- Brazil and Korea on Green Growth -
Elements for a cooperation agenda based on science, technology and innovation

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Abstract

Sustainable development is one of the most challenging goals for mankind and transition towards a greener economy is becoming a major driver on the global development agenda. Climate change requires urgent actions, considering impacts already being felt, with more droughts, floods, strong storms and other climate-related stresses that may draw resources away from development, posing increasingly severe pressures to all nations. Reducing modern society´s carbon footprints without jeopardizing development prospects will depend on intense cooperation, in addition to stable policies and incentives. The trans-boundary nature of these challenges imposes a new vision of interaction and alignment of efforts and no country will be able to face the emerging problems working in isolation. There is already a consensus that strong emphasis on cooperation, coupled with intensive investments in science, technology and innovation will provide the safest route to a lower carbon path to development in the future. Korea is already a leading country among those pursuing a new green growth paradigm. Having adopted a 5 year Green Growth Plan in 2009, the country seeks a new path to development, investing in innovations to decouple economic growth from environmental degradation, extreme dependency on fossil fuels and unsustainable natural resource use. On the other side of the globe, Brazil faces even greater challenges. With an area of 8,511,965 km², Brazil is one of the largest countries in the world, with an extensive surface of continuous land, a large supply of fresh water, abundant solar energy, and a rich biodiversity. In the past five decades the country has used its abundance and diversity of resources to successfully become a world leader in many sectors, including agriculture and green energy production and use. However, Brazil faces many environmental and developmental challenges to fulfill its vision of becoming one of the leading natural knowledge economic powerhouses of the future. Despite the geographical distance, it is feasible to think about a strong scientific and technological collaboration between a resource-rich country, such as Brazil, and an innovation-driven country, such as Korea, to generate, in a synergistic way, new and greener growth engines for the future. In this article we will review the respective development strategies of Brazil and Korea, emphasizing key drivers and pointing out elements for future green growth cooperation between the two countries.

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Introduction

For over a century, the world has been pursuing models of economic development heavily based on rapid industrialization and extreme dependency on fossil fuels, which has led to increased greenhouse gas emissions, global warming and worsened natural disasters and environmental degradation. Many recent studies and analysis have raised concern that our current development path is fundamentally unsustainable.

In all reasonable scenarios, either resource or waste sink limitations would not only constrain growth but also lead to eventual declines in the quality of life around the globe, with more serious consequences in poor nations. To meet the quality of life aspirations of developing countries at anything like the current consumption patterns of the average US citizen would require 3-5 additional planets to supply the necessary resources (WWF, 2008).

The fourth Assessment Report (AR4) prepared by the Intergovernmental Panel on Climate Change (IPCC) indicates that under all assessed stabilization scenarios, between 60 and 80% of the needed green house gas (GHG) emissions reductions would have to come from rationalization of energy supply and use, and improved efficiency of industrial processes (IPCC, 2007). For stabilization at the lower levels, IPCC scenarios point to the need to consider low carbon energy alternatives, such as renewable sources, nuclear power, and carbon dioxide (CO_2) capture and storage.

Considering the close connections between access to energy sources and industrial development, countries must revisit their development strategies, looking for new and creative ways to incorporate more robust sustainable development approaches in their national plans. In fact, a world coalition has been gaining speed in recent years in order to encourage countries to shift their development policies from fossil fuels dependent paths to more sustainable alternatives based on low-carbon, environment-friendly and renewable energy sources.

The United Nations Environment Program (UNEP) has assumed a leading role in the promotion of policies and practices towards “green economy”, which is defined as a “system of economic activities related to the production, distribution, and consumption of goods and services that result in improved human well-being over the long term, while not exposing future generations to significant environmental risks and ecological scarcities”. According to the UNEP, investments, both public and private, are necessary for the reconfiguration of businesses, infrastructure and institutions, and the adoption of sustainable consumption and production processes. (UNEP, 2007, Ellis et al., 2009).

In March 2009, UNEP released a Policy Brief on a “Global Green New Deal” (UNEP, 2009), encouraging governments to use the opportunity presented by the massive fiscal response to the financial and economic crisis to direct public spending and private investment in green sectors such as energy efficient construction, renewable energies, low carbon transport, sustainable agriculture, and restoring ecological infrastructure, especially forests and freshwater bodies. The UNEP Policy Brief argued that an investment of 1 per cent of global GDP over the next two years could provide the critical mass of green investment needed to reduce carbon dependency and to seed a significant greening of the global economy.

These initiatives and actions are based on the belief that the green economy has the potential to create an economic framework which will open up increased opportunities for maximizing the benefits of globalization, such as sharing and transferring knowledge and technologies for more sustainable production processes, for renewable resource development and use and for more efficient management of the natural resource base that sustain human development. However, the trans-boundary nature of the environmental challenges that modern society is facing will impose also a new global vision of economic, social and cultural interaction and coordination of actions since no country will be able to face the emerging problems working in isolation. In this article we will review green economy initiatives being developed in Brazil and in Korea, emphasizing key drivers and opportunities for increasing cooperation between the two countries in the future.

Green Growth in Korea

The Asia and Pacific region covers 40 per cent of the Earth's land area, and is home to 61 per cent of the world's population. It has been the fastest growing region in the world, and its economic advances have enabled a reduction in poverty and social progress in many parts of the region. This rapid growth, based predominantly on export-oriented industrialization, has lifted millions of people out of poverty. But it has also boosted demand for foreign energy and raw materials, contributing to price increases in world markets. At the same time, this increased demand has led to both, natural resource depletion as well as environmental degradation (International Conference On Green Industry In Asia, 2009).

Korea is a leading country in the pursuit of "low-carbon green growth" policies and programs in response to the global efforts to combat climate change and also as an opportunity to revise the path of its industries, towards more sustainable strategies. The concept of "Green Growth" was first adopted at the "Ministerial Conference on Environment and Development" jointly hosted by the Ministry of Environment of the Republic of Korea and the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) in 2005. The green growth movement was initiated in connection with the outcome of the Conference, "Seoul Initiative Network on Green Growth" (Ellis et al., 2009).

Many studies show that Korea, as many other countries in the Asia Pacific Region, is quite vulnerable to the effects of climate change. Also, the country is more exposed than most to fossil fuel dependence. During 1912-2008, average surface temperatures in Korea rose 1.74°C, which is above the world average. The country is 97 per cent dependent on fossil fuel imports out of their total energy demand, and thus highly exposed to oil price shocks. Also, freshwater scarcity has long been, and still is, a critical challenge facing Korea. With global warming likely to continue, the levels of flooding and drought are expected to worsen (UNEP, 2010).

In August 2008, at a national address on the 60th anniversary of Korea independence, "low-carbon green growth" was announced by President Lee Myung-Bak as a new vision and strategy to guide the nation's long-term development. Six months later, in January 2009, the Government of the Republic of Korea responded to the deepening recession with an economic stimulus package of US$ 38.1 billion. Eighty per cent of this package, the highest ratio among comparable packages from other G20 countries, was allocated to more efficient use of

resources such as freshwater, waste, energy-efficient buildings, renewable energies, low-carbon vehicles, and the rail network (UNEP 2009a, UNEP 2010).

Korea's Green stimulus package provided a model for its allocation of stimulus towards green infrastructure and lowering carbon dependency, which is represented in the Five-Year Plan for Green Growth, a medium-term plan for implementing the National Strategy for Green Growth over the period 2009-2013. With total funding of US$ 83.6 billion, representing 2 per cent of GDP, this Five-Year Plan intends to turn the strategy into concrete and operational policy initiatives towards achieving green growth. By extending the Green stimulus package into a full five-year development plan, Korea has signaled its belief that green growth is a strategy well beyond current economic recovery efforts and a model where long-term prosperity and sustainability are the key objectives (UNEP, 2010).

Korea's National Strategy and Five-Year Plan for Green Growth

One interesting aspect of the Korea Green Growth Vision is the intended shift in the country's growth paradigm, from "quantitative growth" to "qualitative growth". The new vision is based on a long-term strategy of green growth up to 2050, which will be implemented through Five-Year Plans for Green Growth.

Under the new paradigm of qualitative growth, the essential factors of production are new ideas, transformational innovations, and state-of-the-art technology. Economic growth based on these drivers is expected to generate substantially intensive, qualitative growth unlike the extensive quantitative growth targeted in the past (UNEP, 2010). According to the Korean officials, this approach enhances a mutually beneficial relationship between economic growth and the environment. Fundamentally, the Korean green growth strategy has three key objectives:

1) Creating new engines of a higher and sustainable growth path by developing low-carbon, environmentally-friendly industries;
2) Ensuring climatic and environmental sustainability; and
3) Contributing to the international negotiations to fight climate change.

Korea is also taking important steps in the area of policy and pricing reforms by creating a new carbon market, reviewing energy pricing, and expanding incentives for environmentally-friendly businesses and consumer behavior. The country's unilateral decision to set a national GHG emissions reduction target is an indication of the seriousness of its resolve to respond to the challenge of climate change and to contribute to the global effort to address this challenge (UNEP 2010).

The Science, Technology and Innovation component of the Korean Green Growth

Technological innovation is considered a key factor in the Korean green growth strategy and the development of new green technologies is considered the pillar of the intended transformation. The establishment of the Science and Technology Council for Green Growth on April 22, 2009 was an important decision regarding the innovation component of the Korean green growth strategy. This committee will contribute to setting agendas for R&D, technology transfer and industrialization, education and human resource development, green

growth platforms, and international collaboration. All the actions are to be made based on creativity, sustainability, integration, marketability, open innovation, responsibility, and communication (Lee, 2009).

The technological innovation component of the green growth plan was derived from a "Strategy for New Growth Engines" announced by the Korean Government on 13 January 2009 (MOSF, 2009). The "Strategy for New Growth Engines" was reclassified as a part of the five-year green growth plan, focusing on 27 core technologies, considered to have a potential to provide new engines for growth to the Korean economy.

The green growth core technologies are divided into four categories: (1) technologies for short-term intensive investment, (2) technologies for mid-term intensive investment, (3) technologies for long-term intensive investment, and (4) technologies for long-term gradual investment. They can be seen in the right column of Table 1, below.

Table 1. List of 27 core technologies in Korea green growth national plan

Sector	27 Core Technologies	
Climate change	1. Monitoring and modelling for climate change	(4)
	2. Climate change assessment and adaptation	(4)
Energy source technology	3. Silicon-based solar cells	(1)
	4. Non silicon-based solar cells	(4)
	5. Bio-energy	(4)
	6. Light water reactor	(1)
	7. Next-generation fast reactor	(3)
	8. Nuclear fusion energy	(3)
	9. Hydrogen energy R&D	(3)
	10. High-efficiency fuel cell	(3)
Efficiency improvement technologies	11. Plant growth promoting technology	(3)
	12. Integrated gasification combined cycle	(3)
	13. Green cars	(2)
	14. Intelligent infrastructure for transportation and logistics	(4)
	15. Green city and urban renaissance	(3)
	16. Green building	(3)
	17. Green process technology	(2)
	18. High-efficiency light-emitting diodes / Green IT	(1)
	19. IT-combined electric machines	(3)
	20. Secondary batteries	(2)
End-of-pipe technology	21. CO_2 capture, storage and processing	(3)
	22. Non- CO_2 processing	(2)
	23. Assessment of water quality and management	(2)
	24. Alternative water resources	(2)
	25. Waste recycling	(2)
	26. R&D in monitoring and processing of hazardous substances	(3)
R&D in Virtual Reality	27. Virtual reality	(2)

(1) Technologies for short-term intensive investment;
(2) Technologies for mid-term intensive investment;
(3) Technologies for long-term intensive investment; and
(4) Technologies for long-term gradual investment.

Source: UNEP (2010).

By 2013, the government plans to build "Green Industry Complexes," which will mainly use waste resources, green power, biomass, and other new and renewable energy sources. Finally, the government will encourage green partnerships between large and small and medium-sized companies. It is envisaged that this green partnership between the large

companies and SMEs will help accelerate the development of advanced technologies for fuel efficiency and emissions reduction (MOSF, 2009; UNEP 2010).

To achieve this technological transformation, a substantial investment plan has been put in place by the Government, covering phases from research and development, deployment to commercialization of the technologies. A total investment of more than 2.8 trillion won (US$2.2 billion) is earmarked to fund research and development up to 2013.

This is compatible with the role the Korean government has always played as an innovation driver. In the past the Korean government has been very successful in building the basic infrastructure for a national innovation system. Also, the government has managed to stimulate a diverse and dynamic R&D actors (public institutes, universities and private sector), with support funds and stimulus to human resources development that allowed a rapid growth of the science and technology sector and, consequently, the competitivity of the Korean industry (Choi, 2010).

Further Challenges and Needs.

Green growth has been approached as a higher level and new growth paradigm of the Korean economy, so the strategic development of green industry through green technology development has now become a core component of the country's development. However, to more actively develop green technologies and industries, the following policy strategies should be considered (Jang, 2010):

a) the first priority in developing green industry is to create a green market. This implies, both, the entrance of green products into the existing markets and creating markets for green products separately from the existing markets;

b) when developing "5-Year Green Growth Plan", the most important focus of the government was to expand investment in technology development. The Green Technology Development Investment Plan, outlined on the technology roadmap, presents key technology areas as potential candidates for green growth. Therefore, to further elaborate a big picture, more detailed sub-plans should be developed for each area. For this purpose, value chain analysis is a must and investment in a certain technology should be made only when the decision is based on an in-depth analysis of economic opportunities, for example, how a certain green technology can be commercialized and in what economic situation it can be effectively utilized;

c) the government should not only create a green market, but also provide various supportive measures to allow new private companies to freely enter the green market;

d) it should develop a green technology certification system to secure differentiation of green technologies from other technologies by providing accurate information to consumers and users; and

e) A systematic and comprehensive coordination of green technology R&D is necessary. The need for comprehensive coordination has been raised in two aspects; one is to secure equality between different research disciplines and between different research

methods and the other is to achieve balance between green market creation and green technology development. By establishing a comprehensive coordination system, the government will not only perform coordination at the macro level between green market creation and green technology development, but also adjust R&D targets and approaches, which will ultimately help maximize the efficiency of government investment.

Green Growth in Brazil

Brazil is one of the largest countries in the world, with an area of eight million and five hundred thousand square kilometers, a large supply of fresh water, abundant solar energy and a rich biodiversity. The country has a large and well-developed agricultural, mining, manufacturing and services sectors and its economy overshadows that of all other South American countries.

Brazil is rapidly expanding its presence in world markets. The economy is based on services (66%), industry (28.5%) and agriculture (5.5%). Around 66% of the population is employed in the services sector, 20% in agriculture and 14% in industry. Per capita income has reached $10,000 (2008 estimate) (Ellis et al., 2009).

Brazil's current strengths and achievements have led some to characterize the country as a 'natural knowledge-economy', a concept that highlights the propitious timing of Brazil's growing strength, when climate change, the environment, food scarcity and rising worldwide energy demand are at the forefront of global consciousness (Bound, 2008).

Despite the importance of its immense natural resource base, Brazil faces major challenges to reverse a trend of unsustainable use of its natural wealth, leading to environmental degradation. The environment has been a rising priority in Brazil because of: (i) growing public awareness of environmental issues and the need for improved sound environmental management; (ii) increasing sensitivity to domestic and external criticism of poor natural resource management; and (iii) growing recognition in both the public and private sectors that better environmental management provides a competitive edge to Brazilian businesses.

Brazil is actively seeking to harness low carbon development to enhance competitiveness and open new markets, particularly for bioethanol. It also recognizes that low carbon growth opportunities are in line with social development and poverty reduction objectives. The country was the first signatory of the Convention on Climate Change and has taken significant steps to show its commitment to reducing emissions. It recognizes that protection of the Amazon rainforest is a critical issue and has made reducing deforestation a major long-term priority (Ellis, 2009).

The Brazilian National Plan on Climate Change (Brazil, 2008) is an important milestone both in terms of outlining a set of programs for low carbon growth and also for the integration and harmonization of public policies. In 2007, the government created the Inter-ministerial Committee on Climate Change (CIM), charged with preparing the National Policy on Climate Change and the National Climate Change Plan. CIM is coordinated by the Office of the

President of the Republic, and consists of 17 federal bodies and ministries and the Brazilian Forum on Climate Change (FBMC).

In 2008, the government launched the National Climate Change Plan (NPCC). In addition to members of CIM, the plan was developed in collaboration with other fora and institutions, including the National Conference on the Environment, the State Forum on Climate Change and a variety of civil society organizations (CSOs). The plan is to be delivered in phases, with most interim targets set between 2018 and 2020.

Targets will be met by promoting sustainable development in the industrial and agricultural sectors, maintaining a high proportion of renewable energy in electricity production, encouraging the use of biofuels in the transportation sector and reducing deforestation. The plan's recommendations are organized into four lines of action:

1. Mitigation and adaptation;
2. Reduction of vulnerability and impact;
3. Research and development;
4. Enhancement of skills and dissemination.

The NPCC states that, to ensure success, it will be implemented in successive phases, as a way to ensure constant evaluation of intended objectives, as well as to include other measures which may be identified and considered feasible, in later stages. The following phases will include mechanisms to evaluate the performance of ongoing actions and their respective results.

Additional actions and instruments will also be presented, including pacts with Brazilian states in order to guarantee that the objectives stipulated here can be fully met. In this sense, studies related to new economic mechanisms for sustainable development will be carried out, also covering fiscal and tax incentives, among others.

Brazil has made an attempt to harmonize its national strategy for low carbon growth with economic growth and poverty reduction strategies, stating that a key goal is to identify the most vulnerable groups and target adaptation assistance, education and infrastructure development in these areas. Another challenge will be to maintain momentum and emphasis on clean energy sources, given their rising demand. Although the Brazilian energy sector is relatively clean – at present 45.8% of the energy matrix consists of renewable energy, while the global average is 12.9% – new targets are very ambitious and newly discovered offshore oil could slacken efforts to meet renewable energy goals.

The Brazilian National Plan on Climate Change has also set important milestones to be met by the agricultural sector. Brazil has set a target to reduce the agricultural sector's carbon dioxide emissions by 4.9 to 6.1 percent by 2020. With its newly-released Agricultural and Livestock Plan 2010-2011, Brazil launched a Low Carbon Agriculture Program to stimulate agronomic practices that help environmental preservation and productivity enhancement. Also, government loans are being made available to support a diversity of low-carbon programs in agriculture and forestry.

However, the global nature of the environmental challenges that modern society is facing will impose a new vision of interaction and coordination of actions, since no country will be able to face the emerging problems working in isolation. In this context, Brazilian innovation will have to be increasingly understood as part of a complex process. Complementarities, mix of technologies and capabilities, together with effective approaches to networking must be viewed as key ingredients in developing scientific and technological innovations for a low carbon, sustainable society in the future.

Strengthening cooperation in science and technology: evolution and strategy

In 2009 Brazil and Korea celebrated the 50th anniversary of political and diplomatic relations. Since 1959, several bilateral agreements were signed regarding immigration, trade, energy, law and taxes (Masiero, 2009). Science and technology joined the collaboration agenda on August 1991, when the first agreement[4] was signed as a result of a joint commission effort to increase the technical and economical cooperation in areas of common interest.

The "Cooperation Agreement for Peaceful Use of Nuclear Energy" [5] that was ratified on October 2005 includes items of joint R&D and development of human resources. The cooperation framework on S&T was complemented in November 2008 with the "Memorandum of Understanding for the Establishment of a Joint Committee for Promotion of Trade, Investments and Industrial Cooperation"[6]. On this occasion, the Presidents of both countries agreed on the expansion of bilateral relations in areas such as nuclear energy, biotechnology, information technology, infrastructure, agriculture and academic cooperation. The integration of trade and S&T has been a request from the Korean side (Masiero, 2009), as an effort to expand the participation of private sector in R&D activities, usually seeking pragmatic results. South Korean companies invest heavily on research in partnership with universities and GRI's (Government Research Institutes). In Brazil, while the main sponsor on R&D is the public sector, this scenario has been gradually changing towards an alignment with the South Korean model.

Brazil-Korea relations are strongly based on trade. Several studies indicate that the Brazilian openness for international trade and the Korean need for raw materials boosted the commercial relationship growing from US$ 2 billion registered in 2002 to US$ 8.5 billion in 2008 (Masiero 2009, Maldaner 2009). South Korea enjoys a surplus in the trade balance between the two countries. There is a strong presence of Korean institutions in Brazil, such as KOTRA (Korea Trade Promotion Cooperation), Export-Import Bank of Korea, Korea Export

[4] Science and Technology Agreement, http://www2.mre.gov.br/dai/b_cors_06_1650.htm

[5] Agreement for Peaceful Use of Nuclear Energy, http://www2.mre.gov.br/dai/b_cors_16_4809.htm

[6] Promotion of Trade, Investments and Industrial Cooperation, http://www2.mre.gov.br/dai/b_cors_22.htm

Insurance Corporation, Kotra Incubator, Korea Development Bank, Small Business Corporation and Korea International Trade Association. Early in 2010, the Provincial Government of Chungnam opened a business promotion office in Sao Paulo. Forty two private Korean companies operate in Brazil, including Samsung, LG, Posco, and others.

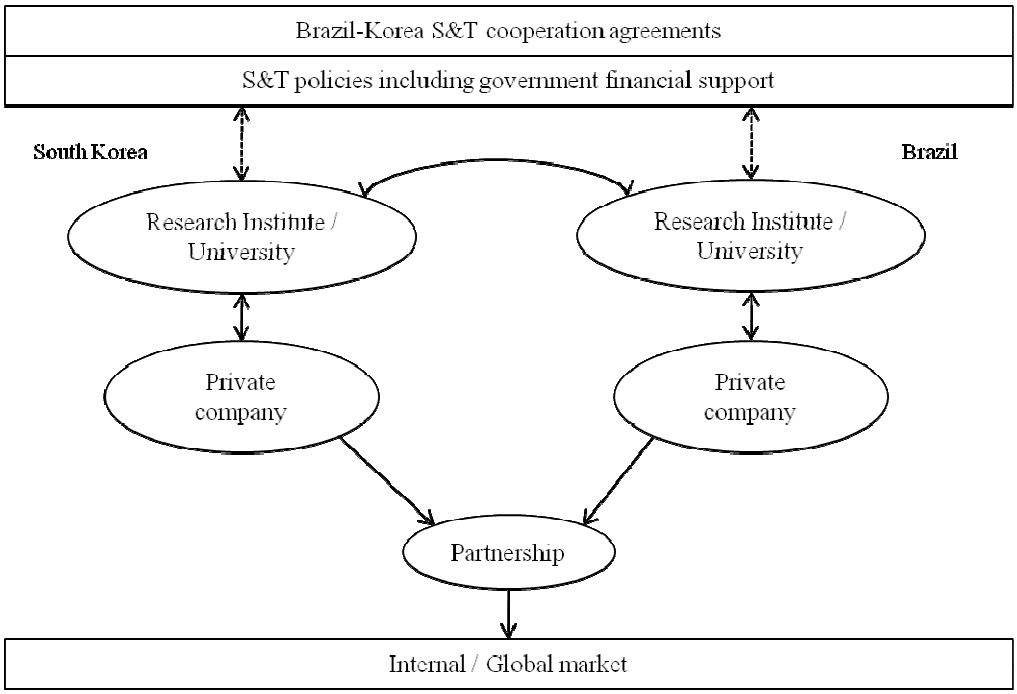
Brazil is increasing its presence in Korea. Besides the Embassy in Seoul, Bank of Brazil (Banco do Brasil) and Vale do Rio Doce established business offices to support potential partners. In 2009 Embrapa inaugurated a virtual laboratory in cooperation with RDA (Rural Development Administration) in Suwon (Lopes, 2009).

The well established commercial relations pave the way for a series of joint business between the two nations. Vale and Posco recently announced a partnership for mining business in Australia. A Brazilian-Korean company called "Kobrasco" is another example of Vale-Posco operations in the area of pelletization, a component for production of steel. In the same sector, Dongkuk Steel is building a new plant in Brazil in partnership with Vale and the Italian steel maker Danieli.

In the area of information technology, the joint venture HT Micron is a partnership of a South Korean backend semiconductor supplier (packaging and testing), Hana Micron, with a Brazilian surface-mount technology (SMT) service provider shareholder Altus. Both companies are distinguished players on their respective fields and decided to join efforts in order to enhance their presence in a growing market and use incentives offered by Brazilian government. The plan is based on assembling memory modules, including packaging and testing chips locally. Imported component will come in form of silicon wafers, adding one important element on the semiconductor supply chain in Brazil (Fink, 2010). HT Micron received a series of fiscal incentives that requires the establishment of a R&D center in partnership with Brazilian universities. The first group of Brazilian engineers will be trained in Korea in the second semester of 2010. This operation represents a potential successful case of business oriented innovation in Brazil, given the broad scope for application of memory chips in a myriad of devices for the South American market. The case of HT Micron might be the first initiative on this nature and may serve an example for a new generation of joint business.

Science and technology cooperation is behind schedule when compared to trade in other sectors Brazil-Korea relations. However, scientists and policy makers may take advantage of the attractiveness of Brazilian market and resources (human and natural) with the capabilities of Korean institutions. From this perspective, the Embassy of Brazil in Seoul is proposing a cooperation model that considers the integration of research institutes with their private sector counterparts. The approach is called "2+2 model" that can be illustrated in Figure 1.

Figure 1. The 2+2 model



The 2+2 model aims to integrate groups and institutions with diversified knowledge and resources into a cooperation and collaboration structure that considers commitment with productive sector (private companies). On the top, the model considers science and technology established agreements and respective local policies of both countries, such as the Korean Green Growth Strategy. Upon identifying prospective partnerships between research institutes or universities, the model proposes the involvement of companies interested in exploring new markets. This model is currently being applied to cooperation initiatives in the nanotechnology sector.

Sustainable science requires the use of non-traditional approaches and represents an opportunity for international cooperation. Involvement of productive sector on innovation efforts is a common objective of both countries and, ultimately, the most effective form to obtain results from R&D outputs.

Studies about knowledge networks and cooperation formats suggest that personal contact among researchers through international mobility of researchers and graduate students is an important starting point to international cooperation (Maciel, 2009). Upon their return to home countries, graduate students become potential important actors. In Korea it is possible to observe this phenomenon among the large number of researchers graduating from North American and European Universities. Neither Brazil or Korea are common destinations for graduate students from both countries, however there are opportunities to overcome this weakness with certain strategies.

First, the Embassy of Brazil is mediating the dialogue between the Korean Ministry of Education, Science and Technology (MEST) and the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) for exchange of graduate students in long and short term programs. Korean students are strongly motivated to take courses on emerging countries

like Brazil, according to officials from the National Institute for International Education (NIIED). NIIED is responsible for international scholarships in Korea. Brazilian students are aware of Korean universities due to increasing number of courses offered in English and the high rank of institutions such as KAIST, SNU and Postech.

Second, the Korean Ministry of Knowledge Economy has developed special graduate programs for young government officials and researchers from emerging countries. Since 2003 three different programs related to IT Policy and Energy (ITPP and IEPP)[7] in Seoul National University and IT Business and Engineering (ITTP)[8] in KAIST have been launched. These initiatives increase chances of concrete cooperation projects in the short run since students are already connected to their respective organizations. Even during study time in Korea, several students already started joint projects and keep investigating opportunities while enhancing personal networks. International programs like ITTP and ITPP facilitates the establishment of a common research agenda with stronger relationships among institutions. Brazil has 2 researchers and 1 government official joining these programs.

Third, the Embassy of Brazil encourages the community of Brazilian graduate students in the matchmaking and mutual understanding efforts. Students are invited to join business meetings and S&T delegations to understand current issues and provide further ideas for connections with Brazil. The communication student-to-student through web based channels such as blogs, social networking portal and direct interaction in the final steps of application produce positive effects in the attraction of new talents. The Embassy is encouraging this movement giving official support to those activities.

As a recommendation, there are opportunities for the creation of new interdisciplinary programs designed to tackle complex problems of sustainability. Universities shall establish joint international programs taking advantage of communication tools such as videoconference and internet to reduce costs and speed up implementation. As a result, these joint programs can prepare a new generation of researchers from Brazil and Korea with expertise in both regions.

Overall, the concept of *brain circulation* has been replacing the idea of *brain drain* feared by policy makers in sending national talents to study abroad (Maciel, 2009). With the internationalization of universities and research institutes through partnerships, the personal interaction and mutual understanding beyond boundaries can be beneficial to all parties, generating gains in human capacity.

Green growth cooperation

The Embassy of Brazil in Seoul received on March 29th,2010, the preparatory mission to the First Science, Technology & Innovation Joint Committee Meeting between Brazil and Korea, to be held in the second semester of 2010. The objective of this mission was to initiate

[7] ITPP and IEPP http://itpp.snu.ac.kr

[8] ITTP http://ittp.kaist.ac.kr

a dialogue towards a long-term strategy for Brazil's cooperation with Korea in Science, Technology and Innovation.

In the field of chemistry, during a visit to the Korean Research Institute of Chemical Technology (KRICT) several cooperation perspectives with Brazilian universities and research institutes were identified. Embrapa Agroenergia[9] and the Bioethanol Science and Technology Center (CTBE) [10] have common interests in pre-treatment of biomass, fermentation technologies, biotechnologies applied to second generation ethanol production, metabolic engineering and biocatalisys. KRICT has advanced in biorefinery research, based on petroleum displacement technologies. The concept of biorefinery for derivation of molecules, polymers, bioplastics and new sources of clean energy are in the center of attention of Brazilian researchers as well. KRICT has already successfully cooperated with France in the nano-scale drug carrier technologies, using French compounds applied to carriers developed in Korea.

The Korean Research Institute of Biosciences and Biotechnology (KRIBB) is another source of cooperation in green technologies. Considering the development of new drugs based on screening of compounds, Brazil can contribute with its vast biodiversity and research capacity for innovative pharmaceutical products. Biological resources are already a topic of discussion between the International Biological Material Research Center and Embrapa. Brazil has expressed interest in the field of phytochemistry (chemicals derived from plants) and medicinal plants. The traditional experience of Asian researchers in this area allied to Brazilian flora may lead to development of new phytotherapics and cosmetics. However, research in this area usually faces sensitive restrictions from both governments. In this sense, Labex Korea is already developing a research project with KAIST (Korea Advanced Institute of Science and Technology) to develop an information system for decision support based on legislation from both countries and international agreements for the development of bioprospection.

Green information technology is included in the scope of cooperation for ETRI (Electronics and Telecommunications Research Institute) and SERPRO (National Data Processing Service) for the development of cloud computing technologies to be applied in data centers in Brazil. The agreement between the institutions was signed in August 2009 and SERPRO indicated the Federal University of Rio de Janeiro (UFRJ) as academic partner in 2010. ETRI is an active member of Open Cirrus[11] international consortium for R&D and evaluation of cloud computing technologies. SERPRO is the main IT service provider for Brazilian government, responsible for large amount of processing and storage of data related to public services. Cloud computing technologies such as virtualization and distributed parallel processing are part of the efforts to reduce the impact of large scale IT systems on consumption of energy and optimization of resources.

In the field on green energy, the Korean Institute of Energy Research (KIER) is discussing joint research in cellulosic ethanol, thermo-biorefinery, bioenergy from microalgae

[9] http://www.cnpae.embrapa.br/

[10] http://www.bioetanol.org.br/

[11] http://opencirrus.org/

and biodiesel from new sources using solid catalysts. Embrapa Agroenergia also started talks in the field of synthesis gas (syngas).

Nuclear energy is also included in the cooperation agenda. The Embassy of Brazil recently received a mission with representatives from all Brazilian atomic energy institutions including fuel, construction, utility and policy makers in June, 2010. The group visited Korean research and safety institutes (KAERI and KINS)[12], heavy industry (Doosan), power plants (KHNP[13]), among others. Brazilian government set up plans for the construction of 8 new nuclear power plants until 2030[14] as an effort to comply with international greenhouse emissions standards. Currently, the country has 2 nuclear power plants in operation (Angra 1 and 2) and is building the third one (Angra 3).

An analysis of Korean and Brazilian profiles of nuclear sector demonstrates potential complementary points that can lead to future collaboration. Brazil has the fifth world largest uranium reserves, with a total of 309 thousand tons of uranium oxide. In addition, the country is proud of its focus on peaceful use of nuclear technologies, with no geopolitical concerns in the region. Brazil dominates the full cycle of fuel production with one of the most efficient uranium enrichment processes. So far, only 1.5% of electricity produced in Brazil comes from nuclear sources and this number is expected to double in the next 20 years.

Korea, on the other hand, produces 40% of its energy from atomic power plants and relies on foreign suppliers for nuclear fuel. However, Korea leads other sectors such as construction, operation and research on peaceful uses of nuclear technologies. The country is taking a global and ambitious approach, targeting the export of 80 reactors in the next two decades.

The first step towards this partnership was made by INB (Brazilian Nuclear Industries) and KNFC (Korea Nuclear Fuel Corporation) in 2002, when both companies established a third party partnership with Westinghouse for development and joint production of a new fuel element called 16NGF (New Generation Fuel) which improves energy production in 10%.

During the recent mission, officials from both countries agreed on start talks regarding the establishment of a joint committee on nuclear energy to increase the scope of cooperation.

Conclusion

Green growth is a most promising field where Brazil and South Korea may develop a synergistic cooperation. Both countries have the capabilities and motivations to give their contribution, not only for the sake of their own interests but also for the international well-being. The adequate blending of knowledge and input materials, software and hardware

[12] KAERI: Korea Atomic Energy Research Institute; KINS: Korea Institute of Nuclear Safety.

[13] Korea Hydro and Nuclear Power Corporation.

[14] National Energy Plan 2030, http://www.mme.gov.br/mme/menu/todas_publicacoes.html

technologies, innovation and consistency, as well as a common desire to spread a green economy culture worldwide, make them natural partners in this endeavour.

The Embassy of Brazil in Seoul is tuned with Korean institutions as an observatory and element of connection among scientists, entrepreneurs, future leaders and policy makers. For instance, the Korean Green Growth Institute was launched on June 2010 as a global think tank focused on green growth strategies. Brazil was selected along with two other countries (Indonesia and Ethiopia) as beneficiary of its first support programs for green growth planning[15]. This initiative will pave the way for the strengthening of existing cooperation projects and inspire policy makers on innovative approaches in the world's transition to new development models. Brazil welcomes the Institute and works towards a joint cooperation agenda that includes the convergence of several sectors such as agriculture, industry, IT, design and infrastructure for the development of global common assets.

Other similar projects and programs between the two countries, not excluding the participation of third countries and institutions, would be seminal in strengthening a common will to open new perspectives for sustainable development. By merging in a creative way the economic, environmental, technological and humanistic concerns, Brazil and South Korea could lead the way in spreading a new world view and cultural attitude better fit to face the challenges of the 21st century.

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