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Why Developing Countries Are Lesser Innovators

Abdul Waheed

Abstract**—**In this paper, we observe that developed countries are generally equipped with innovation capabilities and produce major chunk of the world's knowledge and technology. The contribution of developing countries, on the other hand, is insignificant, and most of them far behind the global technological front. More specifically, we empirically observe that the developing world neither contributes substantially to the world's scientific publications nor to the R&D activities. They also have lesser "absorptive capacity" and "technological capability", and their "innovation systems" are plagued with many problems. Finally, we argue that these countries can break the shackles and improve their innovation capabilities by pursuing genuine innovation policies on long-term basis with honesty and commitment.

Keywords**—**Absorptive capacity; Developing countries; Scientific publications; Technological capability

I. Introduction

INNOVATION is often conceptualized as one of the important determinants of micro-level productivity gains and macro level economic growth. Innovation commitment of a country and/or of a firm can broadly be investigated in terms of two major indicators: inputs into innovation processes and outputs gained by these particular inputs. At the national level, these innovation inputs and outputs are not the results of an individual's efforts but rely heavily on the interlinks among different actors /sources [1]-[2]. Hence, innovation is not a straightforward goal to be carried out easily owing to many complexities involved at the stages of these interlinks, for both innovation types.

Hence, perhaps owing to these complexities, the major chunk of knowledge production (innovation) is carried out by developed countries, and innovations in "the rest" heavily relied on the radical developments of "the north". It does not, however, undermine the innovation studies in developing countries, because even if innovation in a developing country does not contribute substantially to the global knowledge frontier, its impact is still very important in that particular country context [3], and it could contribute substantially to the economic development of that country. And even more importantly, it is very essential for policy making to know why innovation culture is not prevailed in developing countries. Which are the forces that hinder technological advancements and knowledge creation in this region? And how can the situation be improved in order to promote innovativeness at individual, societal, and institutional level in developing countries?

Abdul Waheed is affiliated with UNU-MERIT, Keizer Karelplein 19, 6211 TC, Maastricht, The Netherlands. (phone: + 31 (0)43 388 4415; fax: +31 (0)43 388 4499; e-mail: waheed@ merit.unu.edu).

Innovation in general terms involves abstraction of a new idea, its materialization in the form of a tangible object, its diffusion to the society, and finally its commercial success to maximize the profit (especially for industrial innovation). These all steps involve their specific determinants which induce them to participate successfully in this innovation mechanism. The combination of all these determinants can be broadly translated into absorptive capacity [4]-[5], social capability [6], technological capability [7], and a more systematic approach to link all these concepts with additional innovation-conducive factors, i.e., national innovation system [2]-[8]. The reason why innovation in developing countries is not as much acceptable notion as it should be is the lack, partially or wholly, of all these innovation determinants at macro level, and characteristics of micro level sub-indicators which shape these macro level factors. These micro level characteristics could be the lack of education and of knowledge bases which hinder easy assimilation of new knowledge; lack of technological, telecommunication, and other public infrastructures; wish to stick with status quo and no willingness to accept any change at industrial, institutional, and individual level; involvement of a plethora of laws and institutions in order to launch a new product which obviously slow the pace down of innovation; political instability; insecurity; lack of links between industries and universities (research centers), etc.

More specifically, level of education is considered to be one of the important determinants of innovation, but developing countries are often characterized by the low level of education, and the universities and other research institutes lack the research planning related to their local context because most of the scientists employed there are trained in advanced countries, and they do not have deep-rooted knowledge of their local technological problems and needs [9]. Moreover, these research laboratories and institutions face the problems of scarcity of research funds, and are also not fully equipped with latest research-related instruments.

The migration of, already very little in number, the highly educated and skillful workforce to developed countries is one of those problems that hinder innovation activities in developing countries. As [10] pointed out, this brain drain is a significant hurdle for developing countries to their struggle to upgrade local knowledge bases. He, however, also argued that these immigrants could be a source of enhancing knowledge bases of their own countries through teaching, transferring, and upgrading the technical skills in their countries. The possible ways of this knowledge enhancement, as he argued, could be returning back to home country, FDI, their remittances, and their role as a broker between foreign and local partners.

A healthy condition of the infrastructure is an important source to thrive innovation. These infrastructures could be related to roads, energy, and telecommunications. Most of the developing countries face the problems of insufficiency of these infrastructures. The usage of mobile although change the situation of telecommunication in the developing world and enhance the connectivity among different actors which are necessary ingredients of innovation and economic development (i.e., suppliers, manufacturers, consumers, and analysts), the tele-density is hitherto quite low, and they are also behind in terms of internet use [10]. This insufficiency of infrastructure leads to the risk of not having optimal results of innovation efforts. The consumers/users could also propel manufacturers to carry out certain innovation [11]. As [12] argued, a firm can benefits more by involving the right users at the right time in the right form. In developing countries, the lack of capabilities at the user ends because they simply "do not know" leads to their less involvement in innovation processes. Another related concept is demand-pull innovation. In developing countries, demand for innovative products is lower owing to the consumer's traits, their lower education level and technological know-how. This passive role of demand side factors leads to lesser motivation of the manufacturer to create novelty.

II. Innovation Indicators Across Developing and Developed Countries

We can observe in a number of ways the intellectual property, knowledge base, technology prevalence, scientific strength, and innovation performance of a country. All these indicators in broader sense are different routes to observe the innovation capability of the country. Hence, in this section, we endeavor to compare some of these indicators across developing and developed countries in order to get insight into their innovation capabilities.

A. Scientific publications across developing and developed countries

One of the important ways to gauge the scientific strength of a country is the production of its scientific publications [13]. We can find many studies conducted bibliometric analyses using this measurement [14]-[15]. For our analysis, we use the international scientific publications of those journals that are selected by the Science and Engineering Indicators 2012 of the National Science Foundation (NSF), from the journals listed on the Science Citation Index (SCI) and the Social Sciences Citation Index (SCCI) of Thomson Reuters [16]. Although having language, geographical, and other context-based biases [13]-[15]-[16], these indices (SCI and SSCI) are the most reliable and the most widely used measurements in order to observe the scientific strengths of the countries.

Table I reports the world share of scientific publications and of population of different developed and developing regions. The region OECD-32 includes the countries which are currently members of the OECD, except for Chile and Mexico. European part of the OECD-32 comprises of those countries which are members of the OECD.

TABLE I
World Share Of Scientific Publications And Of Population Across Developed And Developing Regions

Areas	World share (%) of			
	pop.	articles	pop.	articles
	1999		2009	
OECD-32	17.3	86.3	16.5	76.9
European part of OECD-32	7.7	37.1	7.2	33.0
Western European part of OECD-32	6.6	35.2	6.2	30.9
Eastern European part of OECD-32	1.1	1.9	1.0	2.1
USA	4.7	30.8	4.6	26.5
Others in OECD-32	4.9	18.4	4.7	17.5
Latin America and Caribbean	8.4	2.3	8.5	3.1
South Asia	23.6	1.9	24.4	3.5
Sub-Saharan Africa	10.7	0.7	12.1	0.6
Other Africa and Middle East	3.8	0.6	4.2	0.8
CSTT	22.3	4.1	21.0	12.0

Notes: "Articles classified by year of publication and assigned to region/country/economy on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on basis of proportion of its participating institutions. Detail may not add to total because of rounding" [16].

Sources: Our own calculations by using the following sources: (1) for the scientific publications data, those journals that were selected by the Science and Engineering Indicators 2012 of the National Science Foundation (NSF), from the journals listed on the Science Citation Index (SCI) and the Social Sciences Citation Index (SCCI) of Thomson Reuters; (2) for population data, United Nations, Department of Economic and Social Affairs, Population Division.

The Latin America and Caribbean region includes 30 major countries of this region. The South Asian region consists of the following countries: Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka. Sub-Saharan Africa includes those countries that are located on the south of Sahara (including Sudan). The population figures are obtained from the United Nations, Department of Economic and Social Affairs, Population Division [18]. The primary reason to report population statistics, along with the scientific publications, is to get deeper insight into the countries' scientific strengths by observing its science as well as population share in the world's total population of scientific outputs and inhabitants. We report both indicators for the year 1999 and 2009 in order to observe the increase/decrease in the proportions of a certain region. The major share of the world's scientific publications in 1999 is of OECD-32, 86.3%, which is dropped in 2009 to 76.9%, but the figure still indicates that more than three quarters of the world's scientific output in the year 2009 is produced by the developed world (OECD-32). Moreover, Western Europe part of the OECD (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the UK) and the USA separately also faced losses in their world share, with slightly more for the USA. The world share of the former in 2009 is 30.9%, while the figure for the latter is 26.5% (while the population shares in the same year for both of them are 6.2% and 4.6% respectively). In both years, the shares of Eastern Europe part of the OECD (Czech Republic, Estonia, Hungary, Poland, Slovakia, and Slovenia) are quite low, although we notice a slight increase (1.9% in 1999 vs. 2.1% in 2009).

In addition, the statistics clearly demonstrate a very low representation of developing countries. In the year 2009, Latin America and Caribbean (LAC) and South Asia contribute to the world's scientific publications with the respective percentages of 3.1 and 3.5. However, we notice an increase, if compare with the corresponding values in 1999 (2.3% for LAC and 1.9% for the latter). One of the striking findings is the large increase from 4.1% in 1999 to 12% in 2009, for the publication share of CSTT (China, Singapore, Taiwan, and Thailand). The major shift in this change is because of China, with only 2.6% world share in 1999 to 9.4% in 2009. It means that in the year 2009 China is the second largest contributor in the world's scientific output after the USA. Finally, our results show very small percentages of Sub-Saharan Africa and "other Africa and Middle East", with the fractions of 0.6% and 0.8% respectively. We can clearly notice the large differences between developed and developing countries. More specifically, only 16.5% of the world's population of the OECD-32 produces 76.9% of the world's scientific literature in 2009. And despite having 12.1% of the world's population in the same year, Sub-Saharan Africa's contribution is only 0.6%.

B. Research and development (R&D) across developing and developed countries

Innovation can be thought of having two different aspects: innovation inputs and their outputs. Research and development (R&D) is a widely used measurement in order to observe the efforts of a country (and of a business unit) in terms of innovation input, and its adherence to technological efforts and to knowledge enhancement. The positive role of R&D efforts on innovation output is often documented in the literature, and it is believed that a firm can produce more innovative products if it runs R&D activities in a systematic way. Moreover, R&D also has a significantly positive link with productivity output [19]-[20] . One of the implications of wide acceptance of the endogenous characteristics of technology for economic growth, advanced by endogenous growth theory [21]-[22]-[23], is the necessity to increase R&D efforts in order to learn new knowledge and improve technological capabilities. Moreover, today's technological world witnesses quick dynamic changes and requires more R&D efforts at indigenous level in order to compete adequately in knowledge generation and to survive at technological front. As [4] argued, the dual role of R&D is the birth of new knowledge and the enhancement of the firms' ability to assimilate and use existing knowledge; the latter is more important for developing countries given their existing knowledge bases. Despite the well recognized contributions of R&D to enhance firms' knowledge basis, the major expenditures on worldwide research and development activities are hitherto carried out by the developed world and newly industrialized countries of the developing world. One of the major reasons of less frequent R&D efforts of developing countries is the direct purchase of technology from abroad [24], which can be used to produce new indigenous products by employing lesser technological efforts. Moreover, one of the major sources of R&D in developing countries is not the results of indigenous efforts but of current wave of the globalization of R&D. This globalization involves backing of R&D activities through FDI and performance of R&D activities by multinational corporations (MNCs) in their host country. As [25] pointed out, the urge to get access to foreign science and technology resources and availability of trained manpower at lower wage rates relative to developed countries motivated MNCs to carry out R&D projects in some developing countries since the mid-1980s. He further argued that developing countries could benefit more from these R&D activities by improving their frameworks and enhance their capabilities. They should struggle hard to assimilate existing knowledge and to be capable of creating new knowledge emanating from these R&D efforts of the MNCs.

TABLE I
SHARE OF WORLD R&D EXPENDITURES BY REGIONS/COUNTRIES IN 2007

Region/Country	R&D share (%)	Region/Country	R&D share (%)
USA	32.6	Japan	12.9
European Union	23.1	China	8.9
Germany	6.3	NIE Asia	6.3
France	3.7	India	2.2
UK	3.4	Israel	0.8
CIS Europe	2.4	Other Asia	1.1
Russia	2	Oceania	1.6
LAC	3	Africa	0.9
Brazil	1.8	South Africa	0.4
Mexico	0.5	Arab States (Africa)	0.3
Argentina	0.2	Other Africa	0.2
Asia	32.2		

Source: UNESCO Institute for Statistics estimates, 2010
Notes: CIS Europe: Commonwealth of Independent States in Europe; LAC: Latin America and Caribbean; NIE Asia includes Hong Kong, Indonesia, Malaysia, Philippines, South Korea, and Singapore; Other Asia excludes Japan, China, NIE Asia, Israel, and India. Other Africa excludes South Africa and Arab States (Africa).

It would be helpful to understand in more depth the R&D efforts of different regions through some quantitative measurements. Hence, we further discuss descriptive statistics on R&D performances of developing and developed countries in order to observe R&D commitments across these regions.

Table II reports shares in the world's R&D expenditures of different regions and of some selected countries. The top rank country is the USA with the world share of 32.6%. The share of the European Union collectively in the world's total R&D expenditures in 2007 is 23.1%. If we breakdown this ratio into countries, the percentages for Germany, France, and the UK are found to be 6.3, 3.7, and 3.4 respectively.

The Latin America and Caribbean share is observed to be only 3%, with 1.8% for Brazil, 0.5% for Mexico, and 0.2% for Argentina. The Asian continent as a whole contributes 32.2% in the world's total R&D spending of the year 2007, but most of it, 87%, is carried out by Japan, China, and NIE Asia (Hong Kong, Indonesia, Malaysia, Philippines, South Korea, and Singapore), with the specific percentages of 12.9, 8.9, and 6.3 respectively. Moreover, the contributions of India and Israel are 2.2% and 0.8% respectively, while rest of the Asia's contribution is observed to be only 1.1%.

Similar to the scientific publications, the least R&D active continent is Africa, sharing only 0.9% of the world's R&D in 2007, with the value of 0.4% for South Africa and 0.3% for

the Arab States of Africa. Hence, according to the statistics, 55.7% of the world's R&D expenditures in the year 2007 is carried out by the USA and the EU. If we combine Japan, China, and NIE Asia with these two above mentioned regions, the figure turns out to be 83.8%. These results clearly demonstrate the leading role in R&D activities of developed countries and newly industrialized Asian countries, with more significant share for the former. Hence, similar to the scientific publications indicator, the performance of relatively poor countries is substantially lower in terms of R&D activities as well.

III. Technological Capability, Absorptive Capacity, and National Innovation System in Developing Countries

In this section, we will discuss the performance of the developing world with respect to three important aggregate level innovation-related concepts developed relatively recently (in the 1980s and 1990s), and gain prominence nowadays for the successful implementation of innovation.

A. Absorptive capacity and technological capability

The role of "absorptive capacity" is very important as an ingredient of successful innovations. The concept was defined as a firm's ability to recognize external knowledge, assimilate, and apply it to commercial use [4]-[5]. This absorptive capacity is often argued as a significant determinant of innovation efforts [26]. As [27] asserted, the concept of absorptive capacity focuses on the fact that a firm cannot absorb outside knowledge without sufficient efforts and expertise. She further stated that a firm's efforts of absorptive capacity-building through enhancing internal research and through collaboration with universities increase its benefits in terms of superior innovation search. The study of [28] empirically disclosed that a firm's search for outside knowledge (in terms of R&D cooperation) has a significant influence on its internal R&D spending only if it has a sufficient absorptive capacity (in terms of R&D department and of R&D personnel), suggesting the significant role of absorptive capacity in the complementarities between internal and external knowledge. It means that if a firm already has a sufficient internal knowledge base (absorptive capacity), it will try to enhance it in order to absorb external knowledge more aptly. This is an indirect evidence of the argument stressed by [5] that a firm's absorptive capacity is a function of its previous knowledge base. Most of the developing countries are unable to extend their absorptive capacity owing to their lower internally existing levels of knowledge. This lower knowledge threshold does not permit them to understand sufficiently the sophistications of advanced countries' imported technologies, thereby they could not fully optimize this external knowledge according to their needs.

In addition, the access to external knowledge for the enhancement of a firms' innovation capability depends heavily on the positioning of the firm in the knowledge space. The study of [29] observed a positive relationship between the firms' more central network positions and innovation.

He also concluded, by using R&D intensity as an investment to enhance a firm's absorptive capacity, that the increase in absorptive capacity results in the innovation increase. But the advantage of above discussed "near-knowledge-spillover" is lesser for developing countries owing to their intra-country weaker knowledge threshold. Moreover, as [30] argued, the domestic establishment's absorptive capacity is an important determinant to acquire sufficient benefits from FDI spillover, developing countries cannot obtain optimal outcomes in terms of productivity increase until they have sufficient absorptive capacity to assimilate and utilize foreign (advanced) technologies.

Another related concept "technological capabilities" advanced by [31] as the ability to assimilate, exploit, adapt, and change the existing knowledge/technologies, and also as the ability to develop new technologies. These capabilities are also considered to be one of the important ingredients of economic growth [32]. A country with a handsome "amount" of these capabilities could run more smoothly on the technological trajectory than that which lacks them.

As has been argued, the lower knowledge base at the initial stage hiders the struggle of most of the developing countries to enhance their capabilities, but they can improve their technological skills by implementing thoughtful technological policies, focusing on the interactions with foreign, technologically advanced countries as a first step. More specifically, they can enhance their knowledge base through spillover, joint venturing, sending their personnel in advanced countries for training, and hiring skilled management from abroad. The work of [24] described in details how Usiminas (a steel producer in Brazil) started its work and took off by improving its technological capability. In the Beginning, it (Usiminas) hired Japanese steel experts and worked with them in order to improve its local labor's technological capabilities. Once acquired basic production capability, it tried to learn more to enhance its innovation capabilities. It also sent its personnel to abroad for courses and practical experience. As [24] argued, the success story of Usiminas describes how one poor firm of developing country can develop its technological capabilities through systematic long-term efforts. The study of [7] also described the stages of technological development of South Korea. He argued that the success of Korea from a poor to one of the world's leading industrial countries started with the initial establishment of imported foreign technology. Local firms, after accumulating production experience, exerted indigenous efforts to assimilate imported knowledge, which led to their increasing local capabilities. These sufficient local technological capabilities then helped Korea to improve these foreign technologies. He further argued that this pattern is not only confined to Korea, but also to the history of manufacturing industries. Hence, although most of the developing countries lag far behind the global technological frontier, they can catch-up by advancing some systematic innovation policies on a regular basis.

B. National innovation system

In the previous subsection, we have discussed the importance of "technological capability" and "absorptive capacity" for a successful innovation implementation. Since a firm cannot innovate in isolation, a system-level approach, i.e., "national innovation system", developed in the late 1980s [1]-[2]-[8], received considerable attention, and is nowadays considered to be an important concept, focusing on the innovation efforts of a country within its national boundaries. This system-like concept demonstrates the fact that since innovation is a complex phenomenon which entails different actors, smooth interconnections and regular interplays of all national level actors/players could enhance innovation capabilities of a firm and of a country as well.

These national level players could broadly be termed as *organizations* and *institutions*. These *organizations* could be universities, research institutes, private firms, and government institutes, while the *institutions* are those rules of laws which foster a fair play of innovation policies, e.g., patent laws, etc., and are those social norms which shape the relationships between universities and firms [33] and also other social norms and traditions [34]. A healthy connection among all these actors is necessary for a successful innovation policy [35].

The national innovation systems in developing countries at large are suffering from many micro- and macro-level problems, impeding a successful innovation environment in this region. As [36] stated, while the concept of national innovation system (NIS) is in its early stage, it is even in its primary stage in developing countries. They further argued that innovation is a fashionably spoken word in Thai policy making, and they have no well-defined innovation policy at the national level. Moreover, weak user-producer interaction, low technological spillover from TNCs (unlike Singapore), poor industry-university relationship, and weak nexus between public research organizations and firms are some of the problems Thai innovation system is facing. The study of [37] on the Latin American and Caribbean NISs reveals that research institutes in this region are not working optimally, and the research-business nexus is very poor. Moreover, the effectiveness of public policies is a question mark. Moreover, [35] argued that the NISs in South Asia are filled with many problems.

As argued, the NIS approach advocates the system-level connections among different *organizations*, which are controlled by *institutions* in a systematic way. Developing countries perform poorly at both fronts: they do not have sufficient *organizationa*l inputs, and their political and social systems do not allow their *institutions* to perform optimally, in order to have sound NISs.

IV. Conclusions

The role of technology on economic development has long been studied by the economic historians and growth economists. The problem of gauging technology in terms of some quantitative measurements was resolved to some extent by the use of research and development (R&D). A further evolution led to the advent of innovation surveys through which the innovation studies by using more sophisticated methodologies were possible. However, the contribution of developing countries in this evolution was far from satisfactory level and intensity of innovation studies, and of innovation culture, is still very low in developing countries as compared to developed ones.

We argue that the lower prevalence of innovation culture in developing countries is attributable to their very low education level (especially technical), to insufficient infrastructure (roads, telecommunications, and energy), to poor links between academia and industry, to name a few. Our empirical analysis, in terms of two important innovation indicators (scientific publications and R&D commitment), across developing and developed countries reveal that developed countries perform far better than the developing world. We observe that the developing world also less equipped with the technological capability and absorptive capacity, which hinder these countries to have optimal results of technological innovation efforts and of knowledge enhancement. In addition, the national innovation systems in developing countries are also plagued with a number of problems.

Despite the problems for the innovation friendliness culture, developing countries can improve their innovation culture by learning innovation capabilities through hiring advanced countries' experts, through sending their local labor force abroad for trainings, through joint R&D ventures with the developed world, and through FDI. Our conclusion is that developing countries can also enhance their innovation skills by first importing foreign technologies and then learning through working with these technologies. After accustomed to imported technologies, these countries can build up their own knowledge levels and innovation capacities.

However, the success of all these above mentioned routes for technological advancement depends heavily on developing countries' commitments and honesty at individual, societal and institutional level. Having a knowledgeable manpower is not a matter of years but of decade and more. Therefore, only serious and long term innovation policies, which are not influenced by the bureaucratic hurdles, will result in healthy innovation environments. Developing countries should show faith on their innovation commitments with the understanding that these innovation-related progresses are not unachievable goals. We have recently witnessed the industrial advancements of newly industrialized Asian countries (especially South Korea and Taiwan), which gained technological success through the implementation of above mentioned (with varying intensities and scopes) policies on a regular, long term basis.

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