

Commercialization of University's Innovations, A systematic Literature Review

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ABSTRACT

The main objective of this study is assessing the status of commercialization of university's innovations using a systematic review of the relevant literatures. The sample comprised of 42 (fourty two) research articles was reviewed and analyzed using qualitative method. The study revealed that, commercialization of university's innovations has become an area of strong policy interest worldwide for its contribution to national economic development through innovation based industrial development. It was also found that, while the major barriers to commercialization of university innovation are, inadequacy of research funds, lack of appropriate structure and regulations at university level; the strategies for successful commercialization of university's innovation are the presence and implementation of national policy initiatives, structure, funding system to the universities, and collaboration for commercialization of university's innovations. In conclusion, commercialization of university's innovations contributes to creation of jobs, generation of revenue, enhancement of wealth creation and national economic development and such initiatives as, national policy, university-industry-government collaboration, technology parks & university incubators, create fertile ground for commercialization of university's innovations. Therefore, it is recommended that, establishing supervisory board to strictly followup the performance of these initiatives through the triple helix system.

Key words: Commercialization, innovation, initiatives, university-industry collaboration

1. INTRODUCTION

Many of the prior studies (eg. Vic & Robertson, 2018; Ramika 2016; Bolo *et al.*, 2015a; Tayeb, 2015), substantiate that, commercialization of university innovation contributes to innovation based industrial development, create employment opportunities, generate income, and bring about national economic development, enhanced by such initiatives as national policy (Robert, 2019; Ramika 2016); university-industry collaboration, (John , *et.al*, 2016; Samuel & Omar, 2015; Farahan,*et al.*, 2015), technology parks (Farahan, *et al.*, 2015; Schofield, 2013;) and university incubators (Farahan, *et al.*, 2015; OECD, 2013; Chandra *et al.*, 2012). Also, a number of marketable research breakthroughs have been witnessed over the years, across Africa; for instance, South Africa is successful in commercialization of university innovation (UI), (Mustapha *et.al*, 2019). Similarly, Aroture (2017), reported that, many Nigerian universities have commercialized their innovations. In contrast, in Ethiopia, the study by Mulu, (2017), revealed that, commercialized research outputs and patents are almost none-existent. Correspondingly, Amare, (2017), noted that, in spite of the research efforts in various sectors, none of the results of the studies have so far been translated into commercial products.

Regarding the national policy initiatives for commercialization of university's innovations, the United States of America, (USA) congress, passed the University and Small Business Patent Procedures Act of 1980, commonly known as the Bayh-Dole Act, 1980 (Ramika, 2016); which, was established the legal framework for commercialization of university research outputs (Robert, 2019). In Africa, South Africa has developed its technology transfer (TT), platform with the enactment of the 'Technology Innovation Agency Act' (Act 26, 2008), and the 'Intellectual Property Rights (IPR), (Act 51, 2008) (University of Pretoria 2019). In Nigerian, the national office for technology acquisition and promotion, NOTAP, established, & has effectively used to develop technological know-how through technology transfer agreements with universities, (Aroture, 2017). In Ethiopia, the major national legal and policy frameworks for facilitating commercialization are, the Research and Technology Transfer Conceptual and Governance Framework of Ethiopian Higher Learning Institutions (MoE, 2016); and the National Science, Technology and Innovation (STI) Policy (MoSTI, 2012).

Propos the University- industry collaboration (UIC) as an initiative for commercialization of university innovation, prior studies (Oluwaseun et al., 2019; John, et al., 2016; Ayenew, *et al.*, 2015; Wondwosen, 2015), support the notion that, university engagement with industry and government in making commercialization a success is crucial. Vis-a-vis technology parks and incubators as an initiatives for commercialization of university innovation, the studies (Farahan, *et al.*, 2015; Dahlstrand and Politis, 2013), substantiate that, a rapid increase in establishment of incubators and technology parks have become a source of revenue generation, economic development. Vis-à-vis university incubator, the study by Dahlstrand and Politis, (2013), confirmed that, university incubator, as a tool to commercialization, contribute to economic development and social benefit to society. With regard to the innovation commercialization models, the triple helix, was considered. Concerning the barriers to and the success strategies for commercialization of university's innovations, the available prior studies, (Misganu, 2018; Mulu, 2017; Ramika, 2016; Farahan, et al., 2015), revealed that, the major barriers to commercialization of university innovation were, insufficient research fund, and lack of senior management support. On the other hand, Transparent communication network among the actors & senior management support, were mentioned by the various studies, (Farhad, *et al.*, 2018; Misganu, 2018; Mulu, 2017; Ramika, 2016; Sidek, et al., 2014; Correa and Zuñiga, 2013; Schofield, 2013, as key success strategies for commercialization of university's innovation.

2. STATEMENT OF THE PROBLEM

While there is a considerable body of literature on the topic of the commercialization of university's innovations; most of which have focused on the American and European countries context; these literatures are fragmented, unsuitable to get comprehensive understanding so as to put an effort to fill the gap; for instance; some of the prior studies on commercialization of university innovation were by Farhad *et al.*, (2018); Abdulrazak & Murray ,(2017); John *et al.*, (2016); Farhan , *et al.*, (2015); Lennora, *et al.*, (2014). Studies on Universities-industry collaboration, were done by Oluwaseun, et al., (2019), Mamudu and Hymore, (2016), Samuel, and Omar, (2015), Ayenew et al., (2015). Studies on university incubators as commercialization initiatives, were carried out by Farahan, et al., (2015); Ozdemir, and Sehitoglu, (2013); Chandra, *et al.*, (2012). Studies on Barriers to Commercializing Researches and Innovations were carried out by (Farhad *et al.*, 2018 & Amare, 2017). In Ethiopia, though there is slight prior studies on commercialization of university's innovations; these few literatures were not comprehensive, that they did not offer overall understanding, regarding commercialization of university's innovations. For instance, Mulu, (2017), investigated, the role of university-industry collaboration in enhancing innovations and

commercialization; Ayenew *et al.*, (2015), assessed the status of universities - industries linkage. The emphases of these few prior studies were on separate topics which could be considered only as initiatives for commercialization, and couldn't provide complete picture of commercialization of university's innovations. Therefore, with this literature study, the researchers have brought together, a number of separately conducted studies and synthesized their results in a way specific to commercialization of university innovations; so as to provide wider knowledge and experience. Hence, the current study is diverse and provides diverse global experiences, as, such a wide coverage in one study did not previously reported in the literature, that, most studies have concentrated on only one of the commercialization aspects at a time. Based on this research gap, the next section presents the objectives of the study.

3. OBJECTIVE OF THE STUDY

The main objective of this study is assessing the status of commercialization of university's innovations using a systematic review of the relevant literature

The specific objectives of the current study are 1. to assess the status of commercialization of university innovations, and identify the major actors 2. to identify the initiatives for promoting commercialization of university innovation, 3. to describe the benefits of commercialization of university innovation to the actors, 4. to identify factors hindering commercialization of university innovation, and 5. to identify the strategies for successful commercialization of University Innovation.

4. LITERATURE REVIEW

In this section, the major relevant literatures used for the current study are summarized in table 1 below; and the discussion of the literatures is presented under the results and discussion section.

The literatures used, subjects and developments

Table 1 below presents the journals used for the current study along with their subjects and developments.

Table 1. list of publication, subject, major development and country

Author	Year	Subject	Publications	Development	Country
Abdulrazak, & Murray	2017	Innovation strategies for successful commercialisation		Strategic leadership and open innovation strategies are significant predictors for successful commercialization.	Australia
Amare	2017	Transforming Research Results in to Goods and Services		None of the researches' results have translated into commercial products.	Ethiopia
Aroture	2017	Technology Transfer		As a result of NOTAP system, many Nigerian universities have commercialized their innovations.	Nigeria
Ayenew, et al.,	2015	Linkage between universities and industries		Ethiopian higher education institutions are engaged in university-industry linkage, in various forms.	Ethiopia
Bolo, et al.,	2015a	Stimulating innovation and entrepreneurship		CUI create employment, generate income, and bring about national economic development	Kenya
Chandra, et al.,	2012	Business incubation		University incubators enhance CUI, through providing location, human & financial capital, innovation & Formation of spinoffs.	Chile
Correa, & Zuñiga	2013	Public Policies to Foster Knowledge Transfer from Public Research Organizations.		Creation of technology transfer offices (TTO) in universities has become a widespread institutional mechanism to assist researchers in patenting their findings.	USA

Dahlstrand, & Politis	2013	university incubators.	University incubators contribute to commercialization, economic development, & social benefit to society.	Sweden
Etzkowitz	2012	Triple Helix Clusters	Triple helix inspired policies were implemented in Eastern Europe to promote their growth; tying together innovation initiatives at different scales to increase their overall efficiency.	Sweden,
Farahan, et al.,	2015	Commercialization Tools: University Incubators and Technology Parks	Incubators & technology parks have become a source of revenue generation by most of the universities, contribute to CUI.	Malaysia
Galvao, et al.,	2019	Triple helix and its evolution	The major actors in CUI are the Universities, industry, the government, the public, & the natural environment. i.e. the quintuple helix.	Portugal
John, et al.,	2016	Initiatives to Promote Commercialization of Research Outputs	UIC, technology parks and university incubators contribute to CUI by promoting innovation and technology transfer and leveraging additional resources.	Kenya
Kruss, et al.,	2012	Universities & Knowledge-Based Development	As a result of NOTAP system, the number of patents registered has risen from a yearly average of 100 in 2006 to 400 in 2012, in many Nigerian universities.	Nigeria, Uganda & South Africa
Lennora, et al.,	2014	Commercialization of University Research Products & its outcome on University Performance,	CUI provides a potential source of income for universities, thereby reducing dependency on government funds.	Malaysia
Marina, & Etzkowitz	2013	Triple Helix Systems: for Innovation Policy	Triple Helix Systems has a central role in European Union (EU) innovation policies, such as; the European business forum,	UK
McAdam, et al.,	2018	Relationships of University Technology Commercialisation	Government–industry–academia relationship is crucial, if scientific research ideas are to bring about expected developments for society.	Ireland
Misganu	2018	University-Industry Linkage	Industries are benefitted from the UIC, through the training provided to them, consultancies from the universities and joint research projects.	Ethiopia
Mulu	2017	University-industry collaboration & Economic Development,	Commercialized research outputs, & patents are almost none-existent, hence, universities have not been able to influence on their socio-economic environment meaningfully.	Ethiopia
Mustapha, et al.,	2019	Technology Transfer	South Africa is successful in CUI, as a result of national policy initiatives, & through government funding.	South Africa
Ozdemir, & Schitoğlu	2013	The impacts of technology business incubators	University incubators enhance CUI by providing shared space at campus, advanced equipment, managerial support, networking and access to national and international markets, patenting & IP protection, & facilitate formation of university spinoffs.	Turkey
Ramika	2016	Commercialization of University Innovation	CUI contributes to innovation based industrial development, create employment opportunities, generate income, and bring about national economic development; lack of financial resources is the major barrier to commercialization of university innovation.	South Africa
Robert	2019	Bayh-Dole; Past Present and Future,	The Bayh-Dole Act established the legal framework for commercializing the research that is developed within university settings; CUI contributes to innovation based industrial development, create employment opportunities, generate income, and bring about national economic development.	USA
Rose	2013	The government's role in the commercialization of new	Government may influence technology commercialization by regulating the allocation of	USA

		technologies	resources and defining the nature and scope of property.	
Samuel, & Omar	2015	Universities-industry collaboration	The benefit to the universities include: Source of revenue, patents/IPRs/licensing income, additional income to researchers, create business opportunities & contribution to economic development; the industries are: new products and/or processes, improved products and/or processes, patents, prototypes, generate IPRs, improved competitiveness, access to public grants & accelerates commercialization of technologies.	UK
Schofield	2013	Success Factors for Knowledge Transfer Collaborations between University and Industry	UIC, contributes to CUI: Universities benefit from industrial funding, access to industrial testing facilities and practical case studies; industry potentially saves on R&D; key success strategies for CUI are transparent communication network, senior management support, & adequate research funding.	UK
Sidek, <i>et al.</i> ,	2014	Determinants for a Successful Commercialization of Technology Innovation	Strategies for enhancing collaboration for commercialization of innovation include; motivating researchers, having incentives structure, and senior management support.	Malaysia
Tayeb	2015	Technology commercialization	Technology commercialization, that is, transfer of economically useful scientific knowledge from universities to industries could generate substantial economic growth.	Iran.
Vick, & Maxine	2018	University–Industry Collaboration for Knowledge Transfer	The university research commercialization has been recognized as a driver of the national economy, through knowledge transfer.	UK
Viktoriya, & Ken	2014	Commercialization of University Research	The various government initiatives have strengthened the cooperation between university researchers and industry, thus helping commercialization process.	Canada
Wondwossen	2017	Commercialization of Research Outputs through University Business Incubation Center:	Addis Ababa University established its' first incubation center, with such objectives as; to contribute to the general industrialization effort of Ethiopia.	Ethiopia
Wondwossen.	2015	University-Industry Linkage	Ethiopian higher education institutions are engaged in a variety of such activities that could be grouped under UIC; as practical attachment (internship), training, curriculum development, research and consultancy.	Ethiopia
Zuniga & Correa	2013	Technology Transfer from Public Research Organizations:	Commercialization takes an idea to market, thereby, creating financial value.	USA

Note: CUI is Commercialization of university innovations; UIC is university industry collaboration

5. RESEARCH METHODOLOGY

This section presents the research methodology used in this literature research; including, the research design, methods, the techniques for searching relevant literatures, research types, source and type of journals, search terms, method of analysis and the inclusion-exclusion criteria used for the study.

5.1. Research Methods

For the purpose of the current study, a descriptive research design and a systematic literature review method were used. A Systematic literature review has been developed as a way to synthesize research findings in a systematic, transparent, and reproducible way (Davis *et al.*, 2014), and its use has been

increasing in business research, (Snyder, *et al.*, 2016; Perkmann, *et.al.*, 2013). Besides, a systematic review is a study that seeks to answer a clearly formulated question by finding, describing and evaluating evidence from all published research on topic(s) relates to that question within a specific set of boundaries; and it is differentiated from traditional narrative literature reviews in the sense that, in traditional reviews, there is often no attempt to seek generalizations or cumulative knowledge of what is reviewed (Davis *et al.*, 2014; Perkmann, *et.al.*, 2013). Snyder, *et al.*, (2016), also noted that, the task in narrative review is to identify the range and diversity of the available literature, much of which might be inconclusive, opportunistic, selective, haphazard, lacking systematic search of all the relevant literature. Therefore, a systematic review of the literatures in this study was thought necessary to assess the current knowledge and organize scattered findings to present them in a way that is more relevant, comprehensive and provides detail insights on commercialization of university innovation and related topics.

5.2. Search Techniques, Source and Types of Journals

The search technique used to source the literature study was manual searching using search engine-google.com. The major sources of journals used for the study were: Research gate 14(33%), Academia 4(9.5%), Semantic scholar 4(9.5%), Elsevier /creative commons 4(9.5%), Emerald Publishing 4(9.5%), European rapid press 2(5%), Science direct 2(5%), Springer International Publishing, Social and Behaviora 4 (9.5%) and other open access sources 4(9.5%) of the total sources used. The major types of journals used were: Journal of Technology Management and Innovation 14(33%), Journal of Technovation 4(9.5%), Journal of Knowledge Management, Economics and Information Technology 3(7%), Journal of the Knowledge Economy 2(5%), International Journal of Technology Transfer and Commercialization 3(7%), Journal of Innovation and Entrepreneurship 2(5%), Journal of Innovation, Technology, and Entrepreneurship 4(9.5%), European Journal of STEM Education 3(7%), Journal of Technology Transfer 2(5%), International Journal of Research in Management, Economics and Commerce 2(5%), Journal of R&D Management 1(2%), Journal of Entrepreneurship 2(5%), of the journals used.

5.3. Search Terms or Key Words

The data sources were searched to identify the initial relevant studies using such umbrella terms as “*actors and status of commercialization of university innovation*”, “*tools for commercialization of university innovation*”, “*initiatives for commercialization of university innovation*”, “*factors influencing commercialization of university innovation*”, and “*strategies for commercialization of university innovation*”, were used to search for the relevant literature for this study. Accordingly, **121** studies were obtained as initial sample for the current study.

5.4. Method of Analysis

Qualitative research method was used for analysis of the sample literatures of the study; that is coding by reading through each paper performed, word-by-word, to detect parts in the text and ascribe relevant primary themes (i.e. the major aspects). Next, review of the content of each theme carried out. Then, clustering relevant chunks of information together under specific titles, which latter constitute the sub-themes under each of the key themes was done. Accordingly, *five major themes* of commercialization of university innovations were identified as: *the actors and status, initiatives and models, factors influencing, Strategies and benefits*; and *ten sub-themes* were identified as *1. the Actors, 2. Status, 3. Initiatives, 4. Models, 5. Success factors 6. Hindering factors, 7. strategies, 8. benefits to university, 9. benefits to industry, and 10. benefits to government*

5.5. Inclusion & Exclusion Criteria

As a primary inclusion and exclusion criteria, only journal articles published in electronic database, in the English language, published in the year 2012 to 2019 were included, for their likely coverage of the main ideas of the study topic. There was no restriction on country of origin or on source sector (e.g. academic, government, policy, etc.) or the type of industry. In addition to the primary inclusion and exclusion criteria above, the researchers, drawing on the themes and sub-themes aspects above, set the following five questions that were used as the criteria for *inclusion and exclusion* of research articles in this study to obtain the final sample.

1. Does the study address the level of commercialization of university innovations?
 2. Does the study address the actors' commercialization of university innovations?
 3. Does the study address any initiatives for commercialization of university innovations?
 4. Does the study mention the benefits of commercialization of university innovations?
 5. Does the study address barriers to and strategies for, commercialization of university innovations?
- Thus, a literature was included in the final review if, the answer to question 1 and any one of the questions above is "Yes". Accordingly, the final sample comprised of 42 (fourty two) research articles was obtained.

6. RESULTS AND DISCUSSIONS

For simplicity, the results and discussions section first presents the theoretical literature results and discussions, followed by, the empirical literature.

6.1. Results and Discussions on theoretical Literature

6.1.1. The Major Actors in Commercialization of University Innovations

As per the reviewed available literature, globally, it is acceptable that, all of the prior studies Galvao, *et al.*, (2019) agree that, the major actors in commercialization of university's innovations are universities, industry and the government, that is the triple helix model. This indicates that, the presence of government, university and industry collaboration in the triple helix model is highly important for successful commercialization of university's innovations, as it clearly sets the role of each actor in the collaboration. These roles of the stakeholders in the triple helix are mentioned in the next part.

6.1.2. Models as initiative for commercialization of innovation

Based on the available literature, the major models of commercialization of innovation are the triple helix, the quadruple helix and the quintuple helix models. For the purpose of this study, the Triple helix model was considered.

The triple helix model of innovation refers to a set of interactions between academia (the university), industry and government, to foster economic and social development (Galvao, *et al.*, 2019). Likewise, McAdam *et al.*, (2018), & Miller *et al.*, (2018), confirmed that, this government-industry-academia relationship is known to be crucial, if scientific research ideas are to bring about expected developments for society. In the triple helix approach, the government participates by providing financial resources for innovation to occur, mediating the relationship between universities and industry; universities provide human and technological resources, conducting scientific research, and industry provides support by producing the innovation to make it available on the market, commercialization, (McAdam, *et al.*, 2018).

6.1.3. The barriers to commercialization of university's innovations

The available literature indicate that, the major barrier to commercialization is insufficient research funding, Farahan, *et al.*, (2015); Ramika (2016), & Mulu (2017), inadequate rewards or insufficient incentives for innovators, (Ramika, 2016). Likewise, Lack of human expertise lack of innovative

spirit and failure to create and maintain high-quality scientific knowledge, (Farahan, et al., 2015), institutional bureaucratic regulations, Ramika (2016); an inefficient system of decision making and lack of university intellectual property and technology transfer office (IP&TTO), lack of resource and due diligence system lack of awareness of the value and importance of IP protection among business enterprises, Mulu (2017), lack of support from university management (Ramika, 2016). In Ethiopia, the study by Mulu, (2017), also, revealed that, the main causes for the low performance of university's innovations commercialization, were the, absence of institutional intellectual property (IP) policies in public higher education institutions, and lack of awareness of the value and importance of IP protection among business enterprises. Similarly, Misganu, (2018), affirmed that, university-industry linkage in government universities of Ethiopia was challenged by, policy-practice gaps among others.

6.1.4. The Strategies for Commercialization of University Innovations

The strategies for successful commercialization of University innovations commonly mentioned by the majority of the prior studies were, sufficient financial rewards to support technological innovation, (Misganu, 2018; Mulu, 2017; Ramika, 2016; Farhad, *et al.*, 2018; Correa and Zuñiga, 2013; Schofield, 2013), university, government and industry senior executives' genuine support for research and innovation (Misganu, 2018; Farhad, et al., 2018; Mulu, 2017; Ramika, 2016; Sidek, et al., 2014; Correa and Zuñiga, 2013; Schofield, 2013); rules for protecting intellectual property (Farhad, et al., 2018), increasing communication between the academic sector and industry (Misganu, 2018; Farhad, *et al.*, 2018; Mulu, 2017; Abdulrazak and Murray, 2017; Ramika, 2016; Schofield, 2013), sufficient policy-practice, implementing institutional IP policies in public higher education institutions and research & development organizations, (Misganu, 2018; Mulu, 2017), building awareness, trust and commitment between university and industry, (Misganu, 2018), nurturing healthy relationship with partners, (Norian, *et al.*, 2015), the creation of technology transfer offices (TTO) in universities, (Correa and Zuñiga, 2013).

At a university level, important strategies supporting collaboration for commercialization of innovation are incentives structure, researchers' motivation, senior management support and strong leadership, flexibility, information flow, (Schofield, 2013).

From the discussions on the barriers to and strategies for commercialization of university innovation above, it could be inferred that, while the major barriers to commercialization of university innovation identified by the prior studies were, insufficient research fund, lack of senior management support, lack of appropriate structure, and lack of communication network; key strategies for successful commercialization of university's innovations were allocating adequate fund and human resources, top management support, transparent communication network, sufficient policy implementation, proper structure, like, technology transfer offices (TTO), building awareness, trust and commitment between university and industry.

6.2. Results and Discussions on the Empirical Literature

This sub-section presents the results and discussions on the empirical literature, specific to the status of commercialization of university innovations, initiatives and benefits of commercialization of university innovations.

6.2.1. The status of commercialization of university innovations

The status of commercialization of university's innovations is evaluated based on its contributions to the industrial development and national economic development; hence, briefly discussed hereunder.

While, Khan and Anwar, (2013), have argued that, universities have long been recognized as sources of knowledge creation, innovation and technological advances; the university research

commercialization has been recognized as a driver of the national economy; for instance, the USA's industrial development is the result of commercialization of UI, which in turn led to strong economic development, (Vick and Robertson, 2018; Bolo et al., 2015a). Correspondingly, Tayeb, (2015), noted that, one of the major reasons for rapid development of technology in industrial countries is commercialization of research results. The findings of the above prior studies imply that, where commercialization of university's innovation is successful, industrial development & consequently, national economic development is also successful. Contrary to the status of commercialization above, in Ethiopia, the study by Mulu, (2017), revealed that, commercialized research outputs, and patents are almost non-existent; as only two international patents from universities in about 7-decade history of higher education in the country. Similarly, Amare, (2017), noted that, since the 1980s, while different institutions in Ethiopia have been conducting research in *agricultural, industrial, health, and environmental biotechnology*; none of the results have so far been translated into commercial products. The result of these two studies imply that, the effort exerted on commercializable researches is insignificant, in Ethiopia.

6.2.2. The initiatives and commercialization of university's innovation

Initiatives were analyzed based on their role towards commercialization of innovations and include such initiatives as national policy, UIC, Technology parks and university incubators.

National policy initiatives and commercialization of university innovation

With respect to the national policy initiatives towards successful commercialization of university innovation, the Bayh-Dole Act (1980), of the United States of America, (USA), is considered as an exemplary experience, as it has led to a massive increase in funding to universities by venture capitalists; resulting in a rapid rise in commercial knowledge transfer from university to industry; as a result of the Act, the United States has become very advanced in technology transfer and commercialization (TT&C), and the rejuvenation of the entire U.S. economic system transformed from a manufacturing base to an innovation base, (Robert, 2019). The subsequent success of Bayh-Dole Act, had inspired legislative changes in Germany, Denmark, Japan, Canada, India, the United Kingdom and Singapore to enact similar laws to this Act, (Ramika 2016; Robert, 2019). Likewise, Bolo et al.,(2015a), revealed that, the relative importance of university research commercialization as a driver of the national economy has increasingly come to the fore in higher education policy dialogue in Africa. For instance, South Africa, has developed its technology transfer (TT), platform with the enactment of the 'Technology Innovation Agency Act' (Act 26, 2008), as well as the 'Intellectual Property Rights (IPR) from Publicly Financed Research and Development (Act 51, 2008) (University of Pretoria 2019). As a result of the acts, about five South African companies succeeded in spinning-off 45 start-ups from 2008 to 2014; through government funding (Mustapha et al., (2019). Also, in Nigerian, in 2006, the National Office for Technology Acquisition and Promotion (NOTAP) set up more IPTTOs in tertiary institutions across Nigeria & has effectively developed many more possibilities for Nigerian industries and entrepreneurs to develop their technological know-how through technology transfer agreements with universities; as a result of the act, many Nigerian universities that were without a single patent in their many years of existence, boast 10 to 20 inventions (Aroture 2017). Also, the number of patents registered in Nigeria has risen from a yearly average of 100 in 2006 to 400 in 2012 (Kruss *et al.*, 2012).

While the findings of the prior studies above implies that, developing appropriate national policies and properly implementing these policies is highly helpful to remove the potential obstacles to commercialization of university innovation, to facilitate the required support for the universities & industries, and consequently, to the national economic development, through, expansion of industries;

the study by Amare, (2017), revealed that, since the 1980s, different institutions in Ethiopia have been conducting research in *agricultural, industrial, health, and environmental biotechnology*; and a number of interesting results have been obtained from these research efforts; none of these results have so far been translated into commercial products, in Ethiopia. This indicates, though, policies were developed with the focus to strengthening technology transfer, technology development, university-industry linkage and research output commercialization, their contributions to the commercialization of university innovations were at minimal. For instance, This might be due to lack of appropriate structure responsible to followup the status of implementation of the policy at universities and industries.

University-industry collaboration (UIC) and commercialization

University industry collaboration(UIC) refers to the interaction between the higher educational system and industry aiming mainly to encourage knowledge and technology exchange,(Campbell, *et al.*, 2015). In this study, UIC means, the interaction between public universities and any industry. It also means, university-industry linkage. Concerning the university-industry collaborations (UIC) as commercialization initiative, the available literature shown that, governments, including many African's, are urging universities to take the initiative in establishing a strong linkage with the community in general and industries in particular (Ssebuwufu, *et al.*, (2012). Correspondingly, Viktoriya & Ken, (2014), noted that, there is no doubt that various government initiatives have strengthened the cooperation between university researchers and industry, thus helping commercialization process. The study by Oluwaseun *et al.*, (2019), revealed that, universities in Africa are making efforts in university-industry collaborations aimed at bringing significant improvements to the continent in an effort to drive national innovation and regional economic development, through commercialization of their innovations. In addition, the study by Jose, (2013), revealed that, collaboration between universities and industries is critical for skills development through education and training; the generation, acquisition, and adoption of knowledge via innovation and technology transfer, and the promotion of entrepreneurship through start-ups and spin-offs, and for fostering the commercialization of public research outcomes. By the same token, John, *et al.*, (2016), revealed that, engagement of university with industry in making commercialization a success is crucial. Too, Tayeb, (2015), noted that, one of the major reasons for rapid development of technology in industrial countries is commercialization of research results, the basis of which is research-industry collaboration. From the discussion on UIC and commercialization of university's innovation above, it is inferred that, UIC, when properly established, is highly crucial for successful commercialization of university innovation. However, in Ethiopia, though, the studies by Ayenew, *et al.*, (2015), and Wondwosen, (2015), shown that, despite the lack of focus, emphasis and intensity, Ethiopian higher education institutions are engaged in university-industry linkage through, practical internship, training, curriculum development, hiring of university facilities, research and consultancy; Wondwosen, (2017), argued that, the university-industry linkage as an effort towards commercialization of university's innovation is at its rudimentary stage. Likewise, Mulu, (2017), indicate that, universities have not been able to influence on their socio-economic environment meaningful; implying that, though, there is an initiative to have UIC, its contribution to commercialization of University innovation is minimum.

Technology Park and commercialization

Technology park is an organization that works to promote innovation, university industry linkages, developing knowledge institutes, commercialization of products and services, formation of new ventures and other facilities by having managerial, technical and physical capabilities, (Wonglimpiyarat, 2013). Therefore, it is considered as one of the commercialization initiatives, and

discussed hereunder. The prior studies (Jongwanich et al., 2014; Dahlstrand & Politis, 2013), have confirmed the contributions of technology parks to commercialization, economic development and social benefit to society. The experience of these studies is crucial for countries like Ethiopia, where, the status and contribution of technology parks to commercialization of university innovation was not reported yet; to speedup the pace towards economic development through innovation based industrial development.

University incubators and commercialization

University incubators are a university supported incubation system providing such major services as; shared space at campus, advanced equipment, managerial support, networking, access to national and international markets, patenting and IP protection, & facilitate formation of university spinoffs (Ozdemir and Sehitoglu, 2013; Chandra et al., 2012). In this regard, the prior studies (Dahlstrand and Politis, (2013; the organization of economic cooperation & development, OECD, 2013; Ozdemir and Sehitoglu, 2013; Chandra et al.,2012), have witnessed that, university incubators have accelerated commercialization through, providing location, human and financial capital, advanced equipment, managerial support, networking, access to markets, patenting and IP protection, and facilitating formation of university spinoffs; consequently, contributing to economic development and social benefit to society. As per the available literature, in Ethiopia, while Wondwossen, (2017), reported that, Addis Ababa University has established its first incubation center, the performance of this incubation center as an initiative towards commercialization was not reported and there is no piece of report from other universities in Ethiopia, in this regard. From the discussion above, it is inferred that, university incubators enhance commercialization of university's innovations, mainly through, providing work location, human and financial capital, advanced equipment, access to markets, and patenting and IP protection. Thus, establishing incubators enables universities to enhance the commercialization of their innovations, thereby, contributing to the national socio-economic development.

6.3. Benefits of Commercialization of University Innovations to the Actors

The benefits of commercialization of university innovations were evaluated based on the economic, social and institutional benefits to the university, to the industries, and to the overall national economy. These are briefly discussed below.

Economic benefits of commercialization to the university

The available prior studies (Farahan, et.al, 2015; Samuel and Omar, 2015; Lennora, et al., (2014); Schofield, 2013), agree that, the commercialization of innovations provides income for universities, thereby, reducing dependency on public funds. Likewise, Tayeb, (2015), proved that, technology commercialization can provide financial resources required for organizational longevity and transfer of economically useful scientific knowledge from universities to industries could generate substantial economic growth. Besides the revenue, Schofield, (2013), revealed that, universities also, economically, benefit from access to industrial testing facilities and practical case studies.

Social benefits of commercialization to the university

Concerning the social benefit of commercialization to universities, the study by John, *et al.*, (2016), guarantee that, graduates acquire the right skills and knowledge, that help for their employability.

Institutional benefits of commercialization to the university

Universities gain such institutional benefits as, improved prestige and legitimacy by discovering new solutions to solve organizational problems, (McAdam, *et al.*, 2018); enhancement of university's reputation (Samuel and Omar, 2015). According to Misganu, (2018), universities benefitted from

UIC, by attaching their students with the industries, where, students got practical exposure to the real world of work.

Economic benefits of commercialization to the industry

Regarding the *economic benefits* of commercialization to the industry, prior studies (Samuel and Omar, 2015; Schofield, 2013), confirmed that, industry potentially saves on R&D cost, access to public grants (Samuel and Omar, 2015); access to a talent pool, laboratory facilities and supports open innovation, yields new products and/or processes, improved products and/or processes, patents, generate intellectual property rights, competitiveness and national growth (Samuel and Omar, 2015; Schofield, 2013); accelerates speed of innovation to market (McAdam, et al., 2018; Samuel and Omar, 2015).

Institutional benefits of commercialization to the industry

According to Samuel and Omar, (2015), commercialization has enhanced industries' reputation, and make them becoming more socially responsible business.

National socio-economic benefits of commercialization of university innovations

Prior studies agree that commercialization of university's innovations contributes to national socio-economic development (Bolo et al., 2015a); letting active participation in knowledge transfer, open innovation, establishment of new enterprises, (Farahan, et al., 2015; Schofield, 2013); creating jobs, enhancing wealth creation, and finally, national economic development, (Farahan, et al., 2015; Samuel and Omar, 2015; Schofield, 2013). From the discussions on benefits of CUI to the actors, it is noted that, contribution of commercialization of university's innovations is highly crucial for the university, the industry & the overall national socio-economic development.

7. CONCLUSION AND RECOMMENDATION

Based on the discussion on the findings of the study above, the following conclusions and recommendations are forwarded.

7.1. Conclusion

From the above discussions, the following conclusions are drawn.

- Commercialization of university's innovations has become an area of strong policy interest worldwide, for its contribution to innovation based industrial development, that in turn, create employment opportunities, generate income, and bring about national economic development.
- Globally, commercialization of university's innovations is performing at an acceptable level, nevertheless, it is at minimum level in Africa and specifically, in Ethiopia, mainly due to, policy implementation gap, insufficient research fund, lack of senior management support, lack of appropriate structure, and lack of transparent communication network.

7.2. Recommendation

- In order to enhance commercialization of university's innovations, incorporating the triple helix model (university-industry-government collaboration), in national innovation policy, and properly implementing it, will facilitate practicing university-industry collaboration, establishment of university incubators, and technology parks; in a way that avoid duplication of efforts at universities in developing countries, like Ethiopia.
- At university level, incorporating appropriate structure such as innovation commercialization office, technology transfer and intellectual property protection office, into the structure of universities, will help facilitation of successful commercialization of university innovation.
- Finally, it is essential that, future new research be carried out, in a broader scope, with the emphasis on: "the status of commercialization of university's innovations, the national and

organizational readiness for commercialization of university innovations”, so as to make use of university’s innovations for national economic development.

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