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RESEARCH ARTICLE



The influence of informal mechanisms of university knowledge transfer on firm level innovation performance: an empirical analysis in Ghana

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ABSTRACT

This study seeks to investigate firm-level innovation, exploring whether social relationships located in knowledge networks influence the transfer of university knowledge to Ghanaian firms. Firms' informal relationships with universities have been under-researched in developing economies. The extant literature suggests that informal relationships in the context of economies with advanced regional and national innovation systems have a positive association with firm level innovation performance. The research project employs a cross-sectional survey of 245 firms in Ghana. The aim of the project is to explore the influence of informal mechanisms of university knowledge transfer on firm level innovation performance in Ghana. The study adopts a structural model with partial least squares as an analytical technique. The findings reveal that to deliver positive results in a firm's innovation performance by informal means, a well-coordinated social system to attract research knowledge from all aspects of the university system is required. The research project's implications for Ghana's innovation system include a need to be aware of the impact of corruption and lack of intellectual property rights on the efficacy informal knowledge transfer.

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KEYWORDS

University knowledge transfer; knowledge networks; innovation; Ghana


Introduction

The transfer of knowledge from universities to industry is important for firms' market competitiveness (Lam 2000; Victoria et al. 2015). As a result, there is the need for university generated knowledge to be more industry focused to support economic growth (Gibbons et al. 1994). Accordingly, universities are now under pressure to account for public investment and cannot therefore continue to be 'Ivory Towers' (Caniels and Van den Bosh 2011). Extant knowledge generation in universities and subsequent effective transfer to industry literature is typically undertaken in economically advanced nations (Hobday 2005; Léger and Swaminathan 2007). Further, most research undertaken in university knowledge generation typically adopts a qualitative paradigmatic approach, this may limit the generalisability of research findings. This leaves a knowledge gap in the literature on universities' impact on industry in developing economies (Barnes, Pashby, and Gibbons 2002; Hobday 2005). Another issue is that university knowledge transfer literature (Hamilton and Philbin 2020; Cheng 2020) tends to concentrate on formal collaboration, contract research and joint research involving patents, licencing,

and spinoffs, once again, conducted in economically advanced nations (Cohn 2013; Hughes and Kitson 2012). Furthermore, Mendoza-Silva (2020) identifies the need to undertake research into the relationship between informal networks and the innovation capability of firms.

Historically, Ghana's budget statements link knowledge and innovation requirements to actual global economic trends in an environment of persistent international trade deficits (Minister for Finance 2015). Amidst improvement in the knowledge of the market and a constant influx of foreign products and services, the Government of Ghana has called for private sector involvement in economic growth and development. These pleas hinge on the need for new technological solutions to help grow the economy. In addition, there is pressure on knowledge generation actors to ensure that academia and industry work closely together in a productive co-ordinated manner.

Social capital is omnipresent in Ghana, permeating through every facet of society (Adjargo 2012). Adjargo (2012) states, Ghanaians employ social capital as a means to support informal mechanisms of innovative

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technology being transferred to, and being adopted by, Ghanaian farmers. Indeed, given the low level of literacy in Ghana (69.8%), particularly in the rural areas (Ghana Population and Housing Census 2021), informal mechanisms of university knowledge transfer, supported by social capital, may facilitate knowledge transfer. For instance, Ghanaians live in communities, clans, groups and tribes, and adopt a community-based approach for issues of security, information sharing and knowledge dissemination (Bonye, Thaddeus, and Owusu-Sekyere 2013). University researchers form part of the communities and traditionally are typically duty bound to informally offer guidance given their access to university research knowledge. Dissemination of knowledge through informal means and networks may help increase levels of innovative activity. Research undertaken into how such dissemination can be more efficiently and effectively undertaken will be beneficial for Ghana and other developing economies. Through informal mechanisms, university knowledge may trickle down to communities and help work towards resolving global inequalities.

Idea exploitation and the commercial interest of industry, universities and the Government of Ghana have shaped the focus of this research. Namely, to provide empirical data relating to the influence of social relations and knowledge networks on firm level innovation performance. For instance, social networks are documented as enablers of interpersonal relationships among firms and a fertile ground for intellectual capital creation, as an outcome of social capital (Huggins and Johnson 2012). In the knowledge generation infrastructure, universities often form the hub around which exchange of knowledge revolves. In view of this, the study seeks to analyse the significance of social relations and knowledge networks in university knowledge transfer for Ghanaian firms' innovation performance. The study also intends to offer empirical explanations on the roles of social relations and knowledge networks in the knowledge transfer process in developing West African countries per se. Indeed, social networks resultant of social capital are said to contribute to network capital, that helps tie firms together in inter-organizational knowledge networks (Huggins and Johnson 2012). To explore this, the study uses partial least squares structural equation modeling to investigate the influence of informal knowledge transfer mechanisms and knowledge networks on firms' innovation in Ghana, with the research focus on incremental dimensions rather than radical. To underpin the study objectives, three hypotheses are created from extant literature to investigate empirical data with a resulting structural model as our conceptual framework.

For the rest of the paper, the second section covers a critical review of available literature where a conceptual model is developed with three proposed hypotheses for analysis. In the third section, data collection, methods of sampling and use of analytical tools are discussed leading to findings in section four and discussions in section five. The final section is the conclusion which also contains the policy implications, limitation, and recommendations for further studies.

Literature review

Universities' interactions with industry are essential for their mutual good (D'Este and Patel 2007; Rossi and Rosli 2013) and for value creation (Van Horne, Poulin, and Frayret 2010). Such interactions with firms helps universities gain industry experience, obtain data, develop new methods and extend the boundaries of knowledge, and crucially, attract private funding from industry. Consequently, firms achieve their business objectives through improved business practices and more efficient use of technology to solve their production problems (Kaymaz and Eryigit 2011; Bradley et al., 2013). Universities traditionally have been the providers of mass education, development of a skilled workforce and involved in curiosity-driven research. Notably, World economic crises in recent decades have led to universities employing a third stream of responsibility by engaging industry to transfer knowledge for commercial benefit and wealth generation (Guimon 2013; Abdulai, Murphy, and Thomas 2015).

Accordingly, governments have also encouraged this paradigm shift and influenced university involvement with industry through knowledge transfer initiatives. Here, there have been interventions to strengthen entrepreneurial activities with procedural machinery such as technology transfer offices and innovation centers. Finally, current global economic development policies encourage an increase in universities' interactions with businesses to be able to self-fund their research projects (Etzkowitz et al. 2000; Hagedoorn et al. 2000). A test case is the Bayh-Dole Act of 1980 in the US, which formed a policy framework where proprietorship of university research outcomes is explicitly clear in its conditions, resulting in federal government funded research project outcomes a university bona fide (Deiaco, Hughes, and McKelvey 2012). In the Ghanaian context, political independence from British rule in 1957 led the young sovereign nation to set up universities primarily to train a more skilled and productive workforce for the new state. Research was also encouraged to support significant technological development for its then comparatively fragile economy. From this time,

economic development and industrialization were top of the government agenda. For the Ghana government and its business community, knowledge, science and technology would drive government machinery for economic growth leading to an expected 'trickledown' effect on the social lives of citizen (Sawyer 2004; MEST 2010).

Unfortunately, several decades after the declaration of independence, a report by the Organization for Economic Co-operation and Development (OECD) in 2013 described co-operation and co-ordination among institutional players set up by the Ghana Government to govern science, technology, and innovation as weak and dysfunctional (OECD 2013). Similarly, policy frameworks over the years, designed for science, technology and innovation lacked the needed focus on economic growth and development priorities. It follows then, that policy makers in Ghana did not have the necessary awareness and capacity to set national goals (OECD 2013). As a consequence, science, technology and innovation (STI) strategies implemented by past Ghana governments, according to MEST (2010), made limited impact on the lives of ordinary Ghanaians.

Other Ghanaian context concerns include levels of corruption and intellectual property rights. Comparatively high levels of corruption in Ghana (Transparency International 2021) typically negatively impact on Ghana's development (Forson et al. 2015; Asomah 2021). Intellectual property rights are also a principle factor influencing knowledge transfer and innovation levels. The application of intellectual property rights is open to interpretation in developing countries. A strict application of intellectual property rights may stifle a country like Ghana's development (De Beukelaer and Fredriksson 2019). A conflicting view presented by Lui (2016) is the development of lower-income countries such as Ghana would benefit from robustly implemented intellectual property rights. To reconcile these different viewpoints, Adams (2008) states intellectual property rights should be designed to complement a country's stage of development. Consequently, Ghanaian intellectual property legislation should reflect its stage of development.

In line with the Ghanaian practical situation describes above, critics of innovation frameworks, particularly that of the Bayh-Dole Act (1980) in the USA, have contended that there is no convincing evidence of any direct impact of such policies (Janz, Lööf, and Peters 2004; Mowery and Sampat 2005). Notwithstanding, this policy framework has been adopted as a model instrument for a number of governments. For instance, some governments in OECD countries such as Denmark and Germany (Geuna and Muscio 2009) have replicated it

to encourage their universities to work together with industry to strengthen regional and national innovation systems and facilitate social and economic growth and development (Mowery and Sampat 2005). This study seeks to offer guidance to Ghanaian policy makers on how informal knowledge access may be harnessed to increase firms' level of innovative activity and consequently, Ghana's economic development.

Knowledge transfer is a fundamental determinant of firms' innovative activity which consequently may accelerate economic growth and social development (Tekic et al. 2013). As a result, scholars of knowledge of the firm (Kogut and Zander 1992, 1993) and university knowledge transfer (Hamilton and Philbin 2020; Cheng 2020) recognize the significance of different types of mechanisms available to firms to influence knowledge production. Additionally, informal interactions between university faculty members and firms are known to lead to innovation in firms and further to formal collaborations and productive partnerships (Bradley et al., 2013). Informal mode of university knowledge transfer is the transfer of knowledge through personal contacts between university researchers and entrepreneurs and facilitated by interactions within social networks, for example, meetings, and at conferences. It is known for its extensive tacit characteristics in its mode of diffusion and believed to facilitate the flow of technological knowledge through informal communication process (De Wit de Vries et al. 2019). However, the difference between formal and informal mechanisms is blurred and difficult to identify. A reason for this is personal agreements may lead to formal relationships and therefore becomes legally binding on consenting parties. Known for its extensive codification prominence and strict procedural machinery for generation, studies show that formal mode of university knowledge transfer typically encompasses a legal contract between a university and a firm. The definition remains ambiguous though, inviting controversies among researchers (Thomas, Brooksbank, and Thompson 2009). Nonetheless, in most formal university knowledge transfer there are specific target outcomes to be achieved (Muscio, Quagliione, and Vallanti 2013). It is stated in the literature that firms which use both formal and informal mechanisms of knowledge are more likely to benefit from external knowledge sourced at universities (Howells, Ramlogan, and Cheng 2012; Grimpe and Husing 2013).

Typically, any informal process through which knowledge is transferred to firms from universities is often referred to as 'gray market' in the technology transfer literature (Bradley et al., 2013). de Wit, Dankbaar, and Vissert (2007) explain that the grey market is under-

researched and claim though that firms cannot rely totally on interpersonal relations with university researchers for innovation and competence development. Internal firm R&D they suggest should be enhanced to support absorptive capacities for external knowledge inflow and not rely only on freely disseminated knowledge, which has little or no substantial evidence of innovation outcomes. It is expected that most firms, particularly in developing economies, use informal interactions to strengthen their knowledge capability (Mowery and Sampat 2005). Evidence from the US manufacturing sector indicates that 90% of university partnerships in a corporate research environment are initiated through informal contacts (Hagedoorn et al. 2000). Although, Hagedoorn et al. (2000) warns that the informal mode of knowledge transfer can at times be difficult to evidence. Rossi and Rosli (2013) add that open disseminated sources of knowledge have no substantial of impact on firms' intellectual property nor national economic growth and development. In Ghana, informal mechanisms of knowledge transfer are typically used by firms because the majority of them are small, with comparatively fewer resources and lack of capacity to absorb higher level technology developments (Fu et al. 2014).

In summary, irrespective of the mechanism (formal or informal means), knowledge transfer from universities to industry may now be considered to be a fundamental aspect of firms' knowledge and learning process, and a start point of economic success for regions and nations (Abdulai, Murphy, and Thomas 2015). Geuna and Muscio (2009) assert that workshops, conferences, seminars, and other informal mechanisms of knowledge transfer, in general, are recognized as interactions which facilitate the sharing of knowledge. They argue that most formal collaborations and all sorts of partnerships gain their routes from informal links. In effect, universities need industry for financial support for research projects, and industry also needs university-generated research outcomes to create wealth and remain competitive in the market. With the mechanisms discussed, stakeholders have an eminent role to play to improve the effectiveness of university-industry interactions (Siegel et al. 2003). Consequently, this research paper focuses on how social interactions can be harvested in the knowledge generation space for the benefit of Ghanaian firms' innovation performance.

Firm-based knowledge is often considered to be a source of competitive advantage (Cooke and Leydesdorff 2006). Firms as social entities, generate knowledge internally, exchange with other firms and institutions through several mechanisms in a complex network (Kogut and Zander 1992, 1993). Moreover, within the

firm exists a knowledge-base and it is predominantly tacit; residing in individual employees and is difficult to replicate by competitors (Smith 2001; Su, Lin, and Chen 2015). Also, explicit knowledge is another form of a firm's knowledge, a resource that is codified and easy to emulate through social contacts and externalities (Smith 2001; Takeuchi 2013).

Additionally, from an epistemological point of view, individuals are essentially the primary agents of the firm's knowledge capability (Smith 2001; Audi 2011). However, people often move within their social networks due to labor mobility and this may impact on firm-level knowledge (Kogut and Zander 1992). This indicates that firms should ideally be the custodians of their own knowledge. Thus, they preserve the knowledge, norms, beliefs, behaviors, cultures, and values, thereby maintaining the organisational innovative momentum which may contribute to competitive advantage (Edelman et al. 2004).

Firms learn through codified knowledge that is scientific and technical in content – known as the Science, Technology, and Innovation (STI) mode of learning (Smith 2001). Other firms may learn through the experienced-based mode of learning; thus, Doing, Using, and Interacting (DUI) mode (Smith 2001). Depending on the context, extant literature shows that the two have been effective in firm competence building at both the regional and national economic development levels (Smith 2001). Even with either modes of knowledge in firms, evidence further suggests that firms can no longer survive in isolation (Pittaway et al. 2004). This is because the growing demand of complex knowledge-based economies requires firms to take full advantage of knowledge stockpile found in knowledge networks (Cooke and Leydesdorff 2006). As Chesborough (2003) states; '... not all of the smart people in the world work for us'. This suggests that effective interaction with other institutions is vital for firm-level innovation (Abdulai, Murphy, and Thomas 2015). Note also, that Pittaway et al. (2004) warn of network failures and limitations, showing that inter-firm conflicts could arise among firms. Further, when firms join local, national, or international networks they may benefit from lower transaction costs and risk sharing search for knowledge (Murphy, Huggins, and Thompson 2015). A study by Cadger et al. (2016) reveals that knowledge transfer and exchange are effective among farmers who develop good social ties and belong to social networks. Farmers have more exposure to new and innovative agro-ecological practices in Ghana (Cadger et al. 2016).

Innovation may be considered to be a key driver of economic growth and development. Consequently, both public and private organizations may benefit

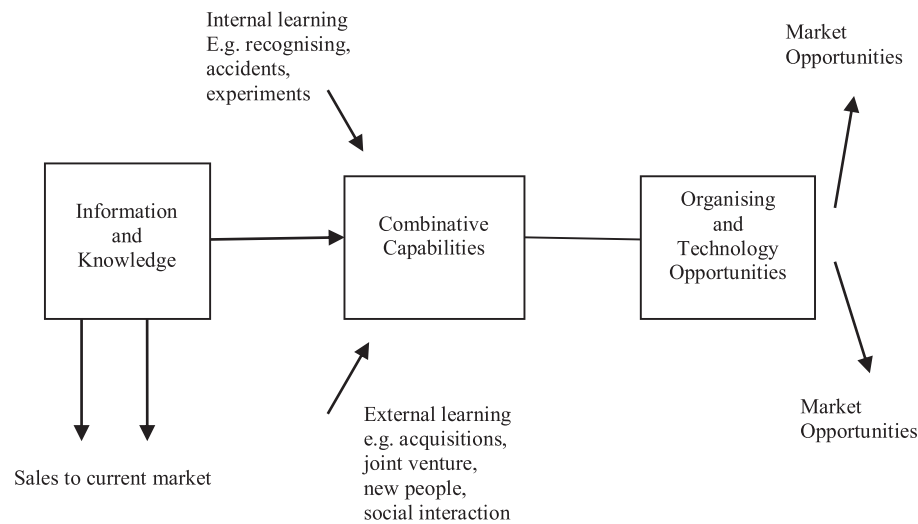
from connecting with individuals, experts, firms, and institutions to enhance innovative performance (OECD 1997; Clancy and Moschini 2013). Governments have played the role of facilitation in industry-university interactions as proposed by Etzkowitz and Leydesdorff (1997, 2000). Such interactions may take place in the context of the Triple Helix framework where an interface is created amongst industries, universities and governments to co-produce knowledge for innovation. In this framework, actors assume the traditional role of each other in an 'innovation space' (Etzkowitz 2002). Although, the Triple Helix framework is heavily criticized for both theoretical and practical reasons, Tunnainen (2002) suggests that the framework has yielded empirical data that calls for future research. For instance, the UK Government is an example with its Research Excellence Framework (REF), which brings in substantial funding for highly ranked universities in areas that yield research results for direct application in industry. Universities can help improve levels of technological innovation and increase the innovative momentum of firms. (Kaymaz and Eryigit 2011).

Innovation happens in a complex network of interconnected structures and institutions interacting in feedback loops seeking relevant innovation for social growth and economic development (Edquist 2001). A loop made of institutions, universities, firms and government agencies. Innovation system theory seeks to explain the generation and transmission of knowledge and technology for firm's innovation performance (Mosey, Wright, and Clarysse 2012). For instance, a national innovation system is the purposive formal interactions that take place among firms, universities, and other stakeholders for the purpose of gaining commercialization, patents, and co-publications. In this system, knowledge exchange for innovation in firms also emanates from informal linkages, where technology and information diffusion, personnel mobility, and technical staff move between public and private sector firms are common (Dooley and Kirk 2007). For Nelson and Winter (1982) and Rosenberg (1982) innovation is a process that brings improvement in solving problems whether business or social, for example, newness in method. Unfortunately, the lack of full understanding on how and whether innovation really affects firms' performance is due to lack of bespoke framework to help determine that in the existing body of knowledge. Nevertheless, Geroski (1994) explains the impact of innovation on firm's performance to manifest in, among other things, its introduction of new processes, product differentiation and marketing, and the ability of a firm to enhance its internal capabilities to respond to market pressures.

For innovation performance, there is a wide variety of university knowledge transfer mechanisms and activities that firms strategically select depending on which suits their area of operation, discipline, industry and even interest (Bradley et al., 2013). Mostly, micro and small enterprises, even start-ups, particularly in low-income countries, rely on their casual contacts with university researchers, which are considered informal form of university knowledge transfer (Bailey, Cloete, and Pillay 2011). Other recognised informal sources available in the literature are knowledge spillovers, conferences, student placements, workshops, and labour mobility where they acquire knowledge or absorb new ideas to achieve incremental changes (Pittaway et al. 2004).

In addition, networks offer seemingly limitless opportunities in the knowledge value chain for new products and services to be developed (Chesborough 2003). Indeed, the development of network theory has enriched further understanding of the relevance of knowledge networks in knowledge transfer process including knowledge from universities. However, our understanding of their formations and relevance to firms' innovation performance in developing countries still remains largely unknown. Arguably, knowledge networks are central to university knowledge transfer that often leads to increased organisational efficacy and economic sustainability (Huggins and Johnson 2012). To a large extent, firms in specific geographical areas and disciplines are encouraged to form networks to absorb university knowledge and re-enforce innovation processes (Huggins and Johnson 2012). Network theory places emphasis on network members' exploitation of low transaction costs advantages and risk sharing (Murphy, 2011). It may be stated that no individual organisation holds all expertise and resources to exclusively develop successful innovation and will require supportive network input at some point (Chesborough 2003). To further support this, in a review of evidence of networking for innovation, Pittaway et al. (2004) indicates that firms that do not network either formally or informally stand little chance of accumulating competitive organisational knowledge base to stand competition in the twenty-first century.

Figure 1 shows how firms accumulate both tacit and explicit knowledge internally and externally to gain competitive advantage and remain profitable (Smith 2001). The hypotheses below are created within the remits of firm's knowledge acquisition process as documented in extant literature. In their argument, Kogut and Zander (1992) support the claim that knowledge within a firm is a combination of internal and external learning processes that serve as a foundation upon which economically valuable products and services can



Source: (Kogut and Zander, 1992)

Figure 1. Growth of knowledge of the firm.

be realized. A pragmatic approach on how firms generate new knowledge suggests that firms combine their capabilities to learn new skills and increase their core competence. The combined capabilities encompass several elements including know-how based on internal and external learning mechanisms. In principle, this supports the creation of a research model to help interpret the relevance of social interactions through knowledge networks and inter-organisational links in an innovation system (Lam 1997).

Our conceptual model in Figure 1 is sourced broadly in the innovation systems theory (Lundvall 1992; Freeman 1995), network theory (Huggins, Johnson, and Steffenson 2008; Huggins and Johnson 2012), organisational learning theory (Smith 2001), the theory of the

firm (Kogut and Zander 1992, 1993) and the theory of social capital (Edelman et al. 2004; Murphy, Huggins, and Thompson 2015). We integrate these theories to help explain firm-based knowledge and how informal university knowledge transfer mechanisms and knowledge networks (Hamilton and Philbin 2020; Cheng 2020), support internally generated knowledge. We eventually draw these from the framework by Kogut and Zander (1992) in Figure 1 to explain the significance of interpersonal relationships, knowledge networks and their impact on the knowledge base of the firm.

To empirically examine the theory, we adopt the structural model in Figure 2 with the aid of our research hypotheses drawn from extant literature. In their framework, Kogut and Zander (1992) link the knowledge-base

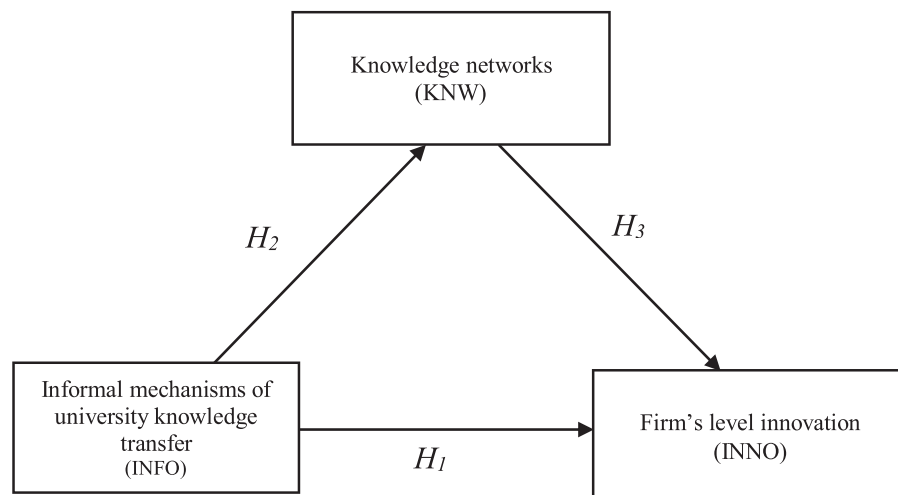


Figure 2. Research model.

of the firm to external social institutions to include both private and public research organisations and universities. Purposely, this is an attempt to explain how firms acquire knowledge from the networks within which they are embedded. Our primary concern here is the benefit of social capital; thus, informal interactions through which firms learn and equip themselves with knowledge to remain competitive.

Naturally, the knowledge of firms is socially embedded (Adler and Kwon 2000; Nahapiet and Ghoshal 2000) and invariably accounts for the diverse nature of business activities across varying firms in different geographic locations (Lam 2000; Howells, Ramlogan, and Cheng 2012). As a social community, firms are a repository of knowledge and influenced by internal operational structures and the capacity to acquire knowledge from external sources for their combinative capabilities (Kogut and Zander 1993; Autio, Hameri, and Vuola 2004). Significantly, external social organisations, networks and sub-networks may determine what happens to knowledge acquisition in firms Kogut and Zander (1992). There is little understanding in economically developing economies on how innovation affects business performance. On this basis, the following hypotheses are developed from the literature to empirically investigate the link between the social dynamics of knowledge transfer and firms' innovation performance in Ghana:

H₁: Informal mechanism of university knowledge transfer is positively associated with innovation in firms in Ghana.

H₂: Informal mechanism of university knowledge transfer is positively associated with knowledge networks in Ghana.

H₃: Knowledge networks are positively associated with innovation performance in firms in Ghana.

Research methodology

The data is collected through a primary source in a cross-sectional survey in Ghana and involved firms across three sectors of the Ghanaian economy, namely primary, manufacturing and service sectors. In the absence of an innovation database with well-defined indicators in Ghana, an instrument has been designed taking into consideration the requisite conditions to reduce all forms of biases for validity and reliability. The self-administered survey was completed by senior-level staff at the firms in the sample. The instrument was a 5-point Likert scale questionnaire which was pre-tested (Punch 2005) and reliability test values were as high as 0.82 (Cronbach α). It is designed to obtain

information based on the experiences and knowledge of respondents on forms of informal relationships their firms had with universities and other knowledge sources, for innovation performance (Gorard 2003).

To measure innovation performance, both soft and tangible elements were considered to ensure validity. Responses are elicited on innovation such as changes made to products and processes, and budgetary allocation for R&D. Then, changes in marketing strategies, general newness in methods, capacity building and management style are considered. For informal mechanism, a relationship with at least one university academic is included, as is, interest in published academic literature and general association with university research staff at personal level. Finally, with knowledge networks, firms' connections with groups and associations available for knowledge dissemination are rated by respondents, another is firms' openness to external sources knowledge consortia and strategic partnerships.

All firms in the survey were private and included: wholesale, retail and processing firms, knowledge delivery and ICT organisations. Stratified simple random sampling method was employed for the sectors, intended to obtain a well-represented sample of data (Cohen and Manion 1985; Krippendorff 2004). Two databases from the Association of Ghana Industries (AGI) and National Small Scale Industries (NBSSI) were accessed to obtain a sample frame of 800 firms. The three industry sectors are considered and 245 usable questionnaires were collected with two follow-ups to obtain a 30.63% response rate (Podsakoff et al. 2003). For a medium effect size of 0.10, a sample size of 100 was estimated a priori for a power of 0.80 (Cohen 1992).

On non-response bias checks, there was no statistically significant difference between early and late respondents in their responses with respect to all the variables 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 KNW; $t_{(243)} = -1.35$, $p = 0.178$, 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 KNW, which, on graphical inspection was good. 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 nor more than 50% of the variances in the variables either.

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	
					<i>t</i>	Sig. (2-tailed)	<i>F</i>	Sig.
INFO	Early	143	3.00	0.93	−0.598	0.550	0.489	0.485
	Late	102	3.07	0.87				
KNW	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				

Results – partial least squares structural equation modelling

Partial least squares structural equation modelling (PLS-SEM) is employed with WarpPLS v5.0 statistical package and PLS regression algorithm to explore the conceptual relationships between the variables (Urbach and Ahlemann 2010). It is a technique specifically designed to analyse causal relationships between theoretical concepts or models involving multiple constructs with multiple measures as in this study. In typical PLS-SEM-based research, researchers formulate theories where effects or relationships are hypothesized to manifest in a certain direction for empirical testing and is currently widely used (Henseler 2018). It is typically employed for its ability to manage various forms of constructs, thus, both reflective measurement and composite models, it is broadly regarded as the “most fully developed and general system” (McDonald 1996, 240) among variance-based estimators for structural equation modelling.

Missing data are managed with multiple regression imputation and the measurement models are reflectively measured (Groenland and Stalpers 2012).

Significantly, a bootstrapping algorithm was used to estimate the model parameters and standard errors with 5000 resamples in 5 iterations (Gefen and Straub 2005; Christian, Roldan, and Gabriel 2016).

The measurement model is assessed for fitness to the data and constructs internal consistency and reliability, for which composite reliability is recommended in dealing with reflective measurements (Hair et al. 2014). Suggested at 0.80 for a reflective construct, the values obtained for composite reliability indicate a high level of internal consistency and reliability for all the constructs in Table 2, thus; INFO is 0.842, KNW is 0.832 and INNO is 0.830, respectively. For convergent validity between latent variables and their observable indicators, the high outer loadings obtained are consistent with the recommended threshold of 0.50 or higher (Urbach and Ahlemann 2010). For discriminant validity, the square roots of their Average Variance Extracted (AVE) in Table 3 are greater than their highest correlation coefficients with other latent variables (Chin 1988) and VIF reported are less than 3.3 showing no multicollinearity.

Table 2. Combined loadings of the measurement model.

Items	Constructs	Loadings	S.E.	<i>P</i> value	Composite Reliability
INFO					0.842
Inf6	Our organisation has a working relationship with at least one university academic	0.756	0.050	.001	
Inf7	We work closely with at least one university department for guidelines on our operations	0.720	0.055	.001	
Inf8	Our organisation follows the work of some academics for improvement in our process/services	0.704	0.061	.001	
Inf9	Our organisation appreciate research findings in our business area	0.737	0.054	.001	
Inf10	Our organisation takes keen interest in published literature	0.671	0.061	.001	
KNW					0.832
Net22	Our organisation is part of an association that aims for improvement in our business practices through knowledge sharing	0.660	0.072	.001	
Netw23	We are active in connecting with professional associations to share ideas on our business prospects	0.737	0.058	.001	
Netw24	The presence of a higher education institution in our region has connected us with other important agencies that are crucial to our organisation's access to new ideas	0.785	0.061	.001	
Netw25	We give attention to established systems that aim at disseminating knowledge in our business interest area	0.646	0.088	.001	
Netw26	We sometimes work with agents that open opportunities for us to gain skills that we need for our business success	0.681	0.064	.001	
INNO					0.830
Tra17	We have made a lot of changes over the years in our business process or products	0.681	0.064	.001	
Trad18	Our R&D is effective and fruitful to our business	0.669	0.068	.001	
Trad19	Our management style is influenced by new knowledge in the system	0.727	0.053	.001	
Trad20	Our staff are efficient in undertaking new business processes	0.731	0.063	.001	
Trad21	Our annual budget for research and development is substantial	0.719	0.063	.001	

Table 3. Correlations among latent variables and square root of AVEs.

Variables	INFO	KNW	INNO	VIF
INFO	0.718			1.23
KNW	0.225***	0.704		1.85
INNO	0.357***	0.528***	0.706	

Note: Square root of Average Variance Extracted (AVEs) shown on diagonal. Sign. (0.05): *, $p < 0.10$; **, $p < 0.05$; ***, $p < 0.001$. VIF below 3.3 shows no multicollinearity.

(Kock and Lynn 2012). Finally, for unidimensionality the manifest variables loaded rightly (more than 0.60) only on their respective constructs (Gefen and Straub 2005). In the Table, the correlation among the variables is high enough to guarantee the use of the chosen technique for reliable results.

In Table 4, the path coefficients (β) evaluate and explain the relationship between the latent variables in the model and here H_1 is too weak (0.09) meaning statistically, there is no relation between informal

mechanisms of university knowledge transfer and innovation performance in firms as shown in Figure 2. Hypotheses H_2 and H_3 show a strong relationship of 0.36 and 0.52 respectively in their response variables due to unit changes in their predictor variable as a result of unit changes in their response variables. The coefficient of determination (R^2) reveals a very low explanatory tendency of 0.024 for H_1 as well, low of 0.131 for H_2 and average of 0.286 for H_3 . The effect sizes (f^2) are fine for all models although theoretically low (0.052) for H_1 . Lastly, Q^2 for the predictive relevance of the observable indicator variables are above zero as required ($Q^2 > 0.00$) indicating their weight and influence in the models (Fornell and Cha 1994).

Table 5 presents the model results and shows a statistically non-significant relationship ($H_1; \beta = 0.087$, $p > 0.05$) between INFO and INNO but a statistically significant and positive relationship ($H_2; \beta = 0.362$, $p < 0.05$) between INFO and KNW and again between KNW and

Table 4. Structural model validation.

	Description	Threshold	Path (Hypothesis)	Values achieved	Outcome
β	This estimates the relationship between exogenous and endogenous latent variables in a model: ($0 \leq \beta \leq 1$)	It is important to consider algebraic sign, magnitude and statistical significance of path co-efficient. $\beta > 0.10$ (Urbach and Ahlemann 2010)	H_1	0.09	A regression weight of 0.09 is too weak between the exogenous latent variable and endogenous latent variable and is far less than the threshold; $\beta < 0.10$; (Too weak)
			H_2	0.36	A regression weight of 0.36 is large between the exogenous latent variable and endogenous latent variable and is more than recommended value; $\beta > 0.10$ (Substantial)
			H_3	0.52	A regression weight of 0.52 is strong between the exogenous latent variable and endogenous latent variable and is more than half (52%); $\beta > 0.10$; (Strong)
R^2	This is a measure of the variance explained by the exogenous latent variable of the total variance in the endogenous; ($0 \leq R^2 \leq 1$)	Substantial = 0.670 average = 0.333 and as low = 0.190 Chin (1998) Substantial = 0.75, Moderate = 0.50 Weak = 0.25	H_1	0.024	This explains very little of the total variation in the endogenous latent variable; even less the low of both criteria: (2%); (Very low)
			H_2	0.131	This explains relatively low variation of the total variation in the endogenous latent variable: (13%); (Low)
			H_3	0.286	This explains relatively low variation of the total variation in the endogenous latent variable: (29%); (Average)
f^2	This measures the impact of the exogenous latent variable on the endogenous latent variable; ($0 \leq f^2 \leq 1$)	Low = 0.020, Medium = 0.150 Large = 0.350	H_1	0.052	This is a relatively low impact of the exogenous latent variable on the endogenous latent variable; (Low)
			H_2	0.131	This is a medium impact of the exogenous latent variable on the endogenous latent variable; (Medium)
			H_3	0.286	This is a large impact of the exogenous latent variable on the endogenous latent variable; (Large)
Q^2	This measures the predictive relevance of the endogenous latent variable to the endogenous latent variable	$Q^2 > 0.00$ (Fornell and Cha 1994).	H_1	NA	NA
			H_2	0.133	This appears as a relevant exogenous latent variable to the endogenous latent variable; (Relevant)
			H_3	0.315	This appeared as a relevant exogenous latent variable on the endogenous latent variable; (Relevant)

Note: $R^2 = 0.315$ is the combined contribution of the two latent variables as seen in Figure 2.

Table 5. Path coefficients for latent variables.

Hypothesis	Direct effect(β)	Indirect effect(β)	Total effect(β)
H_1	0.087 (0.10)	0.188*** (0.11)	0.275*** (0.11)
H_2	0.362*** (0.07)	NA	NA
H_3	0.520*** (0.06)	NA	NA

Note: sign.:*, $p < 0.05$, **, $p < 0.10$, ***, $P < 0.001$.

Standard errors in brackets.

VAF is the proportion of total effect accounted for by the mediating variable (knowledge network).

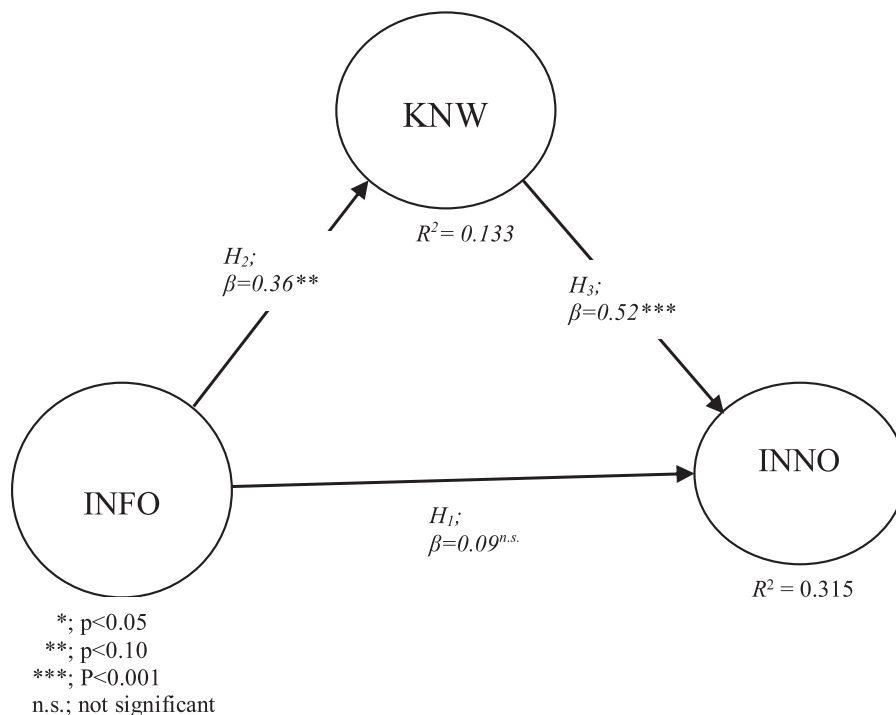
INNO ($H_3: \beta = 0.520, p < 0.05$). Notably, the significant and positive indirect effect of 0.188 ($p < 0.001$) for KNW as a mediator is found to perform a full mediating role between INFO on INNO. The total effect ($\beta = 0.275, p < 0.006$) is not only equally significant and positive but also reasonably strong. Figure 3 gives a structural and statistical representation of the relationships.

Discussion

The study was built on the premise that informal mechanisms of university knowledge transfer and knowledge networks have a positive influence on innovation performance in firms (Nielsen 2020; Silva and Cirani 2020). With this focus, the study adopted a structural model with partial least squares as an analytical technique. However, from the results, it is noted that informal mechanisms of university knowledge transfer do not directly influence innovation in Ghanaian firms as proposed. Implicitly, when firms develop relationships

with universities in Ghana through informal mechanisms; knowledge is typically not transferred directly to facilitate changes in business practices and products. Conversely, we find in previous studies that proximity to universities fosters social relations and familiarity with researchers, in turn, supports business processes and services improvements with new knowledge (Brown-Luthango 2012; Ponds, Oort, and Frenken 2010). The findings infer that efforts to make use of published research from universities and other freely disseminated new knowledge do not enhance innovation performance directly in Ghanaian firms. It will also be logical to suggest that innovative activities in firms in Ghana may be influenced by knowledge generated from other mechanisms. It could be generated from other sources such as industry-based research or technology transfer offices. Consequently, links that establish direct contracts with universities, with more procedural aspects, but not through informal interactions, positively impact firm level innovation performance.

Overall, our findings have not corroborated with extant literature on the effects of social interactions, the benefits of social capital and informal knowledge channels on organisational progress, wealth creation and economic growth (Huggins and Johnson 2012; Thomas and Murphy 2019). Yet, in reference to researchers, such as de Wit, Dankbaar, and Vissert (2007), we know that sometimes external sources, including openly disseminated knowledge are not particularly

**Figure 3.** Structural model.

reliable for firms to source innovative ideas from. Indeed, Howells, Ramlogan, and Cheng (2012) contend that both formal and informal mechanisms of university knowledge transfer produce positive innovative results.

In other research, Abreu et al. (2008) and Meyer-Krahmer and Schmoch (1998) have observed the positive effects of firms' informal interactions with universities directly on firms' core competence, and sometimes indirectly as a viable platform for further collaborations and partnerships to evolve in the long run. The position of this research is that, given the literature is in the context of advanced economies, our findings in this study are a contribution to knowledge in the context of Ghana. This contribution is primarily founded on the principles of relational theory, the theory of social capital and network literature (Hitt, Lee, and Yucel 2002; Edelman et al. 2004), where it is apparent that a firm's relationships may have both positive and negative consequences. To elaborate further, mistrust in a social system and even in administrative and political structures of a society, if not managed well, particularly by leaders and people in responsible positions and positions of trust, can erode the positive effects of social capital. Possibly, this finding is an outcome of a system in Ghana that has lost faith in institutions that are supposed to create and sustain social norms, beliefs and rules that should be collectively self-reinforcing. The loss of trust in institutions is likely to have been initiated and sustained by corrupt practices. In turn, corruption states Forson et al. (2015) acts as an inhibitor to development in Ghana. Due to contracts not being strictly enforced by formal institutions, trust is considered an important economic exchange lubricant in West African economies (Kuépiéa, Tenikuea, and Walther 2016). The findings of (Kuépiéa, Tenikuea, and Walther 2016) may suggest that an impact of a loss of trust may be magnified given a lack of formal contracts, especially among the poorer members of society. As a result, instead of social capital facilitating access to valuable and innovative knowledge, informal relationships in Ghana appear not to support to increased levels of innovative activity. This is evident in a lower factor loading of 0.646 in Table 2 for the construct dealing with trust among actors in the university knowledge generation and transfer system and could be said to manifest a similar scenario in the Asian economies noted in the literature (for example, Adler and Kwon 2000). One other set-back noticed, could be what Hitt, Lee, and Yucel (2002, 357) called '...conscientious exploitation of eminent relationship with political, regulatory, and government posts', where only firms and business executives that have links with certain power sources have the benefit of social capital to the neglect of others. In

support, Asomah (2021) warns of the negative impact corruption can have on Ghana's development.

The findings further reveal that knowledge networks have been empirically found to have a form of mediating influence between informal mechanisms of university knowledge transfer and innovation performance in firms (Nielsen 2020; Cheng 2020). Thus, our second (H_2) and third (H_3) hypotheses suggest direct relationships between knowledge networks and both informal mechanisms of university knowledge transfer and innovation performance in Ghana are supported. Meanwhile, despite informal mechanisms not appearing to influence innovation performance directly, according to the results, there is evidence of its influence on knowledge networks resulting in a cumulative effect of the two, leading up to a 27% increase in innovation performance in firms in Ghana. In this case, it can be interpreted that as stated in the literature (Hagedoorn et al. 2000), business owners' informal links and social interactions with universities in Ghana eventually strengthen weak ties. Consequently, the result creates more trust and long-term productive knowledge networks that support the transfer of university knowledge to firms for innovation and wealth creation. This is how the outcome of social capital really impacts on firms' competence and yields commercial benefits (Adler and Kwon 2000). Undeniably, knowledge networks create informal interactions and social capital which may lead to increased levels of innovative activity. Therefore, the findings indicate that firms which are active in connecting with knowledge sources in networks, clusters and innovation systems stand to gain knowledge and subsequently increase levels of innovative activity.

Conclusion

The results of the research reveal that Ghanaian firms are supported in increasing levels of innovative activity by university knowledge transfer, part of which is via knowledge networks, but not directly from informal mechanisms per se. The implication here is that firms in Ghana gain little from their casual/social relationships with universities as knowledge sources. At the firm level, university knowledge via formal contacts, which are mainly based on procedural machinery are generally more productive. However, open access information or knowledge may not help firms become more competitive in Ghana as absorptive capacities are generally low. This is exacerbated by comparatively poorly resourced research teams found in most universities (Kamien and Zang 2000; Ponds, Oort, and Frenken 2010). Also, few well-resourced researchers and their university departments may not be ready to share relevant knowledge. A possible

reason for this is a need to keep control of their intellectual property to claim royalties. University scientists may need to be engaged by firms on more official terms to be committed to generating knowledge for firms.

Corruption typically negatively impacts on Ghana's development (Forson et al. 2015; Asomah 2021). Consequently, it may be the case that if there is a lack of trust in informal knowledge exchange in Ghana, this may in part be due to the country's level of corruption (Transparency International 2021). This has important implications for other developing countries, which may also have comparatively high levels of corruption. Such corruption may limit the efficacy of informal knowledge exchange in countries like Ghana and negatively impact on Ghana's development. The implications for Ghanaian development are to create bespoke anti-corruption policies and bespoke intellectual property rights. Crucially, both sets of policy should be empathetic to Ghana's stage of development.

As evident in the data analysis, knowledge networks by no means constitute effective means to increase levels of innovation in firms. They remain as strong contenders for predictive knowledge generation and provide ease of access to new knowledge in Ghana. As a result, their formation and subsequent activities need to be supported by policy makers at local, national, and international levels. The government of Ghana can encourage the development of social capital and support its effect on firms' level innovation in Ghana. Again, governments of less technologically advanced nations, including Ghana, can facilitate R&D either directly or indirectly by adopting a modified form of the Bayh-Dole Act (1980) to encourage firms' formal links with universities, support knowledge networks and community spirit that can lead to firms benefiting from informal means in university knowledge transfer. The Ghanaian government can offer more support for university research or offer total sponsorships as practised in other economies to stimulate innovation and support wealth creation and economic growth. Finally, to foster economic growth, the institution and implementation of effective licencing and patent systems could encourage both firms and universities in Ghana to engage in effective collaborations and knowledge transfer.

The study is not without limitations and the main one has been the data collection process, which did not cover all the Ghanaian regional administrative capitals to capture data on the use of informal mechanisms of university knowledge transfer. We, therefore, admit a potential response bias during the data collection process. It is recommended to undertake a further study that will cover all the regions in Ghana, increasing the level of generalization of the findings.

Disclosure statement

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