INDIA AND THE BRICS COUNTRIES: ISSUES OF

TRADE AND TECHNOLOGY

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POLICY BRIEF

A detailed product wide study of intra BRICS trade in the period 1995-2007 suggests the following broad policy guidelines:

- The observed growth in intra BRICS trade is largely illusory and based on exports of low technology natural resources.
- The observed growth in intra BRICS trade is asymmetrical as it is driven largely by Chinese demand for inputs which is not sustainable.
- However, particularly for India, Brazil, South Africa and Russia there is a reasonable possibility of coordinating exports to third countries in the areas of Vegetable Oils, Chemical Products, Plastics and Iron and Steel. There is no competition between these countries in exports of these products to third markets.
- FDI today is the best method of diffusing technology globally. Hence, to promote high technology trade it is essential to link trade and FDI. It is not then surprising that current FDI patterns of the BRICS countries have no relation to the trade pattern.
- It is necessary to evolve methods of technological partnership between India, Brazil, South Africa via tie ups of small manufacturing enterprises (SMEs) which dominate trade of these countries. This requires development of National Innovation systems (NISs) involving firms, the government and universities. The Brazilian and Chinese systems are possible models.
- To allow and promote technological exchange, it is necessary to develop technology nodes in India, Brazil, South Africa and Russia in the areas of Vegetable Oils, Chemical Products, Plastics and Iron and Steel. Depending on a country's own competitive strength, the distribution of the products to the nodes can be determined.
- It is essential for the four countries of India, Brazil, South Africa and Russia to coordinate to balance the excessive economic dominance of China. Only this can make the BRICS bloc an effective economic bloc.
- Political strength of the BRICS bloc can only sustain if this economic strength is first ensured.

EXECUTIVE SUMMARY

In the last two decades there has been a phenomenal growth in intra BRICS trade. In this study we have looked at three issues. One, to what extent is growth of intra BRICS trade sustainable? Second, what is the substitutability and complimentarity in product trade and, third, what are the main issues in technological collaboration between BRICS countries.

On the issue of sustainability, our study shows that this intra BRICS trade took place even while demand growth was still quite high in the developed world indicating that, unlike the 1970s, the trade in the 1990s was not driven by adverse demand conditions in the developed world. However, our study also shows that this intra BRICS trade was accompanied by increasing asymmetry of intra bloc trade due to the over powering presence of China. This is not sustainable in the long run. This issue of sustainability involves some further consideration of the nature of intra BRICS trade particularly in terms of the technology content. To see this we classified intra BRICS trade by its technology content using the UNIDO definition. We see that in medium technology exports, the only quantitatively important products are **propylene polymers** (India) and **nitrogenous fertilizers.** Quantitatively the importance of growing intra BRICS trade in technology intensive products is insignificant and the overall trade seems to be driven mainly by trade in natural resource. For sustainability this must change.

Second, we have used the revealed comparative advantage (RCA) as a measure of complimentarity/substitubability between exports of BRICS members in third markets. We note that where countries compete in similar products in the same third country market, technological cooperation may be difficult. It turns out that there is little substitutability and hence competition between these countries as they are by and large exporting to different markets. The broad industries where technological cooperation is feasible are **Vegetable Oils** (for Brazil, China and Russia), **Chemical Products** (for Brazil, India, Russia and SA), **Plastics** (for Brazil, China) and **Iron and Steel** (for all BRICS countries).

The third issue we have looked at relates to technological cooperation between the

BRICS countries. One major vehicle of technology transfer and trade today is foreign direct investment (FDI). Analysis of FDI patterns indicates that **with the exception of China and Brazil, the pattern of FDI from BRICS countries has not been conducive to promoting intra bloc trade.** FDI patterns have largely promoted the traditional trade pattern. Here the Chinese strategy is worth noting. *China tends to push infrastructure development in far off countries via loans which are then linked to preferential treatment to Chinese companies in specific sectors.*

One of the factors often ignored in looking at BRICS trade is the **dominance of small scale establishments (SSIs) in exportss.** Here, the role of the government in promoting global value chains is crucial given the low resource base of these firms. Finally, the role of the government in promoting technological development via **university-industry partnership is crucial** particularly in making new technologies available to the SSIs. Here, only Brazil and China have any developed systems. The **other countries need to develop such National Innovation Systems.** There is also **no institutional mechanism for intra BRICS coordination in technological partnerships.** Some such mechanism must be developed.

Technological cooperation seems particularly important for the four countries India, South Africa, Brazil, and Russia. In this one possible method is to develop technology nodes in these four countries with specialization in specific areas of cooperative advantage of these countries.

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I. Introduction.

The shifts in the pattern of world trade since about 1995 have been momentous. This was particularly true in the decade or so after the WTO agreement of 1995. This has now been extensively documented (see, UNCTAD, 2009). Some of these shifts need specific mention.

Define the South (S) countries as all countries excluding NAFTA countries, the EU27, the UK, Russia, Australia, New Zealand and Japan. The most momentous change then has been the revival of South-South trade (SS trade). It accounted for 32 percent of world trade in 2005. Even more important, about 50 percent of exports of countries of the South have gone to other South countries. In addition, this trade has grown faster than world trade in both value and volume terms. Third, this SS trade growth has been radically different from a similar expansion in the 1970s when SS trade went up to about 25 percent of world trade. At that time, SS trade expansion was mainly due to a rise in the price of oil which led to a major transfer of purchasing power from developed countries to countries of the South. However, the expansion of this SS trade lasted for a short time and was back at 20 percent of world trade by the mid 1980s. On the other hand, the recent expansion of SS trade has taken place in a period when there were no major exogenous changes in the world trading environment. In fact, the only major exogenous factor, the East Asian crisis of the late 1990s should actually have limited this SS trade. During this period in fact developed countries were enjoying a period of relative boom and it cannot be argued that any SS trade expansion in this period can be attributed to a demand crisis in the N countries. Hence, it is worthwhile to see if this expansion in SS trade will go the same way as in the 1970s. In other words, is the dramatic change in SS trade in recent years sustainable?

The other feature of this SS trade since about 1995 was the emergence of Asia as the major growth pole among the S countries. In 2005, the Asian region accounted for about 85 percent of total exports of the S countries. Second, there seemed to have been some development of regional specialization with the Americas dominating in agricultural goods (Brazil, Argentina etc), Africa in natural resources and Asia in manufactures. It is interesting to note that exports of textiles, clothing and agricultural

goods in this SS trade declined by about 50 percent since 1995. Obviously, these exports then were destined for the developed N countries. In other words, in traditionally labour intensive goods like textiles, clothing and agriculture, trade between N and S countries increased after 1995.

Table 1: Intra and Extra-BRICS Exports (US $ Millions), 1995-2007

Economy	Flow	1995	2000	2007	Annual Growth rate in % (1995-2000)	Annual Growth rate in % (2001-2007)
Brazil	Export to World	46504.9	55118.9	160648.9	4.3	19.5
	Export to BRICS	2353.4	2027.9	17205.8	-3.7	42.8
	Share in BRICS	5.1	3.7	10.7		
China	Export to World	148779.5	249202.6	1220059.7	13.8	30.3
	Export to BRIS	3800.3	6031.3	71424.7	12.2	51.0
	Share in BRICS	2.6	2.4	5.9		
India	Export to World	31698.6	42358.1	145898.1	7.5	22.9
	Export to BRICS	1784.6	2090.6	14445.5	4.0	38.0
	Share in BRICS	5.6	4.9	9.9		
Russia	Export to World	78217.3	103092.7	352266.4	7.1	22.9
	Export to BRICS	4026.8*	6433.3	22934.5	12.4	23.6
	Share in BRICS	5.2	6.2	6.5		
South Africa	Export to World	24514.9	26298.0	64026.6	1.8	16.0
	Export to BRICS	805.1	939.2	6189.8	3.9	36.9
	Share in BRICS	3.3	3.6	9.7		

Source: UNCTAD stat data base.
Note: * 1995 export figure from Russia to South Africa is not available.

Third, this period also coincided with an increase in foreign direct investment (FDI) to and from the South. To take one example, in 2006 the countries of S accounted for almost 30 percent of global inflows of FDI and about 16 percent of outflows. This statistic is particularly important as we know that trade, technology and FDI are closely related. In the literature, trade and FDI are either complements or substitutes in the sense that FDI can either replace exports with domestic production or actually enhance them (see, Krugman, 1984).

Finally, this was also the period when trade among the BRICS countries expanded

sharply. Between 1995 and 2007 the share of intra-BRICS trade to global trade of BRICS countries increased from 6.5 percent to 13.9 percent. Nor was this phenomenon of increased intra-BRICS trade confined to a few of the members. The individual country export shares are shown in Table 1 above.

As can be seen from Table 1, between 1995 and 2007, share of intra BRICS exports of each of the member countries in its world exports has increased by 2 to 5 times, the sharpest increase being for Brazil and South Africa. It can also be seen from Table 1 that the growth rate of each countries' exports have been in double digits particularly in the period 2001-2007. Nor is this restricted to exports as a similar picture is seen in Table 2 where import shares and growth rates are given.

Table 2: Intra and Extra-BRICS Imports (US $ Millions), 1995-2007

Economy	Flow	1995	2000	2007	Annual Growth rate in % (1995-2000)	Annual Growth rate in % (2001-2007)
Brazil	Import from World	53734.3	55850.6	120621.0	1.0	13.7
	Intra- BRICS Imports	1035.5	2291.9	17014.4	22.0	39.7
	Share in BRICS	1.9	4.1	14.1		
China	Import from World	132084.0	225094.0	956115.0	1.0	13.7
	Intra- BRICS Imports	6108.7	9782.1	59265.9	22.0	39.7
	Share in BRICS	4.6	4.4	6.2		
India	Import from World	36592.1	52940.3	218645.0	9.7	26.7
	Intra- BRICS Imports	2351.6	4324.9	30746.9	16.5	38.7
	Share in BRICS	6.4	8.2	14.1		
Russia	Import from World	46301.0	33880.1	199726.0	-7.5	34.4
	Intra- BRICS Imports	1372.0*	2425.0	29541.3	15.3	51.7
	Share in BRICS	2.9	7.2	14.8		
South Africa	Import from World	27436.1	26770.7	79872.6	-0.6	20.0
	Intra- BRICS Imports	952.0	1620.1	12563.4	14.2	40.7
	Share in BRICS	3.5	6.1	15.7		

Source: Same as Table 1.
Note: * exclude South Africa 1995 import figure.

Hence, trends in intra-BRICS trade seem to have mirrored the trends in global trade of the countries of the South.

What about the trends in India's trade? India too seems to have followed the global trends with exports to developed countries down by about 7 percent between 1995 and 2005. These exports seem to have shifted to developing countries whose share in India' exports went up by about 10 percent. However, at the commodity level the main change in the composition of India's exports seems to be a decline in importance of textiles and clothing. The share of these items in India's exports declined from 35 percent in 1995 to 16 percent in 2005. At the same time engineering goods exports have become the driving force of India's exports.

In this paper we will look at three issues. First, what has been the nature of the increase in BRICS trade and how sustainable is this? Related to this is the issue of whether growth in intra-BRICS trade (and Indian trade in particular) has now decoupled from growth in the developed economies. Second, what is the complementarity and substitutability in the commodity trade of the members of BRICS? Third, what are the possible methods of technical collaboration between BRICS countries in the related issues of technical collaboration and FDI? Here we will also comment on the institutional framework that such collaborations could take.

The paper is set up as follows. In Section II we outline the methodology we will use to define sustainability of intra BRICS trade and the issues of complementarity and substitutability. Here we will also detail our data sources. Section III then presents the detailed commodity level investigation. In Section IV we take up the issue of FDI and technical collaboration. Finally, in section V, some policy suggestions are given on possible commodity level supply linkages and methods of technical collaboration.

II. Methodology.

II.A. The Theory.

One of the principal contributions of Paul Krugman was to argue that while geography does determine trade, over a period of time it is also true that trade determines geography. The latter explains, for example, how over time some regions (countries) go into decline while new regions (countries) emerge as the rising stars. That trade is a function of geography was well established in the so called Heckscher-Ohlin-Samuelson

(HOS) model of trade. What Krugman suggested is that, in a dynamic setting, it is also possible that trade may determine geography (see, Krugman, 1991).

Currently we have three possible competing explanatory models of trade. The HOS model indicates that trade is determined by a country's resources. So a country's exports must use extensively its relatively abundant resources. Second, the Ricardian model emphasizes the technology aspect: that what a country exports is a function of what it can produce technologically at lowest cost compared to other countries. This was also the implication of Vernon's product cycle hypothesis (Vernon, 1979). The similarity of the HOS and Ricardian models lies in their focus on the dissimilarities between countries as the factor propelling trade. This dissimilarity could be in resources, technology, consumer tastes etc. Both models also imply that here trade is in dissimilar goods and this is often labeled as inter-industry trade.

The third model of trade, however, focuses on the similarity of countries as being the basis of trade. This was first stated by Linder (1961) when he argued that countries which are similar in economic structure tend to trade precisely because they have similar demand patterns. Hence, in this trade, exporters do not have to invest heavily in sale promotion activities like R&D because consumers in these countries are already familiar with these products. This was formalized by Krugman (1979) in a model of trade with differentiated goods. The crucial difference from earlier models was that this trade between similar countries was also in similar but differentiated goods and labeled *intra-industry trade* as distinct from the trade in dissimilar homogenous goods which occurs in the HOS and Ricardian worlds. In other words, trade between two countries exchanging computers for food would be labelled inter industry trade, while trade in different types of steel products would be categorised as intra-industry trade.

The type of trade taking place has enormous policy implications. Typically, when trade expansion takes the HOS or Ricardian route, countries must undergo structural change (because exporting sector expands and importing sector contracts) as trade expands. Thus, for example, typically trade between developed countries (N) and developing countries (S) is of the HOS or Ricardian type. Here, for example, as the S expands its exports of labour or land intensive commodities, it simultaneously imports

commodities like computers, cars, other capital goods which use more of capital or high technology. This leads to a disappearance of the import substituting sectors in both sets of countries with consequent dislocation of labour employed in these sectors. Political resistance to expansion of such trade follows and the structural adjustment needs a lot of time till labour is relocated and/or re-skilled. This has happened in, for example, the textiles sectors in N and some capital goods sectors in S. To put it another way, trade expansion of the HOS or Ricardian variety typically involves labour displacement in all countries.

On the other hand, trade of the Krugman variety (intra industry trade in similar commodities) typically involves adjustment which only implies relocation of labour within the same industry and not any major labour dislocation across unrelated industries. Most N-N and S-S trade is usually of this type. Since no labour displacement takes place, expansion of such trade faces less political resistance.

The theory outlined above will be used to look at the sustainability of intra-BRICS trade. If intra-BRICS trade is mainly composed of labour intensive goods which are typically exported to the N countries, it could be argued that this trade is not sustainable but is driven by temporary demand problems in the N countries. On the other hand, if this trade is in items where trade is typically of the intra industry variety it is likely to be sustainable. The issue then here is of the proper supply linkages, FDI and technology. Second, if trade is of the intra-industry variety it typically implies that trade is symmetrical. Here some tests of this trade symmetry will be conducted.

On the issue of technology, it has been argued that the principal factor that drives trade today is FDI which also implies technological interchange between countries. It is in fact recognized that the existence of FDI determines technology and productivity to a greater extent than patent and technology purchase agreements (see, Pant and Mondal, 2010; Kathuria, 2000) in our study, we will see what have been the trends in intra BRICS flows of FDI and the sectoral composition of such flows. The issue is whether FDI trends are establishing supply linkages which can make intra-BRICS trade sustainable.

II.B. The Data

Since this is a short term study we will concentrate on the implications of trade patterns and not go into the detailed history of domestic supply and demand issues in individual countries. The emergence of the BRICS trade bloc is a new feature of world trade. Hence, the only possibility is to infer sustainability based on past performance. We have chosen the period of study as 1995-2007 as this was a period of fairly calm growth in world trade with no major exogenous changes. In particular, the period after 2007 was marked by the impact of the global recession particularly in developed countries. Hence, looking at trade in the post 2007 period would have biased our results in favour of intra BRICS trade. Second, this was also the period, after the establishment of the WTO in 1995, which was characterized by a sharp decline in global tariffs and consequent trade expansion. Post 2007, the impact of the recession was felt in the form of non-tariff barriers particularly in developed countries. This would again bias our results. Hence, by concentrating on the period upto 2007 we are eliminating any exogenous factors that may bias our results in favour of intra BRICS trade.

Trade data is often unreliable mainly because of differing country definitions, currency conversion and year of assessment. To eliminate these problems we have relied entirely on the COMTRADE data base using the SITC, Rev. 3 definitions of commodities. Data disaggregation is taken at the 5-digit level where necessary. Other information used is based on secondary published sources.

II.C. Analytical Framework

The issues to be analysed are those relating to sustainability of intra BRICS trade, complementarity and substitutability of exports of BRICS countries, nature of intra BRICS trade (in high or low technology commodities) and, finally, identifying commodities where the issues of technology transfer and collaboration are important.

The issue of sustainability is analysed in three ways. First, we look at each of the member country's trade **(at the 4-digit SITC classification**) with other members and with the rest of the world. We then look at whether a country is a net exporter to BRICS and the rest of the world. For those items in which a country is a net exporter to both

BRICS and the rest of the world we argue that trade in these commodities is sustainable. Second, it is presumed that sustainable trade between similar countries is generally of the intra-industry variety. In the literature it has been argued that intra-industry trade also implies trade symmetry (see, Theil, 1979). We will thus apply some measures of symmetry to look at the trends in trade symmetry (in aggregate) in BRICS over our reference period. Third, sustainability is also interpreted as implying that countries of BRICS should have a comparative advantage in general in those commodities. In other words, countries should not be exporting to other BRICS countries commodities in which they do not have the comparative advantage to export to the rest of the world as in that case the importing country is incurring a welfare loss in its imports. In this case in the language of customs union theory, the BRICS bloc would lead to trade diversion (see, Lipsey, 1957; Meade, 1955). We argue that this trade is not sustainable as the importing country has an incentive to switch trade to countries outside the BRICS bloc. To analyse this issue, we will use the measures of revealed comparative advantage (RCA) commonly used in the literature (see, for example, Balassa, 1965).

Fourth, we will use the UNIDO (2009) definition to separate trade of BRICS countries into natural resource based, low tech, medium tech and high technology trade. We will then characterize intra-BRICS trade by this parameter.

Next the issue of substitutability and complementarity in the exports of the BRICS countries is addressed. This will be in relation to exports to non-BRICS countries of manufactured goods. Once again the measure of RCA will be used to differentiate between commodities. It will be argued that where member countries have an RCA greater than 1 in the same commodity then they are competitors in third countries. The attempt will be to try to identify such commodities. Where, however, countries are exporting outside the bloc in non-competing commodities, there is some complementarity if the commodities belong to the same industry group.

Fifth, as we have already noted we will look at trends in FDI among BRICS countries to identify in which areas technology transfer seems to be occurring and possible supply side arrangements to facilitate this.

Finally, at the highest possible level of disaggregation we will try to identify commodities where intra BRICS trade seems most promising and where concentrated efforts of trade and technological cooperation might yield best results.

III. Empirical Analysis.

The issue of sustainability of SS trade can be addressed at the macro and micro levels. In the next section we look at some macro issues.

III.A. *Macro Issues in Sustainability*

The issue of sustainability is crucial. We have noted in the introduction that a similar jump in SS trade took place in the 1970s but that was not sustainable as it was mainly due to temporary demand slump in the developed countries. How true is this here in our reference period 1995-2007? Table 3 below gives some statistics on GDP growth rates, per capita incomes and demography for the BRICS countries in the periods 1995-2000 and 2000-2007.

Table 3: Economic and Demographic Characteristics of BRICS Countries

Indicators	Year	India	Brazil	China	Russia	SA
Compound Growth Rate of GDP in Current Prices (in %)	1995 -00	5.5	-3.5	10.5	-3.7	-2.5
	2000-07	13.2	11.3	15.9	25.8	11.6
Per Capita in Current Prices (in US $)	1995	371.0	4844.0	601.0	2116.0	3684.0
	2007	945.0	7281.0	2559.0	9100.0	5975.0
Population (in Millions)	1995	953.2	161.7	1189.7	148.5	41.4
	2000	1042.6	174.2	1244.8	146.7	44.9
	2007	1164.7	190.1	1306.2	141.9	49.2
% of Population above 15 years	2001	62.5	69.1	N.A.	82.5*	63.9**
% share of 60+ pop to total pop	2003	7.4***	9.3	N.A.	17.8	2.9

Source: (1) International Monetary Fund, World Economic Outlook Database, April 2010; (2) Labour Statistics, ILO.
Note: * Russia 2002; ** South Africa 2003; *** India 2001.

Inspection of Table 3 clearly indicates that the second period (2000-2007) was characterized by double –digit growth rates for all the countries along with a two to four times increase in the per capita incomes. Clearly income growth in these countries

sustained growth in BRICS trade (relative to world trade) already shown in Table 1 and 2. This sustainability is also clear from the favourable demographics of these countries in 2001. As shown in the last two rows of Table 3, these countries have a fairly young population with only Russia having more than 10 percent of its population above the age of 60.

What about the developed countries? The comparable numbers are shown in Table 4.

Table 4: Economic and Demographic Characteristics of few Developed Countries

Indicators	Year	France	Germany	Japan	UK	USA
Compound Growth Rate of GDP in Current Prices (in %)	1995 - 00	-3.3	-5.5	-2.4	5.1	6.1
	2000-07	10.0	8.3	-0.9	9.6	5.1
Per Capita in Current Prices (in US $)	1995	27183.0	30861.0	41969.0	19947.0	27827.0
	2007	41940.0	40480.0	34286.0	45922.0	46673.0
Population (in Millions)	1995	57.8	81.8	125.4	58.0	266.5
	2000	59.1	82.3	126.8	58.9	282.3
	2007	61.9	82.2	127.8	61.0	301.9
Percent age of Population above 15 years	2003	81.4	85.3	85.9	79.9	73.5
% share of 60+ pop to total pop	2003	20.7	25.8	25.4	33.3*	15.4

Source: Same as Table 3
Note: * indicates UK's 50+ share in total

As can be seen from Table 4, the main developed countries of the OECD (with the exception of Japan) had fairly high growth rates of GDP in the period 2000-2007 so that it cannot be argued that there was a demand contraction which shifted exports to the BRICS bloc. In fact, in the case of the largest demand source, the USA, growth rates of GDP have been high since 1995. The future growth of demand in these countries is likely to be constrained by the fact that per capita incomes have grown by less than half over the period 1995 and 2007. Japan is again the clear outlier. In addition, the future demand expansion in these countries is also likely to be affected by the unfavourable demographics. In Table 4, barring the USA, it is seen that populations are ageing rapidly

with over 20 percent of population in the age group 60 and above.

It may thus be reasonable to conclude that the expansion of BRICS trade has not been at the expense of decline in demand in the developed world. It is also clear, at the macro level, that demographics do not favour future growth in these countries even after recovery from the current recession.

Table 5: Trade Symmetry in Bilateral and Intra-BRICS Trade

Entropy (Hij)		
Bilateral Country Group	**1995**	**2007**
Brazil-Russia	0.596	0.863
Brazil-India	0.745	0.92
Brazil-China	0.963	0.999
Brazil-South Africa	0.998	0.775
Russia-India	0.875	0.776
Russia-China	0.907	0.963
Russia-South Africa	0.964	0.899
India-China	0.884	0.86
India-South Africa	0.949	0.963
China-South Africa	0.894	0.942
Criterion Function for BRICS		
	1995	**2007**
$\mathbf{I_0}$	0.074	0.051
$\mathbf{I_1}$		0.181
$\mathbf{I_2}$		0.119
$\mathbf{I_3}$	0.056	0.039

Source: Author's Calculation.

However, another macro issue in sustainability is the issue of bilateral trade balances. It is often argued that sustainable trade must imply some symmetry in that exports and imports must roughly remain in balance. In particular sustained trade imbalances are politically difficult to sustain. One measure of bilateral asymmetry has been suggested by Theil, op.cit. The entropy measure H of bilateral symmetry increases as trade becomes more symmetric (for a detailed mathematical exposition of H see Appendix 1). We calculated the H indices for all pairs of bilateral trade among BRICS countries over the period 2000-2007. The results are shown above in Table 5.

Inspection of Table 5 clearly shows that trade has been getting increasingly

asymmetric for almost half of the set of bilateral pairs of countries, that is, Brazil-South Africa, Russia-India, Russia-South Africa and India-China.

However it is possible that bilateral trade asymmetry does not imply asymmetry for the BRICS bloc as a whole. To what extent has asymmetry increased or decreased for the BRICS countries taken together?

To look at trade symmetry for the matrix of BRICS trade we have used Theil's criterion function measure of asymmetry which is based on the principles of information theory. The criterion function measure, I, is defined as

$$\mathbf{I} = \sum_i \sum_j P_{ij} \log \frac{P_{ij}}{(P_{ij}+P_{ji})/2}, \text{ for } i \neq j$$

And P_{ij} refers to the share of country i's exports to country j as a ratio of total intra-BRICS exports. It is easy to see that if the trade of any two countries is symmetric then $P_{ij} = P_{ji}$ and I =0. It is clear, then, that an increase in the value of I implies increasing asymmetry of trade. The values of I for 1995 and 2007 is given by I_0 . What we want to measure, however, is to what extent symmetry has changed between our reference years 1995 and 2007? We use three measures for trade symmetry for 2007 compared to our reference period 1995. First, I_1 is an application of I to the actual trade matrix for 2007 given the information from 1995 trade matrix. Second, assuming that the exports of 1995 are a true guess of the probability of exporting in 2007 we get the measure I_2. Finally, the trade matrix for 2007 is re-estimated so that I_2 is calculated from a matrix whose total exports and imports equal the actual exports-imports of each country in 2007 but where the probability of exporting is taken from the 1995 trade matrix. This gives us I_3 (for details see Appendix 1).

It is also obvious that I is necessarily positive if there is trade imbalance for any country. However, it is possible to adjust the trade matrix for these trade imbalances (see Appendix 1 for details). This allows us to define the functions I_3. The values of I_3 are calculated for 2000 and 2007. The results are shown in the bottom half of Table 5.

From Table 5 it can be seen that asymmetry seems to have declined in 2007

relative to 1995 as I_0 in 2007 (.051) is smaller than I_0 in 1995 (.074). Comparing the unadjusted measure of I (i.e. I_1) with the adjusted I (i.e. I_2), we see that the I_2 is smaller than the unadjusted measure of I i.e. I_1.; this means that the 2007 intra-BRICS trade is more symmetric with reference to 1995 intra-BRICS trade when we take adjusted I rather unadjusted I.. However, if we took the 1995 trade pattern as one that would prevail in 2007, we see that asymmetry has actually increased: $I_2 > I_0$. The same asymmetry is implied in comparing I_3 to I_0 in 2007 and 1995. Last, if we impose trade balance on the member countries, we see that asymmetry would have decreased between 1995 and 2007: the value of I_3 has fallen between 1995 and 2007. Hence, we conclude that asymmetry in trade has been driven by trade imbalances and removal of these imbalances is merited as this would make trade more symmetric. The issue of trade imbalances does merit attention within the BRICS bloc.

III.B. *Trade and Sustainability of BRICS trade*

Before looking at disaggregated trade statistics, it is worthwhile to look at the inter-country pattern of BRICS trade in the period of 1995 to 2007. Tables 6 and 7 below give the pattern of BRICS trade for each of the countries for both exports and imports.

Table 6: Percentage Share of Intra-BRICS Exports to Total Country Exports, 1995-

2007

		Partner Country				
Exporting Country	Year	Brazil	China	India	Russia	SA
Brazil	1995	0	51.1	13.6	24.2	11.1
	2000	0	53.5	10.7	20.9	14.9
	2007	0	62.5	5.6	21.7	10.2
China	1995	20	0	20.1	43.8	16.1
	2000	20.3	0	25.9	37	16.8
	2007	16	0	33.7	39.9	10.4
India	1995	4.8	18.6	0	58.4	18.2
	2000	9.2	35.2	0	40.9	14.7
	2007	13.2	65.7	0	6.4	14.7
Russia	1995	2.4	86.8	10.8	0	NA
	2000	6.3	80.9	11.9	0	0.9
	2007	6.5	78.5	13.6	0	1.4
South Africa	1995	35.8	34.2	23.5	6.5	0
	2000	21.5	35.7	39.6	3.2	0
	2007	8.4	67.4	21.8	2.4	0

Source: UN-COMTRADE.

Inspection of Tables 6 and 7 reveal some interesting trends. For one, China's dominance is clear. In Table 6, Brazil, India and South Africa have switched to China as their main trade partner. For India and Brazil this has been at the expense of Russia and for South Africa at the expense of Brazil. Only Russia has reduced the share of its exports going to China in favour of India. Second, India has remained an important market for Brazil and South Africa while becoming more important for Russia. Clearly, then, while China has emerged as the main market for the other countries, India is the second most important market in the trade matrix.

Second, a look at the pattern of imports in Table 7 indicates clearly that China has become the main source of imports of all the countries at the expense of traditional trading partners. It is worth noting that India and China account for 80 percent or more of the imports from and exports to the all other BRICS countries.

Table 7: Percentage Share of Intra-BRICS Imports, 1995-2007

		Partner Country				
Importing Country	Year	Brazil	China	India	Russia	South Africa
Brazil	1995	0	40.4	13.3	17.8	28.5
	2000	0	53.3	11.8	24.9	9.9
	2007	0	74.2	12.7	10	3.1
China	1995	20.2	0	6.5	62.2	11.1
	2000	16.6	0	13.8	59	10.6
	2007	30.9	0	24.7	33.2	11.2
India	1995	12.9	36.4	0	40.7	10
	2000	6.5	44.5	0	23.9	25.1
	2007	3.1	79.5	0	9.9	7.5
Russia	1995	11.4	55.8	32.8	0	N.A.
	2000	14.7	57.5	26	0	1.8
	2007	12.4	83.4	3.5	0	0.7
South Africa	1995	25.1	51.7	19.8	3.5	0
	2000	18.2	61.5	15.6	4.7	0
	2007	13.2	68.2	14.1	4.5	0

Source: Same as Table 6.

In summary, intra-BRICS trade is dominated by China on both the export and import side. India is the next most dominant country. It must thus be noted that the increase in intra-BRICS trade share has also been accompanied by some decline in multilateralism in intra-BRICS trade. Here, the main sufferer seems to have been Russia which seems to be trading more with non-BRICS countries.

It also seems worthwhile to see commodity level changes in intra BRICS trade. We have looked at the period 2000-2007 and the data in Table 8 below presents commodity level data at the one digit SITC, Rev. 3 level of aggregation.

Table 8: Share of Intra BRICS Exports to World Exports, 2000 to 2007 (in %)

Commodity Group	Commodity Description	2000	2007
0	Food and live animals	3.7	7.7
1	Beverages and tobacco	6	9.1
2	Crude materials, inedible, except fuels	10.2	30.3
3	Mineral fuels, lubricants and related materials	1.4	4.4
4	Animal and vegetable oils, fats and waxes	14.2	21.6
5	Chemicals and related products, n.e.s.	9.1	13
6	Manufactured goods classified chiefly by material	3.3	5.6
7	Machinery and transport equipment	2.4	5
8	Miscellaneous manufactured articles	3.4	5.9
9	Commodities and transactions not classified elsewhere in the SITC	0.1	2.2

Source: Same as Table 6.

In table 8 we present data on changes in the share of intra BRICS exports to the world exports of that commodity group. To that extent, the data indicates to what extent the BRICS countries have been switching their trade from the world to other members of the bloc. Inspection of Table 8 indicates that while in all cases the share of intra BRICS trade has increased, the dominating items in intra bloc trade are Crude materials (Section 2), and Animal and Vegetable Oils (Section 4) and Chemical Products (Section 5). In 2007 these two items above constituted about 51 percent of the world trade of the bloc countries in these commodities. We will comment on disaggregated statistics at a later point. However, it is worth noting that all these commodities are largely resource based commodities.

One crude method of judging the issue of sustainability of intra BRICS trade is to look at the main exports of the bloc countries, at a disaggregated commodity level, and see in which commodities they are net exporters to the world and to other bloc countries. To obtain a better idea of the physical commodities involved we have disaggregated data to the 4-digit SITC level. We have then looked at all commodities in which the exports of the country accounted for at least 1 percent of its intra BRICS trade in 2007. This allowed us to account for a substantial part of a country's intra BRICS trade. We then look at changes in the ratio of a country's net trade within BRICS to its net trade in that commodity for the world as a whole. The results are shown in Table 9 below for the

years 2000 and 2007 (for detailed results see Appendix 2).

Table 9: Ratio of Net Intra BRICS Trade to Trade With Rest of the World, 2000 and 2007* (in %)

	Product Code	2000	2007
Brazil	1212	9.1	19.7
	2222	16.4	*42.9*
	2515	4.2	14.1
	2815	9.5	*43.9*
	2816	10.2	18.6
	4211	*26.9*	*34.9*
	6114	6.1	*25.8*
	6715	-1.1	13.4
	7832	1.3	*25.5*
China	3250	*24.4*	*24.3*
	5413	19.5	*40.6*
	6732	0.0	12.4
	7641	6.7	14.1
	7821	-0.5	*44.6*
	8432	3.8	18.1
	8442	3.4	17.2
	8453	1.7	12.2
	8454	1.7	10.2
	8514	6.1	18.0
India	2631	15.7	**109.3**
	2731	*21.6*	*48.8*
	2815	*28.7*	**801.7**
	2816	**124.6**	**5207.7**
	2852	*48.5*	**176.7**
	2875	0.0	**154.6**
	2879	*63.8*	**548.6**
	5112	2.4	14.7
	5429	17.3	15.1
	5751	*25.3*	*45.9*
	6821	*35.2*	*30.8*
Russia	2321	*23.1*	19.5
	2474	*26.6*	*62.9*
	2475	16.4	*47.3*
	2515	*44.1*	*60.5*
	5121	*24.5*	*29.2*
	5156	*62.6*	*49.9*

	5621	*21.6*	*25.2*
	5623	*71.1*	*69.6*
	5629	*21.4*	*26.8*
	6751	*36.0*	*37.1*
	7144	*39.3*	*69.9*
	7648	*67.2*	**110.0**
South Africa	2513	12.7	*20.7*
	2681	13.6	*47.5*
	2816	*32.4*	*34.2*
	2831	0.0	*71.1*
	2877	1.2	*52.7*
	2879	2.2	*67.7*
	2882	15.2	*23.9*
	3212	8.3	14.5
	5223	*89.9*	*84.7*
	6715	4.1	*20.7*
	6753	2.7	*20.9*
	6755	10.6	*21.0*

Source: WITS.

Note: * selection of commodities has been done on the basis of 1 percent or above share of respective commodities in total intra BRICS trade of particular country.

Inspection of Table 9 tells us in which commodities a country's net trade to BRICS has increased relative to its exports to the world. From the table it can be seen that, in almost all cases, the ratios have increased substantially (for details of commodities not included in Table 9, see Appendix 2). This seems to indicate that the members of the BRICS bloc are redirecting more and more of their reasonably competitive exports (still exporting to the world) towards the bloc. As Appendix 2 also shows, there are some commodities where the ratio in 2007 was negative indicating that for that commodity a country is a net exporter to the bloc but net importer from the rest of the world. Hence the county may not have a competitive advantage in exports of these commodities. However, there are very few commodities in this category and restricted to Brazil (four commodity groups) and South Africa (one group). For Brazil these commodities are **Crude petroleum, Copper Ores and Concentrates,** Other ferro alloys (**Silicon, Manganese, Chromium**) and **Motor Vehicle parts (other than chassis and bodies**). However, the net exports of these items are of marginal value.

We can further classify the commodities into three classes: those where the ratio is more than 100 percent (shown in bold) in 2007, those where ratio is above 20 percent(shown in italics) and the rest. A ratio of more than 100 percent indicates that intra BRICS trade is more important than world trade, while the ratio over 20 percent indicates areas where the intra-BRICS trade is substantial. It can be seen that ratios above 100 percent are mainly for commodities exported by India. These commodities are **cotton** *(*SITC 2631) and **Ores of Iron, pellets of iron, alumina, zinc ores and other ores** (SITC 2815,2816,2852,2875 and 2879). Hence, these exports seem to be mainly of natural resource based products. In Table 10 below we indicate the change in these exports from India to the BRICS over the period 2000 to 2007. The data in the table indicates percentage share of intra BRICS trade in these 4-digit exports in India's total world exports of these items.

Table 10: Percentage Share of India's Intra BRICS to Total Exports during 2000 and 2007

Commodity Code	Commodity Description	2000	2007
2631	Cotton (other than linters), not carded or combed	0.1	52.3
2815	Iron ores and concentrates, not agglomerated	28.7	88.9
2816	Iron ore agglomerates (sinters, pellets, briquettes, etc.)	64.5	98.1
2852	Alumina (aluminium oxide), other than artificial corundum	46.2	66.3
2875	Zinc ores and concentrates	0.0	60.7
2879	Other non-ferr.ore,concntr	60.5	85.1
Total of Above Commodities		34.8	78.1

Source: Same as Table 6.

Table 10 clearly indicates how dependent India had become on exports of these items to the BRICS countries. However, these exports of raw minerals are mainly driven by Chinese imports (exports of cotton and alumina to South Africa and Russia are negligible) and there is some doubt that this is sustainable over the longer period. However, in other commodities there seems to be some indication of sustainable growth in intra BRICS trade. We will look at this in some detail next.

The issue of sustainability involves some further consideration of the nature of intra BRICS trade. This is also important in linking the issue of trade to considerations of technology transfer which we take up at the end of this study. To look at this we break up the trade pattern shown in Table 9 in terms of the technology content of exports. We use the UNIDO definition (see, UNIDO, 2009) to classify exports into resource based, low technology, medium technology and high technology items. For a description of the UNIDO classification see Appendix 3). The changes, between 2000 and 2007, in the composition of exports by this classification is given below in Table 11. (For the detailed commodity data see Appendices 4 and 5).

Table 11: Share in Intra BRICS exports, 2000 to 2007: Technological Classification

	Brazil		China		India		Russia		SA	
Technology Classification	2000	2007	2000	2007	2000	2007	2000	2007	2000	2007
Resource Based	64.8	72.7	4.0	-	29.5	42.7	21.0	48.9	44.8	58.8
Low Tech Exports	1.9	3.3	21.4	11.4	17.3	-	-	-	2.4	5.4
Medium Tech Exports	5.4	5.2	5.0	5.6	-	5.2	26.6	19.5	13.7	10.4
High Tech Exports	1.8	-	5.4	10.5	5.5	2.2	6.8	1.1	-	-

Source: Same as Table 9.

From table 11 it is clear that all the countries, barring China, have been excessively dependent on exports of natural resources. Obviously, the main destination is China. There seems to be some technological imbalance in the intra BRICS trade as China clearly dominates in high technology (HT) items. Here, the share of HT items in exports to BRICS countries has been in fact falling for India and Russia. Second, there does seem to some comparable presence of each of the BRICS countries in medium technology (MT) products. From the point of view of sustainability of intra BRICS trade, it does seem necessary to look in details at the prospects of increasing exports of technologically advanced products preferably in MT and HT. We will come back to this theme in a later section.

It seems worthwhile to further identify the commodities listed in Appendix 5 by their importance in trade. Our basic commodity definition in Appendices 4 and 5 is taken at the 4-digit level of classification. We looked at two classes of commodities:

those where the share of the 4-digit commodity in the 2-digit commodity group has increased between 2000 and 2007 (increasingly important commodities) and those where this share has fallen over this period but which accounted for at least 10 percent of 2-digit intra BRICS trade (for each country) in 2007 (important commodities). In Table 12 below we list those 4-digit commodities which belong to the above two commodity groups and which account for at least one percent of a country's intra BRICS trade in 2007. The commodities are also classified by their technological content.

Table 12: Important and Increasingly Important Commodities for BRICS, 2000 to 2007

Brazil			
Technology Classification	Product Code	4 digits Increasingly Important	4 digits important commodities
Resource Based Exports	2222		2222
	2815	2815	
	2816		2816
	4211	4211	
India			
Resource Based Exports	2631	2631	
	5112	5112	
Medium Tech. Exports	5751	5751	
High Tech Exports	5429		5429
Russia			
Resource Based Exports	2474		2474
	2475	2475	
	5121		
	5621		5621
	5629		5629
South Africa			
Resource Based Exports	2816	2816	
	2877	2877	
	2879	2879	
	5223		5223
Medium Tech. Export	5121	5121	

Source: Same as Table 6.
Note: Division is based on UNIDO, 2009.

Inspection of Table 12 indicates that there are very few quantitatively important commodities in intra BRICS exports. In fact, there are no such commodities for China's intra BRICS trade while for the others the trade is dominated by resource based

commodities. To put it another way, of the commodities which comprise one percent or more of a country's intra-BRICS trade in 2007, there are very few which belong to the set of commodity groups where intra BRICS trade is important or has become increasingly important between 2000 and 2007. In fact, these few commodities largely belong to the set of resource based commodities like **iron ores and pellets** (Brazil, India, and SA), **manganese ores** (SA), **cotton** (India), **non-coniferous wood** (Russia), and **soya and soya oil** (Brazil).

In medium technology exports, the only quantitatively important products are **propylene polymers** (India) and **nitrogenous fertilizers** (Russia). Even here, only for India have the medium tech exports increased in importance after 2000.

Thus, on one can conclude that quantitatively the importance of growing intra BRICS trade in LT, MT or HT products is insignificant. At present the dominance in trade is of resource based products. This is unlikely to be sustainable both from the point of view of demand from China and long-run supply constraints from other BRICS members. Sustainability will lie in exports in other technology areas.

III.C. Complementarity and Substitutability

The issue of complimentarity and substitutability is important in that it is likely that countries could have technical collaboration in areas where there is some complimentarity in production. However, where products are close substitutes in production (or consumption) it is possible that such technical collaboration may not be welcomed. While the issue of technology and cooperation will be dealt with in the next section, here we will look at measures to identify this complimentarity/substitutability.

We have already noted that measures of Revealed Comparative Advantage (RCA) will be used to address the issue of complementarity and substitutability among products exported by the BRICS countries (for a definition of RCA see Balassa,op.cit.). The essential principle is that if a product exported by two or more countries to third markets (the rest of the world) have RCAs greater than 1 then these products are competing

(substitutes) in world markets (see, for example, Pant et.al., 2010)[1]. However, this is only true for similar commodities. This is difficult to define empirically and would normally require calculating cross price elasticities of substitution in consumption or production among these products. This requires extensive data. We have used a simpler procedure. Products of different countries are defined as similar if they fall in the same 5-digit level of disaggregation which is the highest level of disaggregation available. These products are substitutable in consumption but horizontally differentiated.

However, if products at the 5 digit level of disaggregation with RCA greater than 1 fall in the same commodity group at the 3-digit (or 2-digit) level but are different in their 5-digit definition, we argue that these products belong to the same industry but represent different levels of finish (are vertically differentiated) and could be considered as complimentary products: countries could coordinate production of these products for the world market as they are not direct substitutes for each other.

We calculated these RCA for each country for the year 2007. However, since the concept of product differentiation is usually applied only to products which are not heavily resource dependent we did our calculation only for commodities falling in Sections 4-8 of the SITC classification system. The detailed results are shown in Appendix 7.

For ease of exposition we list commodities where countries face some substitutability in third markets in Table 13.

Table 13: Product Substitutability among BRICS Countries, 2007

[1] Due to the base affect Balassa's index is often an overstatement. To correct this we have also used a related measure given in UNCTAD (2010). For definition see Appendix 6. It may be noticed that this has no affect on our results which follow irrespective of which index is used.

Product Codes	Product Name	Countries	Major Markets	Total sale in major Markets (in %)
Resource Based Exports				
51124	Xylenes, pure	Brazil	Mexico; USA	89.0
		India	China; Indonesia; Pakistan	83.2
Medium Tech Exports				
51213	Butanols	Russia	China	89.7
		South Africa	China; Netherlands; United Arab Emirates	71.8
56216	Urea, whether or not in aqueous solution	China	US Virgin Isds; India; USA	59.4
		Russia	Brazil; Mexico; Peru	63.6
56293	Diammonium hydrogenorthophosphate (diammonium phosphate)	China	India; Pakistan; Thiland; Viet Nam	72.5
		Russia	Argentina; Iran; Pakistan	59.7
56294	Ammonium dihydrogenorthophosphate (monoammonium phosphate) and mixtures t	China	Brazil; India	45.0
		Russia	Argentina; Brazil; Estonia; Ukraine	62.9
57511	Polypropylene	Brazil	Argentina; Nigeria	35.4
		India	China; Pakistan; Turkey	50.5
67153	Ferrochromium	India	China; Japan; Netherland	63.6
		South Africa	China; Germany; Japan; Other Asia nes	60.1
68212	Refined copper	Brazil	China; Netherland	84.3
		India	China; Malaysia; Other Asia nes; Saudi Arabia	70.0
High Tech Exports				
54131	Penicillins and their derivatives with a penicillanic acid structure; sal	China	India	55.6
		India	Egypt; Spain; Thailand; UAE	26.9
54139	Other antibiotics	China	Germany; India; Italy; Rep. of Korea	41.8
		India	Brazil; China; Germany; Iran; USA; Viet Nam	37.1

Source: Same as Table 6.

Inspection of Table 13 indicates that there are only 10 products at the 5-digit classification where there is some possibility of substitutability (competition) in third country markets. These are *resource based* product **Xylenes (Brazil/India).** In the MT industries there are 5 products: **Butanols** in the *chemicals* industry (**Russia/SA**), **Fertiliser** products (**China/Russia**), one in *plastics* industry , **Polypropyline** (**China/India**). There are also two products in the HT sectors both belonging to the *Pharmaceutical* industries, **Penicillins** and other **Antibiotics** (**China/India**).

However, substitutability also implies competition in the same markets. Closer inspection of Table 13 (see, column 4) shows that the BRICS countries are by and large exporting to different markets. The only competition seems to be for **Butanols** (**China**) where India and Brazil are competing, **Ammonia products** (**Brazil**) where China and Russia compete, **Ferrochromium (China, Japan)** where India and SA compete and **Refined Copper** (C**hina**) where India and Brazil compete and **other antibiotics** (**Germany**) where India and China compete. It is interesting to note that the main markets where these countries compete in these products lies within the BRICS group itself with the exception of pharmaceutical exports. In general, the products where there seems some substitutability belong to the Chemicals, Metals and Pharmaceutical industries and the substitutability (competition) is quite limited. It should also be noted that most of the products above fall in the MT or HT areas where technological cooperation is usually useful and desirable.

A broad idea on areas where there is some complimentarity among the BRICS countries is given in Table 14 below. Inspection of Table 14 indicates that there are a large number of products belonging to various industries where there exists some degree of product complimentarity between countries. While the details are available in Appendix 7, we have summarized the main industry heads and countries in Table 14. From Table 14 it can be seen that our data cover 30-50 percent of the BRICS countries exports with the exception of iron and steel (I&S) products where our data covers about 20 percent of exports.

Table 14: Product Complementarity among BRICS Countries,2007

Industry Code	Industry Description	Product Description	Countries	Major Markets	Total sale in major Markets (in %)
Resource Based					
421	Fixed veg. fat, oils, soft (Edible Oil)	Soya bean oil; Sesame; Groundnut oil; Sunflower seed	Brazil	China; Iran; Netherlands; India	57.3
			China	China, HongKong SAR; Dem. People's Rep. of Korea; Japan	52
			Russia	Egypt; Italy	28.3
51	Various Chemical Products	Acyclic Hydrocarbons; Benzene; Amino-alcohol-phenols; Acrylonitrile	Brazil	USA; Netherlands; Argentina	47.9
			India	USA; China	21.8
			Russia	Finland; China	51.7
			South Africa	USA; Japan; Netherlands	52.5
Low Tech Export					
67	Iron and steel	Iron and Steel; Flat-rld products; hotrld; coldrld	China	Rep. of Korea	16.3
			South Africa	China; USA	21.6
Medium Tech Export					
51	Various Chemical Products	Methanol; Fatty alcohols; Cyclanic; Phenol	Brazil	USA; Netherlands; Argentina	47.9
			India	USA; China	21.8
			Russia	Finland; China	51.7
			South Africa	USA; Japan; Netherlands	52.5
57	Plastics in primary form	Polyethylene; Polyvinyl chloride; Polycarbonates;	Brazil	Argentina	30.1
			China	China; Zambia; Zimbabwe	33.9
67	Iron and steel	Iron and Steel; Ferro-alloys; Ferrosilico-manganese; Flat-rld products	Brazil	USA	26.9
			India	USA	14.7
			Russia	Iran; Italy; Turkey	31.3

Source: Same as Table 6.

Inspection of Table 14 shows that the main industries where there exists some

complimentarity between the BRICS countries are **Vegetable Oils** (Brazil, China Russia), **Chemical Products** (Brazil, India, Russia and SA), **Plastics** (Brazil, China) and **Iron and Steel** (all BRICS countries). In addition, the complimentarity extends from resource based to HT products.

Our notion of complimentarity (as already noted above) indicates each country possibly specializing in some stage of production in any given industry. Some more details can be obtained from Appendix 7. Hence, in vegetable oils there is a clear product differentiation with **Brazil** specialising in **Soya products**, **China** in G**roundnut** and **Russia** in **Sunflower.** Since these are resource based products they are obviously not substitutable in production. However, as they all fall in the category of edible oils there is some degree of **substitutability in consumption**. Hence, while there is some possibility of technical collaboration in production there is the problem of substitutability in consumption. To explore this further we need to look at another parameter of substitutability, markets. However, from the second last column of Table 14, it can be seen that there is very little conflict in markets with each country having a **distinct market segment**.

The other area where complimentarity is indicated is the **Chemicals** industry. Inspection of Appendix 7 indicates that this seems particularly obvious in the MT areas where Brazil, India, Russia and SA seem to specialize in different types of **Industrial Alcohols**. Technical collaboration in these areas is certainly feasible. Again, from Table 14 we can see that the **four countries** barring China share **common markets** of the **USA, China and Netherland b**oth for basic and MT exports.

The third industry where complimentarity seems to exit is Iron **and Steel** (I&S). From table 14, this complimentarity is indicated in both LT exports (**Hot and Cold Rolled Steel**) and MT exports (**Alloys**). An inspection of Appendix 7 clearly indicates the areas of specialization. In LT areas, **China** concentrates on **Iron products**, **SA** in **stainless** steel products. In MT products, the specialization is clear: **India** specializes in **Manganese** and **Chromium** alloys, Russia in **semi finished I&S products** including electrical grade. We have already seen that **India and SA compete in Chromium alloys in the Chinese and Japanese markets**. Yet in other products there is considerable

complimentarity in this industry. Technical collaborations seem indicated. It can also be seen that **Brazil, India and SA** export to a common market, the **USA.**

The last industry where we see some possibilities of complimentarity is the **Plastics** industry. Again, from Appendix 7 we see that **China** and **Brazil** specialize in different varieties of **Polyethylene** products. We have already seen that in one product (Polypropyline) China and India are direct competitors. However, there seems to be some indication of a high degree of complimentarity between India, Brazil and China in the Plastics industry. There does not seem any commonality of markets.

In general, the substitutability and complimentarity seems to exist in four areas: **edible oils, chemicals, metal products and plastics**. While in a few products there may be direct completion in third markets, in most cases the markets are different and there may be no conflict of interest in collaborative arrangements. However, it is only in **pharmaceutical products where India and China seem to compete** in a common third market outside the BRICS bloc. However, in products in which production complimentarity is indicated the only common common market outside the BRICS areas seem to be **Netherlands** (**Chemicals**) and **Iron and Steel** (**USA**).

IV. Technology, FDI and Cooperation.

In the previous section we have already indicated some areas where some kind of cooperation between the BRICS countries is feasible. The empirical literature shows that it is technology which is the most important long term determinant of trade as compared to resources whether natural or human (see, for example, Trefler, 1995). It is now acknowledged that trade and technology are linked through Foreign Direct Investment (FDI). Specifically, FDI could serve as a substitute or complement to trade. Thus if FDI is linked to domestic market access it could reduce trade while if it is linked to exports it could enhance trade. Typically, FDI and trade are substitutes when trade is in final goods but compliments when trade is in intermediates. We also know that declining tariffs and transport costs have led to the fragmentation of international production so that much of the trade today is in intermediate inputs (see, for example, Krugman, 2008; UNCTD, 2009). Hence, we can expect that trade and FDI are complimentary. This also explains

the crucial role of technology in promoting trade.

Traditionally, developing countries have tried to obtain technology through purchase of drawings and designs, patents etc. However, the empirical literature now indicates that this method of obtaining technology is not very effective. In fact , recent literature on FDI, technology and productivity has concluded that it is the presence of foreign firms via FDI that has positive productivity impacts on domestic firms via learning by doing, external economies etc. (see, Pant et.al., 2011,). It has also been argued that the impact of FDI on productivity of local firms is a function of the technology gap between the donor country and host country firms. However, if this gap is very high then absorption of technology by the host country firms becomes difficult. To the extent that this gap is likely to be lower between firms in developing countries, it can be argued that intra BRICS FDI will have greater impact on productivities than FDI from developed countries (see, Gammeltoft, 2008). In other words, to see the possibility of technological upgradation one needs to see the trends in FDI in the BRICS countries.

However, FDI needs an enabling environment. This can be created by host countries via creating the institutional mechanism for cooperation between countries of BRICS. This institutional mechanism has three components: Direct tax treaties (DTTs), Bilateral Investment Treaties (BITs) and TRIMS under the WTO and government role in policy towards FDI.

This section will look at the issues of technology and cooperation using the above theoretical frame based on some data taken from the World Investment Reports of the UNCTAD and other studies on these issues. We will also try to relate this to our discussion in the previous sections on trade between BRICS countries.

IV.A. Intra BRICS Foreign Direct Investment

Today the BRICS emerging markets are a growing and substantial source of world demand and are now, taken together, almost equal in size to the major developed countries. In 2010, the BRICS bloc accounted for about 16.3 percent of world exports as compared to 27.8 percent for the OECD top five countries (ET, Oct. 3, 2011). They also constitute the home and host region for a significant proportion of world's FDI flows.

As can be seen from Table 15, in 2010 BRICS's FDI was around twenty percent of world's inflows and ten percent of outflows. Net FDI inflow from the BRICS bloc increased from $ 41 billion in 1995 to $ 108 billion in 2007 and $ 75 billion in 2010. In addition, we see in Table 15 that Brazil, China, India, and SA were net importers of FDI throughout the period of 1995-2010, whereas Russia was a net exporter of FDI in 2010 but a net importer in 1995 and 2007. In general, we can see that the BRICS economies are important players as the host countries.

Table 15: BRICS FDI inflows, outflows (in % to world) and net to World (Billion US$)

	1995			2000			2007			2010		
Economy	Inward	Outward	Net FDI	Inward	Outward	Net FDI	Inward	Outward	Net FDI	Inward	Outward	Net FDI
Brazil	1.3	0.3	3.3	2.3	0.2	30.5	1.8	0.3	27.5	3.9	0.9	36.9
China	11	0.6	35.5	2.9	0.1	39.8	4.2	1.0	61.1	8.5	5.1	37.7
India	0.6	0.0	2.0	0.3	0.0	3.1	1.3	0.8	8.1	2.0	1.1	10.0
Russian	0.6	0.2	1.5	0.2	0.3	-0.5	2.8	2.1	9.2	3.3	3.9	-10.5
South Africa	0.4	0.7	-1.3	0.1	0.0	0.6	0.3	0.1	2.7	0.1	0.0	1.1
BRICS compared to World	13.8	1.7	41.1	5.8	0.6	73.5	10.4	4.4	108.6	17.8	11.1	75.3

Source: UNCTAD, 2010.

More importantly, BRICS have played a major role in FDI flows from developing countries. From Table 16 we see that the share of developing countries in FDI outflows has jumped dramatically between 1988-90 and 2003-05. A major part of this came from the BRICS countries.

Table 16: Distribution of FDI by region, 1980-2005

Region	Inflow				Outflow			
	1978-80	1988-90	1998-00	2003-05	1978-80	1988-90	1998-2000	2003-05
Developed economies	79.7	82.5	77.3	59.4	97.0	93.1	90.4	85.8
European Union	39.1	40.3	46.0	40.7	44.8	50.6	64.4	54.6
Japan	0.4	0.0	0.8	0.8	4.9	19.7	2.6	4.9
United States	23.8	31.5	24.0	12.6	39.7	13.6	15.9	15.7
Developing economies	20.3	17.5	21.7	35.9	3.0	6.9	9.4	12.3
Africa	2.0	1.9	1.0	3.0	1.0	0.4	0.2	0.2
Latin America and the Caribbean	13.0	5.0	9.7	11.5	1.1	1.0	4.1	3.5
Asia and Oceania	5.3	10.5	11.0	21.4	0.9	5.6	5.1	8.6
West Asia	-1.6	0.3	0.3	3.0	0.3	0.5	0.1	1.0
South, East and South-East Asia	6.7	10.0	10.7	18.4	0.6	5.1	5.0	7.7
South-East Europe and CIS	0.0	0.0	0.9	4.7		0.0	0.2	1.8
World	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: World Investment Report 2006. FDI from Developing and Transition Economies: Implications for Development. UNCTAD.

We now turn to a more detailed analysis of FDI from the BRICS countries in terms of its geographical and sectoral composition. While aggregate data is available from UN publications, it is difficult to get data on intra BRICS and country and sector composition of FDI flows from the BRICS countries. Hence, in the remaining sections we have relied on published secondary data for our exposition.

IV. B. Geographical and Sectoral Composition of FDI flows from BRICS.

From the literature it seems that the FDI inflows into BRICS come mainly from outside the region. This is also true for outflows of FDI from BRICS: they flow to countries outside the region (Gammeltoft, op.cit). For example, the major destinations of Brazil's FDI outflows are Chile, Mexico and Venezuela in Latin America, Western European countries and the USA. In addition, there are outflows to the usual tax havens

of ; Bahamas, Bermuda, and British Virgin Islands. For Russia, the FDI outflows are to the CIS countries, Western Europe and Central and Eastern Europe. The destination for India's outward FDI has changed over time Thus, from 1975 to 1980s the outflow was initially directed towards Singapore, Thailand, Sri Lanka, Malaysia etc. but in recent years the major recipients are developed countries like the USA and UK mainly due to outward FDI by India's software industry. Within BRICS, the Russian Federation was a major recipient with 18 percent of cumulative FDI, 1996-2003 (see Gammeltoft, op.cit.). In addition, FDI flows go to tax havens like Bermuda, British Virgin Islands and Mauritius. In contrast, Chinese FDI has mainly flowed to developing countries of Asia, Latin America and Africa for asset acquisition in areas like mining, oil and gas. Finally, South-African outward FDI has concentrated in the African region. From the above it can be seen that there is a sharp divergence in the destination of FDI from the BRICS countries. Thus, while Brazil, SA and Russian FDI is concentrated in their traditional regional neighbours, Indian FDI has been moving towards the developed countries while Chinese FDI is globally diversified in the natural resource sectors in developing countries.

In concluding, it may be noted that till 2004, the largest stock of FDI abroad was owned by Russia and Brazil and invested largely in their neighbourhood. However, since 2003 Chinese FDI has grown nine times till 2009 and is essentially global in nature. China now seems the dominant source of FDI with India coming a close second. However, the destination of Chinese and Indian FDI is markedly different.

The detailed differences in the sectoral pattern of FDI from the BRICS is also obtained by looking at the major outward investing companies in these countries. This is shown below in Table 17. From table 17, we see different sectoral patterns of the FDI outflow from the each of BRICS countries. Although at the aggregate levels the FDI outflow from the developing countries is increasingly going towards the sectors like infrastructure and resource based sectors, there exist some high tech and service sectors which are attracting FDI flow from the developing countries in general and BRICS in particular (Gammeltoft, 2008).

Box 1. ***Most inflows went into services, but the sharpest rise in FDI was in natural resources.***

Services gained the most from the surge of FDI, particularly finance, telecommunications and real estate. (Since data on the sectoral distribution of FDI are limited, these observations are extrapolated from data relating to cross-border M&As, which accounted for a significant share of inflows.) The predominance of services in cross-border investments is not new. What *is* new is the further and sharp decline in the share of manufacturing and the steep rise of FDI into the primary sector, primarily the petroleum industry.

Source: World Investment Report 2006. FDI from Developing and Transition Economies: Implications for Development, UNCTAD.

Brazil's FDI outflow is concentrated in the offshore financial infrastructure and services and trade related transport services. Although its role in the primary and manufacturing activity is limited, the important recipient sectors in the primary and manufacturing industries are food, beverage, tobacco, petroleum, fuel production and metal industries. Russia's FDI specialises in the resource based sectors like oil and gas and metals. However, there are manufacturing sectors and the telecommunication industry to which Russia's FDI is now going. The sectoral composition of India's FDI is quite different with flows mainly to fertilizer, pesticides & seeds, drugs & pharmaceuticals industries in the manufacturing sector, and information technology (IT) and Business process Outsourcing (BPO) in the service sector. China's FDI outflow has concentrated on resource extraction in oil, gas and minerals although nowadays there is some outflow to the IT manufacturing in Asian countries and R & D activity in the developed countries. South Africa's FDI is concentrated mainly in the resource and financial sectors.

Table 17: Main outward investing and inward receiving industries by country

Country	Outward Investing Industries from BRICS	Major OFDI Firms from BRICS
Brazil	Energy, mining, services	Vale; Petrobras; Gerdau; Embraer; Votorantim; Camargo Correa; Odebrecht; Aracruz; Usiminas
China	Trade and services, manufacturing, resource extraction (oil, gas, minerals), IT	Shanghai Electric Industrial Company; Nanjing Automobile Group; Shanghai Baolong Industries; Danyang Dare Technology Group; Zhejiang Hongsheng Group; Suntech Power Holdings; Dalian Machine Tool Group; Sichuan Century Shuaghong Display Device Co. Ltd.; Harbin Measuring And Cutting Tools; Changsha Zhonglian Heavy Industry Tech. Development Co. Ltd.; Bejing Jingxi Heavy Industries
India	Pharmaceuticals, agricultural inputs, software, IT and broadcasting	Tata Steel; Hindalco (Aditya Birla);Ispat Industry; Ranbaxy Laboratories; Matrix Laboratories; Tata Chemicals; Reliance; Tata Motors; Bharat Forge; Mahindra and Mahindra; Tata Tea; United Spirit; Suzlon Energy; Videocon International; Wipro ltd; Sasken Communication Technologies Ltd; Videsh Sanchar Nigam Ltd.; Reliance Infocomm; Bharti Airtel; Oil and Natural Gas Corporation (ONGC); ONGC Videsh
Russian	Oil, gas, metal, manufacturing and telecommunication	Evraz; VTV Aerospace; NLMK Steel; Vimpelcom; Norilsk Metals; Interrors Energy; Rusal Construction; AirBridge
South Africa	Resource extraction and finance	Sappi Limited; Sasol Limited; MTN group; Anglo Gold; Naspers Limited; Barlowor Id; Nampak Limited;

Source: Gammeltoft (2008); Athukorala (2009); KPMG (2008); DGECFIN (2008); UNECA (2004).

In general it can be seen that FDI from Brazil, India and South Africa has been in the same areas as the major exports of these countries while Chinese and Russian FDI has been largely asset seeking. In general, the trends in FDI flows of BRICS countries seem to follow the general trend in FDI from developing countries summarized in Box 1.

IV.C. FDI Strategies

It is useful to see what strategies are followed by the BRICS countries in their planning of FDI outflows. The essential issue is the role of the state in financing/aiding outflows. There are three possible vehicles for undertaking FDI: public sector companies (PSUs), the transnational companies (TNCs) and the small manufacturing enterprises (SMEs). We see that for Brazil the foreign investors are the large TNCs and SMEs. Russia's FDI outflow is going through PSUs and the TNCs. But the SMEs play an important role in Russia's outward FDI in the CIS countries and the CEE countries. India's FDI outflow is via TNCs in the information technology enabled services (ITES), SMEs in pharmaceutical and entertainment industries and the PSUs in oil and natural gas exploration. China's FDI investors comprise manly the PSUs in resource and minerals explorations, TNCs in IT manufacturing and R& D and SMEs in the textile and small scale IT manufacturing. In SA, the TNCs plays the dominant role in outward FDI. Here the TNCs as well SMEs are concentrated in gold & precious metals, sugar, paper, furniture, cellular phone services, and plastic industries (Gammeltoft, 2008).

The general picture seems to be a mix of strategies involving PSUs, TNCSs and SMEs in outward FDI.

Box 2. ***There has been a significant increase in developing-country firms in the universe of transnational corporations.***

Transnational corporations (TNCs), most of them privately owned, undertake FDI. However, in some home countries (notably in the developing world) and in some industries (especially those related to natural resources) a number of major State-owned enterprises are also increasingly expanding abroad. According to estimates by UNCTAD, the universe of TNCs now spans some 77,000 parent companies with over 770,000 foreign affiliates. In 2005, these foreign affiliates generated an estimated $4.5 trillion in value added, employed some 62 million workers and exported goods and services valued at more than $4 trillion.

Total sales of TNCs from developing countries reached an estimated $1.9 trillion in 2005 and they employed some 6 million workers. In 2004, there were five companies from developing economies in the list of the top 100 TNCs, all with headquarters in Asia, three of them State-owned. These five companies – Hutchison Whampoa (Hong Kong, China), Petronas (Malaysia), Singtel (Singapore) Samsung Electronics (the Republic of Korea) and CITIC Group (China) – topped the list of the largest 100 TNCs from developing countries.

Source: World Investment Report 2006. FDI from Developing and Transition Economies: Implications for Development, UNCTAD.

In Box 2 we see that the role of TNCs from developing countries has been increasing on the global stage. However, not all these TNCs are large corporations and many are actually SMEs. The main point is that, with internationalisation of production, both large TNCs and SMEs are now integrated in the value chain. (see, for example, WIR, 2005*).* In this context the Chinese strategies are worth noting. It has been argued that Chinese outward FDI tends to be underestimated as it does not include state initiatives and SMEs which are induced by FDI by large corporations. This is particularly true for Chinese FDI in Africa (see, for example, Gammeltoft, op.cit.). Typically, infrastructure FDI is driven by the Chinese government on the basis of soft loans to Chinese companies. However, the Chinese government tends to link the availability of these loans to concessions by host countries in areas like oil and gas exploration which is

done by other Chinese companies. The SMEs run by Chinese vendors tend to follow in small manufacturing, retailing etc. The official figures on FDI do not capture the loan and induced FDI components.

We have already noted that one of the principal methods of international transmission of technology is FDI. From the above discussion it is clear that FDI outflows from BRICS countries have been related more to domestic input requirements (as in China) or export promotion (as in all the other countries). In particular, to the extent that trade and FDI are compliments, the broad trends in FDI outflows from the BRICS bloc indicates that these flows have contributed little to trade within the bloc. In the earlier section we have looked at the commodities where there exists some complimentarity/substitutability between countries of the bloc. Very broadly, these commodities belong to industries like **vegetable oils, chemicals, metals, plastics and pharmaceuticals.** From our earlier discussion it is clear that these are not the areas where FDI outflows from BRICS has concentrated. Yet, if technical collaboration is to promote trade within BRICS or of the countries of the bloc with the outside world, these are the areas where FDI should be clearly visible.

However, it may be noted that while the BRICS as a bloc is a recent phenomena, FDI flows noted above are part of a long term pattern. Our conclusion is largely based on observance of the historical pattern of FDI. It is possible that FDI flows may change in response to current trade patterns. Yet, it may be noted that trade has followed FDI rather than the other way around.

IV.D. Institutional Arrangements for Technology Collaboration

The data based analysis of FDI is largely concentrated on flows from large state/private companies. Much of this flows naturally as a consequence of existing trade flows. However, apart for technology arrangements that flow from intra firm transfers in TNCs there is also the issue of the institutional mechanism which either aids FDI or is a precondition of technology collaboration. Here, the state has an important role to play in enabling technology collaboration particularly in the context of SMEs,. In this section we will provide a brief overview of these arrangements within the BRICS bloc.

Typically, countries contract International Investment Agreements or Bilateral Investment Treaties (BITs) and Direct Tax Treaties (DTTs) with investing partners. BITs are largely concerned with creating the institutional arrangements governing FDI between the contracting parties. In particular, they are concerned with creating a level playing field for investors in partner countries, defining conditions for technology transfer and creating a dispute settlement mechanism. On the other hand, DTTs by and large create a preferential tax regime for FDI flows. The objective of both is to element any uncertainty among investors. Here it may be noted that following the TRIMS agreement in the WTO, BITS have become largely irrelevant and the treatment of foreign investment is largely governed by the stipulations of TRIMS. By and large, TRIMS requires that foreign investors get non-discriminatory treatment and this treatment should be no less favourable than for domestic investors. More specifically, investment agreements cannot be tied to trade promotion.

However, a look at the proliferation of BITs and DTTs indicates that developing countries have been moving towards a more favourable treatment of foreign investment. The WIR (2005) indicates that, at the end of 2004 the South-South BITs had a share of 25 percent of the total number of BITs signed in the world. It suggests that within the developing economies and economies in transition the cooperation in the field of foreign investment is gaining momentum. More recently many countries are building investment agreements into their regional trading arrangements (RTAs) in what are now being called WTO plus agreements.

In Table 18 below we list the DTT agreements in the BRICS bloc. As can be seen from the table, most of the countries of the region have some kind of DTT with other bloc countries but these agreements are not standardized nor are all countries included in the set of DTT for any country. Thus, for example, China has an Income and capital agreement with India and Brazil but only an Income agreement with Russia. Similarly, South Africa has an agreement only with China. Thus, if there is to be no clash of interests as between any bilateral group of countries in BRICS, it seems necessary to develop some model DTT which could be applicable to all bloc members.

Table 18: Total Bilateral Investment Treaties and Double Taxation Agreements Concluded, June, 2011

	BRICS		Number of BITs and DITs in Non-BRICS (excluding BRICS)	
Country	BITS	DTA	BITS (excluding BRICS)	DTA (excluding BRICS)
Brazil	-	China (I&C); India (I&C); Russia (I)	14	35
China	India; Russia; South Africa	Brazil (I&C); India (I&C); Russia (I); South Africa (T &I)	125	109
India	China; Russia	Brazil (I&C); India (I&C); Russia (I&C)	78	77
Russian	India; China; South Africa	Brazil (I); China (I); India (I&C)	66	65
South Africa	China; Russia	China (T&I)	44	65

Source: UNCTAD, Country Specific BITs and DTAs, 2011.
Note: Notation in Brackets refers the type of agreements;
Here, T&I: Transport and Income; I&C: Income and Capital; I: Income.

In recent years most developing countries have been contracting one or the other RTA with other developing countries. Typically, some of these RTAs have agreements on investment and services added to the usual agreement on trade in commodities. These are often called 'WTO plus' agreements. In Table 19 below we list the existence of implemented RTAs among two or more of the BRICS countries.

Table 19: Regional Trade Agreements among BRICS Countries

BRICS Members	Regional Trade Agreements	RTA Members from BRICS	Date of Signature	Date of Enforcement	Type of Agreement
Brazil	Global System of Trade Preferences among Developing Countries (GSTP)	India	13-Apr-88	19 April, 1989	Partial Scope Agreement
	MERCOSUR	India	25-Jan-04	1-Jun-09	Partial Scope Agreement
China	Asia Pacific Trade Agreement (APTA)	India	31-Jul-75	17-Jun-76	Partial Scope Agreement
India	Asia Pacific Trade Agreement (APTA)	China	31-Jul-75	17-Jun-76	Partial Scope Agreement
	Global System of Trade Preferences among Developing Countries (GSTP)	Brazil	13-Apr-88	19 April, 1989	Partial Scope Agreement
	MERCOSUR	Brazil	25-Jan-04	1-Jun-09	Partial Scope Agreement
	Southern African Customs Union (SACU)	South Africa	Under Negotiation		Partial Scope Agreement
Russia					
South Africa	Southern African Customs Union (SACU)	India	Under Negotiation		Partial Scope Agreement

Source: WTO, RTA Database.

Inspection of Table 19 indicates that only India and Brazil are linked via the RTA with the MERCOSUR group of countries. India is currently negotiating an RTA with SACU (where SA is the dominant member). However, the countries of BRICS are probably much more strongly linked by RTAs to other regional members. For example, China and India are only linked via the APTA which is really not a very effective RTA and involves a large number of countries. This may have some impact on trade promotion. This would require further detailed study beyond the scope of this study.

IV.E. Role of the Government in Technical Collaboration

It is now well recognized that for R&D in developing economies the state has an important role to play. This is also important in the area of trade where we have noted that SMEs play a pivotal role as part of the global value chain. This is clearly brought out in Table 20 below.

Table 20: Contribution by small and medium-sized enterprises in selected economies

Countries/ areas	SMEs' share in exports	SME share in total enterprises	SME share of total workforce
China	69.2	99.0	74.5
India	40.0	n.a.	n.a.
Russian	54.0*	97.6	60.9

Source: Asia Pacific Trade and Investment Report 2011, UN-ESCAP.
* Share of total sales revenue.

Inspection of Table 20 clearly indicates the crucial role that SMEs play in exports from developing countries and the BRICS bloc in particular. Actually, this is also true for some developed countries in Europe. SMEs also form a large part of the total number of enterprises engaged in trade. However, since these SMEs normally lack the financial muscle to undertake R&D it is important for the state to step in to create the enabling environment for such R&D.

A recent study by UNESCAP has listed the benefits that SMEs can obtain in being part of the global value chain (see, APTIR, 2011). Broadly these benefits fall in the category of backward linkages with suppliers, technology linkages and forward linkages with consumers via befits of brand name in areas like automobiles. Some of these benefits are clearly seen in the case of component manufacturers in the automobile suppliers which are important exporters in both India and South Africa. Here the role of the state is to create an enabling environment via training programmes and, in general, to promote these global value chains.

Apart from promotion of SMEs, developing country governments can play an important in promoting R&D in general. Generally, the share of GDP devoted to R&D in developing countries is low compared to developed countries. Thus, While Brazil invests around 1% of GDP in R&D activities, the US invests more than twice this figure. Many

analysts believe that this higher investment has significantly contributed to the current position of the US as a leader in technology development. In the US, research universities receive income from different sources, from funding and research grants to royalties and donations. Europe on the other hand presents a greater degree of heterogeneity in R&D expenditures. Although their average expenditure is close to 2% of the GDP, three countries (Germany, France and UK) account for around three quarters of total R&D investment. In India, the share of R&D in GDP is a little over one percent but almost all this comes from R&D expenditure by the government. Barring the pharma sector, very little R&D is currently being conducted in the private sector.

It is often not realized that 95 percent of inventions have developed out of research in universities. It is then the private sector that converts these inventions to innovations via market applications. In other words what is necessary is a National Innovation System (NIS) where such partnerships can be internalized. The current strengthening of university-industry partnerships are seen to be similar within BRIC (Brazil, Russia, India, China) countries (Uriona-Maldonado et. al., 2010). However, as the authors have argued, the Brazilian and Chinese governments are far ahead of the other countries in developing this partnership. What is still missing is an intra-BRICS institutional mechanism for promoting university-industry exchange between countries of the bloc. Lack of this mechanism may be reason why the countries of BRICS have lagged behind in technological innovation particularly in the context of their growing SME sector.

V. Conclusion.

The defining feature of trade in the last two decades or so has been the growth of south-south trade which has exceeded growth of world trade and trade between developed and developing countries. Among other country groupings the emergence of the BRICS bloc in recent years has certainly been a new development which merits some study. What is clear is that in the one and half decades there has been a phenomenal growth in intra BRICS trade. In a reflection of this growing importance of BRICS as a trading bloc, the recent BRICS Summit in Sanya (China) on 14th April 2011 concluded with the release of a joint document called the ‘Sanya Declaration’. In one sense the

Sanya Declaration was an expression of intent for the formation of a new developing country bloc. It was also a recognition of the growing trade ties between the countries of the bloc. Second, the Declaration also notes the need for technological cooperation.

However, while BRICS may be an important political bloc in various fora of the UN, it is not clear that it is a sustainable economic bloc. Similarly, it is not clear what form technological cooperation must take. In this study we have looked at economic aspects of the BRICS group on three issues. One, to what extent is growth of intra BRICS trade sustainable? Second, what is the substitutability and complimentarity in product trade and, third, what are the main issues in technological collaboration between BRICS countries.

On the issue of sustainability we have looked at the growth of intra BRICS trade in the period 1995-2007. The choice of this period was dictated by the fact that it was also the decade or so after the formation of the WTO and there were no major exogenous factors in world trade that could have biased our results in favour of intra BRICS trade. Our study shows that the expanded intra BRICS trade took place even while demand growth was still quite high in the developed world indicating that the trade was not driven by adverse demand contraction in the developed world as in the 1970s. However, our study also shows that this growing intra BRICS trade was accompanied by increasing asymmetry of intra bloc trade due to the over powering presence of China. This is not sustainable in the long run.

Another test of sustainability is done at the micro level. Here, at the 4-digit level of disaggregation we calculated the ratio of net intra BRICS trade to net BRICS trade with the rest of the world for each country of the bloc in those commodities which accounted for at least one percent of a county's intra BRICS exports in 2007. We looked at the changes over the period 2000-2007.We see that in almost all cases, the ratios have increased substantially indicating that members of the BRICS bloc are redirecting more and more of their reasonably competitive exports towards the bloc. For India some ratios are over 100 per cent indicating the increasing importance of BRICS trade relative to trade with the rest of the world. This is seen in commodities like **cotton**, **Ores of Iron, pellets of iron, alumina, zinc ores and other ores.**

However, one question is whether the trade in these commodities has been increasing over our reference period 2000-2007. We looked at those commodities where the share of the 4-digit commodity in the 2-digit commodity group has increased between 2000 and 2007 (increasingly important commodities) and those where this share has fallen over this period but where the commodity accounted for at least 10 percent of 2-digit intra BRICS trade (for each country) in 2007(important commodities). We define these as quantitatively important commodities. Here we see that there are very few quantitatively important commodities in intra BRICS exports. Much of intra BRICS trade seems to be in resource based commodities. However, as noted in the previous paragraph, it is in non-resource based commodities that future growth is most promising. It thus seems that the current structure of intra BRICS is likely to alter radically from the pattern of resource based commodity exports which drove intra BRICS trade in the period 1995-2007. In other words, it seems that intra BRICS trade is sustainable but not on the basis of trade in only resource based commodities.

This issue of sustainability involves some further consideration of the nature of intra BRICS trade particularly in terms of the technology content of the trade. To see this we classified intra BRICS trade by its technology content using the UNIDO definition. This gives further clarity to our previous conclusion. We see that in medium technology exports, the only quantitatively important products are **propylene polymers** (India) and **nitrogenous fertilizers** Quantitatively the importance of growing intra BRICS trade in LT, MT or HT products is insignificant,

The second issue analysed is the degree of complimentarity and substitutability in trade of the BRICS countries in third countries. This also allows us to comment on areas where technological cooperation is feasible. The general argument is that where countries compete is similar products in the same third country market technological cooperation may be difficult. Here we have used revealed comparative advantage (RCA) as a measure of complimentarity/substitutability. It turns out that there is little substitutability and hence competition between these countries as they are by and large exporting to different markets. The only competition seems to be for **Butanols** (**Chinese market**) where India and Brazil are competing, **Ammonia products** (in **Brazil**) where China and Russia

compete, **Ferrochromium (in China, Japan)** where India and SA compete and **Refined Copper** (in C**hina**) where India and Brazil compete and **other antibiotics** (in **Germany**) where India and China compete. Most of the above products fall in the MT or HT areas where technological cooperation is usually useful and desirable but which may not happen due to an element of competition in the same market. But apart from these, there are a large number of products belonging to various industries where there exists product complimentarity between countries. These are **Vegetable Oils** (for Brazil, China Russia), **Chemical Products** (for Brazil, India, Russia and SA), **Plastics** (for Brazil, China) and **Iron and Steel** (for all BRICS countries). Our notion of complimentarity is of each country possibly specializing in some stage of production in any given industry. There is also very little conflict here in technological collaboration with each country having a **distinct market segment**.

The third issue we have looked at relates to technological cooperation between the BRICS countries. We have looked at this from two points of view. One, the major source of technological transfer is foreign direct investment (FDI). In general, FDI by its very presence tends to lead to technology transfer and collaboration between countries. In addition, FDI is seen to promote trade given that much of trade today is in intermediate goods. Second, particularly important for developing countries is the role of institutions, particularly the government, in promoting FDI and technological transfer via the creation of enabling institutions.

Our analysis indicates that, **with the exception of China and Brazil, the pattern of FDI from BRICS countries has not been conducive to promoting intra bloc trade.** Barring China and Brazil, FDI outflows have largely been promoting regional trade. For India, in fact, FDI is still oriented towards the developed countries. Here the Chinese strategy is worth noting. *China tends to push infrastructure development in far off countries via loans which are then linked to preferential treatment to Chinese companies in specific sectors.* Subsequently, small scale Chinese traders are encouraged to step in to perform services like retail, small trade etc.

On the issue of institutional factors promoting FDI and trade we see that there has been **little progress in intra bloc level coordination in areas like double taxation**

agreements. However, the issue of bilateral investment agreements is probably not so relevant given the operation of the TRIMS agreement under the WTO. It is also seen that **there is very little cooperation among the BRICS countries via RTAs** where 'WTO plus' agreements are increasingly used to establish investment agreements.

One of the factors often ignored in looking at BRICS trade is the **dominance of small scale establishments (SSIs) in exports of the bloc countries.** Here, the role of the government in promoting global value chains is crucial given the low resource base of these firms. Finally, the role of the government in promoting technological development via **university-industry partnership is crucial** particularly in making new technologies available to the SSIs. Here, only Brazil and China have any developed systems. The **other countries need to develop such kind of interaction among different actors to strengthen the National Innovation Systems.** There is also **no institutional mechanism for intra BRCS coordination in technological partnerships.** Some such mechanism must be developed.

To conclude, **the observed growth in intra BRICS trade seems to be largely due to resource based trade which is not sustainable** for all the countries. It is not surprising that FDI flows from these countries have done little to promote intra bloc trade. However, **there seems to be growing trade in other areas where technological cooperation is feasible**. Here, the need is to establish institutional mechanisms like National Innovation Systems to promote intra BRICS FDI in these areas.

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Appendix 1

a) **Entropy of Bilateral Trade Symmetry**

The following entropy is a simple way of measuring trade symmetry of bilateral trade flows between two countries:

$$H_{ij} = -x_{ij}\ log_2\ x_{ij} - -x_{ji}\ log_2\ x_{ji}$$

Let $x_{ij}\ be$ the amount of exports from country i to country j, measured as fraction of the total trade between the two countries, so that

$$x_{ij} + x_{ji} = 1$$

H_{ij}takes a maximum of 1 when $x_{ij} = x_{ji} = 1/2$ and a minimum of zero when $x_{ij} = 1$ and $x_{ji} = 0$ or $x_{ij} = 0$ and $x_{ji} = 1$

Bilateral entropies H_{ij} can be computed for each 5_{C_2}=10 pairs of countries in our study.

b) The Criterion of Symmetry in Intra-BRICS Trade

Let P_{ij} be the exports from country i to country j in 1995, measured as a fraction of intra-BRICS trade in 1995; q_{ij} is the exports from country i to country j in 2007, measured as a fraction of intra-BRICS trade in 2007.

We have measured four types of criterion functions in our study:

1) $$\boldsymbol{I_0} = \sum_i \sum_j P_{ij}\ \boldsymbol{log} \frac{P_{ij}}{(P_{ij}+P_{ji})/2}$$

Intra-BRICS trade becomes symmetry when $\boldsymbol{I_0}$takes value 0, i.e. $P_{ij} = P_{ji}$for all i and j and i not equal to j. As the value of $\boldsymbol{I_0}$increases then the intra-BRICS trade asymmetry increases.

2) $\boldsymbol{I_1 = \sum_i \sum_j q_{ij} \, log \frac{q_{ij}}{P_{ij}}}$

Here the criterion of symmetry means all countries should maintain the intra-BRICS exports share in 2007 with respect to its intra-BRICS exports share 1995.In other words, the 2007 intra-BRICS trade shares (q_{ij}) are predicted by the 1995 intra-BRICS trade shares (P_{ij}) without any modification or no-change extrapolation.

3) $\boldsymbol{I_2 = \sum_i \sum_j \widehat{q_{ij}} \, log \frac{\widehat{q_{ij}}}{P_{ij}}}$

Here the criterion of symmetry is the all countries should maintain the intra-BRICS expected exports share ($\widehat{q_{ij}}$) in 2007 with respect to its actual intra-BRICS exports share (P_{ij})in 1995. In the language of information theory, the expected information of the message that transforms theP_{ij}'s as "prior probabilities" into the $\widehat{q_{ij}}$'s as "posterior probabilities".

4) $\boldsymbol{I_3 = \sum_i \sum_j \mu_{ij} \, log \frac{\mu_{ij}}{(\mu_{ij}+\mu_{ji})/2}}$

Where, $\mu_i = \frac{1}{2}(P_{i.} + P_{.i})$

Here the criterion of symmetry means all countries should maintain the intra-BRICS trade balances. This criterion function shows how the symmetry changes when we apply a biproportional adjustment to the trade matrix so as to eliminate the discrepancy between each country's total export and total imports.

Appendix 2

Trends in Intra BRICS and World Net Export between 2000 and 2007

		2000			2007		
Economy	Product Code(1% or greater)	Net Intra BRICS Export (X-M)	Net World Export (X-M)	Percentage of Intra to World Net Export	Net Intra BRICS Export (X-M)	Net World Export (X-M)	Percentage of Intra to World Net Export
Net intra BRICS and World from Brazil	1212	65.3	716.7	9.1	403.6	2047.5	19.7
	2222	337.4	2055.2	16.4	2867.8	6679.8	42.9
	2515	55.7	1334.9	4.2	386.9	2746.2	14.1
	2815	176.0	1852.2	9.5	3124.1	7114.1	43.9
	2816	121.7	1194.6	10.2	641.1	3443.8	18.6
	2831	0.0	-257.7	0.0	311.4	-45.4	-685.9
	3330	36.1	-3031.3	-1.2	839.9	-3070.7	-27.4
	4211	87.3	324.3	26.9	585.6	1676.6	34.9
	6114	35.8	588.5	6.1	530.3	2052.4	25.8
	6715	-4.4	404.1	-1.1	161.3	1200.3	13.4
	6821	-0.1	-287.8	0.0	199.4	-957.7	-20.8
	7832	0.9	67.4	1.3	241.2	944.8	25.5
	7843	30.3	-369.7	-8.2	133.7	-509.8	-26.2
Net intra BRICS and World from China	3250	224.0	916.5	24.4	742.4	3057.4	24.3
	5413	74.2	380.6	19.5	722.9	1780.5	40.6
	6732	0.0	0.0	0.0	797.8	6436.9	12.4
	7522	1.0	257.1	0.4	962.9	65915.6	1.5
	7611	37.3	1059.1	3.5	866.3	17664.5	4.9
	7638	24.6	2775.5	0.9	780.0	18325.4	4.3
	7641	30.7	461.6	6.7	820.6	5808.2	14.1
	7643	6.7	1137.7	0.6	3110.7	34349.2	9.1
	7649	86.8	-1496.2	-5.8	1815.0	21879.1	8.3
	7758	42.5	2283.6	1.9	726.4	9914.6	7.3
	7821	0.2	-44.0	-0.5	856.1	1920.1	44.6
	8432	43.7	1161.8	3.8	1379.5	7612.8	18.1
	8442	58.0	1681.9	3.4	1906.2	11102.9	17.2
	8453	74.5	4359.5	1.7	1912.4	15706.7	12.2
	8454	38.5	2244.5	1.7	857.9	8389.6	10.2
	8514	188.2	3065.1	6.1	1253.1	6944.7	18.0

Net intra BRICS and World from India	2631	-50.0	-318.7	15.7	856.6	784.0	109.3
	2731	46.8	216.5	21.6	235.3	481.7	48.8
	2815	94.1	327.8	28.7	3912.1	488.0	801.7
	2816	15.2	12.2	124.6	203.1	3.9	5207.7
	2852	20.0	41.2	48.5	165.6	93.7	176.7
	2875	0.0	-11.5	0.0	279.5	180.8	154.6
	2879	22.7	35.6	63.8	240.3	43.8	548.6
	5112	-5.2	-217.4	2.4	166.5	1132.9	14.7
	5429	90.6	522.3	17.3	311.5	2062.1	15.1
	5751	16.1	63.7	25.3	168.4	366.6	45.9
	6715	-24.9	50.8	-49.0	16.6	554.8	3.0
	6821	11.1	31.5	35.2	386.6	1253.9	30.8
Net intra BRICS and World from Russia	2321	62.0	268.0	23.1	236.9	1215.1	19.5
	2474	287.4	1082.2	26.6	1978.8	3144.5	62.9
	2475	40.7	248.9	16.4	466.8	987.9	47.3
	2482	11.0	704.6	1.6	210.1	3163.0	6.6
	2515	160.6	363.9	44.1	362.7	599.2	60.5
	3330	262.9	23031.0	1.1	5649.3	113614.0	5.0
	5121	40.9	167.2	24.5	210.3	721.2	29.2
	5156	117.6	187.8	62.6	215.7	432.2	49.9
	5621	114.6	531.5	21.6	494.6	1965.8	25.2
	5623	288.4	405.9	71.1	1168.7	1679.7	69.6
	5629	137.0	639.0	21.4	544.1	2030.7	26.8
	6726	255.0	1472.3	17.3	300.6	5011.3	6.0
	6751	60.9	169.4	36.0	459.6	1237.8	37.1
	7144	59.3	151.0	39.3	599.4	858.0	69.9
	7648	20.9	31.1	67.2	199.4	181.3	110.0
Net intra BRICS and World from South Africa	2513	45.9	360.8	12.7	83.4	402.3	20.7
	2681	4.4	32.3	13.6	69.2	145.6	47.5
	2816	105.3	324.6	32.4	518.8	1515.6	34.2
	2831	0.0	0.7	0.0	121.1	170.4	71.1
	2877	1.7	144.4	1.2	215.8	409.5	52.7
	2879	2.2	98.8	2.2	444.3	656.6	67.7
	2882	10.5	69.3	15.2	120.7	504.9	23.9
	3212	103.2	1247.2	8.3	452.4	3125.6	14.5
	3330	0.0	-3453.7	0.0	786.1	-9077.8	-8.7
	5223	106.5	118.4	89.9	192.2	226.9	84.7

	6715	40.4	986.7	4.1	554.4	2684.4	20.7
	6753	10.6	390.6	2.7	188.1	898.8	20.9
	6755	2.3	21.8	10.6	124.2	592.3	21.0
	6841	0.7	709.7	0.1	148.4	1588.9	9.3
	6842	11.6	76.7	15.1	26.7	451.2	5.9

Source: WITS.

Appendix 3

Measuring product sophistication in industry

In the past, the OECD used to use technology classification based on ISIC Rev. 2 industry classifications. The methodology uses three indicators of technology intensity reflecting, to different degrees, "technology-producer" and "technology-user" aspects: *i)* R&D expenditures divided by value added; *ii)* R&D expenditures divided by production; and *iii)* R&D expenditures plus technology embodied in intermediate and investment goods divided by production. From 2003 onwards the OECD made the new technological classification of manufacturing industries based on ISIC Rev. 3 into high-technology, medium-high-technology, medium-low-technology and low-technology groups was made after ranking the industries according to their average over 1991-99 against aggregate OECD R&D intensities. Industries classified to higher categories have a higher average intensity for both indicators than industries in lower categories.

As our analysis in this report is based on the industry classification based on the SITC Rev 3 we have used the UNIDO definition of industries which is classified on the basis of SITC Rev.3.

UNIDO (2009) introduced a new measure of the degree of sophistication of a manufacturing activity or product, P-soph is as follows:

If a product's P-soph index is high, it indicates that it is produced primarily by high-income countries. A lower value indicates that low-income countries are more intensively engaged in production in the sector. More precisely, P-soph is the weighted average of GDP per capita of all countries producing the good, where the weights are the "production intensities" of the sector in each country (normalized to 1). Production intensity is measured by the ratio of the value-added share of the sector in a country's total manufacturing relative to the sector's value-added share in world manufacturing. This approach is analogous to the use of revealed comparative advantage by Hausmann, Hwang and Rodrik (2007).

Correspondingly, the final technological categorisation of industries on the basis

of SITC Rev 3 at the 3-disit level is given below:

1) **Resource-based:**

016, 017, 023, 024, 035, 037, 046, 047, 048, 056, 058, 059, 061, 062, 073, 098, 111, 112, 122, 232, 247, 248, 251, 264, 265, 281, 282, 283, 284, 285, 286, 287, 288, 289, 322, 334, 335, 342, 344, 345, 411, 421, 422, 431, 511, 514, 515, 516, 522, 523, 524, 531, 532, 551, 592, 621, 625, 629,

633, 634, 635, 641, 661, 662, 663, 664, 667,689

2) **Low-technology:**

611, 612, 613, 642, 651, 652, 654, 655, 656, 657, 658, 659, 665, 666, 673, 674, 675, 676, 677, 679, 691, 692, 693, 694, 695, 696, 697, 699, 821, 831, 841, 842, 843, 844, 845, 846, 848, 851, 893, 894, 895, 897, 898, 899

3) **Medium-technology:**

266, 267, 512, 513, 533, 553, 554, 562, 571, 572, 573, 574, 575, 579, 581, 582, 583, 591, 593, 597, 598, 653, 671, 672, 678, 711, 712,713, 714, 721, 722, 723, 724, 725, 726, 727, 728, 731, 733, 735, 737, 741, 742, 743, 744, 745, 746, 747, 748, 749, 761, 762, 763, 772, 773, 775, 778, 781, 782, 783, 784, 785, 786, 791, 793, 811, 812, 813, 872, 873, 882, 884, 885

4) **High-technology:**

525, 541, 542, 716, 718, 751, 752, 759, 764, 771, 774, 776, 792, 871, 874, 881, 891

Appendix 4

Exports Based on UNIDO Technology Definition of Commodities for 2000

Brazil 2000		
	Product Code	% Share in Brazil's Total Intra-BRICS Exports
Resource Based Exports	0122	1.5
	0123	1.6
	0611	14.3
	0612	1.2
	0713	1.7
	1212	3.2
	2222	16.6
	2484	1.2
	2515	2.7
	2815	8.7
	2816	6
	3330	1.8
	4211	4.3
	Share of Resource Based Exports	64.8
Low Tech Exports	6114	1.9
	Share of LT exports	1.9
Medium Tech Exports	5711	1
	7812	2.8
	7843	1.6
	Share of MT	5.4
High Tech Exports	7923	1.8
	Share of HT exports	1.8
China 2000		
	Product Code	% Share in China's Total Intra-BRICS Exports
Resource Based Exports	423	1.0
	2613	2.0
	5157	1.0
	Share of Resource Based Exports	4.0
Low Tech Exports	8411	1.3
	8414	1.0

	8415	1.0
	8442	1.0
	8453	1.3
	8458	1.0
	8481	7.2
	8512	1.6
	8513	2.0
	8514	3.1
	8942	1.0
	Share of LT exports	21.4
Medium Tech Exports	3250	3.7
	7782	1.3
	Share of MT	5.0
High Tech Exports	5413	1.4
	7526	2.5
	7649	1.5
	Share of HT exports	5.4
India 2000		
	Product Codes	% Share in India's Total Intra-BRICS Exports
Resource Based Exports	0342	3.6
	0361	1.4
	0423	1.2
	0713	2.6
	0741	5.4
	0813	1.1
	1211	1.3
	2731	2.3
	2815	4.5
	2852	1.1
	2879	1.2
	4225	1.6
	5169	2.3
	Share of Resource Based Exports	29.5
Low Tech Exports	6513	5.6
	6522	1.1
	8415	1.8

	8424	1.9
	8427	1.9
	8442	1.1
	8453	1.3
	8454	3.0
	Share of LT exports	17.3
High Tech Exports	5421	1.2
	5429	4.4
	Share of HT exports	5.5
Russia 2000		
	Product Codes	% Share in Russia's Total Intra-BRICS Exports
Resource Based Exports	2474	4.3
	2515	2.4
	3330	4.0
	5156	1.8
	6841	7.3
	6411	1.2
	Share of Resource Based Exports	21.0
Medium Tech Exports	5621	1.7
	5623	4.4
	5629	2.1
	5711	1.3
	5731	2.1
	6726	3.9
	6727	3.2
	7932	7.9
	Share of MT	26.6
High Tech Exports	7921	1.1
	7929	1.0
	8911	2.0
	8912	2.7
	Share of HT exports	6.8
South Africa 2000		
	Product Codes	% Share in SA's Total Intra-BRICS Exports

Resource Based Exports	2513	4.9
	2687	1.0
	2816	11.2
	2878	1.1
	2882	1.1
	3212	11.2
	5162	1.5
	5223	11.5
	5236	1.3
	Share of Resource Based Exports	44.8
Low Tech Exports	6516	1.3
	6753	1.1
	Share of LT exports	2.4
Medium Tech Exports	5913	2.2
	6715	5.1
	6832	1.6
	6842	1.4
	7436	2.3
	5121	1.1
	Share of MT exports	13.7

Source: WITS.

Appendix 5

Exports Based on UNIDO Technology Definition of Commodities for 2007

Brazil 2007				
	Product Code	% Share in Brazil's Total Intra-BRICS Exports	4 digits Increasingly Important	4 digits important commodities
Resource Based Exports	0112	5.6		
	0122	3.9		
	0123	2.8		
	0611	6.1		
	0612	1.1		
	1212	2.4		
	2222	16.7		2222
	2515	2.3		
	2815	18.2	2815	
	2816	3.7		2816
	2831	1.8		
	3332	4.9		
	4211	3.4	4211	
	5112			5112
	5113		5113	
	5146		5146	
	5156		5156	
	Share of Resource Based Exports	**72.7**		
Low Tech Exports	6114	3.1		
	Share of LT exports	3.1		
Medium Tech Exports	5121		5121	
	5711			5711
	5751		5751	
	6715	1.5		
	6821	1.2		
	7832	1.4		
	7843	1.2		
	Share of MT exports	**5.2**		
China 2007				

	Product Code	% Share in China's Total Intra-BRICS Exports	4 digits Increasingly Important	4 digits important commodities
Resource Based Exports	2772		2772	
	2782		2782	
	2929		2929	
	2613			2613
	2723			2723
	2919			2919
	4113			4113
	4213		4213	
	4218		4218	
	4229			4229
	4311		4311	
	4313			4313
	5157		5157	
	Share of Resource Based Exports			
	6732	1.1		
Low Tech Based Exports	8432	1.9		
	8442	2.7		
	8453	2.7		
	8454	1.2		
	8514	1.8		
	Share of Low Tech	11.4		
	3250	1.1		
	5621			5621
Medium Based Exports	5629		5629	
	5731		5731	
	5743		5743	
	7611	1.2		
	7638	1.1		
	7758	1.0		
	7821	1.2		
	Share of Medium Based Exports	5.6		
High Tech	5413	1.1		
	7522	1.4		
	7641	1.2		

Exports	7643	4.4		
	7649	2.4		
	Share of High Tech Exports	10.5		
India 2007				
	Product Code	% Share in India's Total Intra-BRICS Exports	4 digits Increasingly Important	4 digits important commodities
Resource Based exports	2631	5.9	2631	
	2731	1.6		
	2814		2814	
	2815	27.1		
	2816	1.4		
	2852	1.3		
	2875	1.9		
	2879	1.7		
	4225			4225
	5112	1.7	5112	
	5169			5169
	Share of Resource Based Exports	42.7		
Medium Tech Exports	5123		5123	
	5711		5711	
	5751	1.2	5751	
	6715	1.2		
	6821	2.8		
	Share of Medium Based Exports	5.2		
High Tech Exports	5413			5413
	5421		5421	
	5429	2.2		5429
	Share of High Tech Exports	2.2		
Russia 2007				
	Product Code	% Share in Russia's Total Intra-BRICS Exports	4 digits Increasingly Important	4 digits important commodities
Resource Based	412	1.7		
	2321	1.3		

Exports	2482	1.1		
	2474	10.2		2474
	2475	2.4	2475	
	2513		2513	
	2514			2514
	2515	1.9		
	2815		2815	
	2874			2874
	3330	29.2		
	4215			4215
	5148		5148	
	5156	1.2		
	5157			5157
	Share of Resource Based	48.9		
	5121	1.1		
Medium Tech Exports	5123			5123
	5124			5124
	5621	2.6		5621
	5623	6.0		
	5629	2.8		5629
	6726	1.6		
	6751	2.4		
	7144	3.1		
	Share of Medium High Export	19.5		
High Tech Exports	7648	1.1		
	Share of High Tech Exports	1.1		
South Africa 2007				
	Product Codes	% Share in SA's Total Intra-BRICS Exports	4 digits Increasingly Important	4 digits important commodities
Resource Based exports	2513	1.4		
	2681	1.1		
	2816	8.9	2816	
	2831	1.9		
	2877	3.5	2877	
	2879	7.2	2879	

	2882	1.9		
	3212	7.3		
	3330	19.7		
	4111			4111
	5111		5111	
	5157		5157	
	5162			5162
	6841	2.5		
	5223	3.2		5223
	Share of Resource Based	58.8		
Low Technology Exports	6753	3.2		
	6755	2.2		
	Low Tech Export	5.4		
Medium Technology Export	5121		5121	
	6715	9.4		
	6842	1.1		
	Medium Tech Exports	10.4		

Source: WITS.

Appendix 6

The rationale for using a variant of RCA index of Balassa (1965) is to eliminate the large values of RCA appearing merely because of country size. Thus a large country's exports of any commodity may be a small part of its own exports but may constitute a large part of world exports of that commodity because that commodity is not important in world trade. At an extreme a country 's RCA should show numbers infinitely high if that country is the only exporter of that product. This is allowed for the variant of the Balassa indes shown below. Since this country is the only exporter of that commodity the issue of substitutability and competition in world markets is irrelevant. To identify this bias we have also used a variant of Balassa's index given below.

Balassa's RCA Indices:

$$RCA_j^i = \frac{X_j^i / X^i}{X_j^W / X^W}$$

Variant of RCA index of Balassa can be defined as :

$$RCA_j^i = \frac{X_j^i / X^i}{X_j^{ROW} / X^{ROW}}$$

Where i is a country in BRICS, j is the commodity, X is exports, W and ROW stand for world and the rest of world respectively. Here ROW implies the world excluding BRICS. Hence, use of the second index (as we have done) indicates that exceptionally high RCAs may be due to the fact that the country is the only exporter of that commodity. Essentially, we are simply eliminating double counting of a country in both the numerator and the denominator of the index. We have calculated both variants of the RCA shown above.

Appendix 7:

Product-Wise Revealed Comparative Advantage across BRICS, 2007

Product Codes	Product Name	Brazil	China	India	Russia	SA
Resource Based						
4218	Sesame (Sesamum) oil and its fractions		yes*			
4225	Castor oil and its fractions			Yes***		
4311	Fats and oils and their fractions, animal or vegetable, boiled, oxidized,					
41112	Fats and oils and their fractions, of fish, other than liver oils					
41135	Wool grease (other than crude) and fatty substances derived from wool gre		yes*			
42111	Soya bean oil, crude, whether or not degummed	yes*				
42119	Soya bean oil, refined, and its fractions	yes**				
42139	Groundnut oil, refined, and its fractions		yes*			
42151	Sunflower seed or safflower oil, crude				yes*	
42159	Sunflower seed or safflower oil, refined, and fractions thereof				yes*	
42299	Fixed vegetable fats and oils, crude, refined or fractionated, n.e.s.					
43131	Fatty acids; acid oils from refining					
51119	Acyclic hydrocarbons, n.e.s.					yes**
51122	Benzene, pure	yes*				
51124	Xylenes, pure	yes*		yes*		
51133	Tetrachloroethylene (perchloroethylene)	yes*				
51135	1,2-Dichloroethane (ethylene dichloride)	yes*				
51464	Lysine and its esters; salts thereof; glutamic acid and its salts	yes*				
51467	Amino-alcohol-phenols, amino-acid-phenols and other amino-compounds with	yes*				
51483	Acrylonitrile				yes*	
51561	Lactams				yes*	
51576	Heterocyclic compounds containing					

	a pyrimidine ring					
51577	Other heterocyclic compounds with nitrogen hetero-atom(s) only					
51579	Heterocyclic compounds, n.e.s.					
51623	Acetone					yes*
51624	Butanone (ethyl methyl ketone)					yes**
51625	Other acyclic ketones without other oxygen function					yes*
51699	Other organic compounds			Yes***		
52234	Diphosphorus pentaoxide; phosphoric acid and polyphosphoric acids					yes*
68411	Aluminium, not alloyed					yes*
Low Tech Exports						
8453	Jerseys, pullovers, cardigans, waistcoats and similar articles, knitted o		yes*			
8454	T-shirts, singlets and other vests, knitted or crocheted		yes*			
61141	Other bovine and equine leather, without hair on, tanned	yes*				
61142	Other bovine and equine leather, without hair on, parchment-dressed	yes*				
67321	Flat-rld prod. of iron or n/a steel, not 673.11, w>600mm,th>4.75mm		yes*			
67324	Flat-rld prod. of iron or n/a steel, not coated, hotrld,w>600mm,th>4.75mm		yes*			
67531	Flat-rld prod. of stnls steel, hotrld, of a width of 600 mm or more and					yes*
67532	Flat-rld prod. of stnls steel, hotrld, of a width of 600 mm or more and					yes**
67534	Flat-rld prod. of stnls steel, hotrld, of a width of 600 mm or more and					yes*
67552	Flat-rld prod. of stnls steel, coldrld,w>600mm,3<th<4.75mm					yes*
67553	Flat-rld prod. of stnls steel, coldrld,w>600mm,1<th<3mm					yes*
67554	Flat-rld prod. of stnls steel, coldrld,w>600mm,0.5<th<1mm					yes*
84324	Trousers, bib and brace overalls, breeches and shorts, men's or boys', of		yes*			
84426	Trousers, bib and brace overalls, breeches and shorts, women's or		yes*			

	girls',					
85148	Footwear, n.e.s., with uppers of leather or composition leather and outer		yes*			
Medium Tech Export						
7611	Television receivers, colour (including video monitors and video projecto		yes*			
7832	Road tractors for semi-trailers	yes*				
51211	Methanol (methyl alcohol)				yes*	
51213	Butanols				yes*	yes*
51215	Undenatured ethyl alcohol of an alcoholic strength by volume of 80% or hi	yes**				
51217	Fatty alcohols, industrial					yes**
51231	Cyclanic, cyclenic or cycloterpenic alcohols and their halogenated, sulph			yes*		
51235	Aromatic cyclic alcohols and their halogenated, sulphonated, nitrated or					
51241	Phenol (hydroxybenzene), pure, and its salts					
51243	Other phenols and phenol-alcohols				yes*	
56211	Ammonium nitrate, whether or not in aqueous solution				yes*	
56216	Urea, whether or not in aqueous solution		yes*		yes*	
56231	Potassium chloride				yes*	
56291	Fertilizers, n.e.s., containing the three fertilizing elements nitrogen,				yes*	
56293	Diammonium hydrogenorthophosphate (diammonium phosphate)		yes*		yes*	
56294	Ammonium dihydrogenorthophosphate (monoammonium phosphate) and mixtures t		yes*		yes*	
57111	Polyethylene having a specific gravity of less than 0.94	yes*				
57112	Polyethylene having a specific gravity of 0.94 or more	yes*				
57311	Polyvinyl chloride, not mixed with any other substances					
57431	Polycarbonates		yes*			

57433	Polyethylene terephthalate		yes*			
57511	Polypropylene	yes*		yes*		
57513	Propylene copolymers					
67152	Ferrosilico-manganese			yes*		
67153	Ferrochromium			yes*		Yes***
67159	Ferro-alloys, n.e.s.	yes*				
67261	Semi-fin. prod. of iron or n/a steel< 0.25% of carbon, spec. rectangular				yes*	
67262	Semi-fin. prod. of iron or n/a steel< 0.25% of carbon, other rectangular				yes*	
67511	Flat-rld prod. of silicon-electrical steel, width > 600 mm				yes*	
68212	Refined copper	yes*		yes*		
68423	Aluminium plates, sheets and strip, of a thickness exceeding 0.2 mm					yes*
71441	Turbojets				yes*	
76381	Video-recording or reproducing apparatus, whether or not incorporating a		yes*			
77586	Microwave ovens; other ovens; cookers, cooking plates, boiling rings, gri		yes*			
77587	Electrothermic domestic appliances, n.e.s.		yes*			
78219	Motor vehicles for the transport of goods, n.e.s.					
78439	Other parts and accessories of the motor vehicles of groups 722, 781, 782					
High Tech Export						
7522	Digital automatic data processing machines, containing in the same housin		yes*			
54131	Penicillins and their derivatives with a penicillanic acid structure; sal		yes*	yes*		
54139	Other antibiotics		yes*	yes*		
54213	Medicaments containing penicillins or derivatives thereof, with a penicil					
54219	Medicaments containing other antibiotics, put up in measured doses or in		yes*			
54293	Medicaments, n.e.s., put up in measured doses or in forms or packings for					

76411	Telephone sets		yes*			
76417	Other apparatus, for carrier-current line systems		yes*			
76432	Transmission apparatus incorporating reception apparatus		yes*			
76483	Radar apparatus, radio navigational aid apparatus and radio remote contro					
76491	Parts and accessories suitable for use solely or principally with apparat					
76493	Parts and accessories suitable for use solely or principally with the app		Yes***			

Note: * RCA value lies between 1 and 20; ** RCA value falls between 20 and 40 and ***RCA value lies above 40.