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Enabling Environment for Research and Development Growth in Africa: IP Protection, Challenges, Drivers and Approaches

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The disadvantaged status of economic development for most countries in Africa, coupled with the challenges faced by these countries in areas of basic human needs, continues to be a hurdle to the successful research and development initiatives on the continent as priority continues to place funding-emphasis on addressing basic human needs. The comparatively low level of research participation by higher education institutions, particularly university level, coupled with the absence of a globally significant involvement of Africa's-industrial sector in research, are factors that will need to be addressed if Africa's contribution to global research output is to realize significant growth. This is particularly important as industry and universities continue to be the main drivers of growth in the area of innovative research development and research application. In light of these challenges, the assertion that research has value for Africa and hence the need for Africa to continue improving its global profile in research, this paper presents a discusses different approaches to IP development, acquisition and protection and how each of the approaches can be utilized towards growing the level of Africa's participation and contribution to research and development output. While drawing attention to research collaboration approaches and to the envisaged benefits of such collaborations, the paper identifies higher education systems, industry, and governments are key drivers of research and development, and hence the need for Africa to leverage on, as well as focus on development to a level where these drivers become more pronounced as instrumental to driving achievements in innovative and impactful research and development for Africa.

Keywords: GDP, Research and Development, Research Imperatives, intellectual property, ICT Research and Development and Innovation Strategy of South Africa, African Socio-Cultural Aspects, African Regional Intellectual Property Organization, Harare Protocol on Patents and Industrial Designs, University-to-University Collaborations, University and Industry Collaborations, The Bayh-Dole Act

African governments continue to recognise the importance of education, knowledge acquisition and dissemination to the growth of a productive human resource capital. A recognition that is demonstrated through the putting in place of; research enabling policies, research and development directed economic expenditure initiatives and the establishment of institutions that are focused on delivering a quality education, and, research development environment.[1-5]

However, these efforts are to a large extent faced with challenges. The magnitude of the challenges that Africa faces in its endeavor to grow in the field of innovative research and development can be stated as " between 2000 through 2004, Africa produced only 1.8% of the world's publications and in comparison India produced 2.4% and Latin America 3.5% of the world's research. Moreover, it has been suggested that much of the African research is concentrated in only two African countries, i.e. South Africa and Egypt which between them account for just about 50% of the continent's publications. The top 8 countries in Africa produce above 80% of the continent's research."[6]

Of the world publications in 21 main fields that are relevant to social sciences, South Africa accounts for a 1.55% share in the field of Plant & Animal Science, 1.29% in the Environment/Ecology, and takes lead in fifteen of the 21 main fields.[7] Nigeria takes lead, at 0.95%, in Agricultural Sciences, while Egypt accounts for a highest share of 0.62% in Chemistry, as well as taking the lead in five of the 21 main fields, while Kenya and Algeria contribute highest at 0.45% and 0.25% in immunology and material Science, respectively.[7]

The reality is that for a majority of African countries, despite the existence of on average, more than ten tertiary level educational institutions or universities per African country, the per country contribution to research driven development within the continent is comparatively very low. In this

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regard, it is therefore, important for initiatives that are designed to encourage research and development in developing countries to have clearly defined objectives. Such objectives should clearly communicate the challenges and expected outcomes – outcomes that emphasise the value of research to national economies, the community and individual researchers. The feasibility of achieving objectives should not be assessed in isolation from the need for an enabling environment as well as mechanisms that are designed to improve the potential for success. In turn, mechanisms that are put in place at both policy and implementation levels should be constructive towards creating research enablers in a macro environment that includes the social environment, the technology environment, the political and the economic environment. The macro level environment enablers are in turn bound to have a positive effect on approaches and initiatives that are geared towards promoting research growth, taking into cognizance the importance of stakeholder engagement, research funding, national research policies as well as the creation, acquisition and protection of intellectual property.

It is thus, important for research initiatives that are supported by national development policies to at all times be value adding; with the ultimate being to realise an improvement in the measures of social-economic capital growth or development. This value-addition should be driven or realisable through industry and higher learning academic institutions and through collaborations that are aimed at delivering a visible positive impact on the socio-economic environment.

Research Imperatives

The imperative for research is fundamentally driven by the quest for knowledge (basic research) and a need to address social and economic challenges that have a bearing on human lives (applied research). Research institutions, both industry and higher education academic institutions, should ideally, prioritize their research agenda in light of these imperative drivers and should be directed through well-defined foci towards impactful implementations. For Africa, the drive to improve on social capital is captured as research priorities under six identified pillars.[3] A number of countries in Africa have thus through policy and strategy implementations[1, 4-6] embarked on developing and implementing national research agendas that put forth research initiatives or projects that are aimed at addressing issues that have a direct bearing on the lives of their citizen communities. Such projects to a large extent tend to revolve around agriculture (food production), health (community oriented health service delivery), energy resources (power and water), etc. The potential benefits of research in these areas are clear as these are encapsulated in the humane value of the need to provide every individual with access to the basic human needs through. On the other hand, the research focus or imperative for industry will to a large extent be commercially driven. For example, from the perspective of financial investments, large manufacturing companies are likely to be interested in research that would improve their production line efficiencies, improve the quality of their products, reduce production costs, increase sales, etc. and thus contribute towards improving profit margins. The contributions of industry to corporate social responsibilities can however not be overlooked.

The knowledge creation imperative for research is therefore likely to be of major interest to academic institutions alongside a focus on basic research with the objective of acquiring knowledge that can result in implementations that have a potential to improve human life. The turnaround times to implementation stand to be accelerated when basic-research -acquired knowledge shows potential for practical applicability and thus potentially attracting increased interest from industry, together with a possibility for research funding.

Initiatives for Driving Research

An impetus to put in place national research driving initiatives is dependent on a number of factors, among them the level of economic development, particularly in the specific sectors from which research originates for example, the level of industrialisation, particularly manufacturing or production; the growth of the agricultural sector and regional capability in the generation and delivery of energy resources and economic capability towards driving projects for the development and delivery of social services. Furthermore, the impetus will also be influenced by the emphasis of national policies as well as the maturity of sectors within which potential research drivers are likely to be found for example in industry and higher education sectors. The direction and emphasis of national-policy thus presents an informed indication of national research interest. As regards basic research, even though this tends to be

mainly academic driven, the impetus for research initiatives in this area can also be encouraged to some extent through the contribution of basic research to achievements in applied research and improved prospects of patentable inventions. From an economic development perspective, the level of tertiary education development as measured by the number and most importantly the standard and research capability of universities - as measured by national and international ratings of universities, their subject specilisations, their academic staff expertise, and their financial capability, will have an impact on the extent and impact of national research engagements.

Taking into consideration the research initiative drivers discussed so far, it can be argued that government emphasis on research, particularly in the developing world, is likely to focus on applied research; with the support of government policy towards addressing basic human need related challenges On the other hand basic research is likely to lag behind as most African governments would be reluctant to channel finances towards basic research in the face of pressure to address and deliver on basic human needs, and especially so in light of the limited budgets that are characteristic of most African nations. The result would be a reduced focus on basic and knowledge creation research unless higher learning academic institutions can themselves afford the funding of such research. Such funding could be sourced by engaging in basic research that stands to contribute to a commercial benefit by industry and hence attract industry funding. In addition, rewarding basic research by academic institution could be a result of the potential to attract funding assistance from governments as basic research results begin to show indications of a potential positive impact on areas that are linked to national research agendas. The downside of this approach sourcing research funding could be a potential stifling of basic research in those areas that do not have an obvious link to applied research areas that are focused on addressing basic human needs.

The dynamics of balancing progress in all forms of research against the background of basic-need priorities and funding challenges, amidst other economic challenges, are in themselves a challenge for a majority of African nations. The effect of these dynamics on intellectual property (IP) protection acquisitions and the challenges posed by the inadequacy of enabling environments for innovative research and development has resulted in very few implementations of international mechanisms for IP protection such as, patenting, among the African countries. The top five countries, being South Africa, Kenya, Egypt, Zimbabwe and Morocco, with South Africa contributing about 84% of the patents awarded to the top four countries.[8] Out of 32 ranked countries, 27 (84%) of the countries had not registered any patents as of 2009.[8] Though patents alone are not an authoritative measure of a country's innovation, they however, are acceptable broad indicators of the pace at which a nation is inventing and creating new ways of doing things. [8]

The situation is even more of a challenge for Africa when viewed against world figures for the different types of patents. Africa has contributed only 0.08%, 0.09%, 0.23% and 0.09% of the world awarded utility patents, design patents, plant patents and reissue patents respectively.[19] In light of the challenges of growing research and development, that are faced by most countries in Africa, and emanating from the social and economic shortfalls these countries face, there is need to explore and adopt enabling approaches towards growing research and development. This means raising an awareness and understanding of the range, the applicability, and the value of implementing mechanisms for intellectual property protection. The next section presents available alternatives to IP protection, with a focus on how each alternative can be applied in growing research and development in disadvantaged economies. Implications of these alternatives on IP protection and ownership for African countries are also discussed.

Intellectual Property - Challenges and Opportunities

Intellectual property gives companies the confidence to license their proprietary technologies for use or further development where they are most needed.[9] In this way IP creates an environment for industrial and entrepreneurship developments thereby contributing to economic growth. However, this in itself is still a challenge to most African countries as they are less industrialised from a manufacturing industry perspective,[10] and in general do not have a highly research-active higher education academic sector - which are both essential for the creation of an environment for innovative research - alongside the availability of friendly Intellectual Property legislation and industrialisation which has been shown to be instrumental to economic growth.[11 -12] Though, Africa has in recent years shown a strong

growth, a large part of this growth has been driven by factors other than industrialisation while a continued inadequacy of industrialisation is placing a restraint on the growth of African economies.[10] The lack of technological innovations that have a positive impact in triggering the emergence of new industries continues to be another restraining factor to growth in Africa.[13] On an average, industry generates merely $ 700 of GDP per capita in Africa, less than a third of Latin America's output ($ 2500 per capita) and barely a fifth of East Asia's ($ 3400 per capita). Industrial GDP influences overall GDP as industrial productivity drives productivity in other sectors.[10] Clearly, if research and development has to make a significant contribution to economic growth, and ultimately social empowerment in Africa, it is necessary that there be an explicable synergetic link or collaboration between research and industrialisation alongside the implementation of instruments for the protection of research outcomes.

The Sub-Saharan Africa ranks lowest and well below average in technological readiness, innovation and business sophistication when compared to other developing regions – Latin America and the Caribbean (LAC) and South East Asia (SEA).[23] This reflects the extent of the challenge to innovative research that is faced by Africa. Furthermore, with respect to the affordability of climate-friendly technology, the Third World Network has made an observation that patents on the new technologies may be keeping prices too high and restricting access by developing countries.[9] This high cost of access to patented technology thus further impacts on the developing countries whose rating on technological readiness is already lowest and well below average in comparison with similar developing regions.[23] Taking into consideration the contribution of patented technology in promoting industrial growth and an environment for innovative research, unless the cost of patented technology is made affordable to developing countries in Africa, the growth of patent driven industrial growth, and the benefit of industrialisation to the growth of research and development may remain forever elusive for most countries in Africa.

Hence, in view of the socio-economic challenges that Africa faces; regional integration and collaboration, in for example, developing state-of-the-art research centers and creating research teams, stands to benefit, not only from the perspective of pooling research expertise, but also from the perspective of resource integration and improved opportunities for research growth; all of which stand to positively impact Africa's potential to register more patents and enhancement of regional-research and furthering industrial growth. With the support of national and regional policies, this approach can over time, achieve improved visibility of impactful research capability among collaborating regional countries. Such a need for an integrated collaborative approach is also highlighted in[15] and in which implore is made for scientists in Africa to unite and coordinate with all the scientific Research Centers in Africa and achieve inter-African integration. In addition, also draws attention to the importance of researchers in Africa to get involved in research that is aimed at improving the standard of living for the people of Africa;[1] A view that is further reflected in one of the aims of the ICT Research and Development and Innovation Strategy of South Africa is stated as "to improve economic competitiveness and the quality of life for South Africans."[16] Though this clearly encourages growth in both adaptive innovation and new innovative applied research that is directed at betterment of society in Africa. The challenge however, for new innovations is that there already exists a body of patented instruments and knowledge (particularly in the social and technology domains) that is already being applied towards improving human through for example, initiatives aimed at availing of access to basic needs to the disadvantaged diaspora in the developing world. Hence, amidst the social challenges that developing Africa faces, there seems to be comparatively very little opportunity for African researchers to register patents on new innovative inventions without leveraging on the potential benefits of integration, collaborations, and adaptive-innovations. Even then it is likely to take some time before most researchers and governments in Africa can draw their focus more intensely on basic innovative research in areas other than those aimed at addressing the basic human needs. This challenge is further alluded as, "Though we wish it were not so, scientists in Africa are engaged in the greatest war on earth. They are waging war against poverty and hunger."[9]

As Africa endeavors, as one of its objectives, to develop research through integrated collaborations and other mechanisms toward future patent registration, it is important that international

benchmarking in terms of policy, attracting experienced research expertise as well as interest from industry, be recognised as critical success factors. In this regard, it is encouraging to note that some African countries realise the value of this objective and have built this into their research and development strategies.[1-5] For example, South Africa through its ICT Research and Development and Innovation Strategy (ICT R&D & I) has as one of their objectives to develop focused and strengthened ICT research activities to achieve world□class research competencies in identified key Science and Technology areas.[16] Coupled with benchmarking, it is also important that an ideal environment for growing research and development initiatives in Africa be inclusive of the African socio-cultural aspects, such as, the development of an indigenous knowledge base, including the development and involvement of indigenous-research-expertise and research on indigenous knowledge. Such inclusions would have the potential to encourage a continuous socio-cultural representation in new and ongoing research findings, as well as improve the potential for registration of patents that are indigenous to Africa. This cultural view is also observed through the South Africa (ICT R&D & I) in its objectives to build a strong and robust ICT innovation environment, with an indigenous ICT sector that is competitive and growing.[16]

Opportunities for Institutional Collaboration

Intellectual property protection through patenting requires, amongst others, the patentable work should be an invention that can be applied in an industrial context. The patent taken on the invention then becomes a property of the inventor. As already presented, for most developing countries in Africa one of the challenges to conducting research that has potential for an invention is the cost associated with the research. To a large extent, universities in the developing world, whose budgets tend to be limited, are less likely to afford such costs. A strategy would be to venture into collaborative research and development initiatives with other universities and with nonacademic research institutions and industry.

Such collaborations, especially with international higher education institutions and industry companies, would, for developing Africa, be leverage for the mitigation of their inherent shortfalls to the delivering of meaningful research and development projects. Successful innovation in industrialised and more advanced developing countries results in most cases from intensive cooperation and feedback loops between firms and supporting institutions, including universities, research centres and vocational training institutions.[14] Such collaborations can be realised through different instruments including joint ventures. It is however, worth observing that though such collaborations would no doubt contribute to the growing of research and development in developing countries in Africa, the likelihood for registering patents in favour of African institutions or industries is likely to remain minimal for many years to come. This to a large extent being a result of the developing world's current resource disadvantages as already discussed and hence potentially less bargaining strength when it comes to negotiations on patenting contracts. Nevertheless the potential value of such research and development collaborations to the developing world cannot be disputed.

Table-1 presents a view to potential institutional research collaborations in a collaboration matrix together with an indication of which of the collaborating entities is likely to take custody of the IP that would result from each indicated collaboration association. The table also indicates some factors that would encourage each type of collaboration in relation to the research drivers previously discussed.

It is therefore, important that the development of research collaborations should be seen as a major driver to creating an environment that is supportive of developing meaningful research participation by countries in the developing world. The success of such collaborations will require governments to take a proactive approach and put in place supportive and friendly research and development policies covering; education, promotion of private sector growth, research funding and a realisation of the potential role that vocational institutions can play in driving innovation for example, through the manufacturing industry.

University-to-University Collaborations

Research collaboration between universities may require that collaborating universities come to an agreement in the joint funding of research initiatives, especially in situations where there hasn't been any expression of interest from industry to fund the research. Issues of IP protection will need to be agreed upon by the research partners. The benefit of such a collaborative approach is that it would encourage research to take off and the result could be

Table 1 — Institutional Research Collaboration Matrix

	Collaboration Entities					IP Ownership		ULE		IND			
S. No	NU1	NU2	NI	IU	II	IPN	IPI	L	H	L	H	Shortfalls/ possibilities	Potential for success
1	√	√				√			√			Requires an advanced education system with a good grounding on research.	Still a challenge in developing African countries whose university level education still lacks in research initiatives. Would make little progress. Requires developing local research capacity.
2	√		√			√					√	Requires a well developed tertiary level education system with a good grounding in research, as well as highly industrialised economy.	Still a challenge in developing African countries whose university level education still lacks in research initiatives and whose industry capacity for research is still low. The possibility of such collaboration is still low.
3	√			√			√					Would benefit from research capabilities of developed Nation's robust university level education and research experience and expertise	In light of the challenges faced by developing countries as far as the level of tertiary level education and research capability, this collaboration combination would be more value adding.
4	√			√	√		√		√			Would benefit from research capabilities of developed Nation's robust university level education and research experience and expertise as well as solid industry base	In light of the challenges faced by developing countries as far as the level of tertiary level education and research capability, this collaboration combination would be more value adding.
5	√				√		√					Would benefit from research and financial capabilities of developed Nation's solid industry base. Requires a well developed university level education system that is well experience and has research expertise. This is the strength of developed nations.	Same as 4 above with the benefit of a strong industry base. The involvement of International Universities would be a potential encouraging factor for the International Industry expressing some interest in research

IU: International University NI: National University
IPI : Intellectual Property- Internationally (developed country) owned II : International Industry
ULE: University led Education

a successful invention that in turn may attract funding from industry. This would provide developing economies with opportunities to get involved in meaningful research with a possibility of them becoming patent owners of research inventions. Nevertheless, whether ownership of patents that result from such collaborations would belong to a local or national entity (the collaborating developing world country) or not, would then depend on the nature of the collaboration and relevant contractual agreements.

University and Industry Collaborations

The ultimate benefit of university-and-industry collaborations could be innovative research outcomes that are attractive to industry and potentially resulting in the acquisition of research funding. University and industry collaborations from the onset are less likely to be achievable for most developing countries in Africa primarily due to the level of research and development in these countries' universities, and also due to the low levels of industrialisation and industry or private sector participation in research. Collaboration between industry and universities as a vehicle towards growing the research agenda also suggests that the largest part of (European) patents in which university researchers are involved as inventors, is owned by private firms, rather than universities.[17] This, as further stated suggests an active involvement of industry in research, much earlier before the patent stage, hence favoring industry to take custody of patents at the time of contract negotiation. This is evidence of the requirement for innovative research in African universities if African countries are to be successful in their aspiration to improve Africa's position in global research. Furthermore, this is also evident of the importance for universities in Africa to get engaged in research that is of interest enough to attract industry or private sector involvement. It is worth observing that the opportunity for early involvement of industry in research stands a better chance in countries with a mature and advanced private sector or industry economy that sees research as a key area. Such a combination of research and development enablers is a long way off for most countries in Africa; hence the need for African universities to explore opportunities for inter-continental university collaboration engagements.

Thus the challenge for developing countries in Africa in developing the level of their research participation to a globally significant level is a huge one. The role of industry and the trend for industry to take custody of patents on research inventions[17] points to the need for Africa at large to provide an impetus for growing a research focused industry that is supported by a robust research-focused university education system that is capable of carrying out research projects for knowledge transfer to the private sector. This challenge is clearly reflected as even though universities in Europe are heavily involved in research (considering university involvement across the different university patent definitions), not many of the patents resulting from the research end up in the custody of universities.[18] This is a trend that African countries and universities have to benchmark against as well as contend with as they drive Africa's research growth and development agenda.

Intellectual Property Development: Acquisition and Protection

University Patenting and Public-Private Research Joint Ventures

In view of the joint venture approach to research and development collaborations [Table-1 (2-4)], taking into consideration the tendency for patent licensing in developed countries to be in favour of industry or the private sector, it is reasonable to assume that even when capacity for innovative research in the developing world finally reaches a globally comparable level, patent licensing to (African) universities is likely to be minimal. This assertion being correct, what it therefore means is that university licensing of patents (in developing countries) in a joint venture is likely to be realised where at least one of the joint venture entities is a public entity. It is a joint venture between a public or private university, and a public instrument of government whose mandate would be to promote the development of research in universities through funding, and leave issues of patent ownership following a research invention to the university. However, in the event of the university being a private entity, it is unlikely that a funding public instrument would not be interested in patent ownership on any invention realised from its funded research. One approach to mitigating this possibility could be to make it a requirement for publicly funded private universities or higher education institutions to invest a certain percentage of, for example funds received from government supported student scholarships or public funding, towards research initiatives, and to deliver on research objectives that respond to government priorities.

In the absence of deliberate initiatives such as suggested above, and in view of the challenges faced by many developing countries in Africa, the feasibility of universities in these countries registering patents in their favour will always be limited not only by limited expertise for innovative research on the part of the universities, but also by limited access to research funding. However, as these universities develop their capacity for research funding and the expertise capacity for innovative research, so will be

the opportunities for these universities to realise to take ownership of indigenous patentable inventions that are realised through their research projects. Even then, the licensing of patents on research inventions is likely to follow the same trend for countries in Europe as already observed. This therefore, means that, unless the research interest and capability of the indigenous industry sector can rise to a level where industry would be interested in research inventions and research funding, ownership of patents to indigenous research inventions will to a large extent always end up in the hands of the non-African international entities, and Africa will forever lag behind in the area of innovative research and patent ownership.

Patronage is defined as a mechanism in which governments take financial responsibility for the development of new knowledge, by means of instituting a publicly financed system of research that is aimed at generating and diffusing new knowledge.[18] Governments have a broader role to play in the development of new knowledge and in growing the profiles of national institutions of learning and research to a level of international recognition. In developing economies, where self-funding by such institutions is not always sustainable, and governments can bear the financial responsibility for research by funding universities and established national public research organisations, imperatives for research in areas that are reflected in government policy and aimed at addressing core human needs present opportunities for primary government involvement in driving research in these areas.

In this model, the government does not influence the IP model to be adopted but rather leaves it to the policy of the public organisation it is funding. This is the *patronage* implementation of IP development.[18] The benefit of the patronage system in less industrialised economies of the developing world is that the system addresses the problem of limited opportunities for research funding from the private sector when compared to similar opportunities in the developed world. By adopting the patronage system, national public research institutions and universities would be supported in their initial basic research, which in itself may be less attractive for industry funding as basic research may not be immediately relevant to private sector priorities. However, once results of basic research start to clearly show a relevance to industry, a collaborative opportunity with an industry partner may avail itself, and at which point the patent system on potential industry inventions for IP protection may then become an option. This would nevertheless be subject to relevant contractual agreements between the collaborating entities (public research institution and procurement of the research knowledge by industry). Such government financial support would provide the necessary opportunities for local or national industry-participation in research and the registration of indigenous patents (Table-1)

Procurement

Procurement refers to a situation in which the development of a specific piece of knowledge is the topic of a contractual agreement between the producer of the knowledge and a party that is particularly interested in the knowledge, and hence is willing to act as a financer and procurer in the contract.[18] The procurement system of IP protection is another system that is likely to be applicable and befitting to a larger extent in the developing world as most universities in the developing world cannot afford the cost of research. In view of most governments in developing countries prioritizing on research in areas that have a more direct bearing on human lives (e.g. food, health and shelter) and which are a mandate of the government structures, a trend is to establish education and training institutions that specialize in specific areas of identified basic human needs, e.g. health and agriculture. In this system a government ministry for example, may be interested in the development of research-knowledge that is specific to their ministerial mandate. The ministry would then enter into a contract with the producer of the knowledge (university). In this contractual relationship, the ministry would finance the research and also be the procurer. IP ownership on resultant inventions would then be agreed on based on an agreed patenting system, with agreements being made as to who between the ministry/procurer and the university/producer of the knowledge becomes the patent owner in the case of an invention.

In this case, the procuring entity, being an arm of the government in collaboration with a national public university, would be financially supported by the government through a national budget process and would then invest the funds in procuring relevant research knowledge with potential for practical or commercial applicability towards addressing a mandate of the ministry. This in itself would be

supportive of the acquisition of patents by indigenous institutions. In adopting approaches to IP development, acquisition and protection through the patronage and or the procurement system, the financially capable patron (government) or procurer (ministry), which in reality is the government, would be instrumental in creating advantages that will contribute to the success of national research and development initiatives and hence to the achievement of national and continental research and development objectives. Included among these advantages are: Quality control in the application of university research; Raising awareness of commercial research in the universities themselves; and Facilitation of technology transfer from universities to the private sector.

Copyright

Finally, copyright is another way of Intellectual Property Protection. This is one form of IP protection that has been mostly utilized by the academic fraternity in most African universities for protection of research work, specifically basic research work that finds its way into in journal publications. Unfortunately, most of this work does not usually result in innovative applications of the research output, but most often is a contribution to existing knowledge. Even then, Africa's contribution in this area has been very minimal considering that between 2000 through 2004, Africa produced only 1.8% of the world's publications.[19] Most of this copyrighted work hardly finds its way into industrial application through research oriented applicable developments or inventions. This challenge exists in the face of an inadequacy in the number of scientific research expertise in most African countries. Disciplinary analysis reveals that few African countries have the minimum number of scientists required for the functioning of a scientific discipline.[19] There is an expedient need for the education system in African countries to bridge this expertise-deficiency challenge. To add to the patent challenge, in Africa very little of copyrighted work is ICT or software development oriented, an orientation that would otherwise provide better potential for industrial applications and patent acquisition in a technology area that still has much potential for growth in Africa. However, more rewarding copyright in a business and economic sense has potential to contribute to Africa's developing economies in the areas of art, culture and other creative industries.

United States of America and Australia are ranking top two in the contribution of copyright to GDP at about 11% and 10% respectively, and the contribution to the employment rate at about 8% and 8.2% respectively.[20] An opportunity therefore exists for developing countries in Africa to achieve in the area of copyright contribution to economic development. The challenge however still remains a huge one.

Conclusion

The disadvantaged status of economic development for most countries in Africa, coupled with the challenges faced by these countries in areas of basic human needs, continues to be a hurdle on the way to growing research and development initiatives on the continent as priority continues to place funding emphasis on addressing basic human needs. The comparatively low level of research participation by higher education institutions, particularly university level, coupled with the absence of a globally significant involvement of Africa's-industry sector in research are factors that will need to be addressed if Africa's contribution to global research output is to realise significant growth. This is particularly important as industry and universities continue to be the main drivers of growth in the area of innovative research development and research application.

Existence of a robust industry economy, a mature education and academic system and overall economic strength, are fundamental to creating opportunities for growth in basic research for knowledge transfer to the private sector. These factors are also essential for the creation of opportunities for the growth of commercial oriented research and development within the education sector. In turn, such growth would contribute towards mitigating the high cost of research funding through proceeds received from patenting of inventions that may result from the research.

Addressing these challenges and building the necessary capacity for research will require the support of government policy and legislation, while leveraging on collaborative research initiatives as well as addressing issues of intellectual property ownership. This address would have to take place at both a national and regional level, and in an approach that is aimed at promoting the development, acquisition and protection of intellectual property, including the registration of patents by African countries. In this regard the African Regional Intellectual Property Organization (ARIPO) which

was established in 1982 and within which the Harare Protocol on Patents and Industrial Designs was formulated and to which the fifteen contracting countries agreed as follows, as per Section 1, general, of the protocol:

> *The African Regional Intellectual Property Organization (ARIPO) is empowered to grant patents and to register utility models and industrial designs and to administer such patents, utility models and industrial designs on behalf of Contracting States in accordance with the provisions of the Protocol, through its Secretariat (hereinafter referred to as "the Office").*[21]

Thus, (ARIPO) provides a regional framework upon which research and development collaborations can be developed, administered and find protection towards a more participative and contributing Africa to global innovative research, and thus to the potential growth or increase in Africa registered patents beyond a handful of African countries. This paper has thus presented a discussion of different approaches to IP development, acquisition and protection and how each of the approaches - in light of the challenges and priorities faced by developing countries in Africa- can be implemented towards growing the level of Africa's participation and contribution to research and development participation output. Largely evidenced by the trend in the developed world the paper has identified Higher Education System, Industry, and Governments as key drivers of research and development, hence the need for Africa to focus on developing these research drivers to a level where they become visibly instrumental to driving achievements in innovative and impactful research and development.

Finally, though the focus of this paper was not on issues of IP legislation, it is acknowledged that even as developing countries in Africa continue to put in place and implement initiatives for promoting research and development, it is important that they maintain cognisance of the debate surrounding legislation, such as the Bayh-Dole Act, and the implication of this in light of issues such as: the use of public funds to promote research-development in universities versus private ownership of public funded research products or inventions through patenting; the potential restrictions or limitation to access to knowledge as a result of legislative control, while at the same time recognising the value of IP protection as an incentive for investing in research, and for national competitiveness. The national competitiveness benefit of IP protection is addressed in which a correlation between IP protection and global competitiveness is demonstrated in a statement that:[22]

> *In 2004, 20 countries that were perceived as having the most stringent intellectual property protection were classed among the top 27 in the WEF's growth competitiveness index. Conversely, the 20 countries perceived as having the weakest intellectual property regimes were ranked among the bottom 36 for growth and competitiveness.*[22]

It therefore, is fundamental that like other countries or regions such as Europe and America[18], Africa has to progressively put in place and implement IP legislation that is more appropriate to the research and development environment, mission and vision of Africa, while at the same time being knowledgeable and accommodative to the synergetic and productive international research and development legislation trends and obligations.

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