>0.562</td>
<td>-0.635</td>
<td>-0.116</td>
<td>0.096</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf10</td>
<td>-0.150</td>
<td>0.753</td>
<td>0.266</td>
<td>-0.169</td>
<td>0.166</td>
<td>-0.363</td>
<td>0.103</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO11</td>
<td>0.186</td>
<td>0.229</td>
<td>0.707</td>
<td>-0.424</td>
<td>0.093</td>
<td>0.260</td>
<td>0.103</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO12</td>
<td>0.158</td>
<td>0.093</td>
<td>0.809</td>
<td>-0.212</td>
<td>-0.030</td>
<td>0.281</td>
<td>0.077</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO13</td>
<td>-0.126</td>
<td>-0.149</td>
<td>0.758</td>
<td>0.043</td>
<td>0.107</td>
<td>-0.315</td>
<td>0.090</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO14</td>
<td>-0.042</td>
<td>-0.133</td>
<td>0.821</td>
<td>0.050</td>
<td>0.311</td>
<td>-0.249</td>
<td>0.069</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO15</td>
<td>-0.173</td>
<td>-0.019</td>
<td>0.752</td>
<td>0.529</td>
<td>-0.502</td>
<td>0.043</td>
<td>0.087</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn17</td>
<td>0.013</td>
<td>0.067</td>
<td>0.162</td>
<td>0.638</td>
<td>0.207</td>
<td>-0.106</td>
<td>0.115</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn18</td>
<td>-0.026</td>
<td>0.027</td>
<td>-0.093</td>
<td>0.910</td>
<td>0.183</td>
<td>-0.033</td>
<td>0.089</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn19</td>
<td>-0.043</td>
<td>0.083</td>
<td>-0.103</td>
<td>0.898</td>
<td>0.024</td>
<td>-0.082</td>
<td>0.096</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net25</td>
<td>0.072</td>
<td>-0.190</td>
<td>0.098</td>
<td>0.749</td>
<td>-0.428</td>
<td>0.229</td>
<td>0.108</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net21</td>
<td>-0.234</td>
<td>0.038</td>
<td>0.149</td>
<td>0.017</td>
<td>0.854</td>
<td>-0.087</td>
<td>0.083</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net22</td>
<td>0.022</td>
<td>-0.157</td>
<td>-0.247</td>
<td>0.024</td>
<td>0.816</td>
<td>0.237</td>
<td>0.086</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net23</td>
<td>0.188</td>
<td>0.066</td>
<td>-0.041</td>
<td>-0.314</td>
<td>0.740</td>
<td>0.221</td>
<td>0.089</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net24</td>
<td>0.063</td>
<td>0.070</td>
<td>0.156</td>
<td>0.296</td>
<td>0.670</td>
<td>-0.423</td>
<td>0.127</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Tra16</td>
<td>-0.055</td>
<td>0.038</td>
<td>-0.243</td>
<td>0.140</td>
<td>-0.077</td>
<td>0.736</td>
<td>0.082</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll26</td>
<td>-0.020</td>
<td>0.182</td>
<td>-0.072</td>
<td>0.233</td>
<td>-0.033</td>
<td>0.778</td>
<td>0.084</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll27</td>
<td>0.296</td>
<td>-0.186</td>
<td>0.152</td>
<td>-0.258</td>
<td>0.057</td>
<td>0.730</td>
<td>0.082</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll28</td>
<td>-0.070</td>
<td>-0.109</td>
<td>-0.022</td>
<td>-0.448</td>
<td>0.218</td>
<td>0.602</td>
<td>0.091</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll29</td>
<td>-0.046</td>
<td>0.035</td>
<td>0.058</td>
<td>0.006</td>
<td>0.041</td>
<td>0.896</td>
<td>0.052</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll30</td>
<td>-0.095</td>
<td>0.000</td>
<td>0.106</td>
<td>0.210</td>
<td>-0.159</td>
<td>0.805</td>
<td>0.087</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Composite Reliability Coefficient</td>
<td>0.866</td>
<td>0.851</td>
<td>0.879</td>
<td>0.880</td>
<td>0.855</td>
<td>0.892</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cronbach's alpha coefficients (α)</td>
<td>0.805</td>
<td>0.781</td>
<td>0.828</td>
<td>0.813</td>
<td>0.773</td>
<td>0.853</td>
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</tr>
</tbody>
</table>

Notes: Loadings are unrotated and cross-loadings are oblique-rotated. SEs and P values are for loadings. P values < 0.05 are desirable for reflective indicators.
Appendix D-7. Correlations among latent variables with square roots of AVEs for primary sector model

<table>
<thead>
<tr>
<th>Constructs</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOS</th>
<th>INN</th>
<th>NETW</th>
<th>COLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM</td>
<td>0.754</td>
<td>0.574***</td>
<td>0.481***</td>
<td>0.248***</td>
<td>0.510***</td>
<td>0.420***</td>
</tr>
<tr>
<td>INFO</td>
<td>0.574***</td>
<td>0.731</td>
<td>0.547***</td>
<td>0.354***</td>
<td>0.411***</td>
<td>0.601***</td>
</tr>
<tr>
<td>TTOS</td>
<td>0.481***</td>
<td>0.547***</td>
<td>0.770</td>
<td>0.286***</td>
<td>0.540***</td>
<td>0.547***</td>
</tr>
<tr>
<td>INNO</td>
<td>0.248***</td>
<td>0.354***</td>
<td>0.286**</td>
<td>0.807</td>
<td>0.572***</td>
<td>0.369***</td>
</tr>
<tr>
<td>NET</td>
<td>0.510***</td>
<td>0.411***</td>
<td>0.540***</td>
<td>0.572***</td>
<td>0.773</td>
<td>0.360***</td>
</tr>
<tr>
<td>COLL</td>
<td>0.420***</td>
<td>0.601***</td>
<td>0.547***</td>
<td>0.369***</td>
<td>0.360***</td>
<td>0.763</td>
</tr>
<tr>
<td>AVEs</td>
<td>0.568</td>
<td>0.534</td>
<td>0.594</td>
<td>0.651</td>
<td>0.598</td>
<td>0.582</td>
</tr>
<tr>
<td>VIF</td>
<td>1.787</td>
<td>2.087</td>
<td>1.904</td>
<td>1.652</td>
<td>2.171</td>
<td>1.827</td>
</tr>
</tbody>
</table>

Note: Square roots of average variances extracted (AVEs) shown on diagonal. Sign. (0.05): *, p<0.01; **, p<0.05; ***, p<0.001.
### Appendix D-8. Structural model validation for primary sector

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
<th>Threshold</th>
<th>Path (Hypothesis)</th>
<th>Values achieved</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>This is a measure of the variance explained by the exogenous latent variable of the total variance in the endogenous; $(0 \geq R^2 \leq 1)$</td>
<td>Substantial = 0.670, Average = 0.333 and low = 0.190</td>
<td>$H_{1a}$</td>
<td>0.37</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{2a}$</td>
<td>0.04</td>
<td>Too weak</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{3a}$</td>
<td>0.34</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{4a}$</td>
<td>0.23</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{5a}$</td>
<td>0.21</td>
<td>Low</td>
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<td></td>
<td></td>
<td></td>
<td>$H_{6a}$</td>
<td>0.02</td>
<td>Too weak</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{7a}$</td>
<td>0.28</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{8a}$</td>
<td>0.03</td>
<td>Too weak</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{9a}$</td>
<td>0.00</td>
<td>No power</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10a}$</td>
<td>0.11</td>
<td>Low</td>
</tr>
<tr>
<td>$\beta$</td>
<td>This estimates the relationship between exogenous and endogenous latent variables in a model: $(0 \geq \beta \leq 1)$</td>
<td>It is important to consider algebraic sign, magnitude and statistical significance of path co-efficient. $\beta &gt; 0.10$</td>
<td>$H_{1a}$</td>
<td>0.61</td>
<td>Substantial</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{2a}$</td>
<td>0.09</td>
<td>Weak</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{3a}$</td>
<td>0.56</td>
<td>Substantial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{4a}$</td>
<td>0.48</td>
<td>substantial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{5a}$</td>
<td>0.46</td>
<td>substantial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{6a}$</td>
<td>0.06</td>
<td>Too weak</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{7a}$</td>
<td>0.48</td>
<td>substantial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{8a}$</td>
<td>0.07</td>
<td>Too Weak</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{9a}$</td>
<td>0.00</td>
<td>Non-existent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10a}$</td>
<td>0.23</td>
<td>Reasonable</td>
</tr>
<tr>
<td>$f^2$</td>
<td>This measures the impact of the exogenous latent variable on the endogenous latent variable; $(0 \geq f^2 \leq 1)$</td>
<td>Low=0.020, Medium=0.150, Large=0.350,</td>
<td>$H_{1a}$</td>
<td>0.37</td>
<td>High</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>$H_{2a}$</td>
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<td>$H_{3a}$</td>
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<td>$H_{4a}$</td>
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</tr>
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<td>$H_{5a}$</td>
<td>0.21</td>
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</tr>
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<td>$H_{6a}$</td>
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<td>$H_{7a}$</td>
<td>0.28</td>
<td>Medium</td>
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<td>$H_{8a}$</td>
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<td></td>
<td>$H_{9a}$</td>
<td>0.00</td>
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</tr>
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<td></td>
<td>$H_{10a}$</td>
<td>0.11</td>
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</tr>
<tr>
<td>$Q^2$</td>
<td>This measures the predictive relevance of the endogenous latent variable to the endogenous latent variable</td>
<td>$Q^2 &gt; 0.00$</td>
<td>$H_{1a}$</td>
<td>0.37</td>
<td>Relevant</td>
</tr>
<tr>
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<td></td>
<td>$H_{2a}$</td>
<td>0.39</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{3a}$</td>
<td>0.24</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{4a}$</td>
<td>0.21</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{5a}$</td>
<td>0.40</td>
<td>Relevant</td>
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<td></td>
<td>$H_{6a}$</td>
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<td>$H_{7a}$</td>
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<td>$H_{8a}$</td>
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<td>$H_{9a}$</td>
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<td></td>
<td></td>
<td>$H_{10a}$</td>
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</tr>
</tbody>
</table>

Note: ($H_{2a}$ and $H_{3a}$): $R^2 = 0.39$, ($H_{1a}$, $H_{2a}$, $H_{3a}$, $H_{10a}$): $R^2 = 0.43$ in Figure 3.14
Appendix D-9. Direct effect of formal mechanism of knowledge transfer on innovation performance in firms

Appendix D-10. Direct effect of informal mechanism of knowledge transfer on innovation performance in firms
Appendix D-11. Combined loadings and cross-loadings for manufacturing sector

<table>
<thead>
<tr>
<th>Indicators</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOs</th>
<th>INNO</th>
<th>NETW</th>
<th>COLL</th>
<th>S.E.</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fm1</td>
<td>0.830</td>
<td>-0.190</td>
<td>-0.203</td>
<td>-0.069</td>
<td>0.080</td>
<td>0.107</td>
<td>0.073</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm2</td>
<td>0.879</td>
<td>-0.094</td>
<td>-0.148</td>
<td>0.388</td>
<td>-0.094</td>
<td>-0.126</td>
<td>0.074</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm3</td>
<td>0.693</td>
<td>0.194</td>
<td>0.077</td>
<td>-0.018</td>
<td>-0.291</td>
<td>0.333</td>
<td>0.094</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm4</td>
<td>0.658</td>
<td>0.160</td>
<td>0.373</td>
<td>-0.413</td>
<td>0.332</td>
<td>-0.317</td>
<td>0.125</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn6</td>
<td>0.169</td>
<td>0.770</td>
<td>-0.107</td>
<td>0.018</td>
<td>-0.046</td>
<td>0.223</td>
<td>0.089</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn7</td>
<td>0.352</td>
<td>0.633</td>
<td>-0.119</td>
<td>-0.652</td>
<td>0.277</td>
<td>0.090</td>
<td>0.109</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn8</td>
<td>-0.524</td>
<td>0.732</td>
<td>0.168</td>
<td>0.060</td>
<td>-0.297</td>
<td>0.412</td>
<td>0.102</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn9</td>
<td>0.151</td>
<td>0.798</td>
<td>-0.173</td>
<td>0.396</td>
<td>-0.175</td>
<td>-0.238</td>
<td>0.093</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn10</td>
<td>-0.117</td>
<td>0.767</td>
<td>0.225</td>
<td>0.052</td>
<td>0.282</td>
<td>-0.445</td>
<td>0.115</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO11</td>
<td>0.071</td>
<td>0.281</td>
<td>0.777</td>
<td>-0.574</td>
<td>0.109</td>
<td>-0.253</td>
<td>0.079</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO12</td>
<td>-0.244</td>
<td>0.168</td>
<td>0.755</td>
<td>0.331</td>
<td>-0.108</td>
<td>0.461</td>
<td>0.098</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO13</td>
<td>0.220</td>
<td>-0.253</td>
<td>0.823</td>
<td>-0.427</td>
<td>-0.063</td>
<td>-0.068</td>
<td>0.094</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO14</td>
<td>-0.086</td>
<td>-0.166</td>
<td>0.742</td>
<td>0.598</td>
<td>-0.006</td>
<td>0.318</td>
<td>0.104</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO15</td>
<td>0.015</td>
<td>-0.017</td>
<td>0.769</td>
<td>0.134</td>
<td>0.069</td>
<td>-0.431</td>
<td>0.100</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn16</td>
<td>0.178</td>
<td>-0.199</td>
<td>0.403</td>
<td>0.631</td>
<td>0.158</td>
<td>-0.329</td>
<td>0.155</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn17</td>
<td>0.271</td>
<td>-0.027</td>
<td>-0.213</td>
<td>0.841</td>
<td>0.174</td>
<td>0.174</td>
<td>0.089</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn18</td>
<td>-0.199</td>
<td>0.487</td>
<td>-0.381</td>
<td>0.812</td>
<td>0.126</td>
<td>-0.129</td>
<td>0.100</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn19</td>
<td>-0.260</td>
<td>0.245</td>
<td>-0.242</td>
<td>0.798</td>
<td>-0.146</td>
<td>0.032</td>
<td>0.126</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn20</td>
<td>0.250</td>
<td>-0.440</td>
<td>0.621</td>
<td>0.682</td>
<td>-0.279</td>
<td>0.235</td>
<td>0.093</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net21</td>
<td>-0.194</td>
<td>-0.197</td>
<td>0.005</td>
<td>0.725</td>
<td>-0.058</td>
<td>-0.026</td>
<td>0.110</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net22</td>
<td>-0.128</td>
<td>-0.527</td>
<td>0.582</td>
<td>-0.206</td>
<td>0.666</td>
<td>-0.198</td>
<td>0.109</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net23</td>
<td>0.000</td>
<td>0.077</td>
<td>0.088</td>
<td>-0.203</td>
<td>0.833</td>
<td>0.212</td>
<td>0.102</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net24</td>
<td>0.028</td>
<td>-0.133</td>
<td>-0.174</td>
<td>0.064</td>
<td>0.845</td>
<td>0.150</td>
<td>0.092</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net25</td>
<td>0.086</td>
<td>0.560</td>
<td>-0.441</td>
<td>0.353</td>
<td>0.713</td>
<td>-0.239</td>
<td>0.140</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm5</td>
<td>0.188</td>
<td>0.071</td>
<td>-0.022</td>
<td>-0.502</td>
<td>0.086</td>
<td>0.728</td>
<td>0.087</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll26</td>
<td>-0.059</td>
<td>-0.048</td>
<td>0.064</td>
<td>0.228</td>
<td>-0.063</td>
<td>0.873</td>
<td>0.080</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll27</td>
<td>-0.122</td>
<td>-0.142</td>
<td>-0.014</td>
<td>0.111</td>
<td>-0.219</td>
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<td>0.077</td>
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</tr>
<tr>
<td>Coll28</td>
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<td>-0.000</td>
<td>-0.203</td>
<td>0.132</td>
<td>0.019</td>
<td>0.886</td>
<td>0.077</td>
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</tr>
<tr>
<td>Coll29</td>
<td>0.111</td>
<td>-0.341</td>
<td>-0.055</td>
<td>0.116</td>
<td>0.089</td>
<td>0.812</td>
<td>0.068</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll30</td>
<td>0.106</td>
<td>0.592</td>
<td>0.296</td>
<td>-0.217</td>
<td>0.147</td>
<td>0.666</td>
<td>0.104</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Composite reliability coefficients</td>
<td>0.852</td>
<td>0.859</td>
<td>0.882</td>
<td>0.885</td>
<td>0.851</td>
<td>0.921</td>
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<td></td>
</tr>
<tr>
<td>Cronbach's alpha coefficients (α)</td>
<td>0.766</td>
<td>0.794</td>
<td>0.832</td>
<td>0.843</td>
<td>0.764</td>
<td>0.895</td>
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</table>

Notes: Loadings are unrotated and cross-loadings are oblique-rotated. SEs and P values are for loadings. P values < 0.05 are desirable for reflective indicators.
Appendix D-12. Correlations among latent variables with square roots of average variances extracted for manufacturing sector

<table>
<thead>
<tr>
<th>Constructs</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOs</th>
<th>INNO</th>
<th>NETW</th>
<th>COLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM</td>
<td>0.771</td>
<td>0.487***</td>
<td>0.497***</td>
<td>0.584***</td>
<td>0.120***</td>
<td>0.495***</td>
</tr>
<tr>
<td>INFO</td>
<td>0.487***</td>
<td>0.742</td>
<td>0.710***</td>
<td>0.546***</td>
<td>0.364***</td>
<td>0.653***</td>
</tr>
<tr>
<td>TTOs</td>
<td>0.497***</td>
<td>0.710***</td>
<td>0.774</td>
<td>0.699***</td>
<td>0.440***</td>
<td>0.628***</td>
</tr>
<tr>
<td>INNO</td>
<td>0.584***</td>
<td>0.546***</td>
<td>0.699***</td>
<td>0.752</td>
<td>0.479***</td>
<td>0.541***</td>
</tr>
<tr>
<td>NET</td>
<td>0.120*</td>
<td>0.364***</td>
<td>0.440***</td>
<td>0.479***</td>
<td>0.768</td>
<td>0.483***</td>
</tr>
<tr>
<td>COLL</td>
<td>0.495***</td>
<td>0.653***</td>
<td>0.628***</td>
<td>0.541***</td>
<td>0.483***</td>
<td>0.813</td>
</tr>
<tr>
<td>AVEs</td>
<td>0.568</td>
<td>0.534</td>
<td>0.594</td>
<td>0.651</td>
<td>0.598</td>
<td>0.582</td>
</tr>
<tr>
<td>VIF</td>
<td>1.866</td>
<td>2.365</td>
<td>2.828</td>
<td>2.616</td>
<td>1.609</td>
<td>2.266</td>
</tr>
</tbody>
</table>

Note: Square roots of average variances extracted (AVEs) shown on diagonal.
Sign. (0.05): *, p<0.01; **, p<0.05; ***, p<0.001.
Appendix D-13. Structural model validation for manufacturing sector

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
<th>Threshold</th>
<th>Path (Hypothesis)</th>
<th>Values achieved</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>This is a measure of the variance explained by the exogenous latent variable of the total variance in the endogenous; $(0 \geq R^2 \leq 1)$</td>
<td>Substantial = 0.670, Average = 0.333 and Low = 0.190 (Chin, 1998)</td>
<td>$H_{1a}$</td>
<td>0.38</td>
<td>Average</td>
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<td></td>
<td></td>
<td></td>
<td>$H_{3a}$</td>
<td>0.16</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{3b}$</td>
<td>0.34</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{5a}$</td>
<td>0.26</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{5b}$</td>
<td>0.15</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{6a}$</td>
<td>0.24</td>
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<td></td>
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<td>$H_{6b}$</td>
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<td></td>
<td>$H_{8a}$</td>
<td>0.22</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{8b}$</td>
<td>-0.02</td>
<td>Too weak</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10a}$</td>
<td>0.22</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10b}$</td>
<td>-0.02</td>
<td>Too weak</td>
</tr>
<tr>
<td>$\beta$</td>
<td>This estimates the relationship between exogenous and endogenous latent variables in a model; $(0 \geq \beta \leq 1)$</td>
<td>It is important to consider algebraic sign, magnitude and statistical significance of path co-efficient. $\beta &gt; 0.10$ (Urbach and Ahlemann, 2010)</td>
<td>$H_{1a}$</td>
<td>0.61</td>
<td>Substantial</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>$H_{3a}$</td>
<td>0.29</td>
<td>Large</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{3b}$</td>
<td>0.51</td>
<td>substantial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{5a}$</td>
<td>0.51</td>
<td>substantial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{6a}$</td>
<td>0.38</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{6b}$</td>
<td>0.34</td>
<td>Large</td>
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<td></td>
<td></td>
<td>$H_{8a}$</td>
<td>0.36</td>
<td>Large</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{8b}$</td>
<td>-0.03</td>
<td>Too weak</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10a}$</td>
<td>0.34</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10b}$</td>
<td>-0.03</td>
<td>Too weak</td>
</tr>
<tr>
<td>$f^2$</td>
<td>This measures the impact of the exogenous latent variable on the endogenous latent variable; $(0 \geq f^2 \leq 1)$</td>
<td>Low=0.020, Medium=0.150, Large=0.350, (Cohen, 1988)</td>
<td>$H_{1a}$</td>
<td>0.38</td>
<td>Large</td>
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<td></td>
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<td></td>
<td>$H_{3a}$</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{3b}$</td>
<td>0.45</td>
<td>Large</td>
</tr>
<tr>
<td></td>
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<td>$H_{5a}$</td>
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<td>$H_{5b}$</td>
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<td></td>
<td></td>
<td>$H_{6a}$</td>
<td>0.24</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>$H_{8a}$</td>
<td>0.22</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{8b}$</td>
<td>0.02</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10a}$</td>
<td>0.33</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10b}$</td>
<td>0.22</td>
<td>Low</td>
</tr>
<tr>
<td>$Q^2$</td>
<td>This measures the predictive relevance of the endogenous latent variable to the endogenous latent variable</td>
<td>$Q^2 &gt; 0.00$ (Fornell and Larcker, 1981)</td>
<td>$H_{1a}$</td>
<td>0.37</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{3a}$</td>
<td>0.50</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{3b}$</td>
<td>0.26</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{5a}$</td>
<td>0.16</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{5b}$</td>
<td>0.72</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{6a}$</td>
<td>0.72</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{6b}$</td>
<td>0.72</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{8a}$</td>
<td>0.72</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{8b}$</td>
<td>0.72</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10a}$</td>
<td>0.72</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{10b}$</td>
<td>0.72</td>
<td>Relevant</td>
</tr>
</tbody>
</table>

Note: ($H_{1a}$ and $H_{1b}$): $R^2 = 0.50$, ($H_{3a}$, $H_{3b}$, $H_{5a}$, $H_{5b}$, $H_{10a}$): $R^2 = 0.65$ in Figure 3.15
Appendix D-14. Direct effect of formal mechanism of knowledge transfer on innovation performance in firms

Appendix D-15. Direct effect of formal mechanism of knowledge transfer on innovation performance in firms
### Appendix D-16. Combined loadings and cross-loadings for service sector

<table>
<thead>
<tr>
<th>Indicators</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOs</th>
<th>INNO</th>
<th>NETW</th>
<th>COLL</th>
<th>S.E.</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fm1</td>
<td>0.764</td>
<td>-0.174</td>
<td>0.041</td>
<td>0.177</td>
<td>-0.141</td>
<td>0.189</td>
<td>0.040</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm2</td>
<td>0.801</td>
<td>0.066</td>
<td>-0.021</td>
<td>-0.039</td>
<td>-0.207</td>
<td>0.112</td>
<td>0.042</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm3</td>
<td>0.845</td>
<td>-0.010</td>
<td>0.011</td>
<td>-0.094</td>
<td>0.067</td>
<td>-0.070</td>
<td>0.031</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm4</td>
<td>0.649</td>
<td>0.084</td>
<td>0.029</td>
<td>-0.084</td>
<td>0.288</td>
<td>-0.247</td>
<td>0.056</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fm5</td>
<td>0.696</td>
<td>0.048</td>
<td>-0.062</td>
<td>0.043</td>
<td>0.042</td>
<td>-0.020</td>
<td>0.050</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf6</td>
<td>0.214</td>
<td>0.758</td>
<td>0.011</td>
<td>0.005</td>
<td>-0.063</td>
<td>0.004</td>
<td>0.041</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf7</td>
<td>0.307</td>
<td>0.752</td>
<td>-0.145</td>
<td>0.155</td>
<td>-0.106</td>
<td>-0.038</td>
<td>0.047</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf8</td>
<td>-0.254</td>
<td>0.685</td>
<td>-0.016</td>
<td>0.136</td>
<td>0.167</td>
<td>-0.111</td>
<td>0.052</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf9</td>
<td>-0.215</td>
<td>0.748</td>
<td>-0.061</td>
<td>-0.066</td>
<td>0.144</td>
<td>0.059</td>
<td>0.043</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inf10</td>
<td>-0.092</td>
<td>0.626</td>
<td>0.251</td>
<td>-0.261</td>
<td>-0.151</td>
<td>0.092</td>
<td>0.052</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO11</td>
<td>0.244</td>
<td>-0.001</td>
<td>0.621</td>
<td>-0.113</td>
<td>-0.049</td>
<td>0.093</td>
<td>0.055</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO12</td>
<td>0.282</td>
<td>-0.232</td>
<td>0.756</td>
<td>0.059</td>
<td>-0.044</td>
<td>-0.077</td>
<td>0.038</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO13</td>
<td>-0.059</td>
<td>0.064</td>
<td>0.784</td>
<td>-0.028</td>
<td>0.048</td>
<td>-0.079</td>
<td>0.045</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO14</td>
<td>-0.156</td>
<td>-0.019</td>
<td>0.799</td>
<td>-0.004</td>
<td>0.057</td>
<td>0.113</td>
<td>0.038</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TTO15</td>
<td>-0.257</td>
<td>0.187</td>
<td>0.754</td>
<td>0.067</td>
<td>-0.026</td>
<td>-0.036</td>
<td>0.050</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn16</td>
<td>0.214</td>
<td>-0.177</td>
<td>-0.128</td>
<td>0.689</td>
<td>0.007</td>
<td>-0.129</td>
<td>0.056</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn17</td>
<td>-0.171</td>
<td>0.087</td>
<td>0.098</td>
<td>0.732</td>
<td>-0.142</td>
<td>0.269</td>
<td>0.046</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn18</td>
<td>-0.270</td>
<td>0.160</td>
<td>0.081</td>
<td>0.757</td>
<td>0.265</td>
<td>-0.140</td>
<td>0.047</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn19</td>
<td>-0.088</td>
<td>0.114</td>
<td>-0.122</td>
<td>0.561</td>
<td>-0.083</td>
<td>-0.059</td>
<td>0.076</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inn20</td>
<td>0.319</td>
<td>-0.176</td>
<td>0.032</td>
<td>0.725</td>
<td>-0.076</td>
<td>0.043</td>
<td>0.046</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net21</td>
<td>0.071</td>
<td>-0.100</td>
<td>0.166</td>
<td>0.029</td>
<td>0.676</td>
<td>-0.113</td>
<td>0.050</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net22</td>
<td>0.118</td>
<td>-0.090</td>
<td>0.030</td>
<td>0.168</td>
<td>0.660</td>
<td>-0.224</td>
<td>0.057</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net23</td>
<td>0.148</td>
<td>0.005</td>
<td>0.034</td>
<td>-0.179</td>
<td>0.707</td>
<td>0.165</td>
<td>0.039</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net24</td>
<td>-0.260</td>
<td>0.191</td>
<td>-0.128</td>
<td>0.101</td>
<td>0.713</td>
<td>-0.012</td>
<td>0.054</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net25</td>
<td>-0.062</td>
<td>-0.018</td>
<td>-0.089</td>
<td>-0.106</td>
<td>0.729</td>
<td>0.160</td>
<td>0.050</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll26</td>
<td>-0.188</td>
<td>0.301</td>
<td>-0.071</td>
<td>0.193</td>
<td>-0.077</td>
<td>0.736</td>
<td>0.046</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll27</td>
<td>0.302</td>
<td>-0.129</td>
<td>-0.090</td>
<td>0.067</td>
<td>0.067</td>
<td>0.727</td>
<td>0.030</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll28</td>
<td>0.169</td>
<td>-0.333</td>
<td>0.136</td>
<td>-0.146</td>
<td>0.007</td>
<td>0.780</td>
<td>0.035</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll29</td>
<td>-0.123</td>
<td>-0.125</td>
<td>0.079</td>
<td>-0.087</td>
<td>0.078</td>
<td>0.844</td>
<td>0.029</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coll30</td>
<td>-0.159</td>
<td>0.346</td>
<td>-0.080</td>
<td>-0.006</td>
<td>-0.094</td>
<td>0.687</td>
<td>0.055</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

| Composite reliability coefficients | 0.867 | 0.839 | 0.861 | 0.823 | 0.826 | 0.870 |
| Cronbach's alpha coefficients (α) | 0.808 | 0.760 | 0.798 | 0.731 | 0.736 | 0.812 |

Notes: Loadings are unrotated and cross-loadings are oblique-rotated. SEs and P values are for loadings. P values < 0.05 are desirable for reflective indicators.
Appendix D-17. Correlations among latent variables with square roots of AVEs for service sector

<table>
<thead>
<tr>
<th>Constructs</th>
<th>FORM</th>
<th>INFO</th>
<th>TTOs</th>
<th>INNO</th>
<th>NETW</th>
<th>COLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM</td>
<td><strong>0.754</strong></td>
<td>0.658</td>
<td>0.314***</td>
<td>0.124***</td>
<td>0.253***</td>
<td>0.517***</td>
</tr>
<tr>
<td>INFO</td>
<td>0.658***</td>
<td><strong>0.716</strong></td>
<td>0.415***</td>
<td>0.139***</td>
<td>0.351***</td>
<td>0.479***</td>
</tr>
<tr>
<td>TTOs</td>
<td>0.314***</td>
<td>0.415***</td>
<td><strong>0.746</strong></td>
<td>0.471***</td>
<td>0.546***</td>
<td>0.451***</td>
</tr>
<tr>
<td>INNO</td>
<td>0.124***</td>
<td>0.139***</td>
<td>0.471***</td>
<td><strong>0.696</strong></td>
<td>0.498***</td>
<td>0.532***</td>
</tr>
<tr>
<td>NET</td>
<td>0.253***</td>
<td>0.351***</td>
<td>0.546***</td>
<td>0.498***</td>
<td><strong>0.698</strong></td>
<td>0.517***</td>
</tr>
<tr>
<td>COLL</td>
<td>0.517***</td>
<td>0.479***</td>
<td>0.451***</td>
<td>0.532***</td>
<td>0.517***</td>
<td><strong>0.757</strong></td>
</tr>
<tr>
<td>AVEs</td>
<td>0.569</td>
<td>0.512</td>
<td>0.556</td>
<td>0.485</td>
<td>0.487</td>
<td>0.573</td>
</tr>
<tr>
<td>VIF</td>
<td>2.003</td>
<td>2.048</td>
<td>1.732</td>
<td>1.766</td>
<td>1.748</td>
<td>2.194</td>
</tr>
</tbody>
</table>

Note: Square roots of average variances extracted (AVEs) shown on diagonal
Sign. (0.05): *, p<0.01; **, p<0.05; ***, p<0.001.
### Appendix D-18. Structural model validation for service sector

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
<th>Threshold</th>
<th>Path (Hypothesis)</th>
<th>Values achieved</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>This is a measure of the variance explained by the exogenous latent variable of the total variance in the endogenous; $(0 \geq R^2 \leq 1)$</td>
<td>Substantial = 0.670, Average = 0.333 and Low = 0.190 (Chin, 1998)</td>
<td>$H_{1c}$</td>
<td>0.44</td>
<td>Average</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td></td>
<td>$H_{2c}$</td>
<td>0.21</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$H_{3c}$</td>
<td>0.16</td>
<td>Weak</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td></td>
<td>$H_{4c}$</td>
<td>0.11</td>
<td>Low</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td></td>
<td>$H_{5c}$</td>
<td>0.15</td>
<td>Low</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td></td>
<td>$H_{6c}$</td>
<td>0.10</td>
<td>Low</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td></td>
<td>$H_{7c}$</td>
<td>0.12</td>
<td>Low</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td></td>
<td>$H_{8c}$</td>
<td>0.20</td>
<td>Low</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td></td>
<td>$H_{9c}$</td>
<td>0.02</td>
<td>Too Weak</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td></td>
<td>$H_{10c}$</td>
<td>0.00</td>
<td>No power</td>
</tr>
<tr>
<td>$\beta$</td>
<td>This estimates the relationship between exogenous and endogenous latent variables in a model; $(0 \geq \beta \leq 1)$</td>
<td>It is important to consider algebraic sign, magnitude and statistical significance of path co-efficient. $\beta &gt; 0.10$ (Urbach and Ahlemann, 2010)</td>
<td>$H_{1c}$</td>
<td>0.66</td>
<td>Substantial</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
<td>$H_{2c}$</td>
<td>0.38</td>
<td>Average</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
<td>$H_{3c}$</td>
<td>0.29</td>
<td>Average</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
<td>$H_{4c}$</td>
<td>0.33</td>
<td>Average</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
<td>$H_{5c}$</td>
<td>0.38</td>
<td>Low</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
<td>$H_{6c}$</td>
<td>0.20</td>
<td>Low</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
<td>$H_{7c}$</td>
<td>0.23</td>
<td>Low</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
<td>$H_{8c}$</td>
<td>0.38</td>
<td>Average</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
<td>$H_{9c}$</td>
<td>0.10</td>
<td>Low</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
<td>$H_{10c}$</td>
<td>0.00</td>
<td>No power</td>
</tr>
<tr>
<td>$\rho$</td>
<td>This measures the impact of the exogenous latent variable on the endogenous latent variable; $(0 \geq \rho \leq 1)$</td>
<td>Low=0.020, Medium=0.150 (Cohen, 1988)</td>
<td>$H_{1c}$</td>
<td>0.44</td>
<td>Large</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td>$H_{2c}$</td>
<td>0.21</td>
<td>Medium</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td>$H_{3c}$</td>
<td>0.29</td>
<td>Medium</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td>$H_{4c}$</td>
<td>0.10</td>
<td>Medium</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td>$H_{5c}$</td>
<td>0.11</td>
<td>Medium</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td>$H_{6c}$</td>
<td>0.10</td>
<td>Medium</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td>$H_{7c}$</td>
<td>0.12</td>
<td>Medium</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td>$H_{8c}$</td>
<td>0.20</td>
<td>Medium</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td>$H_{9c}$</td>
<td>0.06</td>
<td>Too low</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td>$H_{10c}$</td>
<td>0.11</td>
<td>No effect</td>
</tr>
<tr>
<td>$Q^2$</td>
<td>This measures the predictive relevance of the endogenous latent variable to the endogenous latent variable</td>
<td>$Q^2 &gt; 0.00$ (Fornell and Larcker, 1981)</td>
<td>$H_{1c}$</td>
<td>0.44</td>
<td>Relevant</td>
</tr>
<tr>
<td>$Q^2$</td>
<td></td>
<td></td>
<td>$H_{2c}$</td>
<td>0.37</td>
<td>Relevant</td>
</tr>
<tr>
<td>$Q^2$</td>
<td></td>
<td></td>
<td>$H_{3c}$</td>
<td>0.11</td>
<td>Relevant</td>
</tr>
<tr>
<td>$Q^2$</td>
<td></td>
<td></td>
<td>$H_{4c}$</td>
<td>0.15</td>
<td>Relevant</td>
</tr>
<tr>
<td>$Q^2$</td>
<td></td>
<td></td>
<td>$H_{5c}$</td>
<td>0.40</td>
<td>Relevant</td>
</tr>
</tbody>
</table>

Note: ($H_{1c}$ and $H_{2c}$): $R^2 = 0.37$, ($H_{3c}$, $H_{4c}$, $H_{5c}$, $H_{6c}$, $H_{10c}$): $R^2 = 0.44$ in Figure 3.16
Appendix D-19. Direct effect of formal mechanism of knowledge transfer on innovation performance in firms

Appendix D-20. Direct effect of formal mechanism of knowledge transfer on innovation performance in firms
Appendix E-1. Comparison of path coefficients between the main and primary sector

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Main model</th>
<th>Primary sector</th>
<th>Main vs primary model</th>
<th>Levene’s test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$p^{(1)}$</td>
<td>$se(p^{(1)})$</td>
<td>$p^{(a)}$</td>
<td>$se(p^{(a)})$</td>
</tr>
<tr>
<td>$H_1$</td>
<td>0.628</td>
<td>0.030</td>
<td>0.607</td>
<td>0.082</td>
</tr>
<tr>
<td>$H_2$</td>
<td>0.317</td>
<td>0.046</td>
<td>0.093</td>
<td>0.121</td>
</tr>
<tr>
<td>$H_3$</td>
<td>0.351</td>
<td>0.047</td>
<td>0.558</td>
<td>0.111</td>
</tr>
<tr>
<td>$H_4$</td>
<td>0.375</td>
<td>0.042</td>
<td>0.484</td>
<td>0.107</td>
</tr>
<tr>
<td>$H_5$</td>
<td>0.357</td>
<td>0.044</td>
<td>0.458</td>
<td>0.084</td>
</tr>
<tr>
<td>$H_6$</td>
<td>0.230</td>
<td>0.047</td>
<td>0.055</td>
<td>0.125</td>
</tr>
<tr>
<td>$H_7$</td>
<td>0.314</td>
<td>0.056</td>
<td>0.479</td>
<td>0.096</td>
</tr>
<tr>
<td>$H_8$</td>
<td>0.317</td>
<td>0.048</td>
<td>0.074</td>
<td>0.152</td>
</tr>
<tr>
<td>$H_9$</td>
<td>0.033</td>
<td>0.044</td>
<td>0.003</td>
<td>0.124</td>
</tr>
<tr>
<td>$H_{10}$</td>
<td>0.078</td>
<td>0.046</td>
<td>0.232</td>
<td>0.171</td>
</tr>
</tbody>
</table>

Note: $n^{(1)} = 533, n^{(a)} = 91, Sig.: * p < 0.10, ** p < 0.05$

Appendix E-2. Comparison of path coefficients between main and manufacturing sector

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Main model</th>
<th>Manufacturing sector</th>
<th>Main vs manufacturing</th>
<th>Levene’s test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$p^{(1)}$</td>
<td>$se(p^{(1)})$</td>
<td>$p^{(b)}$</td>
<td>$se(p^{(b)})$</td>
</tr>
<tr>
<td>$H_1$</td>
<td>0.628</td>
<td>0.030</td>
<td>0.612</td>
<td>0.080</td>
</tr>
<tr>
<td>$H_2$</td>
<td>0.317</td>
<td>0.046</td>
<td>0.291</td>
<td>0.102</td>
</tr>
<tr>
<td>$H_3$</td>
<td>0.351</td>
<td>0.047</td>
<td>0.513</td>
<td>0.098</td>
</tr>
<tr>
<td>$H_4$</td>
<td>0.375</td>
<td>0.042</td>
<td>0.508</td>
<td>0.089</td>
</tr>
<tr>
<td>$H_5$</td>
<td>0.357</td>
<td>0.044</td>
<td>0.384</td>
<td>0.124</td>
</tr>
<tr>
<td>$H_6$</td>
<td>0.230</td>
<td>0.047</td>
<td>0.342</td>
<td>0.104</td>
</tr>
<tr>
<td>$H_7$</td>
<td>0.314</td>
<td>0.056</td>
<td>0.362</td>
<td>0.094</td>
</tr>
<tr>
<td>$H_8$</td>
<td>0.317</td>
<td>0.048</td>
<td>-0.031</td>
<td>0.158</td>
</tr>
<tr>
<td>$H_9$</td>
<td>0.033</td>
<td>0.044</td>
<td>0.345</td>
<td>0.073</td>
</tr>
<tr>
<td>$H_{10}$</td>
<td>0.078</td>
<td>0.046</td>
<td>-0.032</td>
<td>0.147</td>
</tr>
</tbody>
</table>

Note: $n^{(1)} = 533, n^{(b)} = 72, Sig.: * p < 0.10, ** p < 0.05$
## Appendix E-3. Comparison of path coefficients between main and service sector

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Main model</th>
<th>Service sector</th>
<th>Main vs service sector</th>
<th>Levene’s test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$p^{(1)}$</td>
<td>$se(p^{(1)})$</td>
<td>$p^{(c)}$</td>
<td>$se(p^{(c)})$</td>
</tr>
<tr>
<td>$H_1$</td>
<td>0.628</td>
<td>0.030</td>
<td>0.660</td>
<td>0.032</td>
</tr>
<tr>
<td>$H_2$</td>
<td>0.317</td>
<td>0.046</td>
<td>0.382</td>
<td>0.057</td>
</tr>
<tr>
<td>$H_3$</td>
<td>0.351</td>
<td>0.047</td>
<td>0.294</td>
<td>0.058</td>
</tr>
<tr>
<td>$H_4$</td>
<td>0.375</td>
<td>0.042</td>
<td>0.329</td>
<td>0.051</td>
</tr>
<tr>
<td>$H_5$</td>
<td>0.357</td>
<td>0.044</td>
<td>0.383</td>
<td>0.058</td>
</tr>
<tr>
<td>$H_6$</td>
<td>0.230</td>
<td>0.047</td>
<td>0.202</td>
<td>0.053</td>
</tr>
<tr>
<td>$H_7$</td>
<td>0.314</td>
<td>0.056</td>
<td>0.233</td>
<td>0.070</td>
</tr>
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<td>$H_8$</td>
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<td>0.063</td>
</tr>
<tr>
<td>$H_9$</td>
<td>0.033</td>
<td>0.044</td>
<td>0.101</td>
<td>0.093</td>
</tr>
<tr>
<td>$H_{10}$</td>
<td>0.078</td>
<td>0.046</td>
<td>0.003</td>
<td>0.069</td>
</tr>
</tbody>
</table>

Note: $n^{(1)} = 533, n^{(c)} = 370$. Sig.: *p < 0.10, **p < 0.05

## Appendix E-4. Comparison of path coefficient between primary and manufacturing sectors

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Primary model</th>
<th>Manufacturing</th>
<th>Primary vs manufacturing</th>
<th>Levene’s test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$p^{(a)}$</td>
<td>$se(p^{(a)})$</td>
<td>$p^{(b)}$</td>
<td>$se(p^{(b)})$</td>
</tr>
<tr>
<td>$H_1$</td>
<td>0.607</td>
<td>0.082</td>
<td>0.612</td>
<td>0.080</td>
</tr>
<tr>
<td>$H_2$</td>
<td>0.093</td>
<td>0.121</td>
<td>0.291</td>
<td>0.102</td>
</tr>
<tr>
<td>$H_3$</td>
<td>0.558</td>
<td>0.111</td>
<td>0.513</td>
<td>0.098</td>
</tr>
<tr>
<td>$H_4$</td>
<td>0.484</td>
<td>0.107</td>
<td>0.508</td>
<td>0.089</td>
</tr>
<tr>
<td>$H_5$</td>
<td>0.458</td>
<td>0.084</td>
<td>0.384</td>
<td>0.124</td>
</tr>
<tr>
<td>$H_6$</td>
<td>0.055</td>
<td>0.125</td>
<td>0.342</td>
<td>0.104</td>
</tr>
<tr>
<td>$H_7$</td>
<td>0.479</td>
<td>0.096</td>
<td>0.362</td>
<td>0.094</td>
</tr>
<tr>
<td>$H_8$</td>
<td>0.074</td>
<td>0.152</td>
<td>-0.031</td>
<td>0.158</td>
</tr>
<tr>
<td>$H_9$</td>
<td>0.003</td>
<td>0.124</td>
<td>0.345</td>
<td>0.073</td>
</tr>
<tr>
<td>$H_{10}$</td>
<td>0.232</td>
<td>0.171</td>
<td>-0.032</td>
<td>0.147</td>
</tr>
</tbody>
</table>

Note: $n^{(a)} = 91, n^{(b)} = 72$. Sig.: *p < 0.10, **p < 0.05
Appendix E-5. Comparison of path coefficients between primary and service sectors

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Primary sector</th>
<th>Service sector</th>
<th>Primary vs service sector</th>
<th>Levene’s test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p(^{a})</td>
<td>se(p(^{a}))</td>
<td>p(^{c})</td>
<td>se(p(^{c}))</td>
</tr>
<tr>
<td>H(_1)</td>
<td>0.607</td>
<td>0.082</td>
<td>0.660</td>
<td>0.032</td>
</tr>
<tr>
<td>H(_2)</td>
<td>0.093</td>
<td>0.121</td>
<td>0.382</td>
<td>0.057</td>
</tr>
<tr>
<td>H(_3)</td>
<td>0.558</td>
<td>0.111</td>
<td>0.294</td>
<td>0.058</td>
</tr>
<tr>
<td>H(_4)</td>
<td>0.484</td>
<td>0.107</td>
<td>0.329</td>
<td>0.051</td>
</tr>
<tr>
<td>H(_5)</td>
<td>0.458</td>
<td>0.084</td>
<td>0.383</td>
<td>0.058</td>
</tr>
<tr>
<td>H(_6)</td>
<td>0.055</td>
<td>0.125</td>
<td>0.202</td>
<td>0.053</td>
</tr>
<tr>
<td>H(_7)</td>
<td>0.479</td>
<td>0.096</td>
<td>0.233</td>
<td>0.070</td>
</tr>
<tr>
<td>H(_8)</td>
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<td>0.152</td>
<td>0.376</td>
<td>0.063</td>
</tr>
<tr>
<td>H(_9)</td>
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<td>0.124</td>
<td>0.101</td>
<td>0.093</td>
</tr>
<tr>
<td>H(_{10})</td>
<td>0.232</td>
<td>0.171</td>
<td>0.003</td>
<td>0.069</td>
</tr>
</tbody>
</table>

Note: \(n^{a} = 91, n^{c} = 370\), Sig.: \(* p < 0.10, ** p < 0.05\)

Appendix E-6. Comparison of path coefficients between manufacturing and service sectors

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Manufacturing</th>
<th>Service sector</th>
<th>Manufacturing vs service</th>
<th>Levene’s test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p(^{b})</td>
<td>se(p(^{b}))</td>
<td>p(^{c})</td>
<td>se(p(^{c}))</td>
</tr>
<tr>
<td>H(_1)</td>
<td>0.612</td>
<td>0.080</td>
<td>0.660</td>
<td>0.032</td>
</tr>
<tr>
<td>H(_2)</td>
<td>0.291</td>
<td>0.102</td>
<td>0.382</td>
<td>0.057</td>
</tr>
<tr>
<td>H(_3)</td>
<td>0.513</td>
<td>0.098</td>
<td>0.294</td>
<td>0.058</td>
</tr>
<tr>
<td>H(_4)</td>
<td>0.508</td>
<td>0.089</td>
<td>0.329</td>
<td>0.051</td>
</tr>
<tr>
<td>H(_5)</td>
<td>0.384</td>
<td>0.124</td>
<td>0.383</td>
<td>0.058</td>
</tr>
<tr>
<td>H(_6)</td>
<td>0.342</td>
<td>0.104</td>
<td>0.202</td>
<td>0.053</td>
</tr>
<tr>
<td>H(_7)</td>
<td>0.362</td>
<td>0.094</td>
<td>0.233</td>
<td>0.070</td>
</tr>
<tr>
<td>H(_8)</td>
<td>-0.031</td>
<td>0.158</td>
<td>0.376</td>
<td>0.063</td>
</tr>
<tr>
<td>H(_9)</td>
<td>0.345</td>
<td>0.073</td>
<td>0.101</td>
<td>0.093</td>
</tr>
<tr>
<td>H(_{10})</td>
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<td>0.147</td>
<td>0.003</td>
<td>0.069</td>
</tr>
</tbody>
</table>

Note: \(n^{b} = 72, n^{c} = 370\), Sig.: \(* p < 0.10, ** p < 0.05\)