

A COMPARATIVE STUDY ON NIS (NATIONAL INNOVATION SYSTEM) IN THE BRIC ECONOMIES

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The BRIC (Brazil, Russia, India and China) are the developing countries with the most prospective economic growth in the next generation. Many factors, such as natural resources, land and a large and cheap labor market contributes to the economic growth of this countries. However, in a knowledge-based economy, innovation is far more important than land, physical capital, or labor as the primary factor affecting a nation's economic growth and development. Thus, given the importance of the studies of NIS (national innovation system) in the BRIC countries, this research is to characterize and compare the NIS of the four countries pointing out differences and similarities, common bottlenecks and complementarities, as well as identifying current and potential connections. Particular attention will be given to discuss policy implications and put forward policy recommendations, extract lessons that can be useful not only for these countries but also for other developing countries.

ESTUDO COMPARATIVO SOBRE SISTEMAS NACIONAIS DE INOVAÇÃO NAS ECONOMIAS BRIC

O bloco Brasil, Rússia, Índia e China (BRIC) é formado pelos países em desenvolvimento com os maiores potenciais de crescimento econômico para a próxima geração. Muitos fatores, como recursos naturais, terra e mão de obra farta e barata, contribuem para o crescimento econômico destes países. No entanto, em economias do conhecimento, a inovação é muito mais importante enquanto fator de crescimento e desenvolvimento econômico de uma nação do que terra, capital físico ou mão de obra. Assim, dada a importância dos estudos sobre Sistemas Nacionais de Inovação (SNIs) nos países do BRIC, esta pesquisa tem como objetivo caracterizar e comparar o SNI dos quatro países, apontando diferenças e semelhanças, gargalos comuns e complementaridades, bem como identificar conexões atuais e potenciais. O estudo dedica especial atenção à discussão das implicações e das recomendações sobre políticas, e às lições úteis, não apenas para estes países, mas também para outros países em desenvolvimento.

1 INTRODUCTION

It is well known that the BRIC consists of the four largest developing countries – Brazil, Russia, India and China – with the world's best economic growth prospects for the next generation. Together, in 2009, they generated 22.3% of the global GDP (PPP), shared 28.9% of the geographical area and represented 43.2% of the world's population. The huge potential of BRIC's economic growth can be attributed to advantages in affluent natural resources and land, combined with a large and cheap labor market, and a high density of foreign direct investment.

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However, in a knowledge-based economy, innovation is considered far more important than land, physical capital or labor when taking into account a nation's economic growth and development. Studies on the NIS (national innovation system) of the BRICS are important, especially when considering that effective innovation management is key for corporate success, technological prowess and national economic sustainable development.

This research will characterize and compare the NIS of Brazil, Russia, India and China, pointing out differences and similarities, common bottlenecks and complementarities, as well as identifying current and potential connections. Particular attention will be given to policy implications and recommendations, extracting lessons that may be useful not only for the BRIC, but for other developing countries as well.

Section 2 develops a conceptual framework that analyzes NIS in these countries, including a broader and systemic understanding of these systems. Section 3 compares several of the key economic parameters and social indicators between the four countries, summarizing a few broader economic and institutional characteristics. Section 4 examines several of the support system's chief indicators, including production, trade, investment and education. Section 5 outlines the characteristics of the main players of innovation (including enterprises, research institutes, technology talents and universities) under three aspects: quantity, structure and innovation. Section 6 analyzes the U.S. Patent and Trademark Office granted patents and indexed data of the four countries between 1979 and 2006, focusing on innovation performance characteristics - innovation, field and innovative pattern - while attempting to discover the causes of the differences in performance. Finally, section 7 reviews the lessons that may be drawn from this comparison and the evaluation trends of BRIC national innovation systems.

2 NIS (NATIONAL INNOVATION SYSTEM): A CONCEPTUAL FRAMEWORK

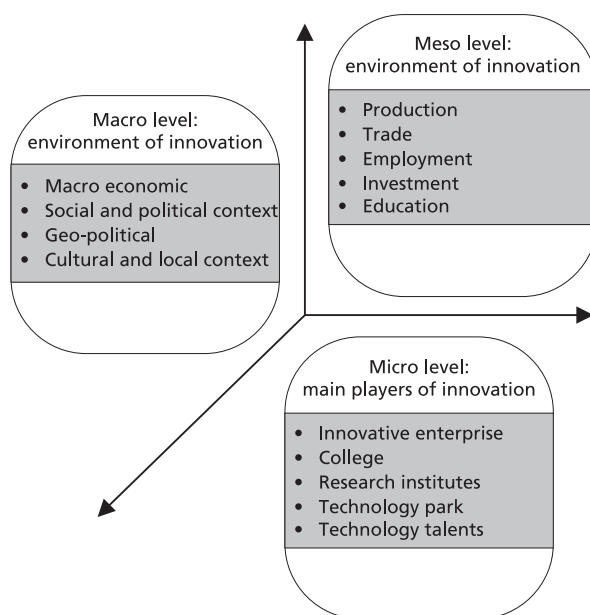
The concept of *national innovation systems* – NIS – was introduced by Freeman (1982, 1987) and Lundvall (1985). This concept stresses the interactivity between production and innovation, the importance of incremental and radical, technical and organizational innovations, as well as their different and simultaneous sources. Enterprises are seen as organization embedded within specific socio-economic-political environments that reflect particular historical and cultural trajectories. Over ten years ago, Chinese scholars introduced this conceptual analysis, producing results and publications on NIS (BINGWEN, 1998; BINGWEN; DUARCOURT, 1994).

Since the beginning of the 1990s this concept has been used as an analytical tool and framework for policy analysis in both developed and undeveloped countries. As a result: (1) research and policy activities, which explicitly focus on systems of innovation, may be found in most countries and a rapidly growing number of studies on specific national systems of innovation have been produced; (2) most countries, BRIC included, have been discussing and implementing public and private policies that focus on innovation, learning and capacity building.

In our opinion, NIS is part of the social system, contributing to the development, dissemination and sustainability of technological innovation. This System encompasses three sub-systems; the first is the micro-level innovation sub-system, including innovative enterprises, universities, research institutes, technology parks, technology, human resources, among others. The second is the meso-level innovation support subsystem, including the structure of production, trade, industry, employment, the financing platform, infrastructure, etc. The third is the macro-level innovation environmental subsystem, including population, economic output, economic growth and income distribution. These three subsystems interact and promote each other, forming a systematic national innovation system. Figure 1 presents the three subsystems of NIS. These will be considered when comparing the NIS between BRIC economies.

Under this analytical framework, a broader and systemic understanding of the innovation process is instrumental when avoiding an overemphasis on R&D, encouraging policy-makers to take a far-reaching perspective on the opportunities for learning and innovation. Considering the historical dependence of the formation and evolution of a national innovation system, deeply rooted in the economic and social environment, emphasis is put on interactions and the role of the historical process. These account for the differences between socio-economic capabilities, development trajectories and institutional evolution, creating systems of innovation with very specific local features and dynamics.

FIGURE 1
Structure of NIS



Source: International Development Research Centre. Available at: <http://brics.redesist.ie.ufrj.br/proj_idrc/>.

3. SUB-SYSTEM: INNOVATION ENVIRONMENT

3.1 Basic Economic and Social Indicators

A large population is a common characteristic between the BRIC countries. China and India are the two most populous countries in the world, accounting for 20% and 17.5% of the population, respectively (Table 1). Brazil has the fifth largest population in the world accounting for almost 2.9%, and Russia has the seventh largest population accounting for 2.13% of the global population. Large population and labor supply are major factors leading to BRIC's rapid economic growth. Considering the development process and its trend, there are several aspects to be discussed: (1) *Child Dependency Ratio (CDR)*. The CDR has obviously decreased during the last two decades. However, CDR in India and Brazil is relatively high, 37.7% and 47.9%, respectively, while Russia and China are significantly lower, 20.8% and 27.7%. The decrease in the CDR indicates that these two latter countries are gradually experiencing the aging of their population, which means that a labor-dependent economy would not be an advantage in the future, especially for China. As we may see, economic growth has no other choice than to rely on the quality of labor; therefore, China must achieve sustainable economic development based on innovation. In India the improvement of

education is very important, it's estimated that in 2007 adult illiteracy rate reached 34%; (2) *Rate of Natural Increase (RNI)*. During the past two decades the RNI in India surpassed the world's average, while the other three countries are below this average. Russia's population witnessed negative growth, annually reducing by 750 thousand people; (3) In Brazil and Russia, the proportion of urban population was 50% higher than the world's average, 86.5% and 72.8%, respectively. When compared to Brazil and Russia, India and China are still in the process of urbanization. Considerable space and resources, besides urbanization, inevitably achieve increasing returns and market size effects, which, in the next twenty years, will be a new driving force for economic growth in both countries. The accumulation of resources in a given space, arising from the urbanization of the population, inevitably affects income and the size of markets, which constitutes a new driving force for economic growth in both countries over the next 20 years.

TABLE 1
Basic economic indicators in Brazil, Russia, India, and China

	Brazil	Russia	India	China	World
People					
Population (millions, 2007)	190.1	141.9	1164.7	1329.1	6670.8
Population as Share of Global Population (%)	2.85	2.13	17.46	19.92	
Urban population (% of total, 2010)	86.5	72.8	30.1	44.9	50.0
Child dependency ratio (1990)	58.5	34.3	64.9	42.9	53.8
Child dependency ratio (2010)	37.7	20.8	47.9	27.7	41.2
Old age dependency ratio (1990)	7.4	15.1	6.6	8.3	10.0
Old age dependency ratio (2010)	10.2	17.9	7.7	11.4	11.6
Rate of natural increase (% , 1990-1995)	1.6	-0.2	2.0	1.2	1.6
Rate of natural increase (% , 2005-2010)	1.0	-0.4	2.0	0.7	1.3
Adult illiteracy rate (% aged 15 and above, 2007)	10.0	0.5	34.0	6.7	
Life expectancy at birth (2007)	72.2	66.2	63.4	72.9	
Human development index					
1995	0.734	0.777	0.511	0.657	
2007	0.813	0.817	0.612	0.772	
Poverty and inequality					
% below \$1/day poverty line (200-2007c)	5.2	<2	41.6	15.9	
% below \$2/day poverty line (2000-2007c)	12.7	<2	75.6	36.3	
Richest 10% to poorest 10% (2007)	40.6	11.0	8.6	13.2	
Gini index (2007)	55	37.5	36.8	41.5	
GDP					
GDP (US\$ billions, 2007)	1313.4	1290.1	1176.9	3205.5	54583.8
GDP (PPP US\$ billions, 2007)	1833.0	2087.4	3096.9	7096.7	64909.7

(Continues)

(Continuation)

	Brazil	Russia	India	China	World
GDP as share of global GDP (2007 PPP, %)	2.82	3.22	4.77	10.93	
GDP per capita (PPP US\$, 2007)	9567	14690	2753	5383	8182.5
% Annual growth rate at constant prices (1990–2007)	1.2	1.2	4.5	8.9	1.6

Source: Unesco, *Human Development Report* (2009a).

Poverty and inequality strongly affect consumption patterns and demand structures. For example, poorer families tend to acquire products and services of lower quality and price, which are compatible with their diminished power of purchase. Demand trends affect a country's technology choice by determining the productive pattern. Therefore, poverty and inequality affect technological innovation. The BRIC, particularly India, suffers from poverty, where 41.6% of the population is below the \$1/day poverty line. In China this rate is 15.9%, in Brazil 5.2%, while Russia is better off with less than 2% of its population below the poverty line. According to the Gini index of 2007, Russia and India are at a relatively reasonable range, around 37%, while China and Brazil's income distribution gap exceed the "Alarm level".

BRIC's economic growth rates varied greatly between 1990 and 2007. China has grown at a faster rate over a longer period of time than any of the other three countries. As a result, although China's economic growth was smaller when compared to the other three countries during the 1980s, its gross domestic product (GDP) in 2007 was almost three times that of India, Brazil or Russia. When considering the GDP per capita, Russia's is almost three times that of China, while Brazil is 56% higher than China; however, China is almost twice that of India. All four are still considered developing countries, at three different levels of development. In terms of their GDP per capita, Russia and Brazil are classified as a high income developing economy; China is classified as a lower middle income economy and India as a low income economy.¹

Brazil had high growth rates from the mid 1960s until 1981, when it was severely affected by the Latin American debt crisis and the first oil shock. The country basically lost two decades of growth as a result of major macroeconomic imbalances that ensued, and only managed to stabilize its economy during the current decade. Even now, its growth rate trails China and India. In the last two decades, especially during the 1990s, the Russian economy was in a recession due to a series of errors in economic policies and reform strategies, situation which improved when Putin came to power. Russia and Brazil's annual growth rate at constant prices between 1990 and 2007 was 1.2%. On the other hand, India, since the 1980s, has shown more consistent growth rates, between 5 and

1. These are based on the classifications made by the World Bank.

6%, except for a severe financial crisis in 1991, which forced the country to liberalize the economy and eventually reach a higher growth rate. During the last four years, the country has been growing at more than 8% per year, closely approaching China's growth rates.

3.2 Broader Economic and Political Characteristics

This section examines some of the broader macroeconomic and political issues, including inflation rate, savings and investments, telecommunication infrastructure, administrative efficiency, political system and the role of government.

Inflation

At the macroeconomic level, Brazil is the most unstable country within the BRIC, having experienced twenty years of high inflation rates between 1980 and 2000. At the beginning of the 1980s, when the country began to face the effects of the second oil shock and the rise of interest rates in the international financial market, the process of industrial development planning, that characterized the previous decades, was abandoned. Throughout the 1980s, the Brazilian economy evolved under extremely high inflation rates: in 1988 this rate was nearly 400% per year, and rose to 2000% in 1990, increasing to 2700% in 1993. Russia faced macroeconomic instability in the 1990s, when the inflation rate reached 1468%; nonetheless, in 1999 it decreased to 36.5%. Since 2000, the Russian inflation rate has been under 20 percent; however, it still remains relatively high. In a high inflation economy, financial engineering and managing supplier's credits and receivables is more important than reducing production costs, improving quality or developing new products, factors which apparently reduce the incentives for innovation. In turn, when considering macroeconomic control, China is the most stable country within the Bric, maintaining a low inflation rate since 1980s. In the past three decades, China's inflation rate witnessed a 3% for the period. When compared to Brazil and Russia, India has a relatively stable macroeconomic environment, nevertheless not as good as what may be expected from the Chinese.

Saving and investment

Since 1990 and during most part of the period, China's Gross National Savings/GDP and Gross Domestic Investment/GDP have exceeded 40% (Table 2). For example, in 2003, China's savings rate was more than twice that of Brazil, nearly twice that of India, while Russia is close to 65% of China's rate. Thanks to high savings rate, Chinese investment rate has been, for a while, one of the highest in the world. During the last decade, China's investment rate was almost twice as high as the other three countries. The "three highs": high savings, high investment and high growth have been the main characteristics of China's economy over the past three decades. High savings, however, also has a negative influence on the

economy. In China's economy, high savings and corresponding low consumption would be the key cause of an over-dependency on exports and investments.

TABLE 2
Saving and investment of BRIC

Country	Gross national savings/GDP (%)				Gross domestic investment/GDP (%)			
	1983	1993	2002	2003	1983	1993	2002	2003
Brazil	–	20.2	18.5	20.7	16.7	20.8	19.8	20.1
Russia	–	33.7	28.6	28.9	-	27	20.2	20.6
India	18.4	23.1	26.3	24.4	19.7	21.3	22.8	23.8
China	35.1	41.8	43.2	47.6	33.8	43.3	40.4	44.4

Source: World Bank. Available at: <www.worldbank.org>.

Information and communication infrastructure

Dissemination and use of knowledge are the major functions of the innovation system and require the support of the information infrastructure. When compared to the other three countries and considering its huge population size, China's information and communication infrastructure is more efficient and modern (see Table 3). China manifests its advantages, especially when compared to India, which has almost the same population. Except for a small number of indicators, such as information and communication technology (ICT) expenditure and price basket for internet, the numbers presented by India represent approximately one third of China, or less. Russia's indicators are slightly ahead of Brazil, however in 2005, when comparing the ICT expenditure it represented less than half of Brazil and the lowest of the BRIC countries.

TABLE 3
Information and communication infrastructure of BRIC

Actual	Brazil	Russia	India	China
Total telephones per 1,000 people (2004)	587.10	773.10	84.50	499.40
Main telephone lines per 1000 people (2004)	230.40	255.80	40.70	241.10
Mobile phones per 1,000 people (2004)	356.70	517.30	43.80	258.30
Computers per 1,000 people (2004)	105.20	132.20	12.10	40.90
Households with television (%) (2004)	90.00	98.00	37.00	91.00
Daily newspapers per 1,000 people (2000)	46.00	–	60.00	59.00
International internet bandwidth (bits per person) (2004)	149.30	99.90	11.40	57.40
Internet Users per 1,000 people (2004)	119.60	111.20	32.40	72.50
Price Basket for Internet (US\$ per month) (2003)	28.00	10.00	8.70	10.10
ICT expenditure as % of GDP (2005)	7.82	3.58	5.91	5.28

Source: World Bank. Available at: <www.worldbank.org>.

Bureaucracy and transaction costs

All four countries have complicated government procedures. Although there are different procedures for different needs, deriving from specific functions, we can see that India has the highest transaction costs. The cost of registering a business in India is the highest of the four countries, 7% of GNI per capita, 7.4 times that of Brazil, 7.9 times that of China, and 27.3 times that of Russia. It's well-known that Brazil has the lowest level of efficiency in relation to bureaucratic procedures, starting a business needs 152 days, that is to say 124 more days than Russia and 117 more days than in China and India.

TABLE 4
Compare of bureaucratic transactions costs of BRIC

Bureaucratic transactions costs	Brazil	Russia	India	China
	High	Low	Very high	Medium
Cost to register a business as % of GNI per capita (2006)	9.9	2.7	73.7	9.3
Days to start a business (2006)	152	28	35	35
Cost to enforce a contract (% of debt) (2006)	15.5	13.5	35.7	26.8

Source: World Bank. Available at: <www.worldbank.org>.

Role of government

During the period of planned economy, everything was controlled by the Chinese government. Since the 1980s, the Chinese government began a market-oriented reform, accelerating the process after entering WTO in 2001. Many state-owned enterprises closed or restructured during this period, private enterprises developed fast, while private property was officially recognized in 2007. By the end of 2007, the number of private enterprises exceeded 70% of the total number of enterprises in the country. Nevertheless, China's share of state-owned economy is still one of the highest in the world. In 2009 the output value of state-owned enterprises accounted for 67.1% of the GDP. An active private economy and a strong state-owned economy coexistence as the two engine of sustained rapid economic growth in the country. An important manifestation of China's government role is that it controls and regulates the macro economy through state-owned enterprises.

India became a democracy after its independence, however, during the early years it mainly remained a government-controlled economy. The Soviet's five-year economic plan was opposed to large businesses and the government restricted the growth of large private enterprises. In the 1980s, these restrictions were loosened and since the 1990s have led to further liberalization. Although India's economy has been partly privatized, the state continues to have a strong presence

in industry and services. Russia experienced a rapid period of privatization between 1991 and 2000, including energy, banking and so on. After President Vladimir Putin came into power in 2000, Russia chose a government-led market economy, which completely controls the country's economic lifeline - such as energy, the military, communications and aeronautic, among others. Brazil is the most market oriented of the three economies. Nevertheless, during the military government, the State had a strong role in the economy, including the creation of many large state owned enterprises, in critical areas. During the 1990s, there were significant privatizations in Brazil; however, the State still is an important presence in the service sector (DAHLAM, 2009).

4 SUB-SYSTEM: SUPPORT SYSTEM OF INNOVATION

For developing countries, technological progress comes mainly from two sources: Opening up of international technology spillovers and domestic innovation. Large numbers of studies suggest that trade and investment liberalization generated from the spillover of technology - including learning, imitation, demonstration and competition effects - are an important source of technological progress for developing countries. Meanwhile, international experiences also show that opening to technology spillovers would produce a "threshold effect". Technology spillovers can become a reality only if the host country has a specific technical base and level of human capital; these two aspects are related to the productive structure and the level of education in the country. Trade, FDI, production and education are the support system of innovation.

4.1 Production structure of BRIC comparisons

As Table 5 shows that Brazil's industrial structure has changed significantly since 1985. The industry's share in total GDP declined, while services were in high growth. The industry's and service share of the total GDP in 2003 represented 19.11% and 75.12%, respectively. It's worth noting that agricultural products play an important role in Brazilian international trade, even though its share in GDP declined from 10.9% in 1985 to 5.77% in 2003.

In India, the agriculture sector showed a downward trend in its share of the total GDP, reaching 22.21% in 2003 compared to 36.6% in 1985. In the past twenty years, the manufacturing industry maintained its contribution rate to the total GDP, averaging around 26%. The service sector is the fastest growing sector in India, especially when considering IT sectors. The share of services in GDP grew from 37.6% in 1985 to 51.2% in 2003.

In Russia, the share of the agriculture sector fell from 14.9% in 1985 to 5.16% in 2003. The participation of the manufacturing sector in the total GDP declined from 62.3% in 1985 to 34.17% in 2003 (and remains highly concen-

trated on heavy industries – oil, energy, metallurgy and machinery). The share of services in the total GDP increased from 22.8% in 1985 to 60.67% in 2003.

China's industry led its evolution in a different way. The share of the manufacturing industry has improved greatly and exceeds 50% of the total GDP, 44.6% in 1985, to 52.29% in 2003. Although most of the labor force still resides in the rural area, there is a huge drop in the agricultural GDP share, from 33% in 1985 to 14.62% in 2003. The share of services in the total GDP grew from 22.4% in 1985 to more than 30% in 1990, remaining at the same level ever since.

TABLE 5
BRIC – value added by sector
(% of GDP)

Country	Year	1985	1995	2000	2002	2003
Brazil	Agriculture	10.90	7.60	7.28	5.84	5.77
	Industry	44.00	41.60	27.97	20.61	19.11
	Manufacturing	33.20	25.00		12.40	11.40
	Services	45.10	50.80	64.75	73.55	75.12
Russia	Agriculture	14.9	8.30	6.43	5.75	5.16
	Industry	62.3	44.60	37.95	33.75	34.17
	Manufacturing	–				
	Services	22.8	47.10	55.62	60.50	60.67
India	Agriculture	36.60	31.00	24.62	22.67	22.21
	Industry	25.80	26.30	26.60	26.61	26.59
	Manufacturing	16.30	16.10		15.60	15.80
	Services	37.60	42.80	48.78	50.72	51.20
China	Agriculture	33.00	19.90	16.35	15.38	14.62
	Industry	44.60	47.40	50.22	51.09	52.29
	Manufacturing	36.50	34.50		35.40	39.30
	Services	22.40	32.70	33.42	33.53	33.08

Source: World Bank, World Development Indicators Database.

4.2 Trade

When considering the total amount of imports and exports and their trends, China has a closer integration with the global economy than the other three countries. Tables 6 and 7 show the exports and imports of the BRIC in current US\$ and as a percentage of world exports and imports, during 2000 and 2004. After a phase of stagnation between 2000 and 2002, world exports grew significantly from US\$ 6,481 billion in 2002 to US\$ 9,123 billion in 2004. Imports also followed the same trend. The participation of the BRIC has varied significantly.

TABLE 6
BRIC – Foreign trade

(In millions of US\$ current and share of GDP – %)

Countries	Exports + imports				Exports + import/GDP				
	1970	1980	1990	2002	1970	1980	1990	2002	2006
Brazil	8,719	25,412	61,212	133,196	13.0	10.3	14.0	28.9	27
China	4,833	38,919	114,710	696,909	5.3	12.9	29.9	55.0	74
India	4,792	28,839	51,144	156,581	7.9	15.7	15.8	30.8	38
Russia			349,249	206,358			36.1	59.7	

Source: United Nations Statistics Division. Available at: <<http://unstats.un.org/unsd/default.htm>>.

TABLE 7
BRIC – Merchandise trade, 2000-2004

(Billion of current US\$ and share in world total %)

Exports	2000		2002		2004	
	Value	%	Value	%	Value	%
World	6,446.61	100	6,481.17	100	9,123.52	100
Brazil	55.09	0.85	60.36	0.93	96.47	1.06
China	249.20	3.87	325.59	5.02	593.37	6.50
India	42.38	0.66	49.25	0.76	72.53	0.79
Russia	105.57	1.64	107.11	1.65	183.19	2.01
South Africa	29.98	0.47	29.72	0.46	45.93	0.50
Imports	2000		2002		2004	
	Value	%	Value	%	Value	%
World	6,705.87	100	6,718.23	100	9,458.27	100
Brazil	58.63	0.87	49.60	0.74	65.90	0.70
China	225.09	3.36	295.17	4.39	561.42	5.94
India	51.52	0.77	56.52	0.84	95.16	1.01
Russia	44.66	0.67	60.22	0.90	94.83	1.00
South Africa	29.70	0.44	29.27	0.44	55.20	0.58

Source: United Nations Conference on Trade and Development (UNCTAD). Available at: <www.unctad.org>.

The most notable fact is the well-known increase in China's participation in international trade: its exports, when compared to the total amount of the world exports, grew from 3.9% in 2000 to 6.5% in 2004 (a 67.9% growth rate) and imports rose from 3.4% to 5.9% of the total world imports during the same period (76.8% growth rate). As may be observed from Table 3, Chinese imports almost doubled in two years (from US\$ 295 billion in 2002 to US\$ 561 billion in 2004). Its worth highlighting the strong role of primary goods in imports,

which also benefits countries specialized in these goods. China is a typical export-oriented economy. Table 6 illustrates that the share of imports and exports in China was 74% of the total GDP in 2006, compared to a 38% in India and only a 27% in Brazil. Purchases of foreign products and services are a key way to gain access to knowledge embodied in those goods and services. In China, trade is an important support for the National Innovation System.

India and Russia experienced a mild growth in both exports and imports. Brazilian imports decreased their relative share of the world imports during the period (from 0.87% to 0.70%), even if the absolute value increased from US\$59 to US\$66 billion.

4.3 Foreign direct investment

Table 8 provides a comparison between 1990 and 2008 of the FDI annual overview across BRIC economies and the FDI as percentage of Gross Fixed Capital Formation (GFCF). It is clear that among the BRIC economies, China tops the annual FDI inflow, followed by Russia, Brazil, and India. However, in terms of FDI as percentage of GFCF, Russia tops the table, followed by Brazil, India and China. According to the growth rate, over the past 20 years Russia's FDI had the fastest growth rate in 2008, it was 35 times that of 1990. Table 9 provides a comparison of FDI inward stocks across BRIC economies and FDI inward stock as a percentage of the GDP. It is clear that since 2000 China leads in terms of FDI stocks inflow, followed by Russia, Brazil and India. However, in terms of FDI inward stocks as a percentage of GDP, Brazil tops the list followed by Russia, China and India. Overall, Tables 8 and 9 show that FDI inflow to Bric economies grew significantly between 2006 and 2008, with few exceptions.

TABLE 8
Comparison of foreign direct investment – overview across BRIC economies

FDI inwardn flows	Millions of US\$				Gross fixed capital formation (%)			
	1990-2000 (annual avg.)	2006	2007	2008	1990-2000 (annual avg.)	2006	2007	2008
World	492674	1461074	1978838	1697353	8.2	13.5	16.6	12.8
Brazil	12000	18822	34585	45058	10.8	10.5	14.8	15.1
China	30104	72715	83521	108312	11.9	6.4	6.0	6.0
India	1705	20336	25127	41554	1.9	6.9	6.5	9.6
Russia	1941	29701	55073	70320	3.3	16.2	20.2	19.5

Source: UNCTAD (2009).

TABLE 9
Comparison of foreign direct investment – inward stocks across BRIC economies

FDI inward stocks	Millions of US\$				Gross fixed capital formation (%)			
	1995	2000	2007	2008	1990	2000	2007	2008
World	2915311	5757360	15660498	14909289	9.1	18.1	29.1	25.0
Brazil	47887	122250	309668	287697	8.5	19.0	23.2	18.3
China	101098	193348	32 087	378083	5.1	16.2	9.7	8.7
India	5641	17517	105429	61765	0.5	3.7	9.2	9.9
Russia	5601	32204	491232	213734	–	12.4	38.4	12.7

Source: UNCTAD (2009).

China is far more attractive for FDI than any of the other three countries, the reasons are listed below. First, China opened its regulatory regime for Foreign Direct Investment more extensively than India and 10 years before. With the development of investment, the Chinese government has introduced tax incentives and other such policies to attract FDI. Second, China's larger and richer market has been an important pull factor, even surpassing Russia and Brazil. Third, China has many cost advantages over the others countries, although its labor costs are now generally higher than India's. Fourth, China has a better infrastructure and a more efficient administrative system. Fifth, China has a more stable macro economy, over the past twenty years, low inflation, interest rates, exchange rate fluctuations has created a good environment for investment. As a result, China has been very attractive not only as a production platform for global markets, but also the Chinese market is the world's fastest growing market. This strong pull towards producing in China has also permitted the government to encourage strong competition among foreign multinational firms so they may bring the very best technologies when locating in China, even though they are aware of poor intellectual property protection and the risk that their technology may be pirated. The most important contribution of FDI to China has not been capital, once China has had high levels of savings and investment rate. More important has been the access to advanced technology and management through FDI. Equally important is the entry into global markets, once foreign investors integrate their Chinese operations into their global supply chains (DAHLAM, 2009).

4.4 Education

Education is the basis for using new technologies, the basis for innovation. The more education people get, the faster mastering new technologies are. Empirical studies show that education leads to higher productivity and higher growth and also show that they lead to higher earnings for individuals.²

This section will compare education across the four countries by comparing basic education attainment, followed by secondary and higher education enrollment rates and a few concluding comments on life long learning.

Basic education

Thirty years ago, as a very poor developing country, China's education level was very low. Nevertheless, China made huge investments in education and implemented a nine-year-compulsory education plan in 1986. The rate of adult literacy in China, the world's most populous country, is 90.9%, less than Russia; however it's a great achievement to attain a 30% higher rate than India (table 10).

Tertiary education

Since the mid 1990s, China conducted a national expansion of higher education aiming to repair the higher education system, severely damaged during the Cultural Revolution (1965 to 1975). By 2005, China's higher education enrollment rate reached 19%. Due to its huge population base, the number of students in higher education in China is higher than the U.S. and 40% of the students are concentrated in engineering and science. Since the 1950s, India has created seven Institutes of Technology and later several Institutes of Management, producing a critical mass of well educated English speaking professionals, who have been instrumental in India's development of software and ICT enabled services. Despite India's efforts to expand enrollment rates in higher education, in 2005 there was a gap of more than 7%, when compared to China. Also, the quality of higher education is poor. The low quality of tertiary education and the regulatory constraints on expanding institutions of high quality will be a major bottleneck for India's continued rapid growth of knowledge intensive services. Brazil is well ahead of China and India in relation to tertiary education; however, it has expanded the least, albeit being slightly ahead of China in tertiary enrollment rates (DAHLAM, 2009, P. 18-20). On the other hand, when considering higher education these three countries are far behind Russia, which has an enrollment rate of 68.20%.

2. There are other benefits from more education. Many analyses show a positive causal relationship between higher educational attainment better mental and physical health, and lower rates of unemployment and to get jobs with higher income. With higher income they can spend more on health. Education can increase a person's self-esteem, problem-solving and social skills, and the capacity to respond to adversity. In addition, research has shown a positive relationship between literacy and participation in voluntary community activities, and between greater civic knowledge and higher levels of civic participation (OECD, 2006).

TABLE 10
Education indicators of BRIC

	Brazil	Russia	India	China
Adult literacy rate (% age 15 and above) (2006)	88.6	99.4	61.00	90.9
Average years of schooling (2000)	4.88	10.03	5.06	6.35
Gross secondary enrollment (2004)	102.00	92.90	53.50	72.50
Gross tertiary enrollment (2004)	22.30	68.20	11.80	19.10
Internet access in schools (1-7) (2006)	3.60	3.80	3.80	4.00
Public spending on education as % of GDP (2005)	4.0	3.8	3.2	2.2
Quality of science and math education (1-7) (2006)	2.90	4.50	5.70	4.10
Extent of staff training (1-7) (2006)	4.20	2.90	4.80	3.40
Quality of management schools (1-7) (2006)	4.10	3.60	6.00	3.40
Brain drain (1-7) (2006)	3.90	3.50	3.70	3.80

Source: World Bank.

Obs.: First, countries are ranked from best to worst, using their scores on each variable. Then the scores are normalized on a scale of zero to ten for all countries.

Education quality

According to the data divulged by the World Bank in 2006, when considering Internet Access in Schools, China has the best performance, scoring 4. When considering the Quality of Science and Math Education, India ranked the best at 5.9, which is twice that of Brazil. When examining the Extent of Staff Training, Russia scored the lowest, only a 2.9, while the other three countries are above 4. Considering the Quality of Management Schools, India scored 6, higher than Brazil who rank second (Table 10). This may be due to the fact that English is India's official language. When analyzing the Brain Drain phenomenon, there is a slight difference between these four countries. Its noteworthy that the GDP share of Chinese investment on education is 1% less than India, which is alarming when considering that the lack of government investment in education may in the long-term affect human resources and China's international competitiveness.

5 SUB-SYSTEM: MAIN PLAYERS OF INNOVATION

Innovations and new emerging knowledge always result from the efforts of research institutions. Research institutions in enterprises, government and universities are the main players of innovation. This section will make a comparative study of the quantities and distribution of researchers, and the innovation efforts carried out by research institutions belonging to the government, enterprises and universities.

5.1 Researchers

Table 11 reveals that China dominants when considering the quantities of researchers, representing 1/5 of the total amount in the world. When it comes to the research expenditures per researcher, the level in China is very low. However,

it has increased in 51% between 2002 and 2007. Although it is 50% higher than Russia, it is only 58% of India and 50% of Brazil. During 2002 and 2007, the number of researchers increased by 75.6% in China, 64.8% in Brazil, 33.6% in India, while a decreasing trend was observed in Russia. Russia's proportion of the total researchers in the world has decreased in 2% during the period, representing 1/3 of the total amount of researchers in China. However, when taking into account the amount of researchers per million inhabitants, the rate was highest in Russia, three times that of China, five times that of Brazil and 24 times that of India. Possibly due to a well-developed higher education system, the foundation for research in Russia is still strong.

TABLE 11
Researchers in BRIC (2002 and 2007)

	Researchers (thousands)		World researchers (%)		Researchers per million inhabitants		GERD per researcher (thousands PPP\$)	
	2002	2007	2002	2007	2002	2007	2002	2007
Brazil	71.8	118.3	1.2	1.7	400.7	624.8	167.8	146.6
China	810.5	1423.4	14	20.1	629.1	1071.3	48.7	73.7
India	115.9	154.8	2.3	2.2	110.8	136.5	102.8	126.7
Russia	491.9	469.1	8.5	6.6	3365.8	3291.8	32.5	50.1

Source: Unesco (2009).

Table 12 compares the the distribution of BRIC researchers by sector of employment. In sum, enterprises in China holds the largest group of researchers with a 62.3%, while the universities hold 19.8% of the total and the remaining 17.9% are in the government. In India, 49% of the researchers were in government institutions of, 37% in enterprises and 14% in the universities (the smallest rate of the four countries). It is different in Brazil, where 56.3% of the researchers are in universities, and 37.6% in enterprises, only 5.3% in government. The situation of Russia is similar to China. About 51.2% of the researchers are gathered in enterprises, while the proportion of governments and universities were 33.3% and 15.2%, respectively. According to changing trends, the proportion of researchers' distribution in enterprises has increased in China, while the amount in government has decreased, contrary to Russia. In India, the amount of researchers in enterprises between 2000 and 2005 increased in 7%. During the same period, the percentage of researchers in universities and the government decreased in 5% and 2%, respectively. In Brazil this rate decreased slightly and was similar to India.

TABLE 12
Researchers by sector of employment, full-time equivalents

	Researchers - Total		Business enterprise (%)		Government (%)		Higher Education (%)	
	2000	2005	2000	2005	2000	2005	2000	2005
Brazil	64002	109420	31.4	37.6	7.4	5.3	60.5	56.3
Russia	506420	464577	57.2	51.2	28.1	33.3	14.3	15.2
India	115936	154827	30.0	37.0	51.0	49.0	19.1	14.0
China	695062	1118700	50.9	62.3	27.8	17.9	21.3	19.8

Source: GDP: World Bank (*World Development Indicators*, as of February 2009), and UIS estimations.

Population: United Nations Population Division; *World Population Prospects: The 2006 Revision*, and UIS estimations.

5.2 Domestic innovation effort

Table 13 shows that the expenditures on R&D in China increased rapidly from 2002 to 2007. The Gross Expenditure on Research and Development (GERD) was 104.9 billions in 2007, compared to 39.4 billions in 2002, increasing by 3 times. The percentage of R&D expenditures in the world also increased to 10% in 2007, which was higher than 2.2% in India, 2.1% in Russia and 1.6% in Brazil. China's ratio of R&D expenditures to GDP was 1.5% in 2007, coming in first place among the developing countries (while the data for Russia was 1.1%; for Brazil, 0.8%; and for India, 1.0%). However, there's a large gap when compared to developed countries. Although R&D expenditures per capita increased rapidly in China, it was still far below the level the OCDE countries and even lower than several developed countries. In 2007, the data was less than 1/2 of Russia, and lower than Brazil. It was only higher than India, which represented 1/4 of China's expenditure.

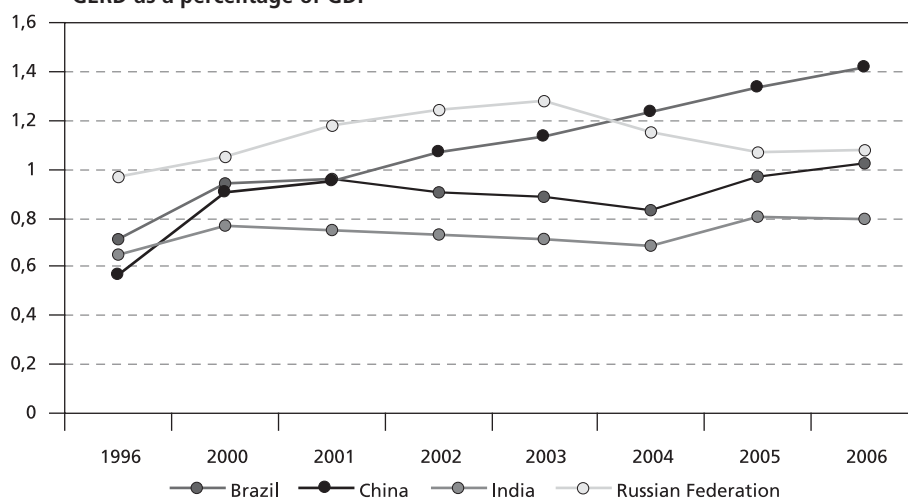
Figure 2 shows that the ratio of R&D expenditures to GDP has increased since the mid-1990s, and that this trend is continuous. In Russia, the process developed in two stages: an increase during 1990 and 2003, and a decrease between 2003 until the present. In Brazil and India trends were similar, after a period of oscillation there's been an increase in this ratio over the past three years.

TABLE 13
R&D expenditure (GERD) of BRIC (2002 and 2007)

	GERD (in billions PPP\$)		GERD (% world)		GERD (% of GDP)		GERD (per capita in PPP\$)	
	2002	2007	2002	2007	2002	2007	2002	2007
Brazil	12.1	17.3	1.5	1.6	0.9	1.0	67.2	91.6
China	39.4	104.9	5.0	9.2	1.1	1.5	30.6	79.0
India	12.9	24.8	1.6	2.2	0.7	0.8	11.9	21.2
Russia	16.0	23.5	2.0	2.1	1.2	1.1	109.4	164.8

Sources: GERD, researchers data and related indicators: Unesco Institute for Statistics (UIS) estimations, May 2009.

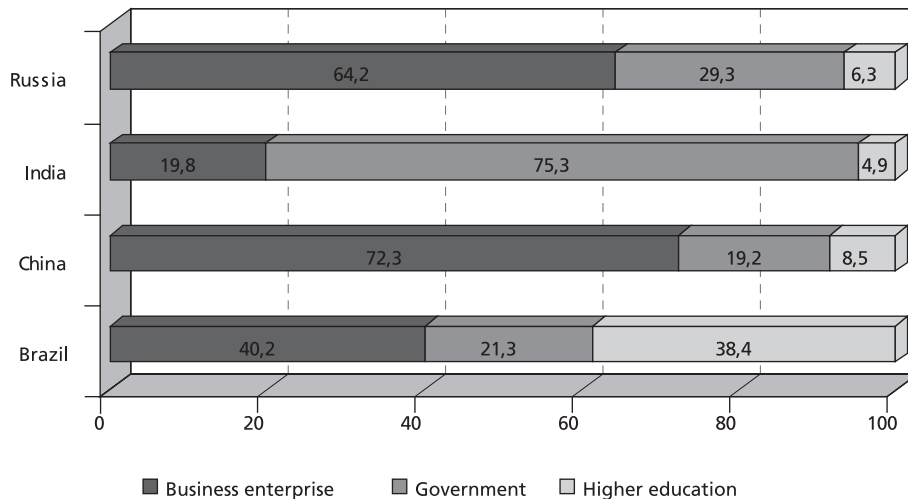
FIGURE 2
GERD as a percentage of GDP



Source: Unesco (2009a).

When analyzing the sources and flow directions of R&D expenditures, one may observe that the real flagships have always been enterprises, with the exception of India. According to the distribution of the sources of R&D expenditures, there are a few market economy characteristics in China. Enterprises are the main source of R&D, 72.3% of the R&D expenditures are made by enterprises. Only 8.5% of the expenditures come from universities. In Russia and India, the R&D expenditures invested by universities was only 6.3% and 4.9%, respectively. At the same time, the R&D expenditures of universities were rather high in Brazil, around 38.4%, close to the rate of enterprises. With a share of 75.3%, India's government made the largest investments in R&D.

FIGURE 3
GERD by sector of performance – 2007
(In %)



Source: Unesco (2009b).

6 CHARACTERISTICS OF INNOVATION PERFORMANCE

We realized a comparative study on the innovation system considering the environment, supporting system, main body and the innovation efforts. This section will compare the innovation performance of the four countries under three aspects: innovation capability, innovational configuration and innovation strength.

6.1 Innovation capability

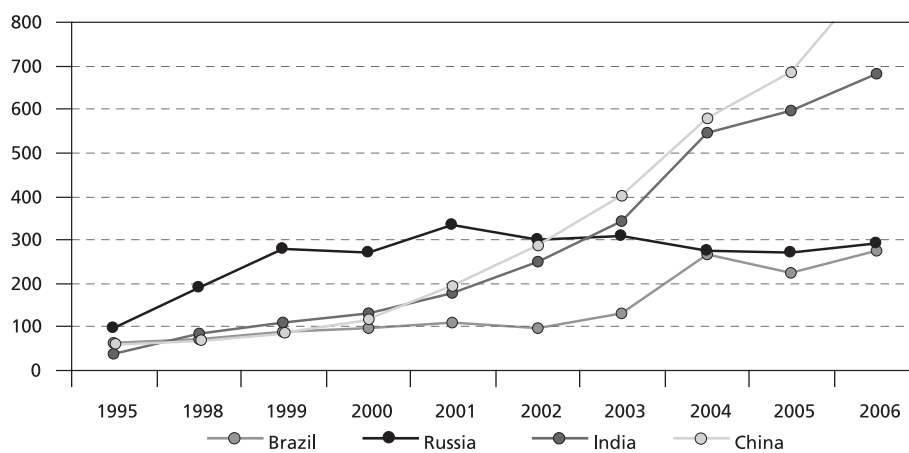
We used patent count and citation ratio to evaluate innovation capability. The patent and citation data used in this study consists of all patents granted by the U.S. Patent and Trademark Office (USPTO) to BRIC inventors between 1976 and 2006.

Figure 4 compares the patent counts for the BRIC countries between 1995 and 2006. Before 1995 there are no significant changes, however the changes realized after this date may be divided into two stages. The newly authorized patents of each country were always less than 100 per yea, only Russia manifested a significant increase of the patents, while the other three countries remained as they were. Since 2001, the increase of new patents in China and India has been a dominant and continuous trend, which coincided with economic development in both countries. At the same time, the number of new patents decreased in Russia. During 2002 to 2004, there was a rapid increase of new patents in Brazil, after which it entered a period of stagnation.

When analyzing the total amount of new patents between 1976 and 2006, China is in first place with the number of 4745 and India follows with a total amount of 3679. The amount was 3029 and 2134 in Russia and Brazil. Considering that between 1995 and 1999, the quantity of authorized patents were approximately the same between China and Brazil, the gap between them has increased. Since 2000, the discrepancy between China and Brazil has been continuously growing, considering they were at the same level in 1995. This becomes clearer than ever after 2005.

Since the qualities of patent are very different, citation ratio has been used to evaluate the qualities of similar patents (SCHANKERMAN; PAKES, 1986). Citation ratio is defined as the average number of a country's patents cited by later patents. As Table 1 shows, the citation ratios respectively are 5.3, 4.7, 3.6, and 3.6 for Russia, Brazil, India and China in 2006.

FIGURE 4
Number of utility patents given for U.S. origin patents



Source: Tseng (2009).

TABLE 14
Citation ratio of BRIC – 1976-2006

Country	Patent count	Cited by later patents	
		Citations	Citations ratio
Brazil	2134	10014	4.69
Russia	3029	15948	5.26
India	3679	13424	3.65
China	4745	16857	3.55

Source: Tseng (2009).

6.2 Innovation configuration

The differences in innovative configurations may be mapped based on constructs of “fundamental vs. applied innovation” and “incremental vs. radical innovation”.

According to Tseng, the following two methods may be employed to examine the differences in innovation configurations among BRIC countries. Organizations whose patents cite many scientific papers are assumed to be partial to fundamental innovation. Conversely, organizations with lower scientific linkage ratios are assumed to focus more on applied innovation. Incremental or radical innovation is usually used to define the overall impact of innovation. In radical innovation, the properties of a product suddenly change and significantly alter market dominance, competitiveness and the overall industrial landscape. Incremental innovation impacts the existing capabilities of organizations and the existing knowledge and demand structures in the environment. A self-citing ratio can be used to distinguish between incremental and radical innovation (TSENG, 2009).

Table 15 summarizes Science Linkage for the four countries. The indicators of Science Linkage show that Russia (5.46) ranks higher than the other countries in scientific research. It is expected that technological innovation in Russia reflect the latest scientific developments. Restated, Russia is partial to fundamental innovation. In comparison, Brazil and China have relatively lower Science Linkage ratios and are assumed to be more focused on applied innovation.

The right side of Table 15 compares self-citing ratios between BRIC countries. Russia (17.1%) and India (15.4%) tend to favor incremental innovation, while Brazil (9.5%) and China (8.8%) tend to engage in radical innovation. That is, Brazil (90.5%) and China (91.2%) are mostly building on other countries’ technologies.

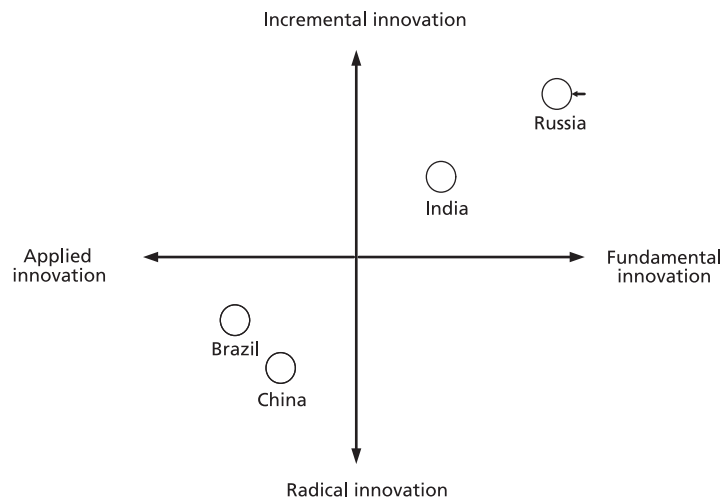
TABLE 15
Comparison of science linkage and self-citing ratio among BRIC – 1976-2006

Country	Citing scientific journal papers and conferences		Citing all previous patents				
	Total citations	Science linkage	Total citations	Citing its own patents	Self-citing ratio (%)	Citing other patents	Other-citing rate (%)
Brazil	4651	2.18	22987	2188	9.5	20799	90.5
Russia	16541	5.46	42782	7314	17.1	35468	82.9
India	13873	3.77	41762	6428	15.4	35334	84.6
China	14125	2.98	60591	5319	8.8	55272	91.2

Source: Tseng (2009).

Figure 5 compares the innovation configuration among BRIC countries on the basis of data consisting of Science Linkage and a self-citing ratio, through the standardization process. Obvious differences in innovation configuration are apparent in the BRIC countries. Russia appears to be highly focused on both fundamental and incremental innovation; India is working closely with applied and incremental innovation, while Brazil and China tend to focus on applied and radical innovation.

FIGURE 5
Innovation configurations differ between the BRIC countries



Source: Tseng (2009).

6.3 Innovation strength

Table 16 presents innovation strength in 30 technological fields for BRIC countries between 1976 and 2006. Innovation strength analysis includes both absolute and relative innovation strength. Absolute innovation strength is measured by the number of patents invented by a country when compared to BRIC countries, in a specific technological field. Relative innovation strength is measured by the number of patents in a specific technological field compared to the total number of patents in the country.

TABLE 16
Comparison of innovation strengths of BRIC countries in 30 technological fields

Technological fields	Brazil		Russia		India		China		Total	
	Patents	(%)	Patents	(%)	Patents	(%)	Patents	(%)	Patents	(%)
Electrical engineering	108	5.1	190	6.3	151	4.1	939	19.8	1,388	10.2
Audiovisual technology	54	2.5	280	9.2	555	15.1	377	7.9	1,266	9.3
Telecommunications	77	3.6	161	5.3	659	17.9	155	3.3	1,052	6.8
Information technology	75	3.5	148	4.9	474	12.9	224	4.7	921	6.8
Semiconductors	33	1.5	163	5.4	308	8.4	252	5.3	756	5.6
Optics	79	3.7	241	8.0	155	4.2	244	5.1	719	5.3
Control technology	134	6.3	73	2.4	52	1.4	348	7.3	607	4.5
Medical technology	114	5.3	144	4.8	112	3.0	200	4.2	570	4.2
Organic chemistry	133	6.2	164	5.4	74	2.0	115	2.4	486	3.6
Polymers	102	4.8	57	1.9	179	4.9	121	2.6	459	3.4
Drugs	79	3.7	133	4.4	11	3.0	90	1.9	412	3.0
Biotechnology	34	1.6	104	3.4	187	5.1	85	1.8	410	3.0
Materials	46	2.2	177	5.8	33	0.9	148	3.1	404	3.0
Food chemistry	53	2.5	91	3.0	144	3.9	114	2.4	402	3.0
Basic materials chemistry	67	3.1	164	5.4	58	1.6	68	1.4	357	2.6
Chemical engineering	20	0.9	34	1.1	60	1.6	225	4.7	339	2.5
Surface technology	119	5.6	105	3.5	42	1.1	55	1.2	321	2.4
Materials processing	116	5.4	68	2.2	21	0.6	97	2.0	302	2.2
Thermal processes	140	6.6	38	1.3	19	0.5	103	2.2	300	2.1
Environmental technology	75	3.5	82	2.7	14	0.4	117	2.5	288	2.1
Machine tools	7	0.3	101	3.3	24	0.7	136	2.9	271	2.0
Engines	115	5.4	34	1.1	20	0.5	78	1.6	247	1.8
Mechanical elements	95	4.5	45	1.5	22	0.6	79	1.7	241	1.8
Handling	61	2.9	47	1.6	20	0.5	104	2.2	232	1.7
Food processing	80	3.7	42	1.4	47	1.3	58	1.2	227	1.7
Transport	13	0.6	45	1.5	46	1.3	118	2.5	222	1.6
Nuclear engineering	33	1.5	9	0.3	44	1.2	21	0.4	107	0.8
Space technology	44	2.1	14	0.5	12	0.3	37	0.8	107	0.8
Consumer goods	23	1.1	18	0.6	9	0.2	14	0.3	64	0.5
Civil engineering	5	0.2	26	0.9	15	0.4	9	0.2	55	0.4
Others	0	0.0	31	1.0	10	0.3	14	0.3	55	0.4
Total	2,134	100	3,029	100	3,679	100	4,745	100	13,587	100

Source: United States Patent and Trade Mark Office. Available at: <www.uspto.gov>.

By analyzing Table 17, the absolute innovation strength and relative innovation strength of the four countries can be defined clearly. It is obvious that BRIC countries markedly differ in the technological fields in which they exhibit innovative strength.

TABLE 17
Comparison of absolute and relative innovation strength of BRIC countries

Country	Absolute innovation strength (Top Five)	Relative innovation strength (Top Four)
Brazil	Surface technology, materials processing, thermal processes, engines, mechanical elements	Thermal processing , control technology, organic chemistry, and surface technology
Russia	Organic chemistry, drugs, materials, basic materials chemistry, and civil engineering	Audiovisual technology, optics, electrical engineering, and materials
India	Audiovisual technology, telecommunications, information technology, semiconductors, polymers	Telecommunications, audiovisual technology, information technology, and semiconductors
China	Electrical engineering, optics, control technology, medical technology, chemical engineering	Electrical engineering, audiovisual technology, control technology, and semiconductors

Source: United States Patent and Trade Mark Office. Available at: <www.uspto.gov>.

7 CONCLUSIONS

7.1 Lessons learned

The *first* lesson is the importance of effectively tapping into the global economy. China has done this extremely well, in many ways. With the opening to the overseas market, especially the entrance to WTO and tariff and non-tariff barriers reduction, China has been continuously opening its domestic market. International trade and investment are the key strategies for China's economic globalization. During this process, we can absorb and consume new knowledge and enhance technological capabilities.

The *second* lesson is that effective use of FDI is more important than the amount of FDI. China's capability of absorbing and effectively using FDI, results from low labor costs and the development of a large domestic market, which strengthens bargaining power. Along with these advantages, China extended its range of options regarding projects and technologies. Another important factor is that China, after a long period of innovation and opening to foreign markets, has developed a sound base of human resources capable of absorbing the spillover of technologies.

The *third* lesson is the importance of competition. Foreign enterprises in China operate in both the domestic and international market, which results in the following: (1) foreign-investment attracts the best technologies and management experiences to China, considering that these enterprises compete in the global market; and (2) domestic enterprises in China must compete with foreign enterprises, incentivizing the enhancement of technologies. After joining the WTO, China's creativity has improved significantly, attesting the importance of open policy and competition.

The *fourth* lesson is the importance of education. In China, the high literacy rate and low labor costs are prime attractions for FDI. Investments in high-level human capital have been critical for Brazil's excellence in aeronautic technology, deep oil exploration, and agricultural research. Nonetheless, good education alone may not be effective. Russia has the best education among BRIC countries and the highest percentage of higher educated population, however the effectiveness of innovation has been low. One may conclude that innovation is a kind of systematic engineering.

Fifth is the importance of macroeconomic conditions. China has a relatively stable macroeconomic environment, including low inflation, low interest rates and stable exchange rates. This has created a predictable business environment which, both, domestic and foreign investors like. Since the 1980s, India also has had a relatively stable macroeconomic environment, except during the financial crisis of the late 1980s, which culminate in 1991. Brazil, on the other hand, went through a period of macroeconomic instability between 1980 and the early 2000s, when it finally attained stability. This also happened in Russia, which experienced a very turbulent 1990s.

The *sixth* lesson concerns the importance of continuous effort. An emblematic case is that of the aeronautics' industry in Brazil, whose development has been included in national strategies and has received continuous investment since the 1930s.

The *seventh* lesson is high investment rates. China has grown faster than any of the other three countries because its investment rate is around twice as high. While it is true that much of this investment has been inefficient, it is also true that high rates of investment allows for new technologies.

Eighth is the importance of the role of government. We do not refer to the amount of the R&D expenditures invested by government, but the definition of policies and laws for innovations. In China, enterprises are the main executors of innovation. At the same time, the government has been the leading proponent of political liberalization, absorbing of foreign capital, the construction of special economic zones, the construction of high-tech development zones, the creation of a tech-business incubator and the Torch Programme for developing new/high tech industries.

Ninth is the attention given to the variation of the population. Along with innovation and opening up to the world, there is a family planning policy in China that plays an important role in the development of the economy. India's population has increased, while Russia's population has decreased, resulting in the depression of the economy.

7.2 Economic implications for BRIC

There are predominant individual characteristics and commonalities among the BRIC countries regarding the construction and evolution of the innovation system. The similarities in future trends are explained below.

Open approach

The process of trade liberalization provides access to the global economy, knowledge and advanced technologies, increasing national capacity for innovation. There are three tasks at hand. The first is to enhance education and develop high-tech human resources to improve learning and the competing abilities of national enterprises. The second is to improve the ability to negotiate with foreign capital and make reasonable choices regarding productive or technological factors, maintaining a balance between the protection of domestic industries and opening to the world market. Finally, create a good local system, law environment and infrastructure that attract foreign high-tech company investment. An attractive investment destination may arouse competition between different projects, where capital and technologies will be filtered.

Construct a competition system

It's crucial to construct a system capable of absorbing foreign advanced technologies and incentivizing domestic enterprises to invest in innovation. Nationally, the competition system may drive domestic enterprises to keep learning and absorbing new knowledge and carry out innovations. Internationally, competition may motivate foreign enterprises to bring the most advanced technologies to the local market.

Government leadership

As Lundvall (1985) observed, institutions (such as enterprises, research institutes or universities), rather than individuals, promote innovation in the economy by interacting with each part of the innovation system and generating mutual influences within the social system. The government is the first instance to promote activities among these interactive activities. The success of a country's innovation policies is based on the continuous efforts of public and private elements, as well as national intervention. Under this model, the government may guide development and promote the creation of new knowledge and its applications. Undoubtedly, government intervention doesn't mean that the government should invest in R&D directly, but that it should formulate and implement better innovation policies and promote cooperation among governments, enterprises, research institutes and universities, motivate enterprises to invest in and implement R&D. Meanwhile, the government should also supply the necessary public goods that promote innovation.

Emphasis on enterprises

In a system of market economy, enterprises are the main players, while the innovation of technologies promotes economic progress. Simply follow this rule and there will be a market-driven path to innovation, moreover market demand will be met. Enterprises should take the lead in R&D investment, technical innovation and its application. Within the BRIC countries China leads in NIS, whereas the other three countries, especially India, still have a long way to go.

From the standpoint of individual characteristics, there are many advantages and disadvantages of the BRIC's innovation systems. In China a stable macroeconomic environment, a powerful government, a large market, economic globalization and the continuous increase in investment in innovation support the national innovation system. The disadvantages are the increase of labor cost and the bottleneck of environmental resources. In India the main advantages are abundant human resources, which have shown an increasing trend, while the development of education is a weakness. In Russia there is a sound higher education system, many natural resources and a strong technology base, however, the continuous decrease of the population, the lack of innovation expenditures and the fluctuation of the macroeconomic environment are its weaknesses. The main advantages of Brazil reside in its reasonable industrial structure and advanced aeronautic industry technology, while its disadvantages are the unfair distributions system and low levels of R&D expenditures.

Likewise, the differences in the configurations of the NIS among BRIC countries allow for complementarities and possibilities of cooperation. On one hand, Russia tends to focus mostly on fundamental innovation, unlike India, while Brazil and China have preferred to pursue applied innovation. On the other hand, Russia and India tend to exhibit incremental innovation systems, while China and Brazil tend to pursue radical innovation systems. The four countries can make full use of each other's comparative advantages and carry out activities of cooperation; otherwise, there are large discrepancies among their innovation strengths.

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