University knowledge transfer and innovation performance in firms: the Ghanaian experience

This paper examines the association between university-industry collaboration and firm innovation performance, and the effect of informal mechanisms of knowledge transfer on such an association, using data from a survey of 245 firms in Ghana and employing PLS-SEM. The results are of significant relevance to the business community and policy makers in Ghana and West African.

We find that whilst university-industry collaboration is positively related to innovation performance in firms, informal mechanisms of university knowledge transfer do not and negatively moderate the positive association between university-industry collaboration and innovation performance in firms. It is also found that to facilitate innovation outcomes formal, legal binding contracts are required. The study recommends that university knowledge generation and innovation policies in Ghana encourage formal collaboration between knowledge exchange actors. It is also suggested, that improvements need to be made to the efficacy of intellectual property legislation in Ghana.

Keywords: University knowledge transfer, collaboration, informal mechanisms, innovation performance, social capital, global south.

1 Introduction

To achieve research and development led economic growth, interaction between universities and industry has attracted the attention of economic development stakeholders (January and Thomas, 2013, Theodorakopoulos et al., 2014). This is a consequence of a constant need within firms for new knowledge to gain competitive advantage and meet the needs of today's knowledge-based markets Mosey et al., 2012). The role of universities continues to evolve; currently focus is placed on universities contributing to economic development through the production and diffusion of industry relevant knowledge. In addition, governments are struggling with scarce resources, which have affected public funding of higher education, and research (Drurey, 2010). As a result, pressure has been placed on universities to attract funding and consider their socio-economic contribution. Indeed twenty first century universities arguably continue to be '*ivory towers*', thus; conducting research without direct benefit to the public that funds them (Mowery and Sampat, 2005).

The '*new mission*' of higher education has changed the role of universities in national economic development Saad et al. (2010). This is supported by Sorenson and Fleming (2001) who suggest there is great benefit when firms participate directly in knowledge generation, science and innovation. Regrettably, the principle of triple helix and other models such as the open innovation framework are arguably concepts that do not yet fit well into the weak innovation systems of developing economies. A generic model for less wealthy nations will offer a platform for firms in all sectors to engage with universities for knowledge and innovation (Kruss et al., 2012). Further, Singer and Peterka (2009) contend that a lack of cultural flexibility within university research and knowledge generation and transfer process in less economically endowed countries seriously hinder universities interactions with industry. In addition, resistance to change and new initiatives have posed a challenge to innovation in such nations (Bailey et al., 2011). Another issue is a lack of shared trust and confidence between universities and

firms (Amankwah-Amoah, 2016). Challenges of this nature are comparatively low in advanced economies and interactions between universities and industry are therefore more advanced and highly sophisticated in many sectors (Mothe and Quelin, 2000). Consequently, this study advocates for a suitable framework for developing economies, particularly those in the West African sub-region to guide in university-industry interaction studies and policymaking.

Ghana was the first nation, south of the Sahara to gain independence and was described as the wealthiest nation in the West African Sub-region at the time (Yusof, 2010, IMF, 2017). For nearly three decades, Ghana has enjoyed a very stable political environment and enviably peaceful democratic transitions as compared with political disturbances in other countries in the region (Herbert, 1994, Obeng et al., 2012). Further, after public investment in education, years of infrastructural developments in universities and increases in research and book allowance in universities, there remains comparatively little evidence to show in terms of sustained innovation performance in Ghanaian firms. Meanwhile, countries in South East Asia, for instance: Malaysia, Singapore and South Korea, that achieved independence at roughly the same time as Ghana and had approximately the same GDP per capita at the time, today have GDP per capita significantly higher than that of Ghana (Herbert, 1994, IMF, 2017).

Given this disparity in GDP and the desire to pursue innovation led economic and social development policy, a better understanding of university knowledge generation and transfer to firms for innovation is currently in demand (Victoria et al., 2015). Thus, better links between academia and industry to expedite the pace of innovation performance in firms has become a subject of discourse among academia and policymakers alike. This study focuses on exploring how new knowledge generated from Ghanaian universities is transferred to industry with particular interest on collaborative research and informal mechanisms of university knowledge transfer. This study intends to offer understanding of the Ghanaian experience of university knowledge transfer in the Ghanaian innovation ecosystem in a hypotheses based study (Xiao and Anni, 2007). Informal mechanisms of university knowledge transfer are also explored as a moderating latent variable on the association between university-industry collaboration and innovation performance in firms in Ghana.

2 Literature review and hypothesis development

2.1 University-industry interaction
From an epistemological point of view, people within firms are deemed indispensable players in knowledge development and its subsequent transmission (D'Este and Patel, 2007). Similarly, Kogut and Zander (1992) contend that firms also exist to facilitate the transfer of knowledge created within them and with other organisations. It follows that, knowledge after its creation is exchanged with external partners in a knowledge network for mutual benefit (Abreu et al., 2009, Gassmann et al., 2010). Further to this, within the framework of this network of knowledge generation, universities remain a traditional core knowledge generation actor. Which, in turn provide knowledge for firms creating regional and national growth and development (Rutherford and Holmes, 2008, Munyoki et al., 2011).

Universities in Ghana can be said to form part of the knowledge network that supplies firms with knowledge to support innovation at both regional and national levels (Fu et al., 2014, Okantey, 2014). However, Singer and Peterka (2009) argue that the lack of structural flexibility within universities' specific objectives, missions and above all their resistance to change have posed a significant challenge to innovation in developing nations. More so, innovation related concepts, for example, the triple helix concept face enormous implementation challenges in developing nations Fleetham et al., 2015). Knowledge creation frameworks in Ghana are typically inefficient and ineffective due to a lack of appropriate governance and resultant corruption (Osei et al., 1993, Oppong et al., 2014). This, they contend, is caused by the absence of robust legal frameworks. Robson et al. (2009) report of needless red tape and widespread corruption connected with the public sector in Ghana that affects the development of small businesses in particular, restricts their operations to the underground economy. A similar phenomenon is reported in the work of Fadahunsi and Rosa (2002) in Nigeria.

Moreover, what is also known in Ghana is the seemingly non-existence of shared trust and confidence between universities and business communities (Adler and Kwon, 2000, Hitt et al., 2002). In contrast, these challenges are alleviated in advanced economies and the link between universities and industry is more efficient and effective (Hughes and Kitson, 2012, Kneller et al., 2014).

Typically, universities in Ghana lack resources and are unable to embark on research of their own or efficiently collaborate with entrepreneurs for commercial gains without external support (Cloete et al., 2011). Although, there are isolated cases like the case of the Technology Consultancy Centre (TCC) of the Kwame Nkrumah University of Science and Technology in Kumasi in the Ashanti Region (Islam et al., 2013). Nonetheless, most countries in the sub-Saharan Africa do not have high-tech industries to establish high intense collaborations with universities and therefore do not have the prerequisite technology-based culture for the twenty-first century research and development (Atuahene, 2011, Bailey et al., 2011). Specifically in Ghana for instance, the majority of firms, made up of small to medium-size firms in the informal economy produce for only their local markets (Oppong et al., 2014, Tetteh and Essegbey, 2014). However, in instances where there are relatively large firms, the majority are subsidiaries of multinational companies, which depend heavily on in-house R&D capabilities of their parent firms (Munyoki et al., 2011).

Due to financial neglect by governments, universities in African lack adequate resources to productively collaborate leaving many of them with obsolete research facilities and be reliant on foreign donors funding for research (Mohamedbhai, 2008, Atuahene, 2011). Further, there is comparatively little investment in Africa in R&D and a dearth of effective economic development strategies. For instance, African economies typically spend less than 1% of their GDP on R&D investment including Ghana (Mouton, 2008). Firms have different ways to learn and innovate and the way they obtain knowledge also very much depends on the type of knowledge or technology and absorptive capacity of participating firms (Kamien and Zang, 2000). Indeed, the size of a firm and the type of knowledge being exchanged are significant factors to consider in knowledge transfer projects; even the discipline or activity of a firm guides the mode of transfer of knowledge from the source to the learning structures of the firm (Dornbusch and Neuhäusler, 2013). Knowledge external to the firm however is

criticised for its high management cost, greater chance of failing to offer core competence to the buyer or satisfy a specified market need (Kraaijenbrink et al., 2007).

Ghanaian SMEs tend to depend on informal forms of knowledge transfer to upgrade their knowledge of the market and business practices (Oppong et al., 2014). This may be resultant of a comparative lack of strong absorptive capacity and inability to fund research or engage in long-term projects as evident in most developing economies (Fontana et al., 2006, Fu et al., 2014). As such, the usual means adopted by such small firms is acquisition of knowledge from the informal meetings held with researchers (Bekkers and Freitas, 2008, Chiaroni et al., 2011). In most cases, start-ups in particular, obtain knowledge from their industry networks, publicly sponsored research, openly disseminated research outcomes, largely in the social sciences and humanities (Porter and Ketels, 2003, Nurse, 2014).

Firms collaborate formally with universities are typically expected to produce innovative outcomes, create business opportunities and new knowledge for industry (Dooley and Kirk, 2007, Abdulai et al., 2015). Such research collaboration usually involves formal contracts, licensing agreements, patents and spin-offs to feed the commercial interest of both universities and participating firms (Clancy and Moschini, 2013). In a multi-case study project in Kenya conducted by, Mwamadzingo (1996) reports of a comparatively high number of successful university-industry interactions emanating through informal mechanisms. Among these is the interesting example of how a local firm grew to become a large-scale commercial producer of milk using a process drawn from the findings of a post-graduate milk fermentation research study as a spillover from the University of Nairobi (Mwamadzingo 1996).

There is a growing debate on whether university research outcomes that are mostly sourced from informal mechanisms are substantive and do actually affect innovation performance in firms. In fact, critics consider such sources as superfluous to innovative activity in firms (Abdulai et al., 2015). Others like Castro-Martínez et al. (2010) also conclude that the subtle use of informal modes of university knowledge transfer like meetings and conferences mainly in the humanities and social sciences have no tangible reward. Contrary to this though, Mowery and Sampat (2005) have considered these forms of knowledge transfer as some of the most important mechanisms of accessing business ideas from universities. Other supporters of such a view include D'Este and Patel (2007).

To increase levels of innovative activity most firms use informal channels alongside formal collaboration, irrespective of their size, discipline focus or industry (Grimpe and Hussinger, 2013). Informal channels are considered to add value to business ideas and/or innovation outcomes at relatively low or no cost in most instances (Howells et al., 2012). In the context of Ghana where publicly sponsored agents are not common as EU and US or are relatively weak, access to knowledge and innovation through formal interactions is still generally limited to international and multilateral firms (Fu et al., 2014, Nurse, 2014).

2.2 Innovation

Definitions of innovation are often structured to reflect current global developments and changes of the markets; for instance - the Chain-Link model (OECD, 2005a), the triple helix framework (Etzkowitz, 2003) and open innovation models arguably provide a clearer understanding of the concept of innovation (Chesbrough, 2006, Bradley et al., 2013).

For the purpose of this study, innovation is interpreted as incremental changes and activities of a firm, which holistically lead to the introduction of a novel or improved product, service or process. Change is considered to be a key facet of innovation (Samson, Gkloet and Singh, 2017) Arguably, definitions of innovation have stereotypically put less emphasis on the soft and less tangible elements of firm's business operations, focusing largely on technology-based innovation (OECD, 2005a). Murphy et al. (2015) provide a critique of such traditional innovation metrics who consider most innovation policies concentrate on technological innovation at the expense of, for example, hidden innovation.

Economically developing nations such as Ghana, exhibit similar characteristics to more developed economies in their innovative activities and constraints in terms of resources, management of knowledge and its generation (Sawyerr, 2004, OECD, 2013). In addition, most of the research conducted in developing economies is funded either fully or partly by government or external agents from developed nations (Osabutey and Jin, 2016). In Ghana, firms typically have comparatively fragile financial resources and weak absorptive capacities consequently limiting their capability to undertake research contracts and projects, (Osei et al., 1993, MEST, 2010). As a result, firms in Ghana usually resort to relying on low cost and easily accessible methods of sourcing innovative ideas like conferences, spillovers and accredited knowledge-based networks for information on innovative business practices (Osabutey and Jin, 2016).

Arguably, there is a comparative dearth of empirical evidence to support innovation theories and models (Edquist and Hommen, 2008, Bradley et al., 2013). It may be stated that innovation models sometimes lack realism and may be considered arguably deterministic and simplistic with usually 'a single best way' suggested for innovation across all industrial sectors. A further critique is that informal mechanisms of university knowledge transfer and use of organisational (hidden innovation) or non-technical innovation (marketing and advertising) interpretations are frequently omitted from firm based innovation studies (Hobday, 2005, OECD, 2005b).

2.3 Social capital and innovation

There are many definitions for social capital. Coleman (1988) believes that social capital exists in the '*relations among persons*'. The notion of location of social capital employed by Conway and Steward (2009) reveals their view that social capital is not owned by any individual or group but exists in their relationships with others. This, they say, is because if an individual were to withdraw from a relationship, the social capital is likely to cease to exist. However, Huggins and Johnston (2010) and García-Villaverdea et al (2018) argue that social capital can be held by an individual. This interpretation of social capital may create a dilemma in terms of its questioning of whether social capital is an individual and/or a group construct. Huggins and Johnson

(2010) question whether individuals seek social capital for personal gain or for an organisational-based motive.

Beugelsdijk and van Shaik (2005) and Anderson and Jack (2002) allude to the multidimensional nature of social capital. Coleman (1988) states that, although social capital may arguably be rather disparate in its construction, there are two common elements, namely social structures, and individuals/organisations undertaking actions. Putnam et al (1993) consider that social capital may increase via a 'virtuous circle' of activity and diminish because of a 'vicious circle' of activity. If there is a virtuous circle present, the likelihood of increasing social capital is improved. Fountain (1998) supports the concept of social capital increasing in a virtuous circle. Similarly, Fountain (1998) also refers to social capital as being constituted of networks, norms and trust. Fountain (1998) has further stated that such norms, networks and trust enable cooperation between individuals and/or organisations.

Innovative activity in firms is frequently associated with social capital (Huggins et al., 2012). The paradigm of innovation is arguably shifting from being a 'classical technical tool' towards a 'novel working whole' where human involvement is considered a vital constituent element for innovation performance in firms (Leeuwis and Ban, 2004). Social capital may also decrease transaction costs (Huggins et al., 2012). Consequently, in a developing country such as Ghana where social ties are relatively strong, social capital may help facilitate the creation of a 'synergy effect,' in social networks (Murphy, 2002). Indeed, levels of societal trust are positively related to a country's innovation performance (Zhu, Habisch and Thogersen, 2018).

However, social networks may sometimes face issues of reaching a consensus and shared understanding, common beliefs and goals (Adler and Kwon, 2000). Such issues are likely to negatively impact on a firms' innovation performance. For example, when small groups or sub-units have unique sub-cultures; for instance, at departmental levels where social ties are often stronger than the ties binding the whole firm together. Finally, in some cases social networks may lose trustworthiness and consequently become unreliable as sources of knowledge (Murphy 2002, Edelman et al., 2004). In Ghana power distance is noted to adversely affect entrepreneurial and innovation activities in small firms more so than large firms (Sleuwaegen and Goedhuys, 2002).

Social capital can positively influence entrepreneurial activities and innovation in Ghanaian firms (Takyi-Asiedu, 1993). Additionally, a number of cultural dimensions including collectivism have been employed to explain how entrepreneurs in Ghana and other countries in the Sub-Saharan Africa may access external knowledge through both formal relationships with universities and informal interactions with universities and networks (Takyi-Asiedu, 1993). In essence, informal mechanisms of university knowledge transfer are also considered highly productive and supportive of innovation in local firms (Cohen et al., 2002, D'Este and Patel, 2007). Given the evidence above regarding the impact of informal modes of knowledge transfer mechanisms available in Ghana (Rossi and Rosli, 2013); this paper investigates this empirically and reports on how that informal types of knowledge transfer influences innovation performance in Ghanaian firms.

2.4 Mapping the research model

[Insert Figure 1 here please]

Figure 1 has been created as a theoretical lens to map out a university knowledge transfer model and explore the Ghanaian innovation ecosystem. To make the model suitable for conditions inherent in developing economies, this study develops a more workable version from the conceptual model (Figure 2). Knowledge acquired by firms from university research and expertise has attracted the attention of economic policymakers seeking solutions for global economic development challenges (Lam, 1997, Wang and Lu, 2007). For that reason, interaction between universities and industry is considered a strategic source for knowledge and sustainable competitive advantage in firms. In effect, scholars of knowledge generation and management typically believe that the knowledge of a firm is embedded within its organisational resources and that new knowledge creation and organisational learning are also embedded in the complex network of social structures (Kogut and Zander, 1993, Osabutey and Jin, 2016). The systems they contend harness both explicit and tacit knowledge for consequential innovative activities within firms, such as new products and improved services (Kraaijenbrink et al., 2007, Smith, 2001, Bessant et al., 2012). Internal knowledge development of a firm typically requires organisational learning routines, which may be shaped by the external environment and dynamics of social institutions (Matlay et al., 2009, Thomas et al., 2009). Further, innovation in firms may rely on a sustained relationships and continuous contact between academia and industry (Freeman, 1995) as illustrated in Figure 1.

Universities are considered important elements of the complex network of external knowledge generation and are key institutions influencing the internal dynamic of firms as learning organisations (Lam, 2000, Abreu et al., 2009). Research indicates that one of the most prominent ways universities influence innovation in firms is through collaboration as depicted in Figure 2, often with legally binding agreements (Lam, 1997, Banal-Estanol et al., 2011). In economically developed countries knowledge–intense service based firms are considered as bridges for innovation performance aided by electronic information resources (Johnston and Huggins, 2016). Accordingly, the collaborative review model (Figure 1) indicates that modern technology has created a platform that facilitates university-industry interactions and stakeholders. For example, the UK Department for Business, Innovation and Skills (BIS), which electronically catalogues information on various universities' research interests, expertise and specialisations in anticipation for operational issues from industry and joint projects from firms (Kamien and Zang, 2000). Generally, electronic resources usually contain information on tacit knowledge available in both universities and industry including intellectual property, patents, copyrights and licence structure (Landry et al., 2006, Kremer and Williams, 2010). Such projects have resulted in innovative outcomes and positively impact on industry performance (Pertuze et al., 2010). Conversely, the situation is different in developing countries such as Ghana and other economies in the West Africa Sub-region. In this region, the majority of businesses are SMEs with comparatively scarce human and financial resources (Johnston and Huggins, 2016). Due to this, most small firms in Ghana, for instance, even struggle just to survive mainly on informal channels of university transfer (Robson et al., 2009, Tetteh and Essegbey, 2014). The same reasons explain how small firms in Mauritius and Kenya appear somewhat less innovative as compared to larger ones (Obeng et al,, 2012).

[Insert Figure 2 here please]

Based on the links established between the significant components of the theoretical model in Figure 1 and supported in the extant literature reviewed in the earlier part of this chapter, the three hypotheses below are designed for further evaluation. The evaluation is framed into a structural model in Figure 2. The hypotheses formulated are:

H_1: University-industry collaborative is positively associated with firm innovation performance.

H_2: Informal mechanisms of knowledge transfer are positively associated with firms' innovation performance.

H_3: Informal mechanisms of knowledge transfer negatively moderate the association between university-industry collaboration and firm innovation performance.

3 Data and methods

The survey questionnaire was designed to capture information on how firms source new knowledge from universities and its likely impact on levels of innovative activity. The sample of firms was drawn from two separate databases in Ghana. One was obtained from the National Board for Small Scale Industries (NBSSI) and the other from the Association of Ghana Industries (AGI); while the former is a Ghana government agent the latter is a voluntary association of industries in Ghana; both include SMEs and large firms in Ghana across all sectors. In each database, firms, as our statistical units of analysis for the study were grouped in strata representing primary, secondary and service sectors for stratified simple random sampling as categories of interest to the study. Another sub-category of firms that were of interest to the study was size, which was considered in terms of number of employees a firm had at the time of the survey. Both categories of interest were then included as dummy variables in PLS-SEM model with sub-levels (entered as '1', '2' etc.) to be controlled for to improve the interpretation of the findings. The questionnaire was pre-tested a month before the main survey and provided valuable guide on many issues including delivery, follow-ups, shaping and rewording of the questionnaire.

On a 5-point Likert scale questionnaire, firms were required to rate statements based on their knowledge, perception and experience in their informal relations, collaborations and innovation activities with universities in Ghana. Measured as indicators as seen in Table 4, the statements focused on their working relationship with universities. The purpose of which is to learn more about the informal relationships established between firms and researchers in Ghanaian universities. To measure such informal relationships, representatives of firms rated their informal interactions with researchers and free sources of university research outcomes. For data on collaboration with universities, respondents rated their potential and actual collaboration outcomes with universities Ghana. Innovation performance measures were based on incremental changes in firms R&D budget allocations and efficiency of staff in undertaking new and improved processes in their operations.

Comprehensive checks on non-response bias showed no statistical significant difference between early and late respondents in their responses to all the variables under investigation and can be seen in Table 1, thus; $t_{(243)}=-0.598, p=0.550$ for INFO, the associated Levene's test for equal variance is $F_{(243)}=0.489, p=0.485$. For COLL; $t_{(243)}=-1.35, p=0.178$, Levene's is not significant; $F_{(243)}=0.389, p=0.529$ and for INNO, $t_{(243)}=0.006, p=0.995$ and Levene's test is $F_{(243)}=0.054, p=0.817$. Normality assessment with a Shapiro-Wilk test results were acceptable with the exception of COLL, which, on graphical inspection was acceptable. Also, Herman's single-factor test with Exploratory Factor Analysis (EFA) using unrotated loadings showed no evidence of common method bias as no single factor accounted for all the variances in the variables and no factor accounted for majority or more than 50% of the variances in the variables either.

[Insert Table 1 here please]

To correct for sampling error, firms were then randomly selected using random numbers generation from each stratum to make a sample frame of 800 firms. The respondents in each firm held senior management positions and the choice of the probability sampling method was to enhance the chances of achieving a true representative sample of Ghanaian businesses. A priori sample size calculation was conducted. A minimum sample size of 100 was estimated to be able to detect a medium effect of 0.10 and a minimum of 290 sample size with respect to the complexity of the model for a power of 0.80. A total sample size of 245 out of 800 in the sample frame was obtained. Overall, the response rate was 30.63%. For flexibility, partial least squares structural equation modelling (PLS-SEM) and PLS regression algorithm for parameter estimate with WarpPLS v6.0 statistical package was found to be suitable for the study. In addition, standard errors estimations were by bootstrapping with 5000 resamples in the analysis (Kock, 2014). Missing data was less than 2% with no outliers and was managed with multiple regression imputation algorithms in the course of the analysis.

4 Findings
In effect, out of the total of 245 firms, as seen in Table 1, 6.94% were from the primary sector *(N=17)* and 8.16% from the secondary sector *(N=20)*. The service sector *(N=185)* had the largest representation (75.51%) in the sample. Nevertheless, about nine per cent (9.39%) did not indicate their sectors in the completed questionnaires. Another classification of firms that had been of interest to the study is the sizes of the firms defined in terms of the number of employees and based on European Commission company classifications. From this, also in Table 1, 15.50% were micro-firms, 34.28% were small size firms and 19.18% were recorded as medium size firms based on the number of workers at the time of the survey. With 2.04% not classified due to non-specification on the item in the questionnaire and finally, 29% were large firms.

[Insert Table 2 here please]

Table 2 gives statistical summaries of the variables under discussion and shows on average, that in the primary sector, there is a higher perception *M=3.44(SD=0.22)* of innovation performance in firms than the perception on both informal mechanisms of university knowledge transfer *M=3.15(SD=0.27)* and university collaboration with firms *M=3.22(SD=0.23*. These two mechanisms are those being looked at as the

determining factors of innovation in firms. In the secondary sector, innovation performance *M=3.37(SD=0.17)* is again perceived to be higher than the two activities; informal mechanisms of university knowledge transfer *M=2.88(SD=0.20)* and university collaboration with firms *M=2.98(SD=0.21)*. The same is noted in the service sector, where innovation in firms is once more rated higher on the average *M=3.50(SD=0.70)* than informal mechanism of knowledge transfer *M=3.04(SD=0.07)* and university collaboration with firms *M=2.94(SD=0.07)*. In all, innovation performance in firms are perceived to have effectively taken place in all sectors, which reasonably could be at least partially attributed to a cumulative effect of both informal mechanisms of university knowledge transfer and the collaboration between firms and universities in the country. Overall, firms in the service sector seem to have done better in innovation than firms in the primary and secondary sectors, with the primary sector being the least performing sector in innovation in the country according to the survey.

[Insert Table 3 here please]

In Table 3, innovation performance in firms, on average is rated slightly higher for larger firms than smaller ones in the sample. The least rated knowledge transfer mechanisms is informal between the two in large firms (*M=2.97, SD=0.12*) whereas collaboration is the highest (*M=3.10, SD=0.12*) for the same large firms. Large firms (250+) rated university collaboration with firms (*M=3.10, SD=0.12*) higher than small firms (10--49), (*M=2.90, SD=0.11*) and micro enterprises (1--9), (*M=2.94, SD=0.16*). Micro enterprises rated informal mechanisms of university knowledge transfer higher (*M=3.10, SD=0.14*) than the small size firms (*M=2.91, SD=0.10*) and medium size firms (*M=3.09, SD=0.14*). It can also be noticed that medium size and large firms (50--249 and 250+) appear to have higher innovation performance, thus; (*M=3.56, SD=0.12*) for (50--249) and (*M=3.54, SD=0.11*) for 250+ respectively than small size firms (*M=3.47, SD=0.09*) and micro enterprises (*M=3.43, SD=0.12*). To conclude, according to the survey large firms (250+) (*M=3.10, SD=0.12*) collaborate with universities more than other size firms.

4.1 *Partial least squares of structural equation modelling*
PLS-SEM was adopted for this study to examine the influence of university-industry collaboration (independent variable) and firms' informal mechanisms of university knowledge transfer (independent variable) on firms' innovation activities (dependent variable as depicted in the model in Figure 3).

[Insert Figure 3 here please]

Informal knowledge transfer mechanism is examined in two roles; 1) as an influencing factor, and 2) as a moderating factor. To achieve the research objective, the measurement instrument is designed to access information on firms' formal collaborative research with universities, their use of informal knowledge transfer means available to them from universities and finally, innovation performance of firms in Ghana.

4.2 *Measurement scale*
There were 3 latent constructs measured in this model with 5 reflective observable indicators in each construct. Items in the dependent latent variable were literature based to include a range of innovation activities, from the incremental development of

products and services to the assessment of budgetary allocation on R&D. Collaboration between university and firms for research is also quantified to consist of partnership projects between universities and firms in readiness to share knowledge with resources provided by firms. The third construct is informal relationships that often exist between local firms and university researchers. For example, conferences, research publications, workshops, spill-overs and typically obtained with the help of interpersonal relationships (Grimpe and Hussinger, 2013). Even personal connections with a university department or faculties are considered. In principle, for all constructs, the measurements considered have been designed to employ a form of stimulus of the observable indicators used to measure them.

4.3 Outer model evaluation

The suggested threshold is 0.80 for composite reliability for a reflective construct to be considered internally reliable (Nunally and Bernstein, 1994). For this analysis as seen in Table 4 the values obtained are 0.837 for informal mechanisms of university knowledge transfer, 0.883 for collaboration between universities and firms and 0.829 for innovation performance in firms. Convergent validity between latent variables and their indicators are also found to have good outer loadings with the AVEs being higher than 0.50 as recommended (Hair et al., 2014) and seen in Table 5.

In addition, factor loadings for constructs determine their discriminant validity and the criteria used is the Average Variance Extracted (AVE). The square roots of AVEs of all constructs in Table 5 (in the diagonal) are higher than their greatest correlations coefficients with other latent variables. Again, the cross-loadings (not shown) are a lot less for other latent variables than their own. Lastly, for unidimensionality, the constructs indicators are considered to have converged and loaded well only on their respective constructs with high outer loadings as seen in Table 4. Thus, all factors are loaded high enough for the constructs to be considered unidimensionally valid since the critical threshold is 0.60 to be theoretically accepted. Meanwhile, 0.40 is considered the lowest range in theory. In fact, in the table, the least is 0.645 for those factors in Table 4.

[Insert Table 4 here please]

[Insert Table 5 here please]

4.4 Inner model evaluation

Inner models in PLS-SEM are used to measure the strength of the relationship between latent variables in the model to ensure valid results. For the evaluation of the inner models at the second stage, path coefficients (βs) are also to evaluate the strength of the structural relationship and can be seen in Table 6 where hypothesis H_1 is seen to be strong (0.554). Hypothesis H_2 and H_3 are accordingly weak. The coefficient of determination (R^2) is good for H_1 but too weak for H_2 and H_3. The effect sizes (f^2) are all within acceptable theoretical range. Another critical measure is Q^2, which also determines the predictive relevance of the independent variables on the dependent variable using the blindfolding techniques in the model, which is also good in the analysis. This is found to be as high as 0.299 when indeed the threshold is anything above zero; $Q^2 > 0.00$.

[Insert Table 6 here please]

4.5 Model results

Table 7 presents the path coefficients for the research model showing a statistically significant relationship, at 0.05 level of significance ($\beta=0.554$, $p<0.001$) between university collaboration and innovation performance in firms but not between informal mechanisms of university knowledge transfer and innovation performance ($\beta=-0.062$, $p>0.05$). The positive, high values; 0.554 indicate a good relationship. Theoretically, path coefficient should be higher than 0.100 for an exogenous (independent) latent variable to have any impact on the endogenous (dependent) latent variable. Further to this, there is evidence of no moderating effect of informal mechanisms of university knowledge transfer ($\beta=-0.068$, $p<0.05$) on the positive relationship between university collaboration and innovation performance in firms. To elaborate further, the high value and positive sign for the effect of university-industry collaboration on innovation performance in firms is a confirmation of the relationship as hypothesised (H_1) in Figure 2. This is also evident in Table 5 where there is a similarly high correlation between university collaboration (0.538) and innovation performance in firms. However, H_2, which is the relationship between informal mechanisms of university knowledge transfer and innovation performance is clearly not statistically significant at 0.05 level of significance ($\beta=0.05$, $p>0.05$). Consequently, the low value of the effect and the non-significant p-value demonstrates this, indicating that the relationship is non-existent as proposed in the hypothesis. Nonetheless, the two are found to correlate as seen in Table 5. In addition, the relationship in H_3 is not statistically significant ($\beta=-0.068$, $p>0.05$), as proposed in the structural model (Fig. 2). Noticeably, the path coefficient, also seen in Table 6 may be negative but the low absolute weight of 0.068 is too low to interpret from a practical perspective. Significantly, Table 5 again shows fairly good correlations between informal mechanisms of university knowledge transfer; as a moderating factor on the one hand and innovation performance in firms (-0.179) and university collaboration (-0.267) on the other hand. Markedly, sectoral levels ($p>0.05$) and firms sizes ($p>0.05$) entered as control variable were not significant.

[Insert Table 7 here please]

5 Discussion

From the analysis of the results, it is evident that collaboration between Ghanaian universities and industry in Ghana is positive and directly related to firms' innovation performance in firms. This result is compatible with the hypothesised model proposed from the outset of the study and the research findings of Dooley and Kirk (2007). It suggests, firms in Ghana have positive experiences and typically gain incremental changes in their activities after collaborating with universities particularly supporting their innovation performance. In this respect, the results show that collaboration (in the form of knowledge generation projects) plays an important role in the commercial relationships between universities and Ghanaian firms. As a result, the proposition in H_1 has been supported as highlighted Table 8, thereby offering an affirmation of the need for university-industry collaboration in Ghana. Theoretically, this finding confirms Johnston and Huggins (2016) findings of a positive impact of university-industry collaboration on firm's innovation performance.

[Insert Table 8 here please]

Additionally, the descriptive statistics in Table 2 reveal that 48.18% of the sample is made of medium to large firms, thus; those employing 50 and above. The same category of firms have the highest means of 3.56 and 3.54 respectively in innovation performance in Table 3, indicating that they may be driving the success of university collaboration and innovation in Ghanaian firms. Evidently, research shows that these categories of firms are usually financially resourceful enough to commission university collaborations and pursue them successfully (Siegel et al., 2003). Consequently, this premise offers a solid foundation to imply that large firms in Ghana constitute the driving force for new and innovative business practices emanating from university research in the country. Ironically, as a control variable in the model, firm size has been found to not influence innovation performance. Industry sectoral differences have equally been found to not influence innovation performance either.

Micro and small enterprises experience the lowest innovation performance in Ghana. This may be to socio-cultural factors, low absorptive capacities and weak financial strength among others challenges (Takyi-Asiedu, 1993, Obeng et al., 2012). The secondary sector has the lowest of innovation from informal mechanisms of university knowledge transfer in Ghana at the sector level. This may be attributed to a comparatively low volume of interactions with researchers, comparatively little access to free knowledge and low absorptive capabilities of most business managers in the sector.

The significance test result of the first hypothesis (H_1) reveals that university collaboration accounts for reasonably a high percentage of innovation taking place in firms in Ghana. Accordingly, 55.4% of innovation taking place in Ghanaian firms may be the result of university collaboration projects. In reality, this indicates that more than half of innovative activities in firms can be attributed to external knowledge and specifically with university involvement. That is to say, 46% of knowledge used in these firms may be made of knowledge from other sources including spillovers, internal R&D, labour mobility, students' placements and consultancies (Ponds et al., 2010).

In the analysis however, other findings have been at variance with some aspects of the research model and the available literature (Grimpe and Hussinger, 2013), particularly, where we suggested that when firms have informal relations with universities and their researchers, tangible innovative outcomes are achieved directly. This has not been supported as claimed with evidence in the analysis and again highlight in Table 8. Surprisingly, what that could mean is that without formal agreement, legally binding commitment and co-ownership of research outcomes between universities and firms, there is usually no productive knowledge generation and subsequent transfer for innovation performance in Ghanaian firms. For instance, personal social interactions between academia and entrepreneurs in Ghana typically do not lead to long-term productive relationships. Consequently, such relationships may not create sufficient trust to share knowledge, which may in turn lead to innovative production processes or products. Perhaps, evidence of this in the literature is in the work of van Rijn (2012), conducted in seven African countries, south of the Sahara and designed to assess diversity in the Sub-region. The van Rijn (2012) research suggests that a high intensity of cognitive social capital might have the tendency to cultivate selfishness in attitude in communities and therefore could discourage innovation through interpersonal

interactions in the countries. These countries include Nigeria and Niger, which have similar social frameworks as Ghana. In addition, from the premise above, we submit that based on a regression weight of -0.062 presented in Table 7; thus, H_2, informal mechanisms of university knowledge transfer virtually has no influence on innovation performance in firms in Ghana.

Finally, to understand the role of informal mechanisms of university knowledge transfer as a moderating variable on the association between university collaboration and innovation performance in firms in Ghana, we refer to Table 7. In Table 7, the effect of the moderating variable is statistically not significant. In essence, the effect is too low in weight to manifest any significant affect. Therefore, university collaboration with industry seems not to be affected by the presence of informal access to university knowledge nor affected by how supportive social network and interpersonal relations are. In fact, both weak and strong social ties may not influence it in Ghana (Granovetter, 1973); after all, collaboration is formal, expensive and highly structured with specific targets and goals. Edelman et al. (2004) found some undesirable effects of social capital where individuals within social networks lose objectivity; tend to reject new candidates and novel concepts that have the potential to bring positive results and innovation. In principle, this will not promote or facilitate formal university collaboration with industry if such a situation prevails in Ghanaian society. It will not enhance the process of value creation in industry (van Rijn, 2012). To support this interpretation, Murphy (2002) in his study into networks, trust and innovation in Tanzania's manufacturing sector argues that interpersonal relations may sometimes limit the flow of information, ideas and even capital because mutual assistance is restricted to narrow social groups. On this note, as seen in Table 8, our third hypothesis (H_3) is not supported and the negative sign for the path coefficient, though not significant, may offer grounds to contend that potentially informal interaction between universities and their industrial partners may play an unfavourable role in university collaboration for innovation performance in Ghanaian firms. On this basis, we emphasise that informal mechanisms of university knowledge transfer, accordingly, has no impact on the relationship between university collaboration and innovation performance in Ghana.

It may be stated, in certain cultural settings, different forms of social capital can lead to unproductive business consequences, social progress or economic growth and development due to power distance, corruption and high illiteracy (van Rijn, 2012). We reiterate here that, much as we affirm the constructive effect of social capital in principle as Murphy et al. (2015) implies, we also, in contrast, admit that it could have negative outcomes. We argue that the incidence of social capital may not offer the support desired of it in Ghana and other developing economies as found in our research. We attribute our finding to the type of communal system where social networking may be rooted in the culture and type that may not encourage social benefit and may not be 'an incentive to knowledge dissemination' (Edelman et al., 2004). When social capital is highly influenced by tradition and culture and in the framework of scarce resources, social dynamics tend to not conform to normalcy. This may be what has found in this study, especially, in the case of developing economies such as Ghana, where social institutions, businesses and the economic system may not be as efficient and effective as those in more developed economies (Hitt et al., 2002).

6 Conclusion

The paper proposes from the outset that informal mechanisms of university knowledge transfer and collaboration have positive influence on innovation performance in Ghanaian firms. Actually, from the analysis, it is clear that university collaboration leads to innovation performance whereas informal mechanisms of university knowledge transfer do not. The findings indicate that when universities and firms in Ghana are formally bound in research projects by clearly written legal agreements on what they need to contribute in the process, it typically leads to tangible innovation outcomes. This suggests that knowledge generation players need to develop more interest in formal agreements and long term projects that detail the objectives and benefits of all partners with perhaps co-ownership clauses attached to encourage effective participation for productive results.

It can be stated that when individuals engage in informal knowledge exchange with universities in Ghana it is less likely to result in positive innovation-related outcomes. Consequently, it is recommended that firms, universities and the Ghanaian government should create a platform for discussion on research contracts/agreements that will encourage knowledge actors, both from academia and industry, to forge a clear common front to achieve innovative business practices. It follows then, that effective formal agreements seem more likely to develop competence and competitive advantage for firms than casual agreement and knowledge obtained through freely disseminated platforms. Of course, this is not to dismiss the benefits of social networking among academia and industry actors in Ghana (Robson et al., 2009). Indeed a source of knowledge for innovative ideas may be informal routes from universities at low or no cost to firms, particularly for smaller firms (Thomas et al., 2006). Consequently, if stakeholders build trust with their social networks that could lead to formal collaborations (Huggins et al., 2012). This can also foster more detailed agreements and memoranda of understanding for specific objectives such as spin-offs and patents.

The implication is that industry actors should not expect academia to deliver productive innovation ideas without financial compensation. This is evident in the extant literature, where universities expect rent for their inventions and innovations (Siegel et al., 2003, Bradley et al., 2013). For example, the academia will not provide ideas on issues that bring huge amount of profit to any organisation without systematic steps in place for them to reap the benefit of their creation. In certain cases without licensing or patenting, little or no knowledge will be accessed.

In terms of a policy framework, this study recommends the Ghanaian government should consider putting in place an effective legal framework for intellectual property and improve existing legislative institutions to support and encourage formal systems of interaction between academia and industry. As stated earlier such developments will give assurance to participating parties to have confidence and to increase involvement in such an interface. In particular, Ghanaian universities consequently consider restructuring their knowledge transfer operations to facilitate formal, collaborative research projects. To enable efficient and effective knowledge transfer a bespoke mechanism specific to each Ghanaian region and industry sectors are needs to be identified and implemented accordingly (Hagedoorn et al., 2000). For this to materialise, the government of Ghana will have to play its part in incentivising firms to venture into partnerships to acquire knowledge and improve their competitive advantage.

Finally, a number of limitations to this study should be recognised. Government agents and other development stakeholders were not recruited for data collection. Further, the data collection framework did not include firms from the informal sector of the economy and consequently the interpretation may not be exhaustive enough for policymaking. Nevertheless, the findings may be considered to be meaningful and of use to innovation policy makers in Ghana. Future research could focus on the impact of current intellectual property legislation, policies and practices on knowledge transfer and innovation performance of firms in Ghana. Other possibilities for future research include integrating the informal/unofficial business sector into the study sample.

Figure 1. Conceptual model
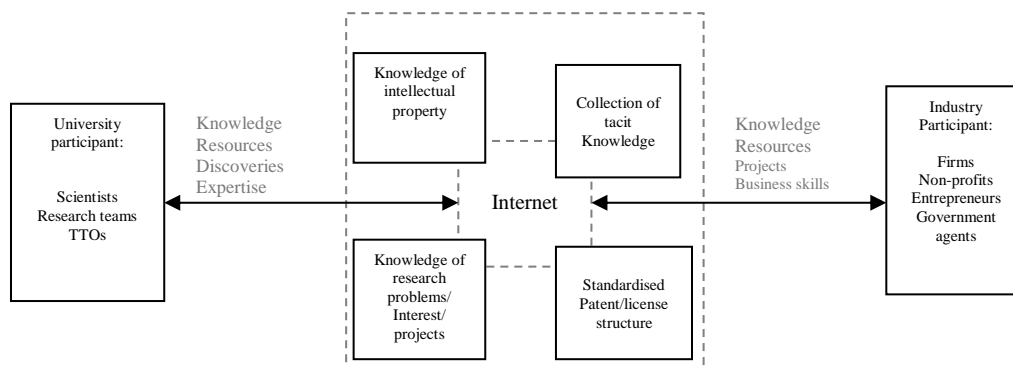
Collaborative review of university knowledge and technology transfer
(Source: Bradley, Hayter and Link, 2013)

Figure 2: R**esearch model**

Figure 3. Structural model

Informal Mechanisms

University -Industry Coloration

$H_3; \beta=-0.06$

$H_2; \beta=-0.06^{n.s.}$

$H_1; \beta=0.55***$

Sectors

$\beta=-0.03^{n.s}$

Innovation performance

*; p<0.05
**;p<0.10
***; P<0.001
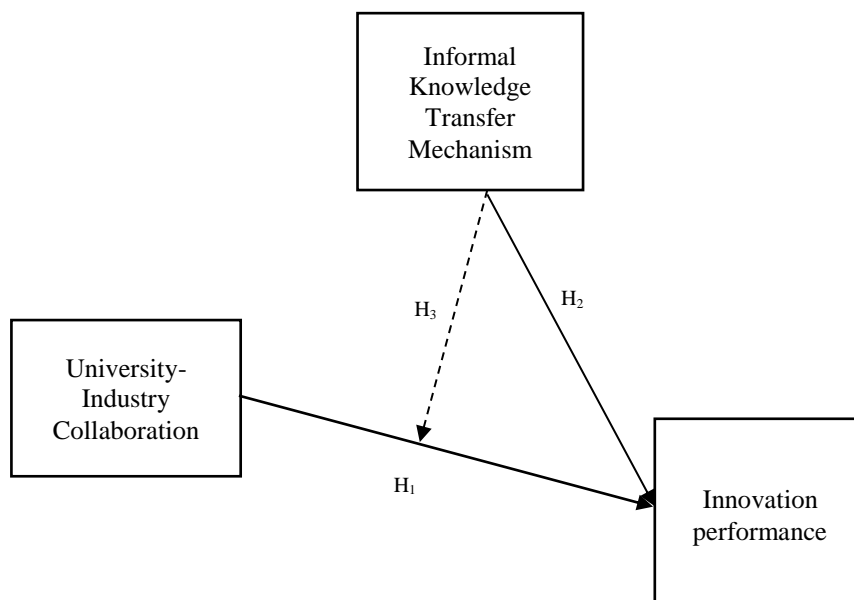n.s.; not significant

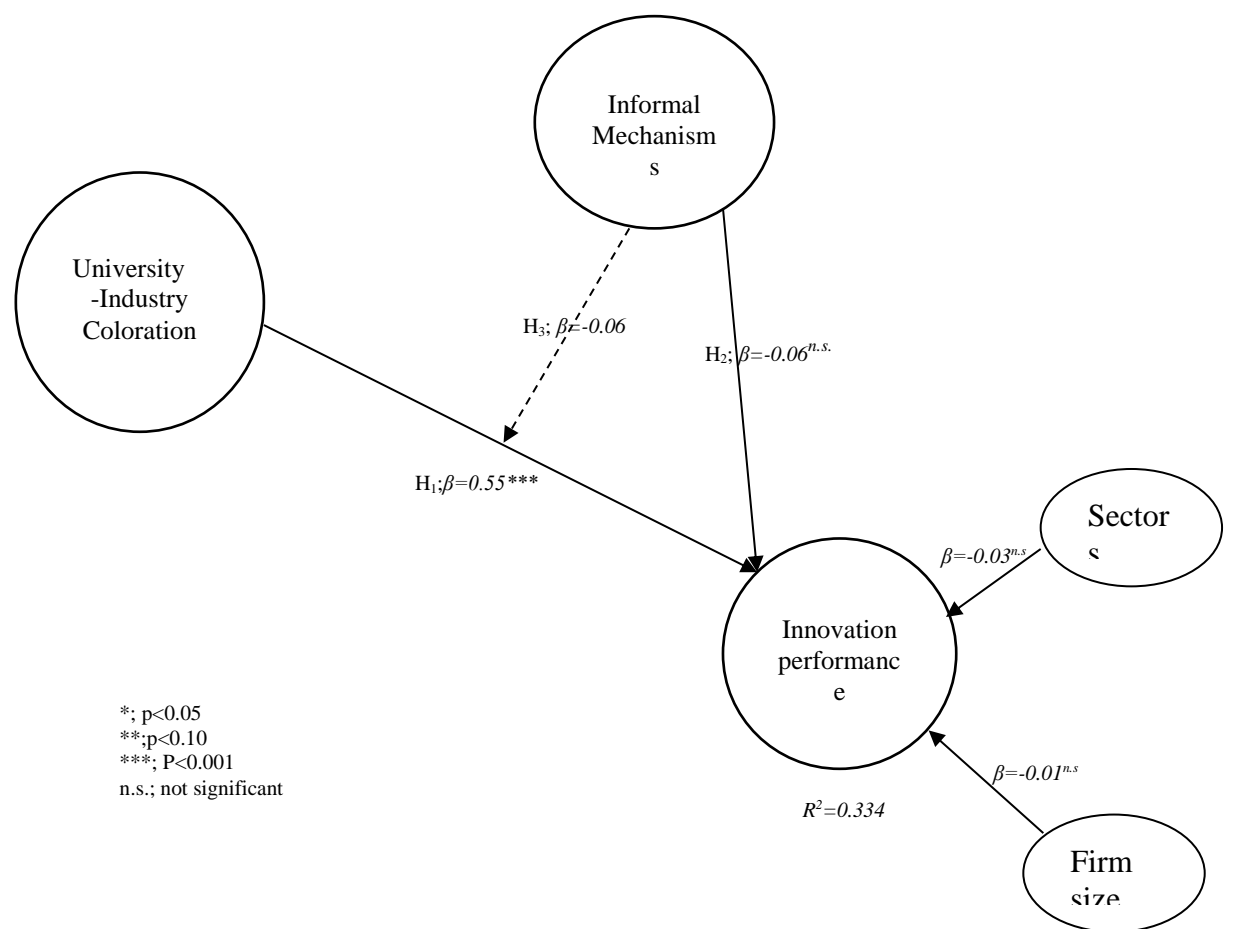$\beta=-0.01^{n.s}$

$R^2=0.334$

Firm size

Table. 1. Assessment of non-response bias with 2-tailed t-test at 5% level

Variable	Wave	N	Mean	SD	t-test for equality of means		Levene's test for equal variances	
					t	Sig.(2-tailed)	F	Sig.
INFO	Early	143	3.00	0.93	-0.598	0.550	0.489	0.485
	Late	102	3.07	0.87				
U-IC	Early	143	2.89	1.00	-1.35	0.178	0.389	0.529
	Late	102	3.07	1.00				
INNO	Early	143	3.53	0.83	0.006	0.995	0.054	0.817
	Late	102	3.53	0.81				

Table 2. Industry sector, company sizes and their percentages in the sample

Industry Sectors				**Number of Employees**			
Category	Freq.	Percentage (%)	Cumulative Freq. (%)	Category	Freq.	Percentage (%)	Cumulative Freq. (%)
Primary	17	6.94	6.94	**Micro(0-9)**	38	15.50	15.50
Secondary	20	8.16	15.1	**Small(10-49**	84	34.28	49.78
Services	185	75.51	90.61	**Medium(50-49)**	47	19.18	68.96
				Large(250+)	71	29.00	97.96
Not stated	23	9.39	100	**Not started**	5	2.04	100
Total	**245**	**100**			**245**	**100**	

Note: (0--9)=micro firms, (10--49)=medium size firms, (50--249)=large firms, (250+) very large firms; GSS, (OECD, 2005)

Table 3. Mean responses of industrial sectors and years of business operation

| Sectors/Variables | Industrial Sectors | | | | | |
| | INFO | | U-IC | | INNO | |
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Primary	3.15	0.27	3.22	0.23	3.44	0.22
Secondary	2.88	0.20	2.98	0.21	3.37	0.17
Service	3.04	0.07	2.94	0.07	3.50	0.70
Sizes	Number of Employees					
0-9	3.10	0.14	2.94	0.16	3.43	0.12
10-49	2.91	0.10	2.90	0.11	3.47	0.09
50-249	3.09	0.14	2.84	0.15	3.56	0.12
250+	2.97	0.12	3.10	0.12	3.54	0.11

Note: INFO= Informal Mechanism of Knowledge Transfer, U-IC=University-Industry Collaboration, INNO= Innovation in the firm

Table 4. Combined loadings of the measurement model and composite reliability values for outer model evaluation

Constructs	Statement	Loadings	S.e.	P-values	Composite Reliability
INFO					0.837
Inf5	Our organisation has a working relationship with at least one university academic	0.742	0.056	.001	
Inf7	We work closely with at least one university department for guidelines on our operations	0.707	0.056	.001	
Inf8	Our organisation follows the work of some academics for improvement in our process/services	0.713	0.057	.001	
Inf9	Our organisation use research findings in our business area	0.723	0.056	.001	
Inf10	Our organisation takes a keen interest in published literature	0.666	0.057	.001	
U-IC					0.883
Coll27	Most of our collaborative project outcomes have been perceived as successful.	0.774	0.056	.001	
Coll28	Our collaborative research team was able to publish at least one journal article	0.756	0.056	.001	
Coll29	At least one of our collaborative project outcomes was filed for a patent	0.803	0.056	.001	
Coll30	Some of our collaborative project outcomes have yielded new business practices/products/services	0.854	0.055	.001	
Coll31	We see collaboration with a university as a way forward in our comparative advantage	0.690	0.057	.001	
INNO					0.829
Trad16	We have made a lot of changes over the years in our business process or products	0.662	0.057	.001	
Trad17	Our R&D is effective and fruitful to our business	0.739	0.056	.001	
Trad18	Our management style is influenced by new knowledge in the system	0.780	0.056	.001	
Trad19	Our staff are efficient in undertaking new business processes	0.633	0.057	.001	
Trad20	Our annual budget for research and development is large enough	0.687	0.057	.001	

Note: (0--9)=micro firms, (10--49)=medium size firms, (50--249)=large firms, (250+) very large firms; GSS, (OECD, 2005)

Table 5. Correlations among latent variables and square root of AVEs

Variables	1	2	3	4	5	6
INFO (1)	**0.712**					
U-IC (2)	0.504***	**0.777**				
INNO(3)	0.231***	0.538**	**702**			
Sec(4)	-0.028	0.092	0.029*	**1**		
Size(5)	-0.038	0.008	-0.006	-0.51	**1**	
INFO*U-IC(6)	-0.179*	-0.267*	-0.201*	-0.141*	**0.**026	**0.576**
AVEs	0.507	0.604	0.493	1	1	0.332

Note: Square root of Average Variance Extracted (AVEs) shown on diagonal
Sign. (0.05): *, p<0.10; **, p<0.05; ***, p<0.001.

Table 6. Inner model evaluation

	Description	Threshold	Path (Hypothesis)	Values Achieved	Outcome
β	Estimate of the relationship between exogenous and endogenous latent variables in a model: $(0 \geq \beta \leq 1)$	It is important to consider algebraic sign, magnitude and statistical significance of path co-efficient. $\beta > 0.10$ (Urbach and Ahlemann, 2010)	H_1	0.554	A regression weight of 0.554 is strong for the exogenous latent variable and endogenous latent variable and is far higher than the threshold; $\beta < 0.10$; **(Strong)**
			H_2	-0.062	A regression weight of -0.062 is too weak between the exogenous latent variable and endogenous latent variable and less than recommended value; $\beta < 0.10$ **(Too weak)**
			H_3	-0.068	A regression weight of -0.068 is ok between the exogenous latent variable and endogenous latent variable and the absolute values is; $B < 0.10$; **(Too weak)**
R^2	This is a measure of the variance explained by the exogenous latent variable of the total variance in the endogenous; $(0 \geq R^2 \leq 1)$	Substantial = 0.670, average = 0.333 and as low = 0.190 Chin, (1998) Substantial=0.75, Moderate=0.50 Weak=0.25 (Hair et al., 2014b)	H_1	0.296	Explains very little of the total variation in the endogenous latent variable; even less the low of both criteria: (29.6%); **(Average)**
			H_2	0.014	Explains relatively low variation of the total variation in the endogenous latent variable: (1.4%); **(Weak)**
			H_3	0.014	Explains relatively low variation of the total variation in the endogenous latent variable: (1.4%);(**Weak)**
f^2	Measure the impact of the exogenous latent variable on the endogenous latent variable; $(0 \geq f^2 \leq 1)$	Low=0.020, Medium=0.150 Large=0.350, (Cohen, 1988)	H_1	0.298	A relatively low impact of the exogenous latent variable on the endogenous latent variable; **(Large)**
			H_2	0.014	A medium impact of the exogenous latent variable on the endogenous latent variable; **(Low)**
			H_3	0.014	A large impact of the exogenous latent variable on the endogenous latent variable; **((Low)**

Q^2	Measure the predictive relevance of the endogenous latent variable on the endogenous latent variable	Q2>0.00 (Fornell and Cha, 1994).	H_1	0.299	Appeared as relevant exogenous latent variable on the endogenous latent variable; **(Relevant)**
			H_2	NA	
			H_3	NA	

Note: $R^2 = 0.296$ is the combined contribution of two latent variables

Table 7. Path coefficients for the latent variables

Hypothesis	U-IC	INFO	INFO*U-IC	INNO	S.E.	P-value
H_1	0.554				0.06	0.001
H_2		-0.062			0.07	0.197
H_3			-0.068		0.06	0.028
INFO*U-IC				-0.068	0.05	0.113
Control variables						
Sectors				-0.034	0.06	0.290
Firm size				-0.013	0.05	0.401

Table 8. Model results summary

Hypothesis	Test Results
H_1: University-industry collaborative is positively associated with firms' innovation performance.	Supported
H_2: Informal mechanisms of university knowledge transfer are positively associated with firms' innovation performance.	Not supported
H_3: Informal mechanisms of university knowledge transfer negatively moderate the association between university-industry collaboration and firm's innovation performance.	Not supported

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