Channels and Types of University Industry University – Industry Technology Transfer and Their Effectiveness: A Case of Public Universities in Uganda

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Abstract

It is widely acknowledged that University-Industrial Technology Transfer (U-ITT) is a key university priority, in addition to the mission of teaching and research. More recently, the increased recognition of universities as core actors in national innovation systems and the changing complexity of societal needs have made it imperative for various stakeholders to work together more strategically. In this vein, we set out to explore the preferred channels and types of U-ITT and their effectiveness. The study intended to answer the following question: What mechanisms do public universities in Uganda use to transfer technology to the industrial sector and how effective are they? We utilised a single case study design anchored in the interpretivist lens and purposively selected a public university that explicitly acknowledges U-ITT as one of its core functions. Data was generated through reviewing government and institutional documents as well as qualitative semi-structured face-to-face interviews and analysed using Nvivo 9. We discovered that different departments and faculties use different mechanisms to transfer technology to industry, ranging from research publications and conferences (informal) to spin-offs and patents (formal). The study concluded that U-ITT at public universities is largely through informal means, implying limited interaction with industry. We recommend that university management should ensure that U-ITT activities are fully integrated into all university academic programmes.

Keywords: *Effectiveness; Innovation; Patent; Spin-off; Technology transfer.*

Introduction

In this study, we set out to explore the channels and types of U-ITT, in addition to establishing their effectiveness. Scholarly literature shows that institutions of higher education are starting to encourage academic staff to engage in activities that enhance and support U-ITT (Guimon, 2013). Under the U-ITT function, the university relates with the industrial partner to improve the transfer of technology to the latter. The partnership advances academic development through enriching the curriculum, providing experiential learning to students and generating real-time research ideas for staff and students. Furthermore, typical motivations to collaborate with industry in the form of technology transfer (TT) include the improvement of teaching, access to funding, reputation enhancement, and access to empirical data from industry. For firms, the motivations to collaborate with universities may include gaining access to complementary technological knowledge, tapping into a pool of skilled workers, providing training to existing or future employees, accessing the university's facilities and equipment, and accessing public funding and incentives. Industry may also seek to reduce risks by sharing the costs of research and development (R&D) and influencing the overall teaching and research agenda of universities (Guimon, 2013).

While the university benefits from the financial muscle of industry, industry benefits from the intellectual knowledge of universities through innovation (Kaweesi, 2018). Thus, agreements need to be established in a commercially timely manner that ensures the ability to commercialise with appropriate returns. Formal channels of U-ITT include collaborative research, intellectual property transactions, research mobility, academic spin-offs and university graduates joining the industry. Informal channels include research publications, conferences and networking, facility sharing, exchange of personnel, policy briefs and cooperative agreement (OECD, 2019).

Preliminary findings indicate that publications in the form of articles published in academic journals are the major means of TT (Steinmo & Rasmussen, 2018; Schneider, 2015). Unfortunately, the above studies were carried out in the developed world. No comprehensive study has been undertaken in Uganda to establish the effectiveness of U-ITT.

Objective of the Study

The main objective of this study was to identify the key mechanisms that public universities use to transfer technology to the industrial sector and to establish the effectiveness of such mechanisms.

Theoretical Review

Institutional theory

The theoretical framework that informed this study is institutional theory, which is rooted within organisational theory. There are varying theories of organisational analysis. These include the contingency, resource dependence and transaction cost theories. These theories focus primarily on material resources, examining their effects

on organisational structure. They look at organisations as "agentic actors responding to situational circumstances. Senior managers steer organisations by interpreting their contexts and taking appropriate actions" (Greenwood, Oliver, Sahlin, & Suddaby, 2008). Each of these theoretical perspectives focuses on the relationship between an organisation and its environment and examines how each organisation adapts to its environment to secure an appropriate fit (Greenwood et al., 2008).

Institutional theory emphasises that organisations are open systems,strongly influenced by their environments. However, these are not the only competitive and efficiency-based forces at work. Socially constructed belief and rule systems exercise enormous control over how organisations are structured and how they carry out their work (Scott, 2004). Resource-based features such as production and control technologies, patterns of inter-organisational exchange, and regulatory processes (Orrù et al., 1991) that exercise output control over organisations influence organisational structure, and shape internal work systems (Scott, 2004).

The institutional environment encompasses the symbolic and cultural factors affecting organisations (Scott, 2004). Institutional theory, therefore, focuses on the processes and mechanisms by which structure, schemes, rules and routines become established as authoritative guidelines for social behaviour. It emphasises how systems come into existence, how they diffuse and what role they play in supplying stability and meaning to social behaviour. It also considers how arrangements deteriorate and collapse and how their remnants shape successor structures (Scott, 2004). It emphasises that institutions are a critical component of the environment and it is interested in understanding the bases of stability of social forms and the meanings associated with them (Scott, 2004). Contemporary 'neo-institutional' approaches stress the role of cultural cognitive controls. Nonetheless, all institutional arguments cohere around the central tenet that institutions matter in accounting for social behaviour that is, "most institutional theories see local actors whether individuals, organizations or nation states as affected by institutions built up in much wider environments" (Meyer, 2008).

Literature Review

University industrial technology transfer mechanisms and their effectiveness

Universities, like companies, vary enormously in the extent to which they engage in and experiment with new mechanisms to promote the commercialisation of academic research and in the extent to which they succeed in generating additional income from third-stream activities. In studies undertaken by Tornatzky, Waugaman and Gray (2002), the World Bank (2013) and D'Este and Patel (2007), there are five approaches to U-ITT.

Formal mechanisms of U-ITT

First is the industry-sponsored contract research where a university agrees to accomplish specific research and the company pays the university. However, small company participation in university-conducted research is low in most countries (Tornatzky et al., 2002) and this represents a particular issue in development goals. This approach also has the challenge of how to share the royalties between the researcher and faculty which provides the facilities.

The second approach to U-ITT is company-sponsored research consortia (D'Este and Patel, 2007) which perform industry-focused research in the university. This arrangement helps in securing long-term, large-scale funding for the university. It is easy to pick graduate students for future employment. However, small company participation is weak and there are uncertainties about how to commercialise technology emerging from consortia. When intellectual property (IP) comes out of the work, it is protected via patenting as copyright where all participating companies get a non-exclusive license.

Third is a consulting arrangement where faculty members work as part-time employees of the company where they are engaged. This is lucrative for the faculty members involved and is intellectually stimulating. However, these arrangements are rife with conflict of interest and commitment. The consultant lecturer has parallel obligations to his full-time employer (the university) that may conflict with industry obligations. This implies that he/she may not devote enough time to either the university or to the industry. Researcher mobility includes both permanent and temporary assignments for university researchers working in the industry. In general, researcher mobility is deemed to be of importance because these individuals will act as what is often termed as "knowledge brokers" between universities and industry actors since these individuals are knowledgeable about both the university and industry sectors (Rosli et al., 2018). As such, these individuals can be important links, which could create better relations and interactions between university and industry partners.

Fourth is the licensing of university-developed technology. This usually occurs when research has proceeded to the point where a discreet invention has occurred. Universities transfer tangible intellectual property (IP) to companies embodied in patents, trademarks, copyrights and know-how embodied in trade secrets. However, compensation is complex because few licences are paid upfront but involve the payment of royalties based on revenues from the future sale of goods. However, there seems to be an insignificant investment in capacity on the part of the university. Cohen, Nelson and Walsh (2002) investigated the impact of patenting and licensing as pathways for the transfer of technology from universities to industry. The UK-US survey asked the responding firms to indicate the types of interactions contributing to their innovation activities. The findings indicated informal contacts as the most common, followed by recruitment at first degree or its level, publications and conferences. Formal mechanisms like patenting and licensing were found to be low down the list. Academic spin-offs are when university researchers (or graduates), through a company they own, develop and commercially exploit technologies which are often the outcomes of research conducted by these academics. This link is often deemed to have one of the biggest impacts on the industry (Norwegian University of Science and Technology, 2019; OECD, 2019).

Siegel et al. (2003b), using data on 113 USA Industrial Liaison Offices (ILOs), investigated the effect of royalty payments on faculty members and found that the high rate of turnover among licensing officers was detrimental to the establishment of long-term relationships with firms and entrepreneurs. They concluded that organisational incentives for university technology transfer appear to be an important determinant of U-ITT success. The concerns they found were insufficient business and marketing experience in the ILOs and the possible need for incentive compensation. In the subsequent papers, Link and

Siegel (2005) and Friedman and Silberman (2003) found that the "royalty distribution formula" which determines the fraction of revenue from a licensing transaction allocated to a faculty member who develops the new technology can potentially enhance technology licensing. However, the above two studies did not go into the details of evaluating the efficiency of the ILOs and did not explain the relationship between institutional factors, researcher profile, innovation and the U-ITT in the context of the engineering sciences. This gap was covered by the current study.

Finally, there is joint development and commercialisation of technology. This may involve the university taking an equity piece rather than cash. Joint commercialisation implies a much more intensive and time-extensive involvement on the part of the university in its partner's business. The faculty inventor is likely to take an equity share in the enterprise. With this arrangement, the purpose is not only to transfer technology but also to start a business.

Universities also engage in collaborative research, which is a reference to research projects carried out by university researchers. These projects can be partially or fully funded by industry and range from small- to large-scale projects. Small-scale projects often happen through contract services and academic consultancy in which firms commission universities to perform research. Long-term strategic partnerships often consist of multiple actors as stakeholders, such as university-industry research centres. Research services are often established to solve a concrete firm challenge or to create new knowledge in line with the specifications of the firm and are generally more applied than research taking place in research centres (OECD, 2019). Research shows that collaborative research is often conducted locally (D'Este and Iammarino, 2010). This especially applies to peripheral regions (Johnston & Huggins, 2016), which implies the importance of having research institutions in close geographical proximity to industry. A large database of patent applications for 35 OECD countries and China from 1992 to 2014 shows that 50% of all industrial inventive activity occurred within 30 kilometres of a university (OECD, 2019), which indicates the importance of universities for economic growth.

However, universities seem not to be linked to external entrepreneurial support structures to energise the internal mission and vision that support these activities. In addition, large segments of the university community are likely to be opposed to joint development and commercialisation of technology. For example, in one national survey in the USA, of 985 faculty members, only 26.5% of the respondents were in favour of the university taking an equity position in firms based on university research (Tornatzky et al., 2002).

Research has revealed that there is an inherent mismatch between the research orientations of firms and universities, with an excessive focus on fast commercial results by firms and on basic research by universities (Kaweesi et al., 2019; Guimon, 2013). Collaboration is costly and the returns only accrue in the medium to long run. On the contrary, firms seek short-term results and clear contributions to current business lines. In terms of outputs, firms are usually interested in delaying publications to avoid disclosing information. University researchers, in contrast, are typically motivated to publish research results as fast as possible. In this, industry is concerned about the secrecy of intellectual property (IP) rights and making a profit from them (p.3).

However, there are several obstacles to effectiveness in U-ITT (Siegel et al., 2004). Such obstacles include cultural and informational barriers, technology transfer office staffing, compensation practices, and inadequate rewards for faculty involvement in U-ITT. Marshall (1985) proposes that the long lag between the discovery of new knowledge at the university and its use by companies could seriously impair global competitiveness. However, both Siegel's and Marshall's studies were conducted in the developed world whose contexts could be different from those in the developing world. Additionally, technological advancement in the past few years could have changed the trends in universities.

Recent studies (Genza et al., 2018) have explored how involvement in the U-ITT activities to industry by academics affects their research productivity, measured by journal publication output. These studies fall into two groups where one of them focuses on academic entrepreneurship and innovative application strategies to the management of educational institutions. This occurs in a way that can result in the reorganisation of an entire education system to meet society's changing needs sustainably.

Informal mechanisms of U-ITT

Informal links of university-industry interaction that diffuse knowledge from universities to industry include research publications that are academic writings presented in academic journals. These interactions take place through conferences, meetings and contact with former classmates employed in universities and industry (Perkmann & Walsh, 2007; OECD, 2019). These networks are recognised as important for developing and maintaining university-industry collaborations (Steinmo & Rasmussen, 2018).

Another form of informal U-ITT mechanism is facility sharing between university and industry partners, who share infrastructure such as laboratories and equipment. It is often expensive to build up a laboratory. Thus, universities often have laboratories that are used for both training students and doing industrial research. Training includes not only courses and continuing education provided by universities to firms, but also lectures held by industry employees at the university.

In a study carried out by Steinmo and Rasmussen (2018), the informal mechanism of U-ITT involves the sharing of facilities between university and industry partners as one of the main channels of U-ITT. Although several studies have been conducted on U-ITT, their respondents are mainly comprised of industry players only. Especially, their cultural contexts differ and it is doubtful whether the same findings can be generalised to the Ugandan context. Additionally, these pathways of TT mechanism have remained under-explored in academic work, often hampered by the unavailability of data (Veugelers et al., 2014, p.39). Specifically, their effectiveness has not yet received much attention from the research community.

Jensen and Thursby (2001) analysed the interaction between university Industrial Liaison Officers (ILOs), university scientists and the central university administration. They found that many scientists reported less than half of the potentially viable commercial faculty inventions to the ILOs. In their model, the principal is the university administration while the faculty and ILOs are the agents who maximise expected utility. They regard the ILO to be a dual agent, that is, an agent of the university and the faculty.

Faculty members have to decide on the stage at which to disclose their invention to the ILO – whether to do it at the embryonic stage or at laboratory scale prototype. Additionally, the ILO has to negotiate licensing agreements with firms as the agent of the administration. In relation to Jensen et al.'s (2001) study, Sierra et al. (2017) investigated the role of the ILO in the university in Mexico's U-ITT. The study looked at the interest and necessity to generate research projects with significant potential to be transferred to different users such as industry, government and society in general terms. However, both studies did not critically look at specific institutional environments. In the current study, the researchers' perceptions, experiences and characteristics were conceived to play an important role.

Siegel et al. (2003) identified several obstacles to U-ITT. These included lack of understanding regarding university, corporate or scientific norms and environments; insufficient rewards for university researchers; bureaucracy and inflexibility of university administrators; insufficient resources devoted to technology transfer by universities; poor marketing/technical/negotiation skills of technology transfer offices; the university being too aggressive in exercising intellectual property rights; faculty members/administrators having unrealistic expectations regarding the value of their technologies; and the "public domain" mentality of universities.

Many authors have attempted to rank the order of the preferred channels and types of U-ITT. The majority of the studies show that informal activities and the 'public space' functions (meetings and conferences, forums, networks, social interactions) are the most widespread forms of interaction (D'Este & Patel, 2007; Abreu et al., 2013). From the review of literature, it was observed that informal mechanisms generate about 60% of the total income obtained by the universities from external sources. At the opposite end, licensing, patenting and spin-outs are the least common forms of interactions, generating less than 3% of the total income that the universities attract from external sources. The explanations lie in the fact that people are more important than patents as a result of like-minded people getting together to address a problem.

Methodology

The study adopted a qualitative approach using a single case study design. During this research, Kyambogo University was selected as the case study. This is because TT at Kyambogo University is on the rise. The target population for this study consisted of the staff from two faculties: the Faculty of Engineering and the School of Vocational Studies. These faculties were selected because they are at the forefront of TT at the university. Moreover, the mission statements of both faculties are " to advance and promote knowledge and development of skills that meet the demands of the modern labour market about job creation, innovativeness and transformation of society." Furthermore, the two faculties have very vibrant and running spin-offs collaborating with industry. The graduates of the two faculties have been more job creators and innovators than job seekers and are at the forefront of implementing the government policy of skilling Uganda within the framework of the National Development Plan and Uganda Vision 2040. In selecting the samples, purposive sampling was used to select the six heads of academic departments from the two faculties. The departments of the Faculty of Engineering included Civil and Building Engineering, Mechanical and Production Engineering, and Electrical and Electronics

Engineering. The participants were assigned the pseudonyms PP1, PP2, PP3, PP4, PP5, and PP6, with PP1 referring to Participant One and so on. The departments of the School of Vocational Studies included Family and Consumer Studies, Nutritional Science and Dietetics, and Cosmetology and Fashion. These departments offer academic programmes at diploma, bachelor's and master's levels. In selecting the samples, we assigned each participant a pseudonym to ensure confidentiality and anonymity. The purposive sampling technique was used because it was found to be ideal for the identification and selection of information-rich participants.

The data for this study was generated through face-to-face semi-structured interviews as well as document reviews. During the study, we visited the selected participants. The choice of methods was influenced by the nature of the research problem, the purpose of the study and the desire to generate detailed data. Out of the six selected respondents, we managed to interview five, as one of the participants was reported to be out of the country. In this study, the organisation of data sources, coding and searching for the data was carried out using NVivo 9. After transcribing the interview recordings, the interviewees' actual names were replaced with participants' (PP) numbers.This aimed to ensure the anonymity of the interviewees and thereafter created a project in NVivo and all the data sources were imported into the project.

Data quality control

Qualitative research seeks to produce credible knowledge of interpretations, processes and understanding, with an emphasis on uniqueness and context. There are four criteria of research trustworthiness developed by Lincoln and Guba (1985) which have been widely cited in social science research methods literature (Kalof, Dan & Dietz 2008; Bryman, 2012) to evaluate the quality of qualitative research. Credibility deals with the accuracy of data to reflect the observed social phenomena. On this aspect, we carefully selected the participants who had some administrative as well as lecturing responsibilities. We then prepared a detailed interview schedule with questions covering all the required data. During the interview process and data analysis, we followed the research procedure and methods that had been used previously.

Transferability refers to the level of applicability of the study findings to other settings. As suggested by Lincoln and Guba (1985), a rich and thick explanation of research sites and characteristics of case organisations should be provided to enhance transferability. Although qualitative research findings are specific to individuals and a small number of particular environments which could not be generalised, inferences can be drawn from our study. Dependability corresponds to the notion of reliability which promotes repeatability (Wahyuni, 2012). With regard to this, general coding was done as well as analysis of data. We also recorded and transcribed verbatim all the interviews.

Confirmability refers to the extent to which others can confirm the findings in order to ensure that the results reflect the understandings and experiences from observed participants, rather than the researcher's own preferences. This research contains detailed information about vital issues and processes relating to U-ITT. In addition to the interviews, the research contains extracts from documents to corroborate issues in the interview.

Findings

We asked the participants to explain the mechanisms used for U-ITT at Kyambogo University. The aim was to explore the perceptions of the various players on how technology is transferred to the industrial sector. The findings reveal that there are two distinctive mechanisms of TT at Kyambogo University. While some departments use structured (formal) means of U-ITT, other departments capitalise on using informal means. **Informal mechanisms of U-ITT** included research publications, staff mobility, conferences, workshops and training services.

Mechanisms of U-ITT

On the issue of the mechanism of U-ITT at Kyambogo University, PP4 said:

> One sugar industry's work processes were not proper. Our department suggested certain ideas. Uganda Communications Commission wanted some work done. It defined the objective of the work needed and they advertised. Our department applied. It was competitive. The other example of industry-sponsored contract research we have worked on is a project for the Engineering and Physical Sciences' Research Council which was accomplished in partnership with other organizations such as the Uganda Electricity Regulation Authority.

On the same issue of the U-ITT mechanism, PP3 said:

> Knowledge transfer graduate students work with knowledge institutions. The graduate students work with their supervisors to discuss and solve particular societal problems. Here we look at the method and procedure and how to solve the problem. For me as the leader at this place, I must ensure that every student has an academic inspector in the company. We visit the students four times in 10 weeks to see what they are doing in companies. I also monitor the inspectors to ensure that they do their work.

A review of the Kyambogo University Strategic Plan (2012/13–2022/23) reveals that the promotion of collaboration with the private sector in research, teaching and information management has enhanced staff participation in consultancy activities and has led to a strategic alliance in consultancy with reputable consultancy firms. This has enabled technology transfer to the following ministries: Education and Sports; Trade and Industry; and Gender, Labour and Social Development (pp. 66–68). Documents such as the Kyambogo University Master Plan (2014–2024) reveal that Research, Innovation and Knowledge Generation initiate partnerships and encourage joint academic research action through the development of a policy framework for the development of collaborative linkage. Furthermore, there has been increased financial resource generation that has increased the inflow of financial resources to the university. This has been achieved when the faculties and schools have undertaken award and non-award research activities as follows: 69 graduate research projects, and 52 staff research projects – 14 for master's and 38 for doctoral programmes. Consultancy projects have been undertaken to train the clerical and administrative staff of Uganda Revenue Authority by the School of Management and Entrepreneurship (pp. 53–54).

PP6 gave a rich narrative that demonstrated the main mechanism of U-ITT at his department:

> We engage in industry-sponsored research. For instance, we are working with an automobile industry that deals with processes within car engines to ascertain whether it is feasible to measure the combustion processes in engines using the academic's laser-based measurement techniques. The industry partner provided the test engines and the fuel injection equipment. The technical work is done largely by master students in collaboration with their supervisors. The industry engineer provides co-supervision and several professors attend meetings to monitor project progress. Another project consists of joint research with industry participation. This project was initiated by academics in this department. The industry partnership was approached at the stage when the project proposals were already defined… This project had an academic orientation and the possibility of publishing in a peer-reviewed journal. However, because of the academic orientation of the project, industry representatives have had little involvement during the execution of the project.

The industry-sponsored research projects often rely on the general expertise of the academics from the university and the labour provided by the graduate fellows (who are usually master's degree students). That is usually the case when an idea originates from an industry rather than the university. When the project idea originates from the university and the research undertaken in university laboratories in the form of joint research, the projects tend to orient towards the long term and is usually considered to be a research project with little immediate commercial payoff.

PP5 added:

> Our department engages in contract research including a great deal of research with food processing firms and NGOs. Some companies pay the university for the consultancy to physically solve a problem. You follow the production process to solve a problem. In this case, there is a direct interaction between academic and non-academic professionals. This will in the future lead to other longer-term U-ITT mechanisms such as licensing. However, consultancy may not generate new technological knowledge but it may promote organisational innovation.

Concerning the benefit the industry gets from the university, it was found that university lecturers train industrial workers. E-kampus was a brainchild of the Department of Electronics. Later proposals were made to the government, which brought engineers from abroad to improve innovation and imposed an Education Information Management System (EIMS) which all public universities have to utilise.

The view held by one participant is different, though, when asked about the mechanisms of TT. He had this to say:

> Our staff do some work in other universities and technology-based institutions. They go to newly established universities to train the young engineers (staff) and help them organise their departments. We have a memorandum of understanding with several engineering-based institutions and this is part of the work we do there. Almost all our staff are involved in this activity. Informal social interactions can help spark dialogue and work relationships. Purposefully using university facilities for events and social engagements can facilitate such interactions.

When asked about the mechanisms departments use to transfer technology to the industrial sector, PP5 responded:

> Kyambogo University with partner universities in Kenya and Nigeria organise annual conferences in which knowledge created in the partner universities is disseminated to the intended beneficiaries. This annual international interdisciplinary research conference (IIRC) draws close to 350 participants and each time, over 200 oral papers are presented. This year, my department shared information and findings on the following: Design and Fabrication of Automatic Garbage Collector. This project was designed to initiate the efficient working of systems that remove the garbage from the drain system each time any solid waste appears and throws it into the waste bin to avoid blockage.

PP1 revealed:

> ...The project we presented at the University of Eldoret conference concerned the characteristics of spot welding electrodes with annual recess designs. The researchers in my department investigated the characteristics of resistance welding electrodes with annual recess design for supplying an electric current to metallic materials for welding two workpieces together. The engineers from my department shared on how electrical and heat-resistant material containing ceramic cement mixed with clay. The study showed that conventional spot welding tools produce joints that are stronger on the edges but weaker in the centre of the nuggets which presumably experience high voltage concentration.

PP2 stated:

> We investigated the properties of *Oxytenanthera abyssinica* bamboo for its potential use as emergency shelter construction materials to respond to the shelter needs of the South Sudanese refugees in Uganda. The results showed that *Oxytenanthera abyssinica* bamboo characteristics strengthen properties that are superior to ordinary wood. Our ideas were shared with participants at the 6th IIRC held at the University of Eldoret last September. I can say that our findings generated a lot of debate among the participants at the conference, many of whom were coming from the industrial sector.

The findings demonstrate that the technology available in Kyambogo University can be used by industry to improve the methods of production and the quality of what is being produced. A key implication of this argument is that industries require a strong contingent of highly qualified research scientists and engineers recruited from universities to develop the ability to assess and absorb scientific knowledge. These highly trained scientists and engineers bring to the firm not only a strong knowledge base and research skills, but also a network of formal and informal academic contacts acquired during their training. However, the university has continued to largely carry out basic research as opposed to applied research. The implication of this is that TT cannot be promoted because research is being undertaken in ways which are not relevant to the industry.

Effectiveness of channels and types of U-ITT

Traditionally, the industrial sector seeks partnerships with universities as a means of identifying and training future employees. Industries also play a role in defining student research projects that focus on problems of direct interest to industry and this, in turn, increases the propensity of firms to introduce new products on the market. According

to one participant, the most important link to the university is through recruitment of skilled graduates. The implication of this is that firms get educated and trained workers. This enables the competitiveness and innovative capacity of industries. The continued emphasis on traditional outputs for academic work, such as publication, has meant that collaborative industrial R&D is not valued unless it adds to their income.

Participants were asked to articulate the main benefits of TT. PP2 elucidated:

> There are quite many benefits that the department gets from industry, including money, training students and acquisition of equipment. For instance, industries give us equipment for our practical use. However, we as a department have also contributed immensely to the productive sector. For example, when our students visited Nsambya Hospital, they found the X-ray was disused. It was repaired by our students. More so, students from this department recently repaired, cleaned and fixed some medical equipment at Lira Regional Referral Hospital in Apac District. This was in the departments of Theatre, Laboratory, Radiology, Air Conditioners and Refrigerators, which had fallen into disuse. The team worked on an autoclave, anaesthesia machine, patient monitors, an oxygen concentrator, an operating lamp, theatre beds, trollies, a diathermy machine and a nebulizer. The beds are now electrical, which saves time during surgery.

The implication of this is that the TT channels at the university are shifting from being informal to formal, where tangible benefits are acquired. This is of great use to both the university and industry.

Discussion

The findings demonstrate that Kyambogo University has made efforts to foster U-ITT with industry through participation in public shows and conferences. With such ventures, Kyambogo University's staff share knowledge with the non- academic public and contribute to public debate. The Kyambogo University staff members sometimes carry out regulated experimental development through a contract with specific industries. The idea is to satisfy the requirement of a particular industry that will have defined the work to be done and finances its variable costs, and the outcome will belong to the industry. The results derived from such a project are usually for the industry that contracts the services of the faculty.

Rewarding scientists at the departmental level is done through conferences sponsored by the university, where the best presenters are given some money by the university. However, even though some measures are being applied to bring the industry closer to the university, there is still no evidence of an aggressive marketing strategy which would include inviting firms to evaluate the technology and look at the equipment being possessed by the university's laboratories. It is a fact that industries usually pursue the university and often engage the researchers themselves.This corroborates the findings of Kaweesi (2019) and Guimon (2013), who revealed a mismatch between the research orientation of the university and that of industry.

This necessitates the presence of enough competencies in user commercialisation and intensive interactions with the technology source. Information asymmetries between the knowledge producer and user can be an obstacle to its effective exploitation and, thus, substantial effort may be necessary to transform such knowledge into products and services

(Fontes, 2005). The transformation process involves devising applications for new scientific concepts and tuning technologies and prototypes into viable products or services. It also entails an uncertainty-reducing element, which is crucial from the adopter's viewpoint. The transformation process involves the integration of knowledge coming from different areas, both scientific and functional. In this regard, personal mobility, shared contexts, and integration of knowledge trial-and-error experiments are key elements.

The absence of an intellectual property rights management (IPRM) policy at some public universities has led to the loss of revenue by the universities. For example, the government did not pay anything to Kyambogo University for the takeover of its innovations. The same scenario happened at Makerere University when the government took over the Kiira car innovation. However, because Makerere University had an IPRM policy, it managed through court to win back a 5% royalty from the government on its innovation.

Continued interactions between universities and industry provide university researchers with a better understanding of the different norms, values and frames of reference that apply to the industrial and academic sectors. The experience of collaboration leads to greater convergence in attitudes, making it easier to arrive at a common understanding of the different aspects of the collaboration process. In this case, interaction has a positive influence on the propensity of universities to enter into collaborations with firms. This is because it increases the probability that each partner gains useful insights in the process. While universities gain in terms of money, equipment, exposure, knowledge and skills from the continued interactions with the industries, the latter acquire knowledge, skills and new innovations from the universities. In other words, academics and industry representatives may have different mindsets, but their differences should not interfere with their capability to interact.

One of the major barriers to U-ITT is that many large-scale industries are multinational corporations (MNCs) with branches across the world. Such industries may not take an interest in local technologies. Instead they import technologies from their mother countries. Action is needed to establish legal conditions to encourage and enable Indigenous researchers to be more innovative. In the same vein, action is required to establish IPRM policies to prioritise the protection of local inventions. The client defines the research to be carried out. Therefore, contract-research involves simultaneous production and transfer of technology to satisfy the needs of the client.

A key finding of this study is that many of the academic start-ups at KyU are based on the researcher's technology. Although entrepreneurial training is spread across all departments of the Faculties of Engineering and Vocational Studies and in other faculties of Kyambogo University, there is a challenge to encouraging academics to turn their business plans into start-up ventures. The creation and support of new ventures remain a marginal activity. This can be reversed by changing the mindset of the university stakeholders from teaching as the main activity of the institution to research and commercialisation. One of the main challenges faced by academic start-ups is that these infant industries come up as a result of technology generated in universities. In addition, many of them tend to leave the university premises where they would benefit from state-of-the-art facilities, free accommodation in the incubator and expert staff. They opt to toil in the world of

competition. The implication of this is that young industries lose the verification of the technical feasibility of their concepts. The above finding corroborates the earlier findings of Rogers et al. (2001), Mendoza and Sanchez (2018) and Rogers and Steffensen (1999), who presented five channels through which technology transfer occurs from university to industry. One of them is through spin-offs. The spin-offs are the technology-based companies whose initiative is generated by university personnel to transfer technology through the market, knowledge or research results with high added value and economic potential. With such a company, the technology is transferred from a patent company. Such a company is formed by individuals who were former employees of the parent university.

Critics of the commercialisation of university inventions (Dalmaco et al., 2018; Rasmussen et al., 2014; Mendoza et al., 2018) claim that too much reliance on commercial orientation endangers the university as an independent knowledge producer. They assert that the primary function of the university is to teach and do research which should be published in academic journals and that patenting is never a primary role of the university.

Regarding the effectiveness of U-ITT mechanisms, the findings reveal that it is more important for an industry to work or collaborate with universities than on publications or conferences. A formal collaborative arrangement between the two institutions is associated with highly innovative industries that have developed R&D units. However, Kyambogo University attaches greater importance to all U-ITT mechanisms than industrial partners do. Often, U-ITT researchers and professionals at Kyambogo University do not use formal tools for the valuation of the technologies developed in the university, yet companies have good knowledge about market opportunities. This implies that Kyambogo University finds it difficult to negotiate and set prices for its inventions. The university's engagement with industry poses great challenges as tension exists between the third mission (entrepreneurship) and the missions of teaching and research.

University lecturers do not view it as one of their roles to take on more entrepreneurial initiatives on behalf of their institutions. This corroborates the findings of Cloete et al. (2011), who found an inherent mismatch between the research orientations of firms and universities, with an excessive focus on fast commercial results in firms and on basic research in universities. Bogoro (2015) agrees with Guimon (2013) when he says that in most African countries, partnerships between local industries and universities are not very common. Hence, the transformation of research results into products/technologies is usually left to the individual who, without the necessary institutional framework and experience, only allows the idea to collect dust in a little-known journal.

Institutional theory explores how political institutions influence organisational behaviour and outcomes. The government's inertia in enhancing technology transfer between universities and industry has affected collaborative arrangements between the two entities.That is why the transfer is largely informal in the form of conferences, individual professor agreements and networking with industry. Institutional theory is relevant to U-ITT in three aspects: institutional environment; institutional actors; and institutional arrangements. Formal and informal structures such as university policies, strategic plans, laws and networks facilitate or hinder U-ITT. Institutional theory, for instance, suggests that the effectiveness of U-ITT channels depends on the alignment between institutional arrangements and the needs of university-industry collaboration. At Kyambogo University,

the faculties/school offices intended to propel collaborations are weak. The licensing and patenting arrangements are poor, yet intellectual property management policy has not been approved by the highest policymaking body of the university. Only training, educational programmes, and research collaborative arrangements have been embedded in all curricula of the various programmes.

Furthermore, given that contract research is carried out on an individual/group basis without being coordinated by academic units, it contradicts the findings of Clark (1998), whose pathways to organisational transformation advocated a strengthened steering core. This is where organisational survival requires faster decision-making processes, flexibility and attention to the increasing diversity in demand. This implies that the steering core comprises the central administration and the academic departments that provide managerial and academic balance at the university.

Although university scientists are required to disclose their inventions to TTOs, the case is quite different at Kyambogo University, where a large percentage of university inventions are informal. This is largely because the IPRM is not well developed at the university. However, the university is devising mechanisms to compensate researchers when their research findings go public. Notable among these mechanisms is the licensing of royalties. This agrees with Abreu et al.,'s (2009) survey that cited intermediaries that facilitate and manage contractual and relational interactions of U-ITT. In the PACEC/CBR survey, only 13% of the academics chose the TTO route. Similar to the UK's position, Bruneel et al. (2009) observe that it was not until 2008 that many UK universities started to invest in professional systems for technology transfer.

Conclusions

This study investigated the channels and types of U-ITT and their effectiveness at the Kyambogo University faculties of Engineering and Vocational Studies. From the findings of this study, a number of conclusions were drawn. It emerged that the two faculties largely transfer technology to the industrial sector through informal means. These include conferences, workshops, research contracts with the industrial sector and spin-off creation. This implies that technological transfers are diversified, with each department pursuing a different mechanism. The implication of this is that there are low levels of professionalism in the departmental management of U-ITT. Regarding the diversity in U-ITT management among departments in the faculties, TTOs are staffed with researchers who have an academic background with no experience in commercialising technology for the market. As such, U-ITT is not effectively and efficiently transferred to industry. More importantly, the activities of the informal mechanisms are not recorded by the university, an indication that the interface between the university researchers and industries is not well documented. However, spin-off creation in departments where it is practised enables academic researchers to interact and share their technology with industries using structured mechanisms. Although the mechanisms of U-ITT are not well managed, they are non-existent in some departments. The majority of the academics in the faculties lack the culture and disposition to link up with the industrial sector.

Recommendations

The study, therefore, makes the following recommendations:

It was found that the staff of Kyambogo University involved in marketing the inventions have expertise in engineering and not marketing. The researchers, therefore, recommend that there is need for experts who understand the marketing process as well as turning new ideas (inventions) into products (innovations).

The study also found that there is minimum interdisciplinary research at the university. Therefore, stimulating interactions within universities across teams of researchers with complementary expertise should be encouraged, regardless of their disciplinary affiliation. Additionally, interdisciplinary research programmes that include industry partners should be encouraged at the university.

It was further found that most of the interactions between Kyambogo University and industry is through informal means. In this regard, the study recommends that the university should take advantage of its position as a public institution to leverage public spaces for open-ended debates on local economic, social and technological challenges. This can be done through organising and hosting events that bring together academics and industrial representatives, along with other relevant stakeholders. Informal social interactions should not be phased out completely because they can also help spark dialogue and work relationships. Purposefully using university facilities for events and social engagements can facilitate such interactions. The private sector should be encouraged to work with universities in the enhancement of U-ITT.

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