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**PhD by Publication as an Argument for Innovation and Technology
Transfer: with Emphasis on Africa**

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Abstract

The contribution of African researchers to knowledge by means of scientific publications is low compared to other regions of the world. This paper presents an argument in favour of PhD by Publication as a tool for innovation and technology transfer. Building on the literature on the key role of a knowledge economy in 21st century development and catch-up processes, we argue that: (i) in order for PhD dissertations to be more useful to society, they should be harmonised with scientific publications which centre on improving the design and quality of existing and new products in developing countries. (ii) Obtaining a doctorate degree should not simply be reduced to a change in candidate's title as is often the case with a traditional thesis. (iii) The PhD by Publication is a more effective route to ensuring that the contribution to knowledge is widely disseminated. The conceptual framework consists primarily of the clarification of the models of PhD by Publication and the linkages between the doctoral education, innovation, technology transfer and development catch-up. Implications for scientific research policies in the light of contemporary challenges to African development are discussed.

JEL Classification: A20; F42; O10; O30; O34

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1. Introduction

The arguments presented in this paper are motivated by three main concerns, namely: (i) issues relating to the paucity of scientific publications in African institutions of higher learning; (ii) the growing relevance of the knowledge economy in 21st century development and (iii) the need to render PhD programs more useful to society through linkages with innovation and technology transfer. We may deal with each in turn.

First, contribution of knowledge through scientific and technical publications by Africans is considerably low compared to researchers from other regions of the world. For example, only four African universities featured among the Top 500 World universities according to the 2015 Shanghai Academic Rankings of World Universities (ARWU)¹. This confirms a recent stream of catch-up literature which consistently shows that African countries would continue to lag behind in terms of contributions to knowledge by means of scientific publications unless there is an extensive overhaul of scientific research policies (see Amavilah, 2009; Asongu, 2013; Asongu & Nwachukwu, 2016a).

Second, it is abundantly clear that for countries to be integrated into the world economy, they must be competitive. Competition in the twenty-first century is fundamentally centred on knowledge economies (KEs). These are key policy themes that have become very apparent in World Bank and the Organisation of Economic Co-operation and Development (OECD) reports over the past decades (World Bank, 2007; Weber, 2011; Amavilah et al., 2014; Tchamyou, 2015). It is within this framework that the dynamics of KEs have been understood by Europe and North America — the two continents that have inexorably determined the course of economic progress in the international arena. Whereas Asia and Latin America have been responding in calculated moves that underscore the relevance of KEs in their regional and national pursuits (Dahlman, 2007; Chandra & Yokoyama, 2011; Tchamyou, 2015)², the overall knowledge index in African countries has been declining since the year 2000 (see Anyanwu, 2012).

Third, there is need to harmonize PhD Programs with the practical necessities of society. In other words, a PhD dissertation should result in a scientific publication (after peer-

¹ Among these universities, there are three from South Africa (University of Witwatersrand, University of KwaZulu-Natal & Stellenbosch University) and one from Egypt (Cairo University). More insights into the rankings can be found on the following link. <http://www.shanghairanking.com/ARWU2015.html>

² It is interesting to note that the historic pattern set by Japan has charted the course for Malaysia, China and the Newly Industrialized Economies of Asia (Hong Kong, Singapore, South Korea and Taiwan). These countries have been experiencing a spectacular march towards 'knowledge-based economies' from the post-industrialization era 'product-based economies'.

review) for the contribution to knowledge to be widely disseminated. Moreover, peer-reviewed publications are much more recognized as contributions to knowledge in academic circles than unpublished PhD theses. The narrative is consistent with Amavilah (2009) on the low production value of African doctoral dissertations. In this study, we argue that if PhD dissertations are published, such journals would enhance technology transfer and innovation which are essential in catch-up processes for African development.

African universities and research institutions have a vital role to play in enhancing the value of the region's scientific publications, innovation and technology for economic development. To be sure, the principal mission of education and contribution to knowledge is to strengthen societal technological capabilities (Kim & Nelson, 2000; Mowery & Sampat, 2005; Morrison et al., 2009). In addition to providing education and training, universities also have vital functions of channeling knowledge developed within higher institutions of learning into society. This key role of education and training is consistent with the early (late) experiences of Germany (Asian countries like South Korea, Taiwan and Japan) in the 19th (20th) century.

Apart from general education, public research establishments and universities can contribute to the development of a nation by undertaking applied and basic research. We argue in this paper that in order for such development to take place, the underlying basic and applied research should be translated into technology transfer and innovation in a timely manner. In other words, limiting basic and applied research to traditional PhD dissertations is a necessary, but not a sufficient condition for technology transfer and innovation because the peer-review process for publication in academia is also imperative. What matters today in the catch-up process in scientific contributions (of less developed countries with developed nations) is a good understanding of how inventions from scientific outputs are translated into economic prosperity (see Morrison et al., 2009; Balconi et al., 2010). Mazzoleni and Nelson (2007) have advanced two reasons for the importance of the aforementioned catch-up procedure, notably the changing nature of science and technology on the one hand and the role of globalization in the diffusion of knowledge and comparative relevance of scientific actors on the other.

In the light of the above, the importance of African countries in catching-up with developed countries by means of scientific publications builds on the core intuition that catch-up in development is a process whereby backward nations successfully reduce their gap in productivity and income with frontier or developed countries. Moreover, from the above

arguments, PhD dissertations are more likely to be translated into income and productivity if they end-up being published for the purpose of technology transfer and innovation. As recently documented by Asongu and Nwachukwu (2016a), the catch-up process has historically been linked to the adoption and transfer of existing technologies from mature industries in developed nations to less developed industries in poor countries. The authors maintain that as a complex process, catch-up embodies a multitude of varying aspects, dimensions and actors for a given economic system, among which are public research centres and universities. Additionally, Mazzoleni (2008) indicated that these underlying institutions of higher learning constitute the supporting infrastructure for the obtaining and constructing of the technological and scientific capabilities that provide the specialized training which contributes to the processes of improving the design and quality of both existing and new products (Morrison et al., 2009).

The arguments presented in this paper serve one main purpose which doubles as a contribution to the literature. We intervene in the research policy debate by making the case for the adoption of PhD processes which are more amenable to academic competitive challenges of globalisation. As we outline here, the PhD by publication route offers candidates in contemporary academia with both a performance incentives/culture and a means by which the scientific gap between rich and poor countries can be reduced.

The rest of the study is structured as follows. Section 2 clarifies the key concepts underlying our arguments in this paper. Issues relating to scientific publication, technology transfer and innovation are discussed in Section 3. Section 4 attempts to link PhD by publication with innovation, technology transfer and the development catch-up process. Section 5 covers implications for scientific research policy in the light of challenges to African development. Conclusions and future research directions are discussed in Section 6.

2. Clarification of concepts and linkages

2.1 PhD by Publication

In this section, we clarify the concept of PhD by Publication by *inter alia*: (i) presenting a brief historical perspective; (ii) elucidating the notion of ‘contribution to knowledge’; (iii) discussing the differences between a traditional PhD and a PhD by publication and (iv) articulating why the PhD by publication route is more conducive to challenges of globalisation. The above strands are presented in a chronological order.

First, on the historical perspective, Davies and Rolfe (2009) have documented that, during the 19th century, the doctoral certificate was for the most part awarded for achievements that were significant in a specific field of study instead of a research thesis of general interest (also see Simpson, 1983). While the literature on the subject is broadly consistent with the fact that the first PhD by publication was awarded in 1996 by the University of Cambridge (see Hoddell et al., 2002; Wilson, 2002), there has been an informal tradition of awarding staff PhDs, with an example in 1935 from the University College London and another at Cambridge University in 1929 (see Monk, 1991).

In the *second* strand, we argue that a PhD by publication is a more valuable form of ‘contributing to knowledge’ compared to the traditional PhD because the award is based on a series of articles that have been peer-reviewed and published for the most part. The peer-review process is also often unbiased because, in principle, authors do not have knowledge of the person who is reviewing their manuscript. This is unlike the traditional PhD where, in most cases, the decision of ‘life and death’ over the outcome of the PhD rests with the supervisor, staff or a panel within the candidate’s university or another higher institution of learning. Moreover, the fact that multiple peers can give objective feedback comments to various manuscripts in the portfolio of papers constituting the PhD by Publication project is an eloquent testimony that more diverse academic perspectives from experts in the field are required in the doctorate process. In addition, a supervisory team is also needed once a student is registered for a PhD by Publication. In a scenario where a traditional PhD process requires the candidate to publish one or two papers in refereed journals before receiving the PhD award, we argue that this requirement improves the value of a conventional PhD in terms of contribution to knowledge. The perception motivating this strand is the fact that an addition to knowledge is more noteworthy if it (i) is the outcome of a peer-review process and (ii) creates multiple peer-reviewed publications.

Third, there are substantial differences between the standard PhD and PhD by Published procedures. According to Robins and Kanowski (2008, p. 2), a traditional PhD is based largely on a supervised research project that is examined on the basis of a thesis whereas a PhD by Publication is “*based largely on the supervised research project, but examined on the basis of a series of peer-reviewed academic papers which have been published or accepted for publication, usually accompanied by an over-arching paper that represents the overall introduction and conclusion*” (p. 2). Some advantages of a PhD by

Publication (vis-à-vis the traditional thesis) have also been documented by Robins and Kanowski (2008). These include:

(1) 'Efficiency, timeliness and feedback' advantages which build on the policy relevance of analysing data and informing strategy with results before their applicability become outdated. (2) Promoting work practices that are professional and more in line with academic development. This is because the process of developing a journal article entails interactions with reviewers and editors which improve the student's ability in the following three key areas: (i) discipline in research conduct, (ii) improvements of elements of style in scientific scholarly communication and (iii) exposure to a wider research community. As a result the candidate is abreast with the essentials that are required to communicate his/her research within the word limit constraints in author submission guidelines. Such reduces the risk of regurgitating basic ideas abstracted from text books which typically characterises traditional PhD theses. (3) Consolidating a research profile and building scientific credibility. This follows from the fact that funding agencies often give preference to proposals that demonstrate substantial potential benefits to the research community and society at large. Hence, submitting to refereed journals is an effective channel of establishing the societal value of research to current and potential funding agencies. (4) Exposing examiners to students' published works prior to examinations decreases the problem of information asymmetry. Hence, a PhD by publication route offers the possibility of a more collegiate and less confrontational assessment than the traditional viva voce examination (Davies & Rolfe, 2009).

In the *fourth* stream, we provide reasons why the PhD by Publication is more suited to the challenges of globalisation and employment. Davies and Rolfe (2009) have summarised four points to substantiate this perspective. They comprised: (1) a framework of uncertainty which helps to inculcate in the candidate the patience and resilience required for the many revisions which are needed to secure an academic publication in high ranking journals³. (2) A preparation of PhD candidates for employment in a job market that requires publications as pre-requisites because most often, students do not have time to publish and/or publicize their theses after defence. This neglect of dissemination is even more apparent when publications

³ For instance, a student requiring eight peer-reviewed papers for a portfolio of published works in the PhD by Publication process may end-up submitting about twice or thrice as many papers for peer-review because a positive outcome in a peer-review process is not always guaranteed. On average, most top-tier journals have a rejection rate of about 95 percent. Hence, making more submissions than the required number of papers for a PhD by Publication (under consideration) is a strategy with which to ensure the acceptable threshold would eventually be reached after some papers are rejected.

are not required in the pursuit of a career path. (3) A clarification of the sequential process of a PhD by Publication and benefits to the candidates in terms of: (i) experience, (ii) broader insights into research methodologies, (iii) integration and (iv) flexibility and quick responses to changing and evolving research environment. (4) An offer of a collegiate collaboration avenue since co-authorship is allowed in most universities. This decreases isolation and endows the candidate with some valuable experience of team work which is essential in post-doctoral funded projects.

Robins and Kanowski (2008) further confirm that candidates for the PhD by Publication are better prepared for the highly competitive research job market because the process involves so much more commitment, especially in terms of time spent on revisions/resubmissions. By contrast, once a traditional thesis is submitted and defended, the PhD candidate is unlikely to revisit the thesis for publication unless he/she has taken an academic position in which journal publications is part of the performance criteria. Moreover, the implications of the limited support (from supervisors) and resources required for publication may not be apparent post-traditional PhD. Eventually the thesis that is unpublished is not widely circulated for the benefit of a broader scientific community, especially in developing countries. A consequence of such a loss is less innovation and improvements in development technology.

2.2 Scientific publications, technology transfer and innovation

Technology transfer which is also known as ‘valorisation’ in academic circles consists of transferring intellectual property rights (IPRs) from the knowledge contributor to a third party like a business entity or government institution. The recipient of the IPRs is thus granted the right to develop the knowledge acquired into a commodity which could eventually be used for commercial purposes by the recipient and/or another party.

Usually, the university by decree has ownership of research results that are developed within the higher institution of learning⁴. This implies that all academic know-how that is developed within the University by a researcher, for which the University has some property, can be the object of technology transfer. Within the framework of this inquiry, we argue that the resulting technology transfer is more likely when the corresponding research results are peer-reviewed and published. In other words, marketing the contribution to knowledge to

⁴ The interested reader can find more information in this regard in most university websites (e.g. For the Vrije Universiteit Brussels, see <https://my.vub.ac.be/en/phd/techtransfer>).

businesses and/or third parties is much easier if the quality of the research has been recognised by peers through a peer-review process. Accordingly, properly investigating the potential for development of the research findings is paramount in the negotiations of technology transfer. It follows that by the nature of the supervisory process, a PhD by publication is more likely to meet this stringent criteria than the traditional thesis program. .

The thorny issue is why technology transfer is important. Consistent with the motivation in the introductory section, in addition to providing research and education, institutions of higher learning have a third and important mission in society. This is to engage in research contracts with businesses and the government with the prime purpose of advancing the findings of research to benefit society as a whole. Technology transfer enables institutions of higher learning to achieve this task.

In the light of the above, the connection between scientific publications and technology transfer within the framework of a university is to create some added value to the researcher, university and society. The multitude of transfer channels include: trade, licensing and the establishment of spin-offs. Hence, the transfer of technology improves research and education for the overall wellbeing of society.

Having presented connections between scientific publications and technology transfer, it is also worthwhile to discuss the nexus between scientific publications and innovation in terms of patent applications. The interesting literature on how scientific publications are directly linked to patent applications and inventions is documented by Singh, (2003); Balconi et al. (2004); Breschi et al. (2006) and Breschi & Lissoni, (2006).

3. Publication Issues in African Countries

As highlighted earlier in the introductory section, the contribution to knowledge on issues of African development by African universities is significantly low compared to other researchers from other regions in the world. To put this point into perspective, Wantchékon (2013) maintains that of the 258 impact evaluations inquiries in 2004, only 11 percent included African authors. He further articulates that since the year 2002, of the 401 publications in the *Journal of Development Economics* that are related to African affairs, only 7 percent were co-authored by Africans.

In a 2006 keynote address at the 49th annual African Studies Association meeting in San Francisco, California, Amina Mama (a Nigerian feminist scholar) showed that as much as producing knowledge about Africa is an epistemological consideration, it is also an ethical

dilemma for both Africans and non-Africans. She emphasised the point by asking whether it was possible to develop studies on Africa that are respectful towards the struggles and lives of Africans and their agenda. Her position is consistent with the observation of Wantchékon above.

According to Pailey (2016), Africanists in America have been complicit in promoting colonially-motivated patriarchal order by debasing the intellectual agenda of scholars from Africa. She (Amina Mama) challenged the ‘externalisation of Africa scholarship’ which according to her viewpoint relies heavily on externally fabricated methods and concepts that reduce very complex processes into simplistic perspectives about Africa. She further argues that the knowledge produced in Africa for the most part is grey literature from academic institutions because there are editorial gate-keepers that are shutting-out Africans from the global publishing industry. This narrative by Pailey ties closely with the motivation of this study because academic grey literature can hardly be considered as substantial contributions to knowledge that eventually leads to the much needed technology transfer and inventions that are essential for catch-up processes.

In the view of Amina Mama, publishing about the African continent is punctuated with inequities of a structural nature which often dismiss Africans from mainstream journal platforms. According to the narrative, this claim has been confirmed by an article demonstrating that the decline in the number of studies published by scholars from Africa in African studies journals such as *Journal of Modern African Studies (JMAS)* and *African Affairs (AA)* dropped during the period 1993-2013. Whereas submissions from scholars that are based in Africa have substantially increased for journals that are based in Europe, even when the corresponding acceptance rates have declined considerably.

According to Mazzoleni (2008), whereas there is a dispute on whether in order to catch-up, public research organizations and universities in developing nations need to undertake frontier research, there is also a consensus that locally-tailored research is imperative to build national absorptive capacities and support indigenous capabilities. Still, Amavilah (2009) has established that the production value of African doctoral theses is low, implying that these doctoral dissertations are neither significantly contributing to frontier research nor to locally-tailored research, in view of addressing development challenges on the continent. This low scientific contribution by African scholars has been confirmed by a recent stream of literature on the subject (Pailey, 2016; Asongu & Nwachukwu, 2016.).

In response to the August 15th 2013 Shanghai Academic Rankings of World Universities (ARWU), Asongu (2013) has investigated whether the impressive growth experienced by ‘latecomers in the industry’ has been translated into contributions to knowledge by means of journal publications. The author concluded that advanced countries which have mastered the dynamics of knowledge economy will continue to dominate in scientific publications because the catch-up process is slow. This finding has been supported by Asongu and Nwachukwu (2016).

Asongu (2016) has investigated how Africa’s share in the global contribution to knowledge by means of scientific publications can be enhanced through the consolidation of existing Intellectual Property Rights (IPRs) channels. He has established that the enforcement of some IPRs channels can enhance scientific publications, notably Main Intellectual Property law, World Intellectual Property Organization Treaties and Bilateral Treaties. In an earlier inquiry on scientific publications, Asongu (2014) suggested that some form of piracy in econometrics software was needed to advance scientific output in African countries because the existing technologies in these countries (which are at their earlier stages of industrialization) are more imitative and adaptive in nature.

While innovation has been identified as a key driver of productivity and economic prosperity in the developed world (see Tchamyu, 2015), the innovation capacity of African countries remains low for a multitude of reasons, among others: the low production value of African dissertations (Amavilah, 2009) which is probably a cause for the decline in the continent’s overall knowledge index since the year 2000 (see Anyanwu, 2012). However, the globalization of technology is bringing new avenues of development for less developed countries and it is up to African governments to put in place enabling conditions that are essential for the building of knowledge-based economies on the continent (African Development Bank, 2007). According to Tchamyu (2015), in order for developing nations to capitalize on their knowledge economy potential, substantial investments are essential in training of a high skilled labour force and the information technology (IT) infrastructure conducive for knowledge-driven industries. Furthermore, the fostering of research partnerships between institutions of higher learning in developed and developing countries is essential for harmonizing standards of comparativeness among nations (see Suh & Chen, 2007; Lee & Kim, 2009).

4. Linkages between PhD by Publication, Innovation, Technology Transfer and Development Catch-up

In this section, we articulate linkages between scientific publications, technology transfer (or/and innovation) and development for catch-up processes that are essential for economic progress. Today what is needed in the catch-up process between less developed and frontier countries is a good mastery of how innovation and technology transfer (resulting from scientific publications) can be translated into economic growth and development (see Morrison et al., 2009; Balconi et al., 2010). There are two principal reasons for such catch-up between poor and rich countries, namely (i) the changing nature of technology and science and (ii) the growing role of globalization in the diffusion of knowledge for development catch-up. These two points are clarified with perspectives on the role of universities in the catch-up process and technology transfer from scientific publication in such a catch-up process.

Historically, the process of catch-up has been connected to the transfer and adoption of existing technologies from industries that are mature (in developed countries) to less developed industries (in less developed or poor nations) (see Asongu & Nwachukwu, 2016). According to the authors, catch-up is a complex process that entails a plethora of changing aspects, actions and dimensions for a particular economic system. It includes both research institutions and universities which encompass the supporting architecture needed for *inter alia*: specialized instructions, general teaching, building of scientific training, equipment and instrumentation and technological information (see Mazzoleni, 2008; Morrison et al., 2009).

A number of reasons elucidate the anticipated cross-country convergence in scientific productivity. The availability of instructors that are skilled, the migration of experts from frontier nations and the training of students in best-performing countries are important conditions for the development of indigenous technological infrastructure (see Morrison et al., 2009; Mowery & Sampat, 2005; Kim & Nelson, 2000). Consistent with Morrison et al. (2009), the essential contemporary element in the process of convergence is that research (both in basic and applied forms) together with other incentives, constitute key drivers of constructing scientific capabilities that are inputs for technological change, innovation and economic prosperity (see Balconi et al., 2010; Morrison et al., 2009). Given that the underlying assertion is increasingly verifiable in developing nations today, Mazzoleni and Nelson (2007) and D'Este & Patel, (2007) have put forward arguments to consolidate the

declaration, notably (i) the evolving nature of science and technology and (ii) the comparative importance of scientific actors and the incidence of globalization in knowledge diffusion.

On the one hand, concerning the changing character of science and technology, Morrison et al. (2009) posited about the shortening life cycle of technology, products and knowledge in the contemporary era. However, the distinction between technology and scientific fields was not clearly articulated. Moreover, novel industrial sectors as well as technologies, for the most part, have a more solid scientific origin. Therefore, the two communities are increasingly exchanging expertise as confirmed by a substantial body of the literature on the subject (see for example D'Este & Patel, 2007; Tchamyou, 2015). These inquiries are in accordance with the perspective that backward nations, in conjunction with universities and corporations, need to improve their networking systems in order to quickly react to constantly evolving external environmental features. To be sure, for this objective to be realised, it is imperative to set-up an IT infrastructure that would permit institutions of higher learning in developing countries to continually modernise their repositories. It follows that efforts are required for nursing and developing locally-tailored research capabilities when it comes to skills acquisition, training and application. In summary, according to Albuquerque (2000), science has four principal roles in the cross-country development catch-up process, namely: (i) public and tacit know-how; (ii) improved research methods and development; (iii) trained instructors and (iv) technological avenues.

On the other hand, globalization has constrained countries in the periphery to adopt new regulatory structures. More specifically, Mazzoleni and Nelson (2007) emphasized that contemporary knowledge is more limited owing to stringent intellectual property rights (IPRs), which further impede fringe countries from catching-up their counterparts at technological frontiers. Therefore, under the framework of a tighter regulatory setting, they remarked that it has become more costly for outlying nations to adopt external technology. Furthermore, less dissimilar policies that are focused on promoting industries at the national level must adhere to more strict rules of competition that are unfriendly to the standardization of industries. In this context, supporting scientific education, training and infrastructure is a sustainable alternative in the support of indigenous technological capabilities. Since, due to globalization, the worldwide research community is more interconnected, scientists in developing nations see more avenues with which to interact with their colleagues in best-performing countries. This is acknowledged as an approach to networking that has contributed to enhance access to important scientific research funding sources. With the above in mind

over the past decades leading industrialized countries have been increasingly relying on knowledge-based economies by relinquishing the over emphasis on traditional resources like capital and labour in the creation of wealth and economic development (Dahlman, 2007; Chavula, 2010; Chandra & Yokoyama, 2011; Tchamyu, 2015; Asongu, 2015a).

It is predominantly understood in the knowledge economy literature that the creation of original knowledge (especially via scientific publications), innovation and technological transformation are fundamental drivers of economic development in advanced economies (Tchamyu, 2015). Moreover, economic activities that are motivated by such creative ideas enhance employment opportunities, stimulate economic growth, increase wages and ultimately improve the competitiveness of a nation at the global level. The positive economic trend that is characteristic in most advanced nations is strongly contingent on high skilled labour, investments in new and high-technology industries. The creation and diffusion of these essential ingredients in the consolidation of knowledge-based societies is, partly dependent on the research capabilities of universities and institutions of higher learning in the countries in question (see, for example, African Development Bank, 2007). To summarize, Asongu and Nwachukwu (2016), stated that the mission of research institutes (public and private) and universities in the process of catch-up lies primarily in contributing towards development in a multitude of ways. Among others, their principal goal of training and education is apparent in the experience of Germany and some Asian countries (e.g. Taiwan, Japan and South Korea) in the 19th and 20th centuries respectively. Therefore development catch-up in the East Asian miracle was substantially traceable to innovation and technology transfer, which depended on contribution to knowledge by public and private research institutes (see Asongu, 2015).

The relationship between university and ‘knowledge transfer to industry’ is vital in both management and economics studies. It is also an important factor in policies surrounding technology, science and innovations in many developed and developing nations (Breschi et al., 2006; Narin et al., 1997; Verbeek et al., 2002). Hence, contemporary variations in performance and development among firms and countries respectively can be explained by their timely access to scientific knowledge of advanced nature (see Zucker et al., 1998; Cockburn & Henderson, 1998). Whereas developed nations have mastered the dynamics of transforming scientific knowledge into industrial processes for their economic development and the common good of society, there is still some perception in the literature that compared to the USA, Europe is lagging in some key high technology sectors like biotechnology and

electronics. This is because of its deficiency in converting its scientific capabilities into profitable economic innovation in a timely manner (see Dosi et al., 2005). According to Breschi et al. (2006), the phenomenon or disparity has been qualified as the ‘European Paradox’ because of the continent’s inability to match its high quality scientific output with beneficial economic innovation for European companies. Therefore, if compared to the USA, Europe is not using its scientific output effectively, compared to the rest of the world, Africa is lagging in its capacity to leverage on traditional PhD theses for economic innovations that can accelerate the development catch-up process. In what follows, we provide some implications for scientific research policy.

5. Implications for Scientific Research Policy

Implications for scientific policy are discussed in three main strands, namely: (i) the conversion of scientific publications into economically beneficial innovation; (ii) proposals on how to increase contribution to knowledge by means of scientific publications and (iii) the connection between IPRs regimes, science and innovation in developing countries. In this section, we resist the urge to discuss the advantages of the PhD by Publication vis-à-vis the traditional PhD because the appeals of the former have been substantially covered in the previous sections.

5.1.1 Converting scientific publications into economically beneficial innovation

There are many potential avenues along which knowledge can be exchanged between industrial researchers/producers and academic scientists, in view of converting scientific know-how into beneficial economic innovation. Such collaboration is more apparent within a PhD by Publication framework than in a traditional thesis setting. In order not to jeopardise future patent applications, it is important to submit articles for peer-review simultaneously with demands for patent. This is when the researchers at the university foresee the potential of research outcomes in the industry. PhD candidates should be advised on the procedure for technology transfer. This is usually through a higher institution of learning’s Technology Transfer Interface. Engaging the procedure of technology transfer without delay enables researchers to determine the possibilities of their findings for industrial development. Moreover, this system of practice enables research results to be protected while being disseminated by means of peer-review journal publications. Like with the traditional thesis, many technology transfer and innovation opportunities may be lost if timely consultation with

the university's Technology Transfer Interface is not considered with the wisdom of maximising the potential research findings. In a nutshell, even in scenarios where there is an urgent need to publish results, the Technology Transfer Interface of most universities has systems in place to protect and manage patented innovations.

5.1.2 Increasing contribution to knowledge by means of scientific publications

Four principal policy implications are noteworthy in view of increasing knowledge contribution through scientific publications, namely: (i) support for indigenous-focused scientific research, (ii) fight against brain drain, (iii) support for regional innovation and (iv) improvement of communication between policy makers and experts.

First, whereas there is a consensus in the literature that locally-oriented research is essential for enhancing absorptive capacities at both the national and indigenous levels (Asongu & Nwachukwu, 2016), it is nevertheless crucial to set standards for locally-focused research. This process enables assessment of scientific rigour by peers (via the standard publication review process) and hence to confirm the suitability of the locally-targeted associations that underpin the research. Moreover, in order for the research findings to contribute to industrial development, interested parties including investors are most likely to investigate whether the methodology with allied policy recommendations have gone through acceptable vetting procedures. Given that publishing in most top tier journals requires authors to pay submission fees, governments in African countries would need to provide substantial incentives to researchers willing to publish during their PhD course so that they can engage more in contribution to knowledge, especially in fields that are closely associated with industrial development.

Second, with regard to the concern about brain drain, it is important for African researchers based abroad to connect/collaborate with peers in their countries of origin. Such international partnerships could include, 'PhD by Publication mentoring' and insights into mechanisms by which ground-breaking research results can lead to industrial development. African Governments should also take necessary measures to ensure that scientists that are fleeing the continent in search for greener pastures and better conditions of work keep-in-touch with local universities. Besides, with increasing globalization and standardization of diplomas, most students from less developed nations that are trained abroad in fields that are closely related with science and innovation seldom return to their own countries upon

obtaining their certificates. Efforts to stem the tide cannot be exclusively national: regional and international common policy initiatives are also paramount.

Third, support for regional innovation and research is also vital in order to enable countries with low levels of output in top-tier journals to catch-up with their counterparts with large number of publications in journals with high impact factor. The initiative should centre around, *inter alia*: encouraging and validating activities focusing on regional and local initiatives so as to promote the development of innovative businesses as well as the ‘exchange and transfer’ of state-of-the-art practices. Such may include the building of cross-country conducive environments for research and PhD programs. It is preferable for the creativities to be primarily focused on the following ideas: (i) transnational cooperation with the aim of facilitating innovation resulting from the PhD course; (ii) orientation of PhD by publication programs to include both local actors and regional policy makers and (iii) involvement of countries at the continental level in publicizing technology transfer projects allied to scientific research at doctoral programs, especially those that have been successful at national and/or local levels.

Fourth, a common feature to the three strands of policy directions discussed in the preceding paragraphs is the need to improve on communication facilities between PhD researchers, policy makers and industries. Establishing joint communication networks and platforms could be a step in the right direction. Furthermore, success stories which clarify the close link between scientific publications and the processes of industrial development need to be properly documented in order to serve as role models for PhD candidates. Clear statistical indicators and updated data on the career progressions of PhD by Publication *relative* to PhD by dissertation candidates are also worthwhile to help potential students leverage on successful implementations and learn from failed endeavours.

5.1.3 IPRs regimes, science and innovation

Scientific contributions and industrial development in African countries by means of scientific publications can be enhanced if reverse engineering is acknowledged as being consistent with the current state of industrial development in most countries in the continent. With the understanding that learning processes and acquisition of knowledge in the majority of developing countries are more adaptive and imitative in nature (see Bezmen & Depken, 2004; Tchamyu, 2015; Asongu, 2015), the PhD by Publication process in areas requiring heavy investment would have to build on existing know-how such that privileges of primary

copyright holders are not abused. But, while some innovations are open to replication in developing countries, others are not. For instance, the right to locally reproduce life-saving drugs for diseases (e.g. HIV/AIDS) that are more prevalent in poor countries has been at the centre of the property rights debate in the pharmaceutical industry (Andrés & Asongu, 2016). Today, India is producing significant quantities of life-saving generic drugs that were originally developed by patent holders in Western industries.

The underlying policy recommendation is consistent with some factors behind the East Asian Miracle. In principle, the newly industrialized countries of Asia have achieved their economic progress by copying technology-intensive products and services from more developed nations (see Kim, 1997; Kim & Kim, 2014; Kim et al., 2012; Lee, 2009). The suggestion is also in line with Asongu (2014) who indicated that less stringent intellectual property rights could boost scientific publications in Africa. Overall, this commendation is within the framework of Kim et al. (2012), who established that alternative forms of property rights in developing countries are likely to enhance adaptive scientific endeavours. We have argued that the PhD by Publication framework that aims at industrial development can leverage on such schemes to enable locally-tailored research to benefit from established scientific underpinnings of dominant industries in the developed world.

6. Conclusion and future research directions

The contribution of African researchers to knowledge by means of scientific publications is markedly low compared to other regions of the world. This study has presented the PhD by Publication as a means of innovation and technology transfer. Building on the key role of the knowledge economy in 21st century development and catch-up processes, we have argued that in order for PhD dissertations to be more useful to society, they should be harmonised with publications in top-tier journals in order to enhance innovation and technology transfer that are essential in improving the design and quality of existing commodities and new products.

The conceptual framework has consisted of: (i) clarifying the ideas of PhD by Publication, scientific publications, innovation and technology transfer; (ii) discussing issues concerning the quality and dissemination of contribution to knowledge in Africa; (iii) presenting linkages between PhD by Publication, innovation, technology transfer and development catch-up and (iv) discussing the implications for policy in the light of contemporary challenges to African development.

Future studies can focus on country- and/or university-specific case studies in order to improve existing knowledge on the advantages of deviating from traditional PhD thesis and embracing PhD by Publication route. This approach is more consistent with the challenges of globalisation and contemporary relevance of knowledge economies as key to 21st Century development.

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