BUILDING SUB-SAHARAN AFRICA'S COMPETITIVENESS IN HEALTH RESEARCH AND INNOVATION: LESSONS FROM INDIA, CHINA AND BRAZIL.

Bahati Prince Ngongo
Chandaria Graduate School of Business Administration,
United States International University, Kenya

Prof. Paul Katuse
Chandaria Graduate School of Business Administration,
United States International University, Kenya

John Mugabe
Graduate School of Technology, University of Pretoria

CITATION: Ngongo, P., B., Katuse, P., Mugabe, J. (2016). Building Sub-Saharan Africa's Competitiveness in Health Research and Innovation: Lessons from India, China and Brazil. *International Journal of Strategic Management.* Vol. 5(5). PP. 52-72.

ABSTRACT

Sub-Saharan Africa has a rapidly growing health research and pharmaceutical industry and is prone to contribute significantly to economic growth in the region. There are many initiatives that have been launched in the region to increase Sub-Saharan competitiveness to the level of other emerging economies such as India, China and Brazil under the umbrella of the Africa Pharmaceutical Manufacturing Plan (PMP) that was developed by the African Union (AU). However, we have found that Sub-Saharan Africa continues to lag behind China, India and Brazil in scientific productivity, patent applications and investment in health research and development. While India and China continue to attract on average 28.7% of foreign direct investment in knowledge based health research and development and 30.6% in design,

development and testing, Sub-Saharan Africa has barely attracted 1%. We analyzed factors affecting Sub-Saharan competitiveness and factors that have contributed to the success of India, China and Brazil in health research and innovation. We derived lessons that Sub-Saharan Africa should adopt to increase its competitiveness. We showed that to increase its competitiveness, Sub-Saharan Africa must address four fundamental bottlenecks. These include addressing its economics of clinical trials management processes, its capacity to provide competitive quality low cost R&D outsourcing, its adaptive and progressive technology transfer and its optimal product portfolio mix to include product based on neglected disease affecting Sub-Saharan Africa and the more profitable global market.

Improving Sub-Saharan Africa's competitiveness in health R&D ad innovation relies on a mix of strategic business strategies, policy incentives and investment framework that incentivize long-term health innovation systems as opposed to isolated short-term capacity buildings and manufacturing plans. A greater focus is needed on strategies to increase competitiveness as a market destination for more efficient and cost-effective clinical trials. This includes addressing its high cost of human resources improve efficiency of ethical and regulatory frameworks, intellectual property regulations, procurement processes and importation policies. We proposed a mix of fiscal and non-fiscal policies, internal market and capital markets approaches that would stimulate both technological adaptation and innovative capabilities. However, for long-term competitiveness, the industry portfolio and investment mix should include a stronger focus on profitable markets beyond government publicly funded health products and pricing based on equity.

Key Words: Africa Health Research and Innovation, Africa Economics of Clinical Trials, Africa Outsourcing of Health Research and Development, Africa Pharmaceutical competitiveness, Africa Health Research Policy effectiveness, Lessons from BRICS countries.

Introduction

Sub-Saharan African pharmaceutical industry and innovation is growing fast (catching up with its Agriculture and IT industries) and is prone to compete with other emerging markets. The Africa Pharmaceutical Manufacturing Plan (PMP) developed by the African Union aims to

increase Africa pharmaceutical competitiveness, solve the problem of sustainability of disease burden (currently heavily donor-dependent), meet international requirements for universal health coverage and reduce dependence on costly health product importation. One of the goals and aims of the African Pharmaceutical Manufacturing Plan is to achieve the same level of competitiveness as seen in China, India and Brazil. It is very optimistic about the capacity of the Africa pharmaceutical industry to catch up and leapfrog other emerging markets. It states "therefore, the Sub-Saharan African pharmaceutical industry, like that of other emerging markets, is expected to grow tremendously in the coming years" (PMP 2012)

Despite the heavy concentration of the Sub-Saharan Africa health innovation and pharmaceutical industry in few countries (South Africa, Nigeria, Ghana and Kenya) there are numerous positive economic factors to justify optimisms of its growth in the coming years. These include a projection population growth to 1.3 billion by 2020, a combined GDP of 2.9 trillion USD, healthcare expenditure of around 200 billion USD; a pharmaceutical market valued at an estimated 23 billion USD, 50 percent of households with a disposable income of more than 20 USD per day (PMP 2012). In addition, the patent expiries of many leading medicines will open new opportunities and incentives for local manufacturing and global relocation. There are also medical factors such as a large number of diverse patient pool, continued growth of non-communicable and communicable diseases requiring innovation in treatments and vaccines (such as HIV, TB, Malaria, Cancer, Diabetese, etc); an improving health insurance and coverage environment, and a consequent increase in the number of people with access to healthcare; an ageing population leading to increased prevalence of geriatric disorders; an increase in lifestyle diseases associated with growing economic prosperity and urbanization (PMP2012).

However, despite continued investment in improving Sub-Saharan pharmaceutical competitiveness, evidence continue to show low scientific productivity and innovative capabilities compared to other emerging markets. We sought to identify factors affecting Sub-Saharan Africa's competitiveness in health R&D and innovation and to propose key strategies for achieving its long-term strategic competitive advantages. There is evidence that pharmaceutical industries in the developing country markets can increase their competitiveness and leapfrog developed countries innovative capabilities. For instance, by

analyzing the size and the change in number of patents in years 1990–2011, Ross (2013) noticed at first the predominance of developed countries in the number of patents, with the highest number in the United States (608 patents/25 per year), followed by Japan (232 patents/20 per year), as well as Germany and the United Kingdom. However, in the twenty-first century they experienced a decreasing trend and were outrun by China and South Korea with countries like India and Russia showing an upward trend. By 2011 it was estimated that China cemented its place as the third largest pharmaceutical market in the world – almost 50 per cent bigger than Germany in fourth place – while Brazil overtook the UK, Italy, Spain and Canada to take sixth spot. China and India, together now contribute more to global expenditure on business R&D than Western Europe (UNESCO, 2016))

Objectives and Purpose of the Study

We sought to identify factors affecting Sub-Saharan Africa's competitiveness in health research and innovation and to propose short and long-term strategies for achieving sustainable competitive advantage vis-à-vis other emerging markets. We conducted a comparative analysis with India, China and Brazil using internal industry performance indicators and external attractiveness indexes. We purposed to conduct an analysis of factors behind the success of the pharmaceutical industries in China, India and Brazil and extract lessons and strategies for the nascent Sub-Saharan pharmaceutical industry.

Methodology

This study is mainly based on a desk review of literature and secondary data analysis. Data was obtained from major databases such as Global Innovation Index, UNESCO Science and Innovation reports, World Intellectual Property Organization database, and reports of the World Bank and Africa Observatory for Science, Technology and Innovation (AOSTI).

Findings

I. A Comparative Analysis of Sub-Saharan Africa with India, China and Brazil

We organized our comparative analysis in two fundamental categories. First we compared industry internal performances using three principal factors: scientific productivity, innovation capability and investment in R&D. Second we compared external factors such as attractiveness of industries to attract global Foreign Direct Investment (FDI) and outsourcing in health research and innovation.

Using scientific publication as proxy for scientific productivity, Sub-Saharan Africa continue to lag behind other emerging markets in biomedical scientific productivity (see table 1). For instance, India or China or Brazil continue to publish more peer-review publications individually than the combined total of the top six Sub-Saharan African countries conducting Health R&D. Sub-Saharan Africa's scientific output, although growing rapidly remains relatively small. It is also heavily dependent on global collaborations and funding as opposed to Sub-Saharan collaborations as envisioned by the PMP. Only 4.1% of the papers produced in Africa between 2005-2007 involved collaboration with other African countries and 4.3% between 2008-2010 (AOSTI, 2013).

Using patent applications as proxy for innovation, Sub-Saharan Africa lags behind China, India and Brazil in terms of patents applications and, share of patents applications in medical technology, biotechnology and pharmaceuticals (See Table 2 and 3),

South Africa which generates about one-quarter of Sub-Saharan African GDP leads the continent on innovation and patents. For instance, it filed 96% of the Southern Africa Development Community (SADC) patents between 2008 and 2013 (UNESCO,2016).

Spending on health R&D has increased in Sub-Saharan Africa following renewed commitments by African heads of states to transform African countries into knowledge-economies by increasing R&D spending to 2% of Gross Domestic Products (GDP). For instance Kenya has increased its R&D spending from minimal spending in the last decade to 0.79% of GDP in 2010. Similar trend have happened in countries such as Ethiopia that has reached 0.61% in 2013, Gabon 0.58% of GDP in 2009 and Uganda 0.48% in 2010. South Africa has also increased its R&D spending from 0.73% in 2013 to 0.76% in 2014 (UNESCO, 2016; World Bank, 2015; South Africa. Info, 2014)).

However, Sub-Saharan African countries still lag behind India, China and Brazil in terms of % of GDP spending on R&D. India invested 0.82% of its GDP in R&D (in 2012), Brazil at 1.15% in 2012 China at 1.93 % in 2012 and 2.01% in 2013.

Table 2 Patent 2000 – 2014 Total count by filing office and Total patent applications

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Africa	7200	10000	10400	9700	10100	11400	13300	14700	14500	13000	13100	14400	14700	14600	14900
Asia	637200	674800	669200	699600	772100	854600	889800	932400	979900	944100	1028800	1178800	1321100	1497600	1607500
Latin America and the Caribbean	48300	46600	44000	43100	45000	49800	54000	57400	59000	51800	55200	60200	63300	63600	64100

Source: World Intellectual Property (2015)

Table 3. Share (in %) of patent applications in medical technology, biotechnology and pharmaceuticals: 2000-2014

Regions	Medical Technologies	Biotechnology	Pharmaceuticals
Sub-Saharan Africa			
Botswana	3.03	0	0
Gabon	5.26	5.26	13.16
Ghana			21.88

Kenya			
Morocco		4.96	15.29
Nigeria	12.63		17.89
Senegal	5.41		12.16
South Africa	5.01		
Seychelles	43.73		2.55
North Africa			
Egypt	11.88	3.44	7.71
Tunisia	3.95	3.67	16.95
Morocco	3.66		7.78
Asia			
China			5.49
India	2.45	5.03	19.91
Latin America			
Brazil	5.77		4.15

Source: World Intellectual Property (2015)

Table 1. A Comparison of Publications in Biomedical Research and Clinical Medicines between 6 Sub-Saharan African Countries and India, Brazil and China: 2002 -2008

Countries	Publications in Biomedical and Clinical Research		Percentage Change
	2002	2008	
Botswana	23	41	78%
Kenya	223	426	98%
Rwanda	6	17	183%
South Africa	1322	2143	62%
Uganda	97	261	169%
Zambia	44	98	122%
Brazil	4826	12266	154%

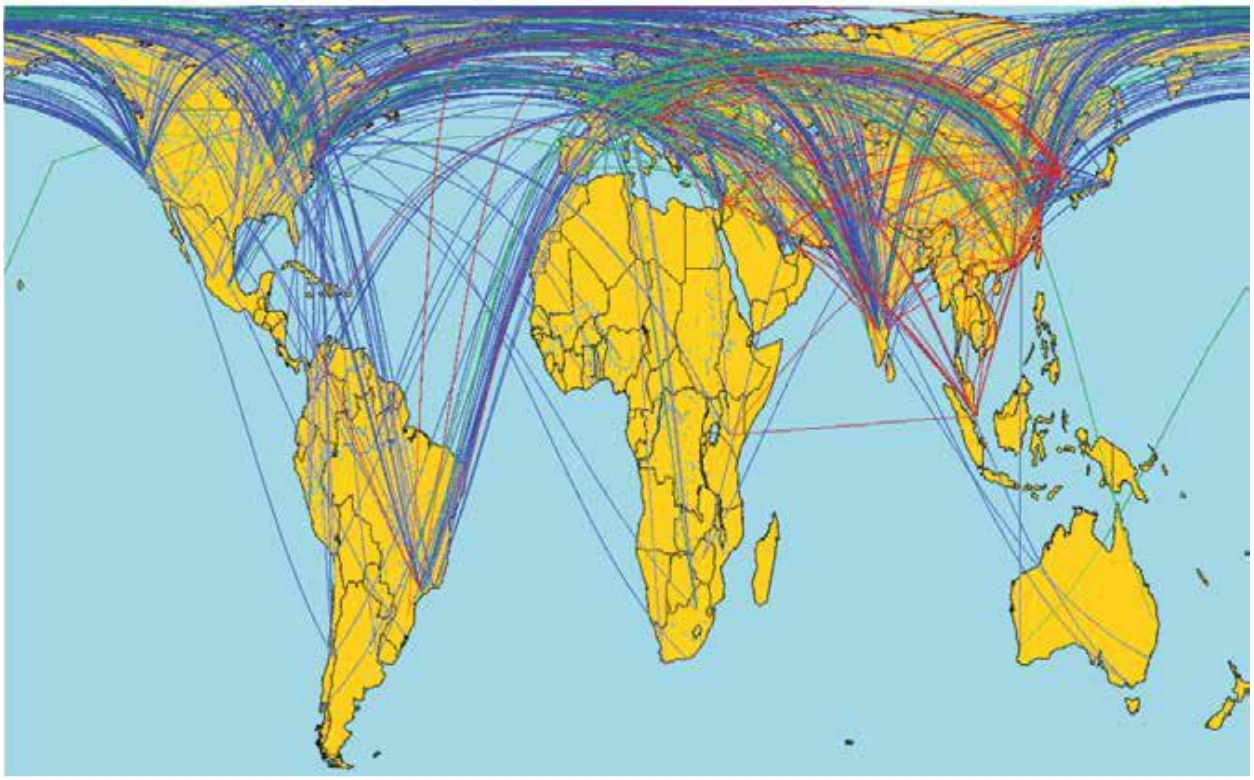
China	6545	22663	246%
India	5268	11335	115%

Source: UNESCO Science Report 2010

Sub-Saharan Africa is also lagging behind in attracting Foreign Direct Investment (FDI) in Health R&D. Between 2003 and 2014 on overage India and China attracted 28.7% of knowledge-based Health R&D FDI, Latin America 4.3% while Sub-Saharan Africa attracted 0%. The same trend is seen in terms of less knowledge-based projects such as design, development and testing. Sub-Saharan Africa share is 1.1% while China and India both hold 30.6% share of projects in design, development and testing (see images 1 and 2)

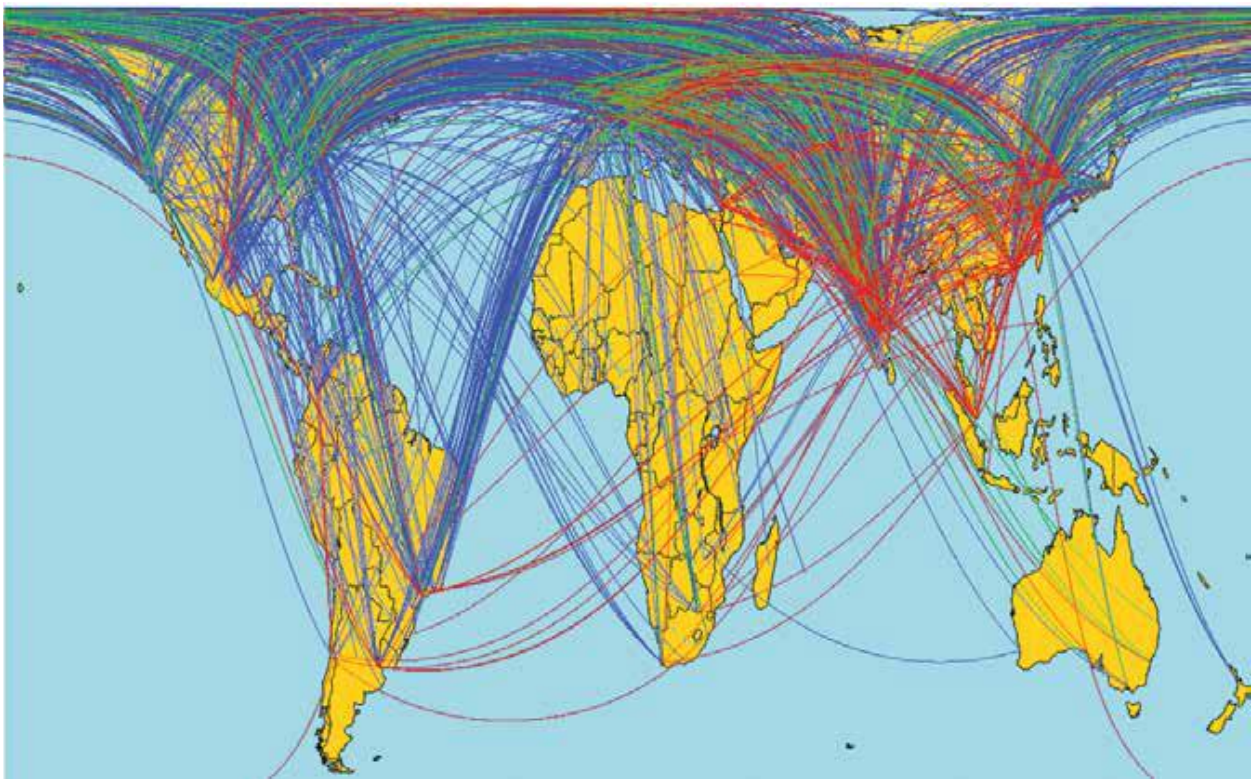
The low performance in attracting FDI for Health R&D is disappointing in comparison to the increasing performance of Africa attractiveness in other areas of R&D such as in Information Technology and Communications (ICT) where it attracts more FDI than in any other sector at 7.2% followed by Education at 5.9% of global share (UNESCO science report 2016).

Image 1: Trends in knowledge-related FDI projects, 2003–2014



Source: UNU-Merit

Image 2: Trends of FDAs in projects in design, development and testing



Source: UNU-Merit

II. Strategies to improve Africa's competitiveness in Health R&D and Innovation

As demonstrated above, Sub-Saharan Africa overall has not been able to improve its competitiveness and innovation in health research. It needs innovative strategies to catch up and converge with the rest of the world.

We analyzed factors affecting Sub-Saharan pharmaceutical industry's competitiveness and strategies to increase competitiveness. We identified four major factors affecting its competiveness and proposed potential solutions. These include improve sub-Saharan economics of clinical trials, invest in competitive quality low cost R&D outsourcing, leverage adaptive and progressive technology transfer to increase attractiveness of relocation of innovative capabilities and develop an optimal R&D product portfolio mix conducive for long-term profitability of the industry.

a. Addressing Sub-Saharan African economics of clinical trial management processes

The inefficient, risky and expensive drug development processes of pharmaceutical industry in Europe and America will not be able to deliver enough new products to market to generate revenues sufficient to sustain their own growth or meet the global demand for diseases affecting the poor (Paul et al 2010). Most importantly, the diminishing market exclusivity for recently launched new medicines and the huge loss of revenues owing to generic competition over the next decade will continue to accelerate the relocation of the pharmaceutical industry and pharmaceutical innovation to low cost and high return economies in Asia and Sub-Saharan Africa. Therefore, it is important to understand the factors that have determined the relocation patterns of major pharmaceutical industries and for Sub-Saharan Africa to build its competitiveness in attracting them.

The search for low-cost destination of clinical trials (economics of clinical trials) has been one of the most important determinants of relocation. One of the most important challenges for pharmaceutical innovation remains increasing its productivity in the design and conduct of clinical trials in order to minimize cost related to attrition.
Clinical trials account for two third of the cost of developing a drug (Kearney, 2006). According to Paul et al. (2010) clinical development (Phases I–III) accounts for approximately 63% of the costs for each New Molecular Entities (NME) launched of which 53% is from Phase II to launch. Preclinical drug discovery accounts for 32%.

In developing countries, phase III trials can be completed up to six to seven months sooner than in domestic markets thus providing a high return on investment, competitive edge and longer patent protections. China, India, Russia and Brazil top the list of attractiveness to US companies in search of low-cost clinical trial with South Africa at the 11th place. (Kearney,2006). It is estimated that conducting clinical trials in India can cost from one-tenth of the price in the US (Lang and Siribaddana, 2012) to 50% to 75% less than in the US and European Union (Moza, 2005). Sub-Saharan Africa is still considered highly expensive by global pharmaceutical companies.

A survey of big spenders on health R&D and innovation in the European Union revealed that USA, Germany, China and India are the most attractive relocation destinations because of existence of quality R&D personnel, knowledge-sharing capabilities and proximity to a vibrant ecosystem with similar companies, technologies, incubators and suppliers. The key attraction factors to China and India where respectively market size, economic growth rate, quantity and labor cost of R&D personnel. The most deterrent factors for India and China were lack of clarity and enforcement of intellectual property rights, limited public and financing support for R&D (UNESCO, 2016).

For Sub-Saharan Africa to leverage the benefits of the global relocation of the pharmaceutical industry, it needs to complement its human resource and infrastructure development with capacity to improve its economics of doing clinical trials. The PMP should focus more attention in improving Africa's economics of clinical trials that is proactive in addressing key barriers of relocations such as high-cost of labor, expensive regulatory

processes, progressive intellectual property agreement, joint North-South-South regulations and approval of vaccines and medicines that are friendly to global pharmaceutical companies. There are empirical evidences that creating a friendlier R&D policy framework and ecosystem that can lead to high level of investment and FDI relocation.

The WHO (2005) report on increasing health innovation in developing countries notes that Brazil has been able to increase its innovation capability by attracting global pharmaceutical relocation and by improving its clinical trials economics. Its clinical research strategy attracted big pharmaceutical industries such as GlaxoSmithKline (which dedicated around US$2 million annually with 15 studies in 60 centres, involving 1,200 patients); Novartis (invested approximately US$3 million per annum). The same report also attributes one of the factors for India's rise of the biotechnology to its ability to take advantage of its cost-effective quality R&D and clinical trials to attract international companies. Sub-Saharan African countries' nascent R&D innovation sector would need to adapt lessons from India and Brazil to improve their attractiveness to global pharmaceutical industries in such for relocation.

The policy implications for improving innovation in the pharmaceutical nascent pharmaceutical industry, therefore, should be geared towards increasing competitiveness as a market destination for more efficient, cost-effective conduct of clinical trials. Using lessons from India and Brazil, this will include addressing bottlenecks in the health innovation systems and business environment including efficiency of ethical and regulatory frameworks, intellectual property regulations, efficiency of procurement processes and importation policies. For instance, India has instituted policies requiring fast tracking of review of applications for clinical trials within 45 days from date of submission.

b Addressing the Sub-Saharan African capacity to provide competitive quality low cost R&D outsourcing.

It is important to note however, that relocation of clinical trials does not necessarily translate to relocation of innovation. Sub-Saharan Africa has been conducting public and private

funded clinical trials for years with limited gain in competitive advantage in product innovation capacity (as seen in Table 1,2, and 3). For instance, South Africa and Kenya despite their track records in numbers of clinical trials are still ranked number 60 in 2015 (from 54 in 2012) and 92 in 2015 (from 96 in 2012) respectively out of 141 countries in the health innovation sector (the Global innovation Index, 2015). In addition to improving the economics of clinical trials, Sub-Saharan Africa should develop policies that facilitate outsourcing and capacity building on areas that promote innovation. The most popular option of outsourcing in the developing countries are the Contract Research Organizations (CROs) that carry out medical and scientific studies on a contractual basis for multiple clients and perform part or all of the process of clinical research including clinical trial management, data management, statistical analysis, protocol design and final report development (Frost and Sullivan Services, 2005).

Globally, in 2010 they generated US$21.69 billion in revenue, and are expected to generate US$32.73 billion in 2015 (Rawlinson, 2015).

Among all emerging countries for outsourcing, China and India have risen rapidly and become stars in the global pharmaceutical outsourcing arena as both countries possess the unique combination of low cost and quality service. The pharma outsourcing industries in both countries have grown rapidly in the recent few years. They are currently valued at about $1.42 B in China and $1.77 B in India, respectively; each occupying only about 2% share in the global pharma outsourcing market (Dorrocki, 2014). Sub-Saharan Africa has yet to leverage this opportunity by developing and supporting its nascent CRO industry. However, it needs to be keen on ensuring strategic approaches to ensuring transfer of innovative capabilities through CROs. Not all outsourcing have led to acquisition of innovative capabilities.

For instance, according to Dorrocki (2014) China outsourcing strategies have led to more transfer of innovative capacity than India. For instance in India, big pharmaceutical companies tend to form close collaborations such as risk-sharing outsourcing with an Indian company to co-develop drug candidates, but very few of them are willing to permanently set up a decent size of R&D center or manufacturing facility in the country (keeping the most innovative research phase in the US and Western Europe). In stark contrast, almost all major pharma and biotech companies have invested hundreds of millions of dollars in China to

establish their wholly owned R&D centers and large-scale manufacturing and marketing facilities. Many of their China R&D centers have already reached decent sizes and gained strong capabilities for innovation. They are ready to conduct full-scale research independently. Sub-Saharan Africa is still lagging behind in terms of number of CROs in comparison to India, China and Brazil.
Hasenclever and Paranhos (2014) also found that governments 'policies and incentives played a key role in India and Brazil growth.

However, in most Sub-Saharan countries' strategies on Science, technology and Innovations, there is very limited attention to business strategy, policy instruments and incentives that would facilitate the growth of CRO markets and attract transfer of technologies and innovative capacities. The protectionist tendency by governments of the nascent Sub-Saharan African pharmaceutical innovation system may have an impact on the growth of CROs and relocation of innovative capacities. In addition to creating a conducive environment for CROs, Sub-Saharan Africa will need to develop policy framework for attracting global pharmaceutical relocation of innovative capacities. This could include innovative co-funding mechanisms or tax incentives that will promote relocation of innovative capacities in Sub-Saharan Africa.

c Addressing the ability to leverage adaptive and progressive technology transfer

However CROs alone will not ensure sustainable relocation of innovative activities and research base from the traditional big pharma in developed countries to new countries.

The most successful country in promoting relocation of innovative activities seems to be China. According to the WHO (2005) report on innovation for developing countries, China had attracted the largest relocation of innovative activities by global pharmaceutical players in 2003 and 2004: Roche established its fifth biggest R&D centre in China's Shanghai, which is also its only R&D centre in a developing country; GSK set up an OTC R&D centre in China's Tianjin; Eli Lilly built a testing centre in Shanghai; and Novo Nordisk doubled the size of its

R&D centre in Beijing. GSK, Roche, AZ, and Pfizer have cooperated in R&D with China's universities and research institutes (CPIRDA, 2014).

While the success of China is multifactorial, it seems like China's coordinated industrial development framework provided economic incentives for adaptive and progressive technology transfer. The size of the market for China coupled with its economic growth provided a good incentive for long-term investment. A market based and regional approach for prioritizing innovation investment in regional centers of innovations linked to an industrial development framework is urgently needed for Sub-Saharan Africa. No single country in Sub-Saharan Africa would have the potential to compete or leapfrog in the global pharmaceutical innovation. Thus, the Sub-Saharan African pharmaceutical innovation catch up and competitiveness will be conditioned on its ability to leverage large regional markets (or regional economic blocs similar to India and China's market size) for it to be successful.

d Addressing the ability to develop an optimal R&D product portfolio mix that include product based on neglected disease affecting Sub-Saharan Africa and the more profitable global market.

Lastly, and probably one of the most challenging hurdle for health innovators in developing countries – is the dilemma between focusing their innovation strategies on country disease burden (seen as with low return on investment) or to global money-making opportunities for diseases affecting the rich in both developed and developing countries. The hopes that new IP regimes will incentivize local pharmaceutical companies to increase investment in research on neglected diseases have not materialized for most developing countries. For instance; companies looking to increase their in-house R&D facilities in India are targeting major diseases in industrialized countries (e.g. cancer and diabetes) as opposed to neglected diseases affecting India. As of 1999, only 16% of R&D expenditure in India was targeted on tropical diseases or developing-country markets, and about half was focused on developing more suitable products for diseases of global incidence. R&D in the leading Indian pharmaceutical companies is currently not dictated by seeking local market share but by the

race to access the more lucrative developed country markets as evidenced by over 50% of their production being exported (WHO, 2005).

The success of the Sub-Saharan African nascent pharmaceutical innovation path would be determined by its ability to leverage profitable markets beyond government publicly funded health products and pricing based on equity. With the Sub-Saharan African market already flooded by cheaper imported drugs from India, China and Brazil and free drugs sponsored by US and EU public funding, a good mix of policy incentives, pricing strategies and market niches identification would be required for health innovators. In a free market, policy incentives may have limitations in the absence of a predictable local demand. As seen in the India case, policy incentives to promote innovation capabilities may not necessarily translate into focus for diseases affecting the continent (major focus of the African PMP). It is also important to note that there are also substantial variations in disease profiles and pharmaceutical-sector specific issues in North and Sub-Saharan Africa (SSA). The SSA region suffers from a high infectious disease burden whilst the North has a profile not dissimilar to that of the developed world, with cancer, diabetes and cardiovascular disease being leading public health priorities (PMPA, 2012). Policy incentives in Sub-Saharan Africa should therefore seek to ensure focus for major diseases affecting its population but also promote incentives for private sectors to extend their reach for global profitable markets, pricing differentiation in view of the economic growth and growing health insurance market.

III. Discussion and Limitations of the study

With the increasing relocation of innovation activities in the developing countries, a catch up and leap frogging trend is emerging between countries. We demonstrated that Sub-Saharan Africa can improve its competitiveness in health R&D and innovation. While in agreement with the PMP (2012) that increasing investment in African manufacturing capacity is a key factor for increasing Africa competitiveness, we found more evidence that addressing the underlying factors of high cost and unattractiveness to global relocation as key for sustainable competitive advantage. Our findings is in agreement with conclusions by Gardner, Acharya, and Yach, (2007) that developing countries such as those in Sub-Saharan Africa should focus more on strengthening innovative capacities to meet the their health system challenges.

Addressing policy, public financing barriers and establishing a strategic health innovation ecosystem at regional level would be additional factors to consider if Africa is to improve its competitiveness. However, this study primarily used desk review and secondary data from globally acknowledged databases. Availability of data in health R&D and innovation for most Sub-Saharan countries is scanty and not longitudinally captured. Therefore, there is need for further empirical and contextual research that will collect primary data and perspectives from Sub-Saharan countries, global pharmaceutical companies, local African pharmaceutical companies and policy makers to validate evidence gathered through secondary data.

A regional approach (as opposed to individual country) to pharmaceutical market analysis has been used in literature, including by the Africa PMP, to analyze Africa or Sub-Saharan Africa vis-à-vis Brazil Russia, India and China (BRIC). The sheer sizes of individual markets and GDPs of China, India and Brazil presented a challenge for single Sub-Saharan African country comparison with the exception of South Africa. Our analysis supports the fact that a regional approach to Sub-Saharan competitiveness in Health R&D is more viable than a single country approach. While North African countries were not the focus of this study, they could leverage similar strategies for their competitive advantage strategies. In fact their proximity to Europe (with one of the largest global pharmaceutical industries) presents additional advantage for the region.

IV. Conclusion and Recommendations

Improving Sub-Saharan Africa's competitiveness in health R&D ad innovation relies on a mix of strategic business strategies, policy incentives and investment framework that incentivize long-term health innovation systems as opposed to isolated short-term capacity buildings (Sub-Saharan African Centers of Excellences) and manufacturing plans. Beyond isolated human resource and infrastructure capacity building, Sub-Saharan Africa needs a revamped approach to address its clinical trial economics, competitiveness in quality low cost R&D outsourcing, attractiveness to global pharmaceutical relocation, a long-term strategy to leverage adaptive and progressive technology transfer and adopt a product portfolio mix that

include product based on neglected disease affecting Sub-Saharan Africa and the more profitable global market. There is plenty of evidence of impact of strategies and policies on innovation to stimulate the catch up process that Sub-Saharan African nascent industry can learn from. Case studies from India, China and Brazil point to effective use of a mix of fiscal and non-fiscal policies, internal market and capital markets as critical factors in their catch up process. Innovation policies that stimulate meaningful catch up should focus on stimulating both technological adaptation and innovative capabilities. They should also be cognizant of the environmental context of each country or region (size of the market and existing innovative capabilities). We recommend a regional market size approach as opposed to country approach for comparative advantage. Further in-depth studies to identify factors affecting health product innovation, market selection of Sub-Saharan African pharmaceutical industries would be needed. More analysis is needed to understand the granularity of economics of clinical trials by regional economic blocs and by country and related policy changes that would promote global pharmaceutical innovation relocations in Sub-Saharan Africa.

V. REFERENCES

African Union (2012), the Pharmaceutical Manufacturing Plan for Africa downloaded from http://apps.who.int/medicinedocs/documents/s20186en/s20186en.pdf

AOSTI (African Observatory of Science, Technology and Innovation) (2014), Assessment of scientific production in the African Union, 2005–2010, Assessment of Scientific Production in the African Union Member States 2005-2010 downloaded from http://www.aosti.org/index.php/report/finish/5-report/15-assessment-of-scientific-production-in-the-african-union-2005-2010

Bastian, E.F., Catching up theories: a critical survey, downloaded from http://www.ungs.edu.ar/globelics/wp-content/uploads/2011/12/ID-476-Bastian-The-links-between-microeconomic-learning-and-macroeconomic-policies.pdf

China Pharmaceutical Innovation and Research and Development Association (CPIRDA), 2014, Initiative to Promote Pharmaceutical Industry Innovation Collaboration among BRICS Countries of 2014, International Pharmaceutical Innovation Collaboration Forum, downloaded on February 15, 2015 http://www.phirda.com/En/News_Mes.aspx?type=2&id=54

Dorocki, S (2014) Contemporary Trends in the Development of the Pharmaceutical Industry in the World, Pedagogical University of Cracow, Poland downloaded from http://www.academia.edu/7677741/Contemporary_Trends_in_the_Development_of_the_Pharmaceutical_Industry_in_the_World

Frost and Sullivan (2005), Clinical Trial Outsourcing Emerging as a Key Trend in Drug Research and Development Markets, downloaded from http://www.frost.com/prod/servlet/press-release.pag?docid=KGRR-54ER9R

Gardner, A.C., Acharya, T., Yach, D. (2007) Technological And Social Innovation: A Unifying New Paradigm For Global Health, Health Affairs, downloaded from http://content.healthaffairs.org/content/26/4/1052.full.pdf+html

Global Innovation Index (2015), downloaded from https://www.globalinnovationindex.org/content/page/gii-full-report-2015/#pdfopener

Hasenclever, L. Paranhos, J. (2014) The development of the pharmaceutical industry in Brazil and India: technological capability and industrial development, downloaded from http://www.researchgate.net/publication/228859162_The_development_of_the_pharmaceutical_industry_in_Brazil_and_India_technological_capability_and_industrial_development

Kaitin, K (2010), Deconstructing the Drug Development process: The New face of Innovation, Clin Pharmacol Ther., HHS Public access, downloaded from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2953249/

Kearney, A.T. (2006) Make Your Move: Taking Clinical Trials to the Best Location downloaded from https://www.atkearney.com/documents/10192/312631/EA+vol+IX+no+1-Make+Your+Move.pdf/bb05c14b-2709-4ff1-828f-8ef851f303de

Lang T, Siribaddana S (2012) Clinical Trials Have Gone Global: Is This a Good Thing? PLoS Med 9(6): e1001228. doi:10.1371/journal.pmed.1001228

Moran, M., Ropars, A.L., Guzman,J., Diaz, J., Garrison, C., (2005), The new landscape of neglected disease drug development, Policy Cure, downloaded from http://www.policycures.org/downloads/The_new_landscape_of_neglected_disease_drug_development.pdf

Moza, V. (2005) Opportunities and Challenges for Clinical Research in India, downloaded from http://www.consortiumcr.com/html/weexecute/Training/Careers/11%20Opportunities%20and%20Challenges%20for%20Clinical%20Research%20in%20Ind.pdf

Rawlinson, P. (2015), Ethics vs economics: the cost of outsourcing clinical trials to developing countries downloaded from , http://theconversation.com/ethics-vs-economics-the-cost-of-outsourcing-clinical-trials-to-developing-countries-43246)

Ross, C. (2013), Building BRICs: pharma's key emerging markets are becoming giants, downloaded from http://www.pmlive.com/pharma_intelligence/building_brics_pharmas_key_emerging_markets_are_becoming_giants_483972

Paul, M.S., Mytelka, S.D., Dunwiddies, C.T., Persinger, C.C., Munos, H.B., Lindborg, S.R., Scach, A.L, (2010) , How to improve R&D productivity: the pharmaceutical industry's grand challenge, Nature Reviews Drug Discovery 9, 203-214 (March 2010) | doi:10.1038/nrd3078, downloaded from http://www.nature.com/nrd/journal/v9/n3/full/nrd3078.html#top on February 11, 2015

South Africa.Info (2014) South Africa 'turning the corner' on R&D spending, downloaded from

http://www.southafrica.info/about/science/research-110414.htm#.VwZdaE1PrDc

UNESCO Science Report (2016) Towards 2030, downloaded from http://en.unesco.org/unesco_science_report

UNESCO Science Report (2010) The Current Status of Of Science Around the World, downloaded from http://unesdoc.unesco.org/images/0018/001899/189958e.pdf

World Bank (2015)Research and Development Expenditure (% of GDP) downloaded from http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS

WHO (2005), Innovation in developing countries to meet health needs – experiences of China, Brazil, South Africa and India, Country Reports for submission to the Commission on Intellectual Property Rights, Innovation and Public Health,
WHO Ref. CIPIH Study 10d (DGR)

World Intellectual Property Organization (2015)Statistical Country Profiles, downloaded from http://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=GA