University of Oxford

Department of International Development

SLPTMD Working Paper Series

No. 023

Innovation Strategies of three of the BRICS: Brazil, India and China— What can we learn from Three Different Approaches?

Carl Dahlman

Innovation Strategies of three of the BRICS: Brazil, India and China— What can we learn from Three Different Approaches?[1]

Carl Dahlman

Georgetown University

[1] This paper is dedicated to the memory of Sanjaya Lall, who wrote prolifically on innovation issues, including on these three countries and on their implications for other countries-see for example Lall 2003, 2004 and Lall and Weiss (2004).

I. Introduction

Innovation in developing countries should not be defined just in terms of shifting global frontier technology but in terms what is new to the country. Innovation strategy should include policies and mechanisms that affect a country's ability to draw on global knowledge as well as domestic R&D effort. Such strategy will be affected by policies that include trade, foreign investment, technology transfer, domestic R&D, human capital and education more generally. From this broad perspective, the innovation strategies of Brazil, China and India—the three largest developing economies[2]-- have been quite different. India has been the most autarkic until recently. China has drawn the most on global knowledge, although more recently it is investing massively in it own R&D. Brazil is somewhat in between. It has been almost as closed as India to trade, but more open that India in terms of FDI. Moreover, Brazil is falling behind both countries in domestic R&D effort. The three countries have also had very different growth performance over the last 25 years. This paper examines the innovation strategies of the three countries, compares their economic performance over the last 25 years, and draws some implications about the link between innovation strategy and economic performance**.**

Section 2 develops a conceptual framework for analyzing innovation in developing countries. This includes the need to look at the broader economic and institutional regime as well as education and skills. Section 3 summarizes some of the key economic parameters of the three countries including population, economic size and performance, and various social indicators. Section 4 summarizes some of the key broader economic and institutional characteristics. Sector 5 analyzes the extent to which the have tapped global knowledge through various modes. Section 6 reviews their domestic R&D inputs and outputs. Section 7 summarizes their education and training strategies. Finally section 8 summarizes their innovation strategies and the lessons that can be drawn by this comparison.

II. Innovation in the Context of Developing Countries

There has been acceleration in the rate of creation and dissemination of knowledge.[3] Because the global stock of knowledge is increasing rapidly, innovation in the context of developing countries should be considered not just in terms of the creation of new knowledge that is new to the world, but also in terms of products or services or forms of organization that are new to local practice, not necessarily to global practice. Furthermore innovation can be new to the country, new to the sector, or at a more micro level, new to the firm. Therefore it is useful to distinguish three sources of innovation. One is acquiring technology that already exists abroad. A second is the domestic creation of

[2] Largest in terms of gross national income or gross domestic product in 2006.

[3] This can be seen, for example, in the increase in patenting activity, the proliferation of new products and processes, the shortening of product life cycles, and rapid advances in information and communications technologies.

relevant new knowledge[4]. The third is the dissemination and effective use of this new knowledge throughout the economy, whether it has been created locally or imported from abroad.

Innovation is affected by the broader economic and institutional regime. This includes the macro conditions of a country (inflation, interest rates, and exchange rates), the business environment (rule of law, quality and effectiveness of government including whether there is appropriate or excessive regulation, and competition policy); the quality and efficiency of the physical and information and communications infrastructure; and the education and skills of the population and the workforce. All of these will be considered in comparing the innovation strategies of the three countries.

III. Characteristics of Three Countries

A. Basic Economic and Social Indicators

China and India are the two most populous countries in the world, accounting for 20% and 17% of the world population (Table 1). Brazil is fifth largest accounting for almost 2%. China has grown faster for a longer period of time than either of the other two countries. As a result, although it was smaller than the other two in 1980, its gross national income (GNI) is almost three times that of India or Brazil. However, because of its earlier start, Brazil's GNI per capita is more than twice that of China, whose GNI per capita is more than twice that of India. In purchasing power terms China's GDP is more than twice the size of India's, but India is roughly 60% larger than Brazil. Brazil actually had high rates of growth from the second half of the 1960s to until about 1981, when it was severely affected by the Latin American debt crisis and the first oil shock. It basically lost two decades of growth as a result of major macro imbalances that ensued, and only managed to stabilize its economy in the current decade. However, even now, its growth rate trails that of the other two countries. India, on the other hand, has had more steady rates of growth of 5-6% since the 1980s except for a severe financial crisis in 1991 which forced it to liberalize the economy and eventually put it on a higher rate of growth. In the last four years it has been growing at more than 8% a year, nearly approaching Chinese rates of growth.

Table 1: Basic Economic Indicators Brazil, China, and India

	Brazil	**China**	**India**
GDP (2006)			

[4] Technology, whether domestically created or imported from abroad often has to be adapted to local conditions. This is particularly true in agriculture, where new technologies such as hybrid seeds are very sensitive to specific local conditions. Thus further research and experimentation is often required to adapt them to specific temperate, soil, and water conditions as well as local pests. To a lesser extent even industrial technologies have to be adapted to local conditions, including local raw materials, special characteristics or other local idiosyncrasies such as sources of power or local standards, and climate or health conditions, etc.

GNI (2006 nominal billion)	893	2,621	909
GNI as share of Global GNI (%)	1.83	5.38	1.87
GNI/capita (2006 nominal)	4,710	2,000	820
GDP (2006 PPP)	1,648	6,119	2,726
GDP as share of global GDP(2006 PPP)	2.74	10.16	4.53
GDP/capita (2006 PPP)	8,700	4,660	2,460
Growth of GDP (1980-2006)			
1980-1990	2.7	10.2	5.8
1990-2000	2.7	10.6	5.9
2000-2006	3.0	9.8	7.4
Exports (2006)			
Merchandise Exports (millions)	137,470	968,936	120,254
Merchandise Exports(% of World Total)	1.14	8.02	1.00
Commercial Service Exports (millions)	17,946	91,421	75,057
Service Exports (% of World Total)	0.65	3.30	2.71
People (2005)			
Population (millions, 2006)	189	1,312	1,110
Population as Share of Global Population	2.89	20.07	16.98
Life expectancy at birth(2006)	72	72	64
Human Development Index			
1995	.737	.681	.545
2004	.792	.768	.611
Poverty and Inequality			
% below $1/day poverty line (2004)	7.5	9.9	33.3
% below $2/day poverty line (2004)	21.2	34.9	80.0
Gini Coefficient (2004)	57.0	46.9	36.8

Note: The GDP in PPP figures are based on new PPP series published in the December 2007, which decreased the estimates for both China and India by 40%.
Source: World Bank WDI 2008, 1999, and World Bank KAM 2008.

What distinguishes China the most is the very rapid growth of its exports. By 2006 its merchandise exports accounted for 8% of global exports, roughly eight times the exports of Brazil or India.[5] In a sense, China has become the manufacturing workshop for the world. On the other hand, India's strength has been in the export of services its share of global service exports is almost three times those of its merchandise exports—and its strength there is in exports of information and communications (ICT) enabled services. Therefore in terms of the two unbundlings referred to by Baldwin (2006), China has benefited the most from the unbundling of production, while India has benefitted the most from the unbundling of tasks facilitated by the rapid advances in ICT. Brazil has not really taken advantage of either. It remains primarily an exporter of commodities, although it has made impressive improvements in agricultural productivity, and has developed some island of excellence, including the export of airplanes.

[5] In 2007 its merchandise exports surpassed those of the US and reached 10% of world exports.

All three are still developing countries, at three different levels of development. In terms of their GDP per capita Brazil is classified as a high income developing economy, China as a lower middle income economy, and India as a low income economy.[6] Moreover they still have significant pockets of poverty. In Brazil 20% of the population still lives on less than $2 a day[7], while that share jumps to 33% for China and to 80% for India.[8]

B. Basic Economic and Political Characteristics

The three countries differ in their economic structure, degree of global integration through trade, structure of trade, consumption versus investment, political systems, and role of government (Table 2).

Economic structure China is very heavily industrialized. The share of industry in GDP at 48% is one of the highest in the world (contrasted with 38% in Brazil and only 27% in India). On the other hand, the share of its service sector is relatively small for an economy with its GDP. India is still primarily an agricultural economy. More than half of its labor force is in agriculture, and the share of agriculture in GDP is still 18%, compared to 13% in China and just 8% in Brazil. However the share of its service sector at 54% of GDP is above the average for a county of its level of GDP, and is due in part to the rapid growth of its ICT and business sectors as will be detailed below. Brazil, on the other hand, has a smaller service sector than expected for an economy of its level of development.

Degree of Global Integration China is the most globally integrated of the world's largest economies, in terms of the share of import and exports of goods and services in the economy. India is still one of the most closed economies in the world in terms of tariff and non-tariff barriers. Brazil is similar to India. Although its average levels of import tariffs are a little lower than India's, its level of global integration is lower than India's. While the share of merchandise exports in GDP is larger than India's, its share of commercial services trade is much lower. In India service exports account for more than on third of total trade

Trade structure In terms of structure of exports, China is mainly an exporter of manufactured products; India is mainly an exporter of services and manufactured products. The share of manufactures in merchandise exports in China has increased to 94%, compared to 70% in India. Although the share of manufactures in Brazil merchandise exports is 54%, export of primary commodities is almost as important at 46%.

---

[6] These based on the classifications made by the World Bank.

[7] This is because Brazil has one of the most unequal distributions of income in the world as revealed by a gini coefficient of .57 compared to .47 for China and just .37 for India.

[8] These calculations are based on the international poverty lines constructed around daily income in purchasing power terms using the old ppp series. New calculations for all countries based on the new ppp series released in December 2007 are not yet available.

Consumption vs. investment China has been a very heavily investment driven economy. For the decade 1995-2004 the investment as a share of GDP averaged 36.1% compared to 24.8% for India and only 21.0% for Brazil. India had been a very heavily consumption driven economy. However, in India the share of investment in GDP has been increasing over the past few years and reached 31% in 2005. Brazil has the lowest investment rate. It also has the highest shared of government consumption in GDP at 21% compared to 14% in China and just 11% in India.

Political system China is an authoritarian one party state since the Communist takeover in 1949. India has been a democracy since independence from the British. Brazil has been a democracy since it independence although it has gone threw various military dictatorship regimes, the last of which (1964-1985), coincided with a large part of Brazil's miracle growth years (1968-1980) until the economy ran into trouble and the military regime was ousted.

Role of Government As a centrally planned economy, the role of government has been and continues to be the largest in China. However, starting in the 1980s the Chinese government began to move slowly towards a market economy. This process accelerated with its entry into WTO. Many state enterprises have been shut down or restructured, private enterprises have been allowed to develop (private property was officially recognized in 2007), and the private sector is estimated to account for over 60% of economic activity. Although a democracy since its independence, the early years of the Indian economy were marked by a very strong role of the state in the economy, including the institutionalization of five year industrialization plans originally structured on the Russian model. In addition government was very anti big business. It restricted the growth of large private businesses, and reserved several hundred products to very small scale businesses. Controls on private business began to be lifted in the 1980s. There was further liberalization in the 1990s which has continued through today. While there has been some privatization, the state still has a strong presence in the industry and services.
Brazil was the most market oriented economy. However during the military period the state has a strong role in the economy, including creating many large state owned enterprises in critical areas. In the 1990s there was considerable privatization so Brazil is the most market oriented of the three economies. However the state still has an importance presence in the service sector.

Table 2: Basic Economic and Political Characterization of Brazil, China, India

	Brazil	**China**	**India**
Economic Structure	*Industry* and ***services***	Heavily ***industry*** dominated	***Agricultur***e and ***Services***
Global integration through trade (2006)	Relatively ***high*** tariff and non-tariff barriers ***Not very globally integrated***: trade only 26% of GDP	***Lowest*** tariff and non tariff barriers ***Very globally integrated***: trade 74% *o*f GDP	***Highest*** tariff and non-tariff barriers ***Not very globally integrated***: Trade only 38% of GDP
Trade Structure (2006)	***Still heavily primary based*** *Merchandise exports*: 49% primary/51% manufacturing *Service exports*: very low-only 1.68% GDP, ICT related 56.9 % of this total	***Very heavily manufactures based*** *Merchandise exports*: 92% manufacturing/8% primary *Service exports* :low at 3.46% of GDP: ICT related only 39.1% of this total	***Heavily service based-more than 30% total exports*** *Merchandise exports*: 70% manufacturing/30% primary *Service exports* very large—8.23 % of GDP, ICT related 73.7% of this total
Consumption vs. investment orientation (2005) *Average Gross Investment to GDP 1995-2004*	***Heavily consumption oriented***: 76% GDP, with 20% government consumption. Investment only 21%. 21.0	***Heavily investment oriented***: 44% of GDP. Total consumption only 51% with government consumption 14%. 36.1	***Previously heavily consumption oriented:*** 78% GDP in 1990, but down to 70% in 2005. with only 11% government consumption. ***Investment increased to 31%*** GDP in 2005 24.8
Government	***Multi party Democratic*** (except for military regime--most recently (1964-1980)	***Single party Authoritarian*** since Mao Zedong took power in 1949	***Multi Party Democratic*** since independence from India in 1947

IV. Broader Economic and Institutional Regime

This section will examine some of the broader macro economic and institutional regime issues including: inflation, interest rates, the exchange rate, physical infrastructure, telecomm infrastructure, and bureaucratic transactions cost (Table 3).

Inflation Brazil has had the most unstable macro conditions among the three countries. It suffered several bouts of very high inflation in the two decades between 1980 and 2000. The high inflation made it very difficult for business, or government to plan long term. In addition, financial engineering and managing supplier's credits and receivables, ad pricing was much more important than reducing production costs, improving quality, or developing new products. China, on the other hand, has had the most stable macro regime of the three countries, with low inflation for most of the period since the 1980s until relatively recently. In addition government plans have been quite clear and stable and this has facilitated long range planning by domestic and foreign investors. India has also had a relatively stable macro regime over the last two and a half decades, except for the financial crisis at the beginning of the 1990's. However, the macro environment has not been as stable and predictable as in China.

Cost of capital A low cost of capital in a critical variable to induce greater investment. Thanks to it very high savings rate, the cost of capital in China has been extremely low for a very long period. The Chinese investment rate has been one of the highest in the world and it has actually increased to over 44% in the last three years. However, the bulk of the investment in directed to state enterprises and the capital output ratio has been rising in China. The real cost of capital in India has been more in line with the real interest rate in developed economies. The banking system in India is also more developed and more efficient that than in China. The cost of capital in Brazil has been one of the highest in the world and is a major source of disadvantage for investment and growth in Brazil. The high real interest rate is due to large government borrowing to service the domestic debt. In addition the banking sector has one of the highest interest rate spreads between deposit rates and lending rates.

Exchange rate China has pegged the Yuan to the dollar for many years. As the US dollar has been depreciating relative to most currencies since 2001 the value of the Chinese Yuan has been appreciating. There was a one time 2.5% appreciation of the Yuan against the US dollar in mid 2005. Since then the Yuan has appreciated a total of almost 8% vs. the US dollar. Many economists argue that the Yuan may be still 20% to 30% undervalued relative to the US dollar. It is also that China has an explicit policy of undervaluing the Yuan in order to support its dramatic export expansion.[9] The real value of the Indian Rupee has been maintained more or less constant since the major devaluation of 1991. However, with the recent boom in foreign and domestic investment in India the rupee has started to appreciate in 2007. The Brazilian real has been appreciating significantly since 2003. This is having a negative effect on exports of manufactures.

[9] See for example Surjit Bhalla (forthcoming).

Table 3: Broader Economic Regime Variables

	Brazil	**China**	**India**
Inflation			
Cost of capital ***2005*** ***Real interest rate*** ***Banking spreads****	***Extremely high*** due to crowding out by government borrowing 44.5% 37.8%	***Very low*** real interest rates, thanks to high saving rate 1.6% 3.3%	***Intermediate*** interest rates, relatively efficient banking sector 6.0% Na
Undervalued exchange rate	***No***, after a sharp devaluation in 1999 the real exchange floated upwards, gradually at first and then appreciated rapidly in 2003-2006 to pre-devaluation levels. It is continuing to appreciate.	***Yes***, Chinese Yuan has been pegged to dollar for many years and has become undervalued as dollar has depreciated. Chinese current account surplus soared from 1% to 9% of GDP between 2001 and 2006. Very small revaluation of 2.1% in 2005 leaves Yuan still undervalued by 20-30%	***No***. Real rupee rates have been relatively constant since a major devaluation in 1991, but have begun to appreciate slightly in real terms in 2007.
Cost and availability of Infrastructure physical infrastructure *Cost to export 20' container***	***High cost***, moderate availability. High cost international transport *$895*	***Low cost***, good availability, good logistics with low cost international transport *$335*	***Low cost***, very poor availability except for cell phones. High cost of international transport *$864*
Fixed and mobile phones per 1000 1995/2006	90/693	37/570	13/128
Computers/1000 1995/2006	17/105	2/41	1/16
Internet Users/1000 1995/2006	1/195	0/85	0/54
Bureaucratic transactions costs	***High***	***Medium***	***Very high***

*Lending rate minus deposit rate percentage points
** Taken from World Bank Cost of Doing Business 2007

Cost and availability and infrastructure China has more modern and efficient trade infrastructure than either Brazil or India. Brazilian infrastructure and transport services are more expensive than those of either country, but better than India's. The availability and cost of infrastructure services (except cellular telephone calls) are worse in India and

are a major source of competitive disadvantage. The ICT infrastructure has been built up very rapidly in China and India.

Bureaucracy and transaction costs All three countries have lots of government red tape. Although the requirements vary by specific function they are generally more onerous in India's in terms of number of clearances and time required, followed by Brazil and China.

In sum the most important elements of the broader economic and institutional regime-namely the cost of capital, and labor as well as the exchange rate, Brazil is at a competitive disadvantage with respect to China and India. Given the magnitude of the differences, it could be argued that this is a major handicap for Brazilian competitiveness and growth which would be hard to offset through traditional industrial policy. While Brazil is not as disadvantaged on the other elements of the broader economic and institutional regime, they also are not very favorable compared to conditions in China.

V. Acquiring Foreign Knowledge

Countries that are still behind the technological frontier in specific industries are likely to get higher increases in productivity and improvements in welfare from acquiring already-existing knowledge than by doing R&D to push back the technological frontier. Creating new knowledge is generally more difficult and risky and requires much more technological capability. The main means of tapping into global knowledge are trade, foreign direct investment, technology licensing, copying and reverse engineering, foreign education and training, and accessing foreign technical information in print, and now through the internet. On all these counts, China has been more aggressive and systematic than Brazil or India.

Trade China began opening up to the world much earlier than did India and has become much more integrated into the global economy. The share of imports and exports in China was 74% of GDP in 2006 compared with 38% in India and only 27% in Brazil (Table 4). China's high degree of trade integration was second only to Germany's among the world's large economies in 2005, and it will surpass Germany soon.[10] Purchases of foreign products and services are a key way to gain access to knowledge embodied in those goods and services.

By initially protecting its industries from imports, China developed basic technological capability. Then by opening up to foreign investment in special economic zones with near free trade status it was able to get access to world class technology and inputs. This worked very well and not only began to modernize China, but also provided needed foreign exchange and employment. The number of these special economic zones was

[10] In 2005 the share of merchandise and service trade in GDP was 63.6% and 7.1%, respectively for China, and 62.4% and 12.8% for Germany. Thus China was more integrated in merchandise trade but less in service trade. Because of the faster rate of growth on both types of trade China will soon overtake Germany in both the share of trade in GDP and in the absolute volume of trade by 2010.

expanded from the initial four to 19 and then to many more.[11] This program was very so successful in generating employment and foreign exchange that by the late 1990s China decided to significantly generalize this free trade status by joining the WTO. This involved committing to a major program of reduction of tariff and non-tariff barriers and opening up to foreign investment not only in the manufacturing, but also in financial and other service areas. [1]

Unlike China, which has significantly removed tariff and non-tariff barriers to trade as part of its joining the WTO, India is still one of the most closed economies in the world. In the 1950s India followed a very autarkic policy of self reliance, relying initially mostly on massive capital goods imports from the Soviet Union, as was also done by China. However unlike China, India maintained it strongly inward oriented nationalist policy through the 1980s. It was only after the trade liberalization of the early 1990s that India began to open up more to foreign technology imports. There were also very strong restrictions on direct foreign investment and on the licensing of foreign technology. During this period technology policy focused very much on self reliance.

Brazil has also had a relatively autarkic policy, but not as extreme as India's. Brazil has a period of rapid economic growth during the miracle years of 1965-1980 when it continued a period of rapid import substituting industrialization. Even in the mid 1990s after India's liberalization, Brazil still had lower tariff and non-tariff barriers than India or China (Table 3). However after China's joining the WTO, China has become more open. Furthermore, as already noted, Brazil is still the least integrated into global trade among the three countries in terms of imports and exports as a share of GDP. This has meant that its industry has been and continues to be relatively protected from global competition. This has meant less pressure to innovate with new products and processes and lower costs.

Foreign Direct Investment The inflows of foreign direct investment into China have been several multiples those into India and higher than those to Brazil (Table 3). This is the result of several factors. First, China opened up it regulatory regime towards foreign direct investment more than ten years earlier and more broadly than did India. Second, China's larger and richer market has been an important pull factor so it has surpassed even Brazil. Third, China has many cost advantages over India and Brazil, even though its labor costs are now generally higher than India's. Transportation is more efficient, service infrastructure is more developed, and the red tape for trade in physical products is less burdensome. As a result, China has been very attractive not just as a production platform for global markets, but also of producing for the Chinese market as it is the world's fastest growing market. This strong pull of producing in China has also permitted the government to encourage strong competition among foreign multinational firms to bring their very best technology when they locate in China, even though they are very aware of poor intellectual property protection and the risk that their technology will be pirated.

---

[11] For a good analysis of Chinas progressive entry into the global system see Barry Naughton (2007), Chapter 16: "International Trade," and Chapter 17: "Foreign Investment," pp. 375-424, in ***The Chinese Economy: Transitions and Growth.***

The most important contribution of FDI to China has not been capital since China has had a high savings and investment rate. More important has been access to advanced technology and management through FDI. Equally important is entry into global markets as the foreign investors integrate their Chinese operations into their global supply chains[12]. Moreover the latter does not even require owning production plants in China, but just sourcing from China. An excellent example of this is Wal-Mart which sources over $25 billion dollars from China directly into its retail stores without even using middlemen.

India only began to open to FDI in the 1990s and only slowly and selectively. As a result it got very small inflows. In the last five years India has liberalized FDI inflows and trade inflows but, as noted, both are still very small compared to China. Thus Indian industrial policy has protected domestic industry for too long and also did not take advantage of the technology it could get from abroad, or the economies of scale and scope of pushing its firms to operate global. Relatively little FDI has been attracted because of high transactions costs and poor infrastructure Exception has been in software and ITC related services which have not been constrained by regulatory regime or physical investment infrastructure.

In Brazil, a large percentage of total FDI came either for the protected domestic market or to exploit domestic natural resources or as part of privatization of state owned enterprises.. In addition, although the government put various export and local content requirements on FDI into manufacturing, it did not have as much leverage as China. The main reason is that it was not as attractive a location for exports or for the domestic market.

Technology licensing China has also been much more aggressive in licensing foreign knowledge through formal technology-licensing agreements than either Brazil or India Chinese royalty and fee payments are almost 13 times those of India in absolute terms, and more than 10 times even in per capita terms.

Diasporas It should also be noted that both China and India have benefited enormously by drawing on their respective Diasporas. Brazil has a very small Diaspora so it has not had this as a major way to gain access to global knowledge. China had done this more systematically and for longer than India. More than one half of the FDI in China has come from Taiwan, Hong Kong and Singapore. These are market economies which have had great experience operating in global market. They were already well plugged into global supply chains. They initially moved their more labor intensive operations into China. As China moved up the technology ladder they have been moving more technology intensive operations. This is particularly true for Taiwanese companies which are now putting some of their most advanced production facilities in China.

In addition, China has set up special high technology parks specifically targeted at attracting back experienced Overseas Chinese to set up high tech companies in China.

[12] Gil and Kharas (2007)

Table 4: Acquiring Global Knowledge

	Brazil	China	India
Trade as Share of GDP			
1990		35.4	16.5
2006	26.5	73.9	47.6
Merchandise exports % of GDP			
1990		17.5	5.7
2006	12.9	36.6	13.2
(Manufactured Exports % of merchandise exports)			
1990		72	70
2006	51	92	70
(High tech exports % of manufactured Exports in 2006)	12	30	5
Commercial Service Exports % of GDP			
1990		1.6	1.5
2006	1.7	3.5	8.2
(Comp. info, comm, & other business services as % of Service Exports)			
1990		18.7	42.7
2006	50.9	39.1	73.7
Tariff & Non Tariff Barriers* (2006)			
1995	56	20	0
2006	71	70	51
Average Tariffs (2006 in %)			
Average simple tariffs	12.1	8.9	16.8
Average weighted tariff	6.7	4.3	14.5
Foreign Direct Investment	Much FDI has come to produce for protected domestic market rather than for export.	One of main means of rapidly modernizing China.	Much less DFI overall India has only recently liberalized FDI regime
Average Gross FDI/GDP 1995-2004	***3.72***	***3.89***	***0.68***
Royalty and license fee payments ($ million 2006)	1404	5321	421
Royalty and license fee payments/million population (2006)	7.53	4.08	0.38

* Normalized such that 0 is very high protection and 100 is very low protection
Sources: WDI 2008, and World Bank KAM 2007

Several of the more than 100 high tech parks in China cater specifically to this Diaspora. India has done this much less. Furthermore, China has also made a more sustained effort to attract back Chinese professors and former foreign students to staff the rapid ramp up of its tertiary education sector. India has had much les success in doing this because it is more constrained by regulations that do not allow its universities to pay professors competitive salaries.

Copying and reverse engineering While there are no hard data on this, it is quite certain that China has been much abler on doing this than India or Brazil. Greater access to foreign knowledge through all the formal channels listed above, higher levels of human and technological capital, and a policy (now changing) of ignoring intellectual property rights laws have given China an advantage in copying and reverse-engineering foreign technology.

In China besides the large state owned firms, thousands of township and village enterprises were developed behind strong trade protection. Some of these, such as Haier, have gone on to become globally competitive companies. In China, the government also negotiated with the large multinationals that wanted access to the Chinese market. Initially they forced companies to go into joint ventures with domestic firms. They also negotiated local content and training requirements.[13] This greatly helped them develop technological and management capability. In the case of the auto industry the Government managed to force both Honda and Toyota to do joint ventures with the same Chinese manufacturer. This allowed the Chinese company to use the best of both system to develop its own brand and production. The Government was able to negotiate this because of the attractiveness of the domestic Chinese market to the foreign manufacturers. Once the cost advantage of producing in China became apparent to both the Government and to multinational companies, the government relaxed the joint venture requirement in order to encourage the foreign firm to bring its best technology.

VI. Domestic Innovation Effort

The creation of knowledge is the process of inventive activity. It is usually the result of explicit research and development effort normally carried out by scientists and engineers. The key institutions involved in the creation of knowledge are public R&D laboratories, universities and private R&D centers. However not all creation of knowledge is the result of formal R&D effort. Sometimes the invention comes from the experience of production or from informal trial and error. Sometimes it comes from serendipitous insight. This raises a measurement problem because not all R&D activity results in an invention, and not all inventions come from formal R&D activity.

Moreover, invention is just the process of discovery. If the discovery is basic knowledge, it is often published in a scientific and technical journal. If it is applicable, it may be kept as a trade secret. If it is novel enough, and its inventor is so inclined, it may

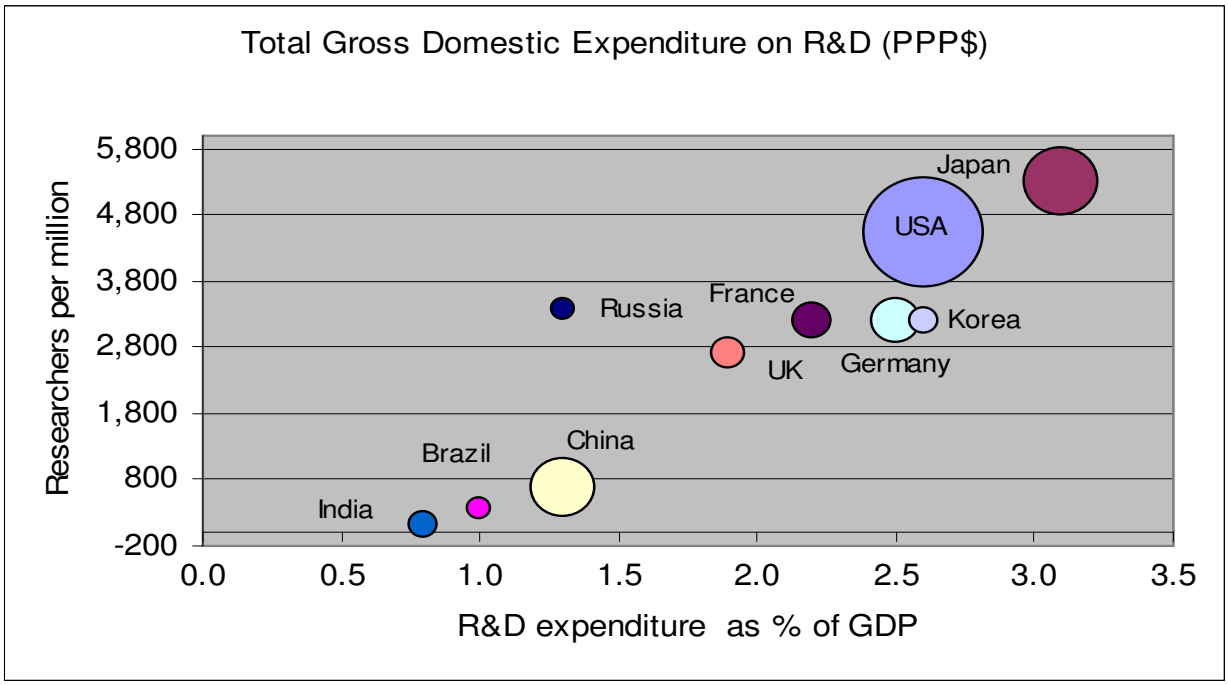
[13] Motorola, for example was forced to develop and extensive training program for the management of the 1000 largest Chinese State owned enterprises.(Dahlman, Zeng and Wang 2007)

patented. But even when it is patented it is not a contribution to productive activity. Normally further development and engineering work is required to use the discovery in some concrete application which involves more costs—often even larger than the original costs of the invention.

The main actor in the creation of basic knowledge is the government or university research lab. However the main actor in the creation of applied, commercialized knowledge or innovation is usually the productive enterprise. Moreover, the main actor in the creation and dissemination of applied knowledge is the multinational corporation. As noted above, more than half of all global R&D is done by transnational companies.[14] The R&D budgets of just one of these large multinationals are larger than the total R&D expenditures of all but the very largest developing countries. For example the expenditure of GM ($7.9billion in 1998) was larger than the total R&D spending of even the largest developing countries in that year.

This section will compare the innovative effort of the three countries in terms of two inputs (R&D and scientists and engineers) and two outputs (scientific and technical publications) as well as some measures of commercialization of technology and intellectual property rights.

Figure 1: Relative R&D Expenditure and Scientists and Engineers (2004 PPP)



Author's calculation based on WDI 2006

[14] UNCTAD, ***World Investment Report 2005.***

Figure 1 puts the R&D expenditures and the relative intensity of scientists and engineers in R&D in perspective for the largest spenders. As can be noted, only China, India and Brazil are in this league. The data are dated as they are for 2004 and both China and India have considerably increased their R&D spending since the. By the end of 2006 China surpassed Japan in actual PPP dollar of spending to become the second largest spender in the world. This is the result of an explicit strategy by the Chinese government to go beyond acquiring global knowledge through copying, reverse engineering, FDI and technology licensing; to actually invest in innovation on its own account. In 2006 the Government announced a 15 year plan to increase expenditures on R&D to 2.0% by 2010 and to 2.5% (the average level of developed countries) by 2025. By 2006 it has already increased it to 1.6% of GDP. In addition, as part of the global out sourcing trend, many MNCs are increasing their R&D work in developing countries, particularly China and India. By 2006 there were more than 750 MNC R&D labs in China and over 250 in India.[15]

In India the additional R&D investment by the MNCs as well as increased investments by the domestic private sector, particularly in pharmaceuticals, ICT, electronics and auto-parts have raised Indian R&D expenditure from a 20 year average of .88% of GDP to 1.1% in 2005.[16]

However, the efficiency of domestic R&D spending in both countries (China in particular) is still very low (Table 5). Moreover other developing countries except to some extent Russia and Brazil have the scale for critical mass of R&D. Most developing countries will get more immediate returns by putting more effort into acquiring and making effective use of knowledge that already exists. Even these big developing countries can still get a lot more mileage from more proactive efforts to acquire and use global knowledge. However they and other developing countries do need to do more on developing their own R&D, but to do it more efficiently.

Countries or firms that are near the global frontier need to put a lot of effort into developing new knowledge in order to remain competitive as other countries or companies catch-up. Countries therefore have to place a premium on strengthening the whole institutional infrastructure to develop new knowledge. For these countries, this means placing emphasis on public and private research centers, university research and training of scientists and engineers. For companies, it means scanning the world for relevant technical knowledge, developing strategic alliances with other firms who can contribute relevant knowledge, and interacting closely with government and university laboratories to get access to relevant basic knowledge, and undertaking the effort to create new knowledge.

Once created, knowledge has to be commercialized, particularly if it has been created in government research labs or universities as opposed to firms that can directly apply the technology. This requires an appropriate technological commercialization infrastructure.

[15] The R&D spending data in Figure1 and this paragraph are still based on the old ppp series. They will be adjusted for the final version of the paper.

[16] For more detailed information on R&D spending and innovation in India see Dutz (2007).

Table 5: R&D Inputs and Output

Indicator	Brazil	China	India
Researchers in R&D, 2006	84,971	926,252	117,528
R&D researchers per million population**,**			
1995		445	157
2005	462	714	119
Spending on R&D (US$ billions)			
US $ billion nominal 2006	9.7	35.4	5.6
US $ billion in PPP 2006	15.0	82.0	16.6
Spending on R&D (percentage of GDP)			
1995		0.85	0.8
2006	0.91	1.34	0.61
Scientific and technical journal articles,			
1995			
2005	9,889	41,596	14,608
Scientific and technical journal articles per million population, 2003			
1995		7.69	10.29
2005	52.3	31.9	13.4
Patents granted by U.S. Patent Office, (average 2002-2006)	135	448	316
Patent applications granted by U.S. Patent Office per million population			
1991-1995 average		0.05	0.04
2002-2006 average	0.75	0.35	0.30

Source: Compiled from data in KAM 2006 and World Development Indicators 2007

R&D	Has been near 1% of GDP, slightly higher at ***1.1%*** recently, but still ***predominantly government led***	Has expanded rapidly in last 5 years from 0.85% of GDP to ***1.6%*** in 2006. ***More than 65% by productive sector*** since 2003	Had traditionally been at 0.85% of GDP, but increased to ***1.1%*** in last two years with significant increase in private so now ***50/50 govt/private***
Science parks and Business Incubators	***Few*** science parks, few business incubators Few spin-offs as commercial firms	***Many*** and rapidly expanding science parks and business incubators with many spin-offs to productive high tech enterprises	***Few*** science parks and few business incubators, Few spin-off as commercial firms
Intellectual Property Rights	***Historically stronger*** than in either China or	***Very weak until required to update as part of WTO***	***Weak until completed compliance with***

	India, ***but now lags*** updated regimes in those two countries Enforcement is weak, but not as serious a problem as in other two countries	***accession***. Enforcement is very weak and is likely to become a very controversial issue in future relations with advanced countries	***WTO requirements in 2005*** Enforcement is weak, though not considered as much of a problem as in China

that includes: adequate IPR protection, technology transfer offices at universities and research institutes, science-industrial parks, business incubators, early stage technology finance, and venture capital. The bottom panel of Table 5 provides some comparative information on these elements across the three countries

Disseminating knowledge The dissemination of knowledge takes place by the expansion of the enterprises that have developed the knowledge, their sale or transfer of that knowledge, as well as by various forms of imitation or replication by other firms or organizations. For the dissemination of knowledge it is important to have appropriate mechanisms to educate potential users in the benefits of the technology. This often involves more than just providing technical information. In agriculture for example it involves showing the potential users the actual performance of the new technology in their domestic conditions. In manufacturing, much dissemination occurs not just by the expansion of the innovating firm but by the sale of the new machinery or other inputs, that embody the new technology. There also are explicit training, demonstration projects, or technical assistance on how to use the technology. In services, the technology is disseminated through direct interaction with the user of the service. However the new service may require new equipment, procedures, or inputs, and training is also usually required to disseminate a new service.

To appreciate the gains that can be obtained from dissemination and effective use of existing knowledge it is useful to examine some country empirical data. A recent study on Brazil that the differences in value added per worker difference is between the most- and least-efficient firms was as much 300,000 times in the machinery and equipment sector. The average for all nine sectors studied was an amazing 57,000 times. To obtain a conservative measure less influenced by outliers, the maximum was adjusted by "eyeballing" the distributions of dispersion and taking as the maximum the value when the distribution began to have some density. That adjusted maximum averaged 53 percent of the distance to the recorded maximum. Even with these conservative adjustments, it appears that *if* average productivity could be raised to the adjusted maximum level, average productivity would increase by a factor of 10![17]

Using a similar methodology, the average level of productivity was estimated to rise by a factor of five in India. It is surprising that the productivity dispersions are, on average,

[17] While this is a thought-provoking exercise to analyze the dispersion in productivity within sectors, it must be noted that in some cases the variance in productivity levels may be caused by other factors such as economies of scale and intensive use of capital.

twice as large in Brazil as in India, considering that dispersions in the latter already exceed those in most of the countries to which it has been compared.[18]

This analysis suggests just how much national output could be raised—at least in principle—if all Brazilian or Indian firms were to adopt existing technology that other firms already are using. Obviously, moving to these higher-productivity technologies is not costless. The firms that use them now are likely to be much larger; they are using other modern equipment; they generally employ more up-to-date management practices; they use better inputs; and they have better educated and more-skilled workers. Yet the larger point is that these production technologies are being used by at least by some firms, while typical firms that do not are operating far behind their more efficient counterparts. Far more must and can be done to disseminate and effectively employ existing knowledge across the board.

VII. Education t[19]

People need education and new skills to use new technologies. To produce new knowledge, they need more specialized tertiary education. More educated people tend to adopt new technologies faster. Despite very rapid increases in the supply of higher education in most countries of the world, the gap has not narrowed between the earnings of college graduates relative to that of persons who only finish secondary school. Why? Because higher order skills are necessary to make effective use of new technologies. Empirical studies show that more education leads to higher productivity and higher growth. They also show that they lead to higher earnings for individuals.[20]

Higher productivity Better educated workers are generally more productive and may also raise the productivity of coworkers. Higher stocks of human capital facilitate investments in physical capital and enhance the development and diffusion of new technologies and raise output per worker (OECD 2005b**).** Studies tracing the relationship between the stock of education and the long-run level of GDP find that a one-year increase in average educational attainment raises the level of output per capita between 3 and 6 percentage points. Studies examining the relationship between the stock of education and the rate of growth of GDP find that an increase of one year of education raises the growth rate of GDP by around one percentage point.[21] The cumulative impact of a one percentage point

[18] See Dutz et al (2007) .

[19] This section draws on work by the author for Dahlman, Zeng and Wang (2007)

[20] 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 2005b).

[21] However research suggests that there are diminishing effects on growth above an average or 7.5 years of education. See Krueger and Lindale (2001).

increase in the rate of growth soon exceeds the one time increase in output.[22], [23] Rising labor productivity accounted for at least half of GDP per capita growth in OECD countries from 1990 to 2000 (OECD 2005b

This section will compare the education across the three countries first comparing basic educational attainment. It will then secondary and higher education enrollment rates and make some concluding comments on life long learning.

Basic education As a very poor developing country even just 25 years ago, China had very low levels of education. However it has made massive investments in basic education and now has the highest literacy rate as well as highest average educational levels among the three countries... India still has very low literacy rates. Illiteracy is 52% among women and 27% among men. Its basic education system is still very poor with tens of millions of primary school children out of school. Brazil was ahead of both countries, although even 10 years ago it had very low secondary enrollment rates for a country of its per capita income. However Brazil ramped up secondary education, but it still has a [24]lower literacy rate than China.

Tertiary education. China has undertaken a massive expansion of its tertiary education system starting in the late 1990s to make up for the havoc reeked on the educational system after the Cultural Revolution (1965 to 1975). By 2005 its enrollment rate reached 19% and because of is large population it had more students at the tertiary level than the US and 40% were in engineering and sciences. India started set up seven Indian Institutes of Technology starting in the 1950s and latter several Indian Institutes of Management, which produced a critical mass of well educated English speaking professionals who have been instrumental in India's emergence in software and ICT

[22] The first studies are based on neoclassical growth theory, the second on the new growth theory. See OECD (2005b) and Woman (2003).

[23] There are also conceptual and data difficulties. The key conceptual issue is whether more education increases growth or whether growth causes persons to invest more in education. In practice causality operates in both directions. The data difficulties arise from the use of imperfect proxies for human capital such as year of education, adult literacy rates, school enrollment ratios, which do not fully capture the quality of education or the skills and competencies acquired by on-the-job training, experience, and other informal channels, as well as the atrophy of skills caused by disuse. Some recent work has used the results of OECD's Adult Literacy Survey as the measure of education and skills. It indicates that literacy scores perform better in growth regressions than indicators of schooling. A country able to attain scores 1 percent higher than the international average achieves labor productivity 2.5 percent higher and GDP per capita 1.5 percent higher than the average (Coulomb and others 2004).

[24] Careful studies on OECD countries have differentiated between private, fiscal, and social rates of return. There is great variation across countries in the extent to which education is public or private, and in the marginal tax rates (the Nordic countries tend to provide more free public education, but they also generally have higher marginal tax rates). The private and social rates of return are generally higher than the risk-free real interest rate, indicating that investments in education are worthwhile. But returns on human capital accumulation are not risk free, as indicated by the wide dispersion of earnings among the better educated. So, some individuals contemplating investments in education may need a compensating risk premium, which may require policy intervention to alleviate the constraints (OECD 2005b).

Table 6: Education in Brazil, China and India

	Brazil	China	India
Literacy rate, population 15 & above			
1995	83.2	80.8	53.3
2006	88.6	90.9	61.0
Av. Ed. Attainment of Adult Pop. (2000)	4.88	6.35	5.06
Basic education	Basically ***universal but poor quality***	***Universa***l but spotty quality	***Incomplete and poor quality***
Secondary Education Enrollment Ratio (%)			
1980	34	46	30
2006	106	76	54
Higher education **Enrollment ratio (%)**	***Was leader,*** but is falling behind	***Very rapid ramp up***	***Initially high*** through Indian Institutes of Technology, relatively little expansion and high variance and much low quality
1980	11	2	5
2006	24	22	11
Skilled labor	***Relatively underdeveloped***	***Well developed*** training market inside and outside firms	***Very under developed*** Very poorly developed training market

Source WDI various years.

enabled services. Although India has expanded tertiary enrollment rates, it has not done so as fast as China and now is considerably behind. Also, the quality of higher education is poor with the exception of those mentioned above (which produce less than 7,000 graduates a year), the Indian Institutes of Science ands some of the regional engineering colleges. The low quality of tertiary education and the regulatory constraints on expanding high quality institutions will be a major bottleneck to India's continued rapid growth in knowledge intensive services. Brazil was considerably ahead of both China and India in tertiary education. Its system has expanded the least, but it is still slightly ahead of China in tertiary enrollment rates (although tertiary enrollment rates reached 22% in China in 2006)

VIII. Conclusions

Lessons

The ***first*** lesson is the importance of effectively tapping into global knowledge. China has done this extremely well through all modes. India has not made much use of any of the channels except the Diaspora and more recently FDI. Brazil, like India has not made as much use of trade. Unlike India, though, it did attract high levels of FDI.

The ***second*** lesson then is that it is not just a matter of getting lots of FDI. It is important to use it effectively. China was able to do this because it was an attractive location for FDI. Initially the attractiveness was its low cost labor for export oriented FDI. Subsequently it was the lure of the very large and rapidly growing domestic market. Both these gave the government strong negotiating power with respect to FDI.

The ***third*** lesson is the importance of competition. One of the reasons Brazil did not get as much from FDI as China was that most FDI to Brazil in manufacturing came to exploit a protected domestic market. In China it came initially as a low cost production base for export markets. Subsequently, when China allowed FDI for the domestic market there was some similar attractiveness of producing for a protected domestic market, but that quickly disappeared when China committed to reducing tariff and non-tariff barriers as part of its commitments to joining the WTO. Therefore foreign companies had to bring in their best technologies because they were competing with the best foreign firms for export as well as domestic markets.

The ***fourth*** lesson is the importance of education. High levels of literacy were part of the attractiveness of the low labor costs of China. The creation of critical mass of highly educated engineers and MBAs was critical for the successful development on India's software and ICT enabled services. Investments in high level human capital have been critical for Brazil's islands of excellent in airplanes, deep oil exploration, and agricultural research.

The ***fifth*** lesson is the importance of copying and reverse engineering. This has meant low enforcement of IPRs. As noted this has been a key element of China's rapid catch-up. In India the explicit lack of protection of process patents was a key to the development of a strong indigenous pharmaceutical industry. Domestic firms were able copy foreign products and to produce them with slightly different processes. This had the double benefit of producing pharmaceuticals at low prices to improve the welfare of Indian citizens as well as developing a strong domestic pharmaceutical industry. By the time India extended process patents to pharmaceuticals in 2005, it has developed a strong domestic industry that could compete with foreign firms. Brazil has not made as much use of copying and reverse engineering. To some extent it has been more respectful of IPRs.

The ***sixth*** lesson is the importance of the Diaspora. The Diaspora has been critical for China's very rapid development. The first export processing zones were set up opposite Hong Kong and Taiwan as most of the foreign investment came from those two

economies. The market knowledge and entrepreneurship from the Overseas Chinese communities beyond Hong Kong and Taiwan has been very important. Many of the special high technology industrial parks located in China were set up explicitly to attract back overseas Chinese. Indian success in the ICT enabled export services industry has also been due to a large extent on the linkages to its Diaspora in the high tech area of the US and Europe. Initially India did not make much use of its Diaspora. It was joked that NRI (non-resident Indians) were not required Indians. However India eventually learned the importance of harnessing its Diaspora and since then has make special efforts to attract it back by giving special tax breaks and other fringe benefits. Brazil does not have much of a high technology Diaspora. Also it has not made any significant efforts to attract back its Diaspora.

The ***seventh*** is the importance of macro conditions. China had has relatively stable macro conditions, including low inflation, low interest rates, and a stable exchange rates. This had made for a predictable business environment which both domestic and foreign investors like. India has also had relative stable macro conditions since 1980 except for the financial crisis at the end of the 1980s that culminated in the financial crisis of 1991. Brazil on the other hand had a very unstable macro situation between 1980 and the early 2000s when it finally managed to attain macro stability.

The ***eighth*** is high investment rates. China has grown faster than the other two countries because it has had a more or less twice the investment rate. While it is true that a lot of this investment has been inefficient, it is also true that high rates of investment allow the embodiment of new technology. In the case of China nearly 90% [check] of its imports (which are – of GDP) are components and capital goods.

The ***ninth*** is the importance of strong diffusion efforts. These have been quite systematic in China. They have included not only extension work in agriculture, but also special programs such as Spark for rural innovations and Torch for high tech innovation. In India and Brazil they have been mostly in agriculture—the green revolution in India and the extensive research and dissemination efforts through Embrapa in Brazil. Although both Brazil and India have set up dissemination efforts in manufacturing and services, these have not been as systematic or successful as those in China. It is also likely the more competitive environment in China has lead to more rapid diffusion through imitation as well as by the rapid expansion of the more innovative firms.

Implications for Strategies of Developing Countries

A key priority for all developing countries is to acquire and use knowledge that already exists. This is less costly and less risky than creating new knowledge. While some of this knowledge is protected by intellectual property rights and therefore would have to be purchased, a tremendous amount is in the public domain. Therefore policies of opening to global knowledge are critical. This includes trade, foreign direct investment, technology licensing as well as copying and reverse engineering. In addition there is great scope for acquiring foreign knowledge through foreign education, travel, participation in foreign

trade shows internet access to information and database, attracting back the Diaspora, setting up R&D antennae abroad, buying foreign companies to get access to their technology, brand name or market.

How well countries use this form of innovation will depend not only on the policies, but also on the support institutions of the country as well as the capability of the institutions and the people in them. Therefore much more attention needs to be put on how to scan for global knowledge that is relevant. This means explicit effort to develop capabilities of how to assess it, how to acquire it, and how to adapt it to local conditions. Most developing countries have not put too much effort into this so there is great scope for improving in this area.

Also as noted the multinational corporation is the principal creator and disseminator of knowledge. In addition they control most of the global supply and distribution chains. Therefore developing countries need to put much more effort not only to attract foreign investment, but very importantly how to leverage what they can get out of it. This is not just production, employment and exports, but access to technology, development of backward linkages, standards, worker and management training, and access to global markets. This is not easy to do as foreign investment does not even go to many countries. Therefore it requires careful thinking of how to improve conditions that may be foreclosing the possibility of enticing foreign investment to come (poor investment climate, corruption, poor infrastructure, poor skill base, etc). It also requires proactive strategies to move realize the externalities that foreign investment can bring.

The second key priority for all developing countries is to disseminate and make effective use of knowledge that already exists in the country, whether is has been brought from abroad or developed locally. As noted, within any country there is a tremendous dispersion of productivity within-in any sectors. Therefore there are great returns to being able to raise average productivity to local best practice (even better to global best practice by acquiring more knowledge from abroad). This requires stronger public policies focusing on dissemination and use. This includes standards and quality control legislation. It also requires an institutional infrastructure consisting of technical information services; extension services for agriculture, industry and services; productivity organizations; metrology standards and quality control institutions; and industrial clusters. In terms of capabilities, people need to have not just basic literacy but numeracy and many job and technology specific skills to be able to use the new technologies and production organizational techniques. Some of these need to be provided through an improved basic education curriculum. Others have to be provided through specialized training at vocational centers or even technology suppliers, or as part of firm specific training.

Again, this is an area with tremendous potential, but most developing countries have not developed the policies, institutions or capability to exploit it. Therefore it merits much more effort. Developing countries have a big challenge on the creation and commercialization of knowledge given that new knowledge has become so important for competitiveness. This is most relevant for larger countries, even if they are low income

such as India, because of the critical mass it has from its large size. But even smaller poor countries have to have some capability to create knowledge. At the very minimum they need some R&D capability to assess relevant global knowledge, to help negotiate and acquire it, and to help adapt it to local conditions.

Some of the critical policy issues here are how limited public resources are allocated and how effectively they are used. Unfortunately in most developing countries these very limited resources are not allocated or used very well. Therefore with-in this area a priority is to improve the allocation of public resources. This includes better definition of what areas the government should support as this is very critical when budgets are small. A second priority is how effectively these resources are managed and what their contribution to the economy is. It is difficult to justify very pure academic research in countries with pressing social and economic needs where more applied R&D can make an important contribution.

Going beyond R&D done by the public sector another key issue is how to get the private sector to do more R&D. The private sector needs to be encouraged to undertake more R&D, not only to be able to keep up to date with new developments and incorporate them, but to also carry out cutting edge research in areas critical for their competitiveness Because of the problems of market failure in the appropriability of the returns to private R&D this calls for design public support programs such as matching grants, and tax subsidies to stimulate R&D by the private sector.

.Furthermore while in the first instance it makes sense to invest in the areas where developing countries already have comparative advantage in order to not just maintain, but also to enhance that advantage, it is also important for developing countries to invest in new technological areas such as genetic engineering, bio technology, nano-technology. The public sector will have to play a greater role in carrying out this type of riskier and more uncertain research. It should be seen as part of an investment portfolio strategy of exploring new areas with potential high returns. These investments are necessary to have the capability to move in rapidly to into those areas that begin to show promising results.

Therefore it is necessary not just to put in place the appropriate policies but also the supporting institutions, public and private to create new knowledge as well as to support the acquisition and dissemination of knowledge. In addition a key problem in most developing countries is that even when relevant knowledge is created in public labs or universities, it is not commercialized. Therefore it is also necessary to put in place he supportive infrastructure of technology parks, business incubators, technology transfer centers, and venture capital to commercialize knowledge as much as is happening in East Asia, particularly in Korea, Taiwan, and China. Also it is necessary to make sure that the country also develops the necessary human resources to do and manage R&D and to commercialize relevant knowledge (techno-entrepreneurs).

Obviously how much a country should invest in all this R&D and commercialization infrastructure will depend on its resources and its size. The richer and more developed in terms of institutions and human capital, the more it can do. And as mentioned even some

poor countries in terms of average per capita income, such as India, or slightly higher such as China, do have the critical mass of resources, institutions and people to do a lot on the creation and commercialization of knowledge. Therefore improving the allocation and efficiency of resources used for this is also very important. However, even these R&D giants will still benefit tremendously from continuing to improve on the acquisition, dissemination and effective use of existing knowledge.

Bibliography

Baldwin, Richard. "Globalization: the Great Unbundling(s)" (2006), paper contributed to event on *Globalization Challenges to Europe and Finland* organized by the Secretariat of the Economic Council, Prime Minister's Office (June).

Bergstern, C. Fred; Bates Gil, Nicholas R. Lardy, and Dereck Mitchell (2006). ***China The Balance Sheet: What the World Needs to Know now about the Emerging Superpower***. Washington, DC: Center for Strategic and International Studies and Institute for International Economics.

Business Week (2005). Special Issue on China and India (March).

Chang, Ha- Joon (2003). ***Kicking Away the Ladder.***

Dahlman, Carl; Douglas Zhihua Zeng, and Shuilin Wang (2007). ***Enhancing China's Competitiveness through Life Long Learning***. Washington DC: World Bank

Dahlman, Carl (2007). "Innovation Capacity in China and India". ***Issues in Science and Technology.*** (Journal of US National Academies of Science-April).

Dahlman, Carl (2006). "Technology, Globalization, and Competitiveness: Challenges for Developing Countries". ***Industrialization in the 21rst Century***. New York, UN.

Dahlman, Carl; and Anuja Utz (2005). ***India and the Knowledge Economy: Leveraging Strengths and Opportunities.*** Washington DC: World Bank.

Dahlman, Carl; and Jean-Eric Aubert (2001). ***China and the Knowledge Economy: Seizing the 21rst Century.*** Washington DC: World Bank.

Desai, Meghnad (2005). "India and China: An Essay in Comparative Political Economy". In Wanda Tseng and David Cowen, Eds. ***India's and China's Recent Experience with Reform and Growth***. New York: Palgrave MacMillan.

Dutz, Mark, Editor (2008). ***Unleashing India's Innovation Potential.*** Washington DC: World Bank.

Fu, Xiaolan. "Foreign Direct Investment, Absorptive Capacity and Regional Innovation Capabilities: Evidence from China". Geneva: UNCTAD paper prepared for "Meeting of experts on FDI, Technology and Competitiveness: a conference convened to honor Anaya Lall".

Gill, Indermit; and Homi Kharas (2007). ***An East Asian Renaissance: Ideas for Economic Growth***. Washington DC: World Bank.

Gordon, Robert; and Poonan Gupta (2006). "Understanding India's Services Revolution," pp. 229-263, in Wanda Tseng and David Cowen, eds. ***India's and China's Recent Experience with Reform and Growth***. New York: Palgrave and International Monetary Fund.

Kaplinsky, Raphael (2005). ***Globalization, Poverty and Inequality: Between a Rock and a Hard Place***. Cambridge: Polity Press.

Lall, Sanjaya (2004). "Industrial Success and Failure in a Globalizing World". ***International Journal of Technology Management and Sustainable Development***, Vol. 3, No. 3, pp. 189-213.

Lall, Sanjaya (2003). "Reinventing Industrial Strategy: The Role of Government Policy in Building Industrial Competitiveness". Oxford: Queen Elizabeth House. Working Paper No. 111 (October).

Lall, Sanjaya; and John Weiss (2003). "China's Competitive Threat to Latin America: An Analysis for 1990-2002". Oxford: Queen Elizabeth House. Working Paper No. 120.

Maddison, Angus (2006). ***The World Economy: Volume 1.*** Paris: OECD Development Centre.

OECD (2006). ***Education at a Glance 2007.*** Paris: OECD.

Panagariya, Arvind (2005. "India in the 1980s and 1990s: A Triumph of Reforms", in Wanda Tseng, and David Cohen, eds. ***India's and China's Recent Experience with Reform and Growth***. New York: Palgrave MacMillan.

Rodrick, Dani (2003). ***In Search of Prosperity: Analytic Narratives of Economic Growth*****,** Princeton: Princeton University Press.

Rodriguez, Alberto; Carl J. Dahlman and Jamil Salmi (2008). ***Brazil: Knowledge and Innovation for Competitiveness***. Washington DC: World Bank.

Singh, Ajit (2007). "Globalization, Industrial Revolutions in India and China and Labour Markets in Advanced Countries: Implications for National and International

Economic Policy". Geneva: UNCTAD paper prepared for "Meeting of experts on FDI, Technology and Competitiveness: a conference convened to honor Sanjaya Lall".

Singh, Nirvikar (2007). "Services-led Industrialization in India: Assessment and Lessons," pp. 235-291, in David O'Connor, ed. ***Industrial Development for the 21rst Century: Sustainable Development Perspectives.*** New York: United Nations.

UNCTAD (2006) ***World Investment Report.*** Geneva: UNCTAD.

World Bank (2008). ***World Development Report 2008***. Washington DC: World Bank.

World Bank (2008), Knowledge Assessment Methodology 2008, see www.worldbank.org/kam.

World Bank (2007). ***Cost of Doing Business***. Washington DC: World Bank