

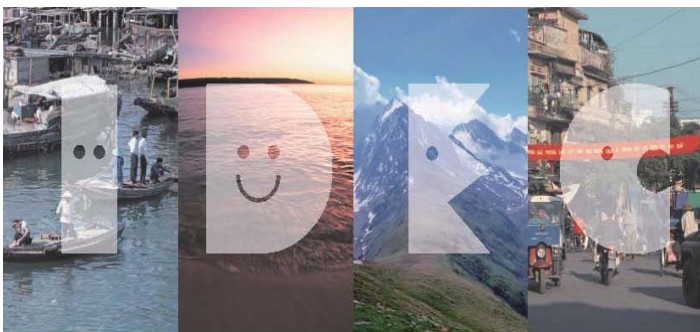
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Structural change, labor productivity growth, and convergence of BRIC countries

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Abstract

In this study, we seek to understand the patterns of structural change, labor productivity growth and convergence in BRIC countries. In the first part, we employ the dataset of labor productivity from de Vries et al. (2012) and the Groningen Growth and Development Center (2013) and utilize the shift and share analysis to investigate the contribution of within shift, static shift and dynamic shift effects on growth of labor productivity. In the second part, we use the convergence tests to check for the cross-country convergence in each economic sector. Our aggregate shift-share decomposition results report that labor productivity growth within sector itself is the main source of aggregate growth, while an effect of labor movement exists (shift effect) but not substantial. Among BRIC, we found that, during 1980-2008, China had the highest rate of labor productivity growth, following by India, Russia, and Brazil, respectively. The results of the convergence analysis show that service sectors in BRICs have faster catching-up rates than industrial sectors, and there is no convergence in agriculture. Among service sectors, financial, insurance, and real estate sector has highest speed of convergence. The BRICs results are then used to compare with the four OECD countries' results. It is found that in OECD countries, the sectors that converge fastest are mining and finance, insurance, and real estate. Nevertheless, the magnitudes of speed of convergence in OECDs are not comparable to BRICs. This confirms the growth theory in that less developed countries converge faster than developed nations. In sum, our findings imply that service sectors are the driving force of economic growth and economic convergence in BRICs.

Key words: Structural change, shift-share analysis, sectoral convergence, BRICs.

JEL Classification: C80, N10, O10, O11, O41, O47

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1. Introduction

It is widely accepted that labor productivity growth and structural change are connected issues. In the development economic literature, structural change is regarded as a necessary condition for a nation to attain high growth as labor moves from less productive sectors to higher productive sectors. As many countries have experienced a similar pattern of structural change, some economists claim that there might be a certain style of it. One of the most recognizable patterns of structural change occurred in most developed countries (such as Europe, Japan, and the U.S) is the shift of labor and capital from primary sector, to manufacturing, and then to service sector (Denison, 1967; Maddison, 1987; Jorgenson and Timmer, 2011; de Vries et al, 2012). According to literature, there are at least two channels through which structural change occurs. The first channel is that the labor productivity growth of manufacturing and service sectors induce the increase of wages in those sectors and attract the labor from the less productive agrarian sector (Lewis, 1954). The second channel is through the changes of domestic demand and international trade. These two are also the main factors that induce the reallocation of labor, capital and intermediate inputs between firms, sectors, and countries (de Vries et al., 2012). In the current world of globalization, most developing countries adopt liberalization policies in the hope that they could industrialized their economies and achieve high growth as advanced countries and the newly industrialized economies (NIEs) have had. Nevertheless, the introduction of more liberal policies, such as promoting exports to earn foreign currencies and encouraging foreign investment to accumulate capital and acquire more advanced technologies, could induce unprecedented pattern of structural change in some developing economies. Whether the current patterns of structural change in developing countries is similar to the conventional pattern or not would be an interesting issue to explore.

Another issue that is closely related to the study of labor productivity growth is the labor productivity convergence. Since the emergence of Solow's (1965) and Swan's (1965) growth theory, economic convergence (or catching-up effect) has been one of the most discussed, examined and tested issues in the circle of economic growth literature. The convergence is the hypothesis that the poorer countries will tend to grow faster than the rich nations due to the lower rate of diminishing returns and that poor nations can replicate the production methods, technologies, and institution of developed countries. Initially, most studies worked in this field emphasized only on the aggregate level or the convergence of income per capita. It was not until 1990s that some growth economists questioned the possibility of convergence of labor productivity in the sectoral level and tested whether there is actually the convergence effect in sectoral level. Bernard and Jones (1996a, 1996b) were prominent in this sectoral study of convergence. Bernard and Jones (1996a) employed the cross-section analysis and used the data of OECD countries. They found that not all sectors converged. The non-converged sectors

included agricultural, mining, and manufacturing sectors. In parallel, in their separated study, Bernard and Jones (1996b) employed a dynamic panel data analysis; they found that had a diverging trend. Other studies in this vein gradually emerged (see, for example, Gouyette and Perelman, 1997; Hansson and Henrekson, 1997; and Boussemart et al, 2006). Although their findings were mixed due to different estimation methods, they found that most sectors did converge.

In this paper, we bring together the issues of structural change, labor productivity growth, and labor productivity convergence. We choose to analyze the cases of Brazil, Russia, India, and China (hereafter BRICs, or BRIC countries), due to the data availability, their economic sizes, the relatively similar pattern of economic development, and their prospect of becoming global economic leaders in the near future. Thus, we attempt to explore and elaborate the pattern of structural change that induces growth of BRIC countries, and seek to know whether there is a uniform pattern of structural change that spurs growth among these large countries. This paper is organized as follow: in the first section, we discuss the overview of structural change, labor productivity, and convergence. In sector 2, we provide an overview of BRICs' economies and labor productivity. In sector 3, a brief discussion of methodology and data is provided. Section 4 demonstrates the method and the results of the labor productivity decomposition. In section 5, we provide the empirical tests of labor productivity convergence using a convergence model. And, in the last section, the conclusion and interpretation are discussed.

2. Overview of the BRICs' economic transformation

The acronym BRICs was coined by Jim O'Neill in 2001 to put together Brazil, Russia, India, and China who are deemed to be at the similar stage of development, have similar growth pattern, and have potential to be the world's key economic players in the future, due to their large population, land areas, and economic sizes (de Vries et al., 2012). Recently BRIC countries have had impressive growth and are among the top ten economies in the world. Putting together, their land areas account for over 25% of the world's land coverage, their population encompasses about 40% of the world's population, and their production was a quarter of the world's total production by the end of 2010. In the book "*Dreaming with BRICs: The Path to 2050*" published by Goldman Sachs (2003), it is predicted that China and India will become the world's leaders in supplying manufactured goods and services, while Brazil and Russia will be dominant in supplying raw materials (Goldman Sachs, 2003). Given the size of the economies, the economic potential, and the current tremendous growth, speculation and hypothesis that BRICs would be dominant in the global market and take over the advanced countries in the near future seem to be promising. At least, by 2012, China already proved to take over Japan to become the second largest economy in the world. This is a significant

phenomenon to which most economists and policy makers paid attention. Nevertheless, although with the recent success of BRICs, it is worth questioning whether all BRIC members could sustain their economic growth in the long run, given their different backgrounds in economic policies, regimes, political, institutions, and the recent trends of labor productivities. In this section, we briefly discuss these backgrounds and the future prospect of BRICs' economies and their labor productivities, before moving to the detailed analyses of the labor productivity growth.

Table 1: Key macroeconomic indicators of BRIC

	GDP growth (%)	Investment over GDP (%)	Export over GDP (%)	Labor productivity (US\$ per worker)
Brazil				
1960-1979	7.26	21.38	6.95	-
1983-1994	2.56	20.63	9.78	9,271.21
1995-2008	3.03	17.32	11.84	9,798.59
Russia				
1990-1998	-6.16	26.62	30.11	3,856.83
1999-2008	6.90	20.82	35.95	5,323.59
India				
1960-1979	3.39	16.74	4.55	-
1980-1990	5.29	22.35	6.13	645.11
1991-2008	6.56	27.59	13.97	1,139.36
China				
1960-1979	5.34	25.22	4.71	-
1980-1996	10.16	37.57	14.78	786.39
1997-2008	9.87	39.70	28.87	2,077.44

Source: All data, except labor productivity, are from World Bank's World Development Indicators (2013). The labor productivity data are from Groningen Growth and Development Center (2013).

Brazil

After the Latin American debt crisis erupted in 1982, Brazil economic performance was deteriorated and was incompatible to the pre-crisis period. Before 1982, the growth rate of Brazil was as impressive as 7%, on average, and reached its high at 14% in 1973; thanks to the post-1964 reform policies and the state of the world economy at that time. However, when the debt crisis hit Latin America, Brazil experienced economic downturn. The crisis brought about a sudden capital flight and balance of payment crisis that induced a series of high levels of inflation (which reached 2596 percent at its peak), which ultimately deteriorated growth. The average growth rate was -2.4% and the share of total investment over GDP dropped from 23% to 15%, during 1981-1983. Numerous policy packages and stabilization programs were carried out to rescue the Brazilian economy in the aftermath of the crisis, but many of them failed, and the economy was volatile from time to time. Over the course of 1980-1994 period, the labor productivity dramatically decreased in many economic sectors in both industry and service – except agriculture, mining, and electricity, all sectors experienced a sudden and dramatic drop of labor productivity (see figure C1, in Appendix C). 1990 marked the end of military-led regime in Brazil. The new administration of president Fernando Collor de Mello introduced a stabilization plan aimed at removing restrictions on enterprises, increasing competition, and boosting productivity. At this time, The GDP growth rate slightly increase and the labor productivity of many sectors had had reverse increasing trends. However, the chronic inflation problem still existed. In 1994 that the Brazilian government proposed another stabilization program, the so-called *Plano Real* (the real plan), to revamp and move the economy forward. The plan brought with it the more deregulation, privatization, and liberalization. After this plan was implemented, Brazil saw an increase in export and foreign capital re-inflow. This new scheme was also an effective tool to fight with high inflation; it brought down the inflation to a single digit. With a stable inflation, the economy started to recover; both consumers and investors had more confidence leading to a revival of the Brazilian market. In late 1990s, the Brazilian government further provided structural reform and devaluated the real (which had long been peg with the US dollar) that help boost the economy. During 2004-2008, Brazil attained an average of 5%, but this promising growth was disrupted by the global financial crisis that marked a minus 0.32 percent growth. Nevertheless, the economy bounced back and growth reached 7.5% in 2010.

Russia

After the collapse of communist regime, Russia suffered a decade of economic depression and a series of economic volatilities during 1990s. The hyperinflation, resulted from the removal of price controls, forced the authorities to employ exchange-rate stabilization measure

that led to severe over-valuation of currency. Contemporaneously, with low oil prices and an economic depression, the government was unable to collect tax to offset the large expenditure commitments, leading to the rush in privatizing state-owned assets (Goldman Sachs, 2007). Nevertheless, the government still could not cover its huge expenditures and external debts carrying from the Soviet era. To make things worse, Russia faced a financial crisis in 1998. The average growth rate during this period was -6%; with the lowest figures of -14% and -12% in 1992 and 1994, respectively. The share of investment to GDP decreased by half – from 30% in 1990 to 14% in 1998. Reversely, the share of export to GDP increased, as a result of exporting of oil and natural resources due to the increasing needs of foreign currencies. There was a stagnation of total labor productivity in this period. Looking at sectoral level (see Figure C.2 in Appendix C), there was a stagnation, or at most a slight increase, of labor productivity in many sectors, while there was a huge decline in electricity, and some service sectors such as whole and retail trade, hotels and restaurants, financial intermediate, and public services. Russia experienced significant positive growth rates for the first time after a decade of economic turmoil in 1999, when the GDP growth was 6.4%, and it hit its high of 10% in 2000. The average growth during 1999-2008 was as impressive as 7%. There was also an improvement in the investment-GDP (compare to the figure of 1998) ratio and export-GDP ratio which had an average number of 21% and 36%, respectively. This period also marked the increase in labor productivity in most economic sectors. Nevertheless, the most substantial sectors that have high labor productivity belonged to services. The driving forces of economic growth since 1999 were attributed to the devaluation of the Ruble and the expansion of oil exports. The ruble devaluation led to the import substitution. The reduction in imports led to the decreases in the relative prices of production (Vorobyov and Zhukov, 2004). The devaluation of the Ruble also benefited exports. From 2000, there was a sharp increase in exports caused by an increased demand for Russia raw materials, especially oil. There was also an increase in investment demand of enterprises due to the increase of revenue resulted from the devaluation. In 2009, Russian was severely affected by the global financial crisis that saw a dramatic slump of Russian growth rate to -7%. Nevertheless, the economy recovered and attained the average growth rate of 4% during 2010-2012.

India

In 1947, India also embarked in the inward-oriented economic regime after gaining the independence from Britain. High tariffs and import licensing were imposed to prevent the inflows of foreign goods. To some extents, the Indian economy was similar to the socialist countries. Government interventions, strict economic regulations, price controls and many restrictions were imposed in the Indian economy. Many major industries, such as steel, mining,

machine tools, water, electricity, telecommunications, and many others, were owned by the states. These saw the average growth rate of 3.4% over 1960-1979, and 5.3 % during 1980-1991. The shares of investment to GDP were about 17% and 22% during 1960-1979 and 1980-1991, respectively; and the share of export to GDP were 4.5% and 6% during 1960-1979 and 1980-1991, respectively. In mid-1991, the balance of payment crisis and economic instability – that caused GDP growth to only 1%, forced the newly elected government of India to adopt wide-ranging economic reforms. The reform packages included the abolishment of import tariffs and restrictions and widening export incentives, as well as the promotion of foreign investment. In addition, industries and services that were previously reserved for the public sector were opened up to private investors, Rao and Dutt (2004). These liberal policies were aimed to improve allocation, production efficiency and state of well-being. With the new policies, India saw an improvement of share investment and export to GDP, which increased, on average, to 27.6 % and 14 %, respectively over the course of 1990s to 2000s. The GDP growth had increased from the average of 6% during the 1990s – 2000s. It grew up to 9% in 2005-2007, before it slowed down to 4 % in 2008, due to the global financial crisis. Many economists believe that the recent high growth of India was attributed to the productivity growth. This is consistent with the figures shown in Table 1. It can be observed that labor productivity increased almost twice as much during 1990s-2000s. With this promising growth path, there has been increasing expectation that India will sustain high growth, along with China, for quite a long time and could become one of the world's largest economies in the near future.

China

China's outstanding economic development and growth have been the most talk-of-the-town recently. It has been and still be one of the fastest growing economies in the world. China's economic development can be traced back to 1949 – the time when the communist party came into power. After the revolution, in early 1950s, the Chinese government adopted the Soviet-style economic model. In other words, it adopted the centrally-planned economy, with full controls of government over economic activities and allocation. Government also owned all the production units in the country. At the same time, a landownership reform was carried out and the agricultural collective units were formed. However, at the end of 1950s, due to the imbalance growth between industry and agriculture, Chinese government at the time abandon the Soviet model as it deemed inappropriate for China. The government proposed a readjustment and recovery plan which gives the priority to the agricultural sector. Some advantages of this reformation to farmers were the reduction of agricultural taxes and the increase of agricultural products. During this period, the economic stability was restored; both agriculture and industry grew in parallel. However, this growth path did not last long; in the late

1960s, the Cultural Revolution was set out in order to bring an order to politics and social. Unfortunately, it disrupted economic activities and caused an economic turmoil throughout the country, especially in urban areas. In the beginning of 1970s, the political stability was restored the economy was revived. The industrial output grew at an average of 8% annually. Although the post Mao Zedong era ended with a quite satisfactory economic performance, the modern economic transformation of China had actually just begun. In 1978, the government started a reform of economic system. They adopted market-oriented economic system while maintain the communist political system. This reform program had intention to increase economic transaction and productions, and to expand exports and balance growth between economic sectors. Most restrictions were loosened during this time, and foreign relations and foreign trade started to increase. These policies proved successful. The fraction of investment on GDP increased by 50%; and exports on GDP expanded three folds. Growth of GDP increased spectacularly from the average of 5% during 1960-1979 to the average of 10% during 1980-1996. GDP growth hit 14% during 1992-1993. This was the period that witnessed the influx of foreign capital due to the introduction of more than 2000 special economic zones. Although China experienced high growth during the past decades, the government still found that the banking system and state-owned enterprises still proved inefficient. This led to the reform to modernized banking system and reshaped the state-owned enterprises in 1997. The effects of this reform combining with the accession to the World Trade Organization (WTO) of China helped maintain the growth rate to the level of 10% per year over the course of 1997-2008. The share of investment and export to GDP reached almost 40% and 29%, respectively. Total labor productivity also increased two folds compared to the 1980s period. Up to now China still grow at high rate even with the disruption of the global financial crisis in 2008-2009. Currently, China growth rate has been around 9% annually. Although with this light decline, many economists still believe that China would become the global economic leader and surpass the advanced countries in the future.

3. Methodology and data

To fulfill our objective, we perform two types of analyses. In the first part, we utilize the shift-share decomposition method to investigate the different growth effects that contribute to the total labor productivity growth of BRICs. This method allows us to see the pattern of structural change in the supply side using only the simple data of labor productivity. In the second part, to test the hypothesis of sectoral convergence across countries, we employ the so-called “beta convergence” test to check for the catching up phenomena among sectors across countries.

For both analyses, we utilize the data taken from de Vries et al. (2012) and the Groningen Growth and Development Center (GGDC). This dataset provides a detailed and harmonized time-series database of value added and employment in 35 sector classification (see Table 3) for BRICs and 10 sector classification (See Appendix A) for OECD countries. The data range from 1980-2008, 1995-2008, 1980-2008, and 1987-2008 for Brazil, Russian, India, and China, respectively.

4. Productivity decomposition

In this section, we use the shift-share analysis to decompose the labor productivity growth of BRIC countries. Shift-share analysis is a convenient tool to investigate how aggregate growth is linked to the growth of labor productivity and the labor reallocation between industries. Following Timmer and Szirmai (2000) and Peneder (2003), we can decompose the aggregate growth of labor productivity into three separated effects (see Appendix B for the derivation):

$$growth(LP) = \frac{(Y/L)_t - (Y/L)_{t-1}}{(Y/L)_{t-1}} = \frac{LP_t - LP_{t-1}}{LP_{t-1}}$$

Or we write

$$\frac{LP_t - LP_{t-1}}{LP_{t-1}} = \frac{\overbrace{\sum_{i=1}^n S_{i,t-1}(LP_{i,t} - LP_{i,t-1})}^{\text{Within shift effect}} + \overbrace{\sum_{i=1}^n LP_{i,t-1}(S_{i,t} - S_{i,t-1})}^{\text{Static shift effect}} + \overbrace{\sum_{i=1}^n (LP_{i,t} - LP_{i,t-1})(S_{i,t} - S_{i,t-1})}^{\text{dynamic shift effect}}}{LP_{t-1}} \quad (1)$$

Or simply write

$$\frac{\Delta LP}{LP_{t-1}} = \frac{\sum_{i=1}^n S_{i,t-1} \Delta LP_i + \sum_{i=1}^n LP_{i,t-1} \Delta S_i + \sum_{i=1}^n \Delta LP_i \Delta S_i}{LP_{t-1}} \quad (2)$$

Where

LP is labor productivity.

S_i is the share of industry i in total employment.

Subscript $t-1$ represents previous year.

Subscript t represents current year.

The first, second, and third terms on the right-hand side of equation (1) are called within shift, static shift, and dynamic-shift effects, respectively. The implications of these effects are as follow:

- **Within shift** effect is the intra-branch productivity growth (the labor productivity growth within individual industries).
- **Static shift effect** measures productivity growth caused by changes in the allocation of labor between industries. It will be positive if the share of high productivity industries in total employment increases at the expense of industries with low productivity. This means that it reflects the ability of a country to move resources from low to high productivity activities.
- **Dynamic shift effect**, on one hand, captures shifts toward more dynamic branches. In other words, this effect will be positive if the fast growing sectors in terms of productivity growth also increase their share of total employment. Hence, it reflects the ability of a country to reallocate its resources towards industries with rapid productivity growth. On the other hand, its positive sign also implies that there is a reduction of labor share in parallel with the reduction of productivity.

4.1 Results of Aggregate level

Prior to discussing the results of the decomposition, we define the time period that is deemed necessary to see the different patterns of structural changes. For most countries (except Russia), the periods used to compare are divided by the year when a major economic reform was taken place.

Table 1: Some major economic reforms in BRIC countries

Country	Year	Events
Brazil	1995	The introduction of Inflation control measures.
Russia	-	-
India	1991	The Adoption of free-market principles and trade liberalization.
China	1997	The reformation of state-owned enterprises and banking sector.

The aggregate comparative results of the labor productivity decomposition of supply side, using equation (1) to BRICS, are reported in Table 2. The total results in the last column show that among BRICs countries, Brazil seems to have worse performance of within-sector labor productivity growth, while Russia and India have relatively similar performance. In fact, India performed slightly better than Russia if one considers only the period 1991-2008 (the period after trade liberalization in India). Above all, China's performance is the most impressive among the BRIC countries. These results confirm the findings of de Vries et al. (2012), McMillan and Rodrik (2011), and Bosworth and Collins (2008). The decomposition in specific effects (within-shift, static-shift, and dynamic shift) demonstrates that the main source of labor productivity growth is the within-shift effect. Except Brazil, all other countries have an average

Table 2: Labor productivity decomposition for BRICS

	Percentage (%) of annual average of labor productivity growth explained by:			
	Within shift effect	Static shift effect	Dynamic shift effect	Total
	$\frac{\sum_{i=1}^n S_{i,t-1}(LP_{i,t} - LP_{i,t-1})}{LP_{t-1}}$	$\frac{\sum_{i=1}^n LP_{i,t-1}(S_{i,t} - S_{i,t-1})}{LP_{t-1}}$	$\frac{\sum_{i=1}^n (LP_{i,t} - LP_{i,t-1})(S_{i,t} - S_{i,t-1})}{LP_{t-1}}$	$\frac{\Delta LP}{LP_{t-1}}$
	(I)	(II)	(III)	(I+II+III)
Brazil				
1980-1994	- 1.420	0.888	-0.364	-0.896
1995-2008	0.986	0.255	-0.119	1.122
1980-2008	- 0.226	0.572	-0.242	0.104
Russia				
1995-2008	2.963	1.066	-0.214	3.815
India				
1981-1990	2.473	0.864	-0.076	3.261
1991-2008	3.081	1.538	-0.137	4.482
1981-2008	2.864	1.297	-0.115	4.046
China				
1987-1996	7.092	1.074	-0.121	8.045
1997-2008	8.137	1.140	-0.166	9.111
1987-2008	7.689	1.112	-0.147	8.654

Note: Authors computed from the 35 sector dataset.

positive increase of productivity growth within sectors (among which, China has the highest growth rate). Particularly, these numbers slightly increased for India and China after the reforms. This implies that the growth of labor productivity within each sector itself has been the main driving force of growth during the studied period. For Brazil, the within-shift effect is negative during 1980-1994; this could be the consequence of the chronic impact of the Latin American Lost Decades (de Vries et al, 2012). Nevertheless, the within growth effect turned positive after 1995, thanks to the inflation control measure. For the static shift effect, surprisingly, it shows only a moderate increase in the growth rate of labor share for all countries. On average, for

Brazil the growth rate of labor share was 0.5%, while for the rests was about 1%. These figures were quite small compare to those of within shift effect. Nevertheless, this still confirms that there was a slight movement of labors in entire sectors over the period. Regarding the dynamic shift effect, all figures are negative for all countries. This implies that, on average, there is no growth of labor share in the fast growing sectors. Nevertheless, the results for the disaggregate sectors suggest otherwise for some countries (this point will be discussed in the next sub-sections).

4.2 Results of disaggregate level

The aggregate level gives some insights about the overall performance of BRICs. However, one would not be able to clearly understand the process of structural change without going deeper to sectoral level. In this section, we investigate the sectors that were the main contributors to the structural change and growth in the four countries. 35 sectors are classified following the data of (de Vries et al, 2012) and Groningen Growth and Development Center, as shown in Table 3. These sectors include one agricultural sector, 17 industrial sectors, and 17 service sectors. We decompose and compare the results of each country in the following sub-section.

Table 3: BRICs' sectoral database

No.	Sector description	classification
1	Agriculture, Hunting, Forestry and Fishing	Agriculture
2	Mining and Quarrying	Industry
3	Food, Beverages and Tobacco	Industry
4	Textiles and Textile Products	Industry
5	Leather, Leather and Footwear	Industry
6	Wood and Products of Wood and Cork	Industry
7	Pulp, Paper, Paper, Printing and Publishing	Industry
8	Coke, Refined Petroleum and Nuclear Fuel	Industry
9	Chemicals and Chemical Products	Industry
10	Rubber and Plastics	Industry
11	Other Non-Metallic Mineral	Industry
12	Basic Metals and Fabricated Metal	Industry
13	Machinery, not elsewhere classified	Industry
14	Electrical and Optical Equipment	Industry
15	Transport Equipment	Industry
16	Manufacturing not elsewhere classified; Recycling	Industry

17	Electricity, Gas and Water Supply	Industry
18	Construction	Industry
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	Service
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	Service
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	Service
22	Hotels and Restaurants	Service
23	Inland Transport	Service
24	Water Transport	Service
25	Air Transport	Service
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	Service
27	Post and Telecommunications	Service
28	Financial Intermediation	Service
29	Real Estate Activities	Service
30	Renting of Machinery and Equipment and Other Business Activities	Service
31	Public Admin and Defense; Compulsory Social Security	Service
32	Education	Service
33	Health and Social Work	Service
34	Other Community, Social and Personal Services	Service
35	Private Households with Employed Persons	Service

Source: de Vries et al. (2012) and Groningen Growth for Development Center (2013)

4.2.1 Within shift effect

Table 4.1-4.4 report the ranking of top ten sectors that had high growth rate of labor productivity in within shift effect component. It can be observed that the leading sectors in four countries were partially different. Some similarities among them are that, except for Russia, agricultural sector still had the highest growth rate in BRIC countries. However, these rates had been declining dramatically in Indian and China, while in Brazil there had been only a small decline. In fact, in Brazil, there was an increase in productivity growth from the average of 0.149% during 1980-1994 to 0.306% during 1995-2008. The improvement of agricultural labor productivity growth was attributed to the advancement in farm yields and the reduction in surplus labor from the movement of workers to service sector (Baer, 2008; de Vries et al, 2012).

The agricultural sectors of India and China were also declining; their patterns seemed to follow the structural change patterns of past developments in US, Europe and Japan, where agricultural workers moved mainly to manufacturing, leading to the decline of agricultural productivity. For Russia, the agricultural sector was at the 8th position among the top 10 sectors. This implies that the agricultural sector in Russia was less significant compared to other counterparts. In Brazil, Russia, and India, the growth of service sector was dramatic, especially after the reforms in each respect country. In fact, the total within shift effect in these three countries was attributable to some service and industrial sectors. Particularly, the growth rate of real estate activities was impressive in Brazil and Russia. In China, industrial sector was still a major dominant of labor productivity growth.

Brazil

Table 2 shows that, on aggregate, Brazil has the lowest performance in terms of labor productivity growth compared to other BRIC counterparts. One of the major causes of this low performance figures was the Lost Decade – the 1980s to late 1990s period when Brazil, as well as other Latin American countries, experienced negative or low output growth. Nevertheless, after the Brazilian government took a major step in adopting a reform, the Brazilian economy could marginally enjoys a positive growth. In this section, we shall look more closely on each sector's performance of Brazil. Table D1 in Appendix D shows that, for within shift effect, during 1980-1994 most sectors had a negative intra-sector labor productivity growth. Only agriculture and some industrial sectors such as electricity, gas and water supply, and mining and quarrying are major contributors of positive growth. After the reform in 1995, many sectors yielded an average positive growth throughout the period 1995-2008. The growth rates of agriculture and other service sectors such as real estate activities, financial intermediation, hotels and restaurants, and chemical and chemical products, were particularly significant.

Russia

Table D4 in Appendix D reports that, in case of Russia, the sectors that contributed to within shift effect the most are from service sector (similar to after-reformed Brazil) which includes renting of machines and equipments; real estate activities; wholesale trade and commission trade; other inland transport; financial intermediation; post and telecommunication; and so on. The industry sector was the second major contributors to the labor productivity growth, leading by construction and mining and quarrying; then by food, beverages, and tobacco; and basic metals, respectively.

Table 4.1: Brazil's top ten of within shift effect

$(LP^t-LP^{t-1})S^{t-1}$		1980-1994	1995-2008	1980-2008
		(average)	(average)	(average)
Agriculture, hunting forestry and fishing	(A)	0.149	0.306	0.228
Real estate activities	(S)	-0.010	0.249	0.120
Electricity, gas and water supply	(I)	0.118	0.088	0.103
Chemicals and chemical products	(I)	-0.046	0.144	0.049
Hotels and restaurants	(S)	-0.079	0.173	0.047
Mining and quarrying	(I)	0.038	0.035	0.037
Post and telecommunications	(S)	0.000	0.018	0.009
Transport equipment	(I)	-0.029	0.040	0.006
pulp, paper, printing and publishing	(I)	-0.028	0.032	0.002
Machinery, NEC	(I)	-0.023	0.023	0.000
Manufacturing NEC; Recycling	(I)	-0.019	0.015	-0.002

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Table 4.2: Russia's top ten of within shift effect

$(LP^t-LP^{t-1})S^{t-1}$		1995-2008
		(average)
Renting of machine & equipment and other business activities	(S)	0.727
Real estate activities	(S)	0.313
Construction	(I)	0.250
Mining and quarrying	(I)	0.247
Wholesale trade and commission trade	(S)	0.189
Other Inland transport	(S)	0.166
Financial intermediation	(S)	0.158
Agriculture, hunting forestry and fishing	(A)	0.139
Food, beverages, and tobacco	(I)	0.134
Post and telecommunications	(S)	0.134

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Table 4.3: India's top ten of within shift effect

$(LP^t-LP^{t-1})S^{t-1}$		1981-1990 (average)	1991-2008 (average)	1981-2008 (average)
Agriculture, hunting forestry and fishing	(A)	0.609	0.472	0.521
Public admin and defense; compulsory social security	(S)	0.245	0.320	0.293
Financial intermediation	(S)	0.223	0.320	0.285
Post and telecommunications	(S)	0.033	0.372	0.251
Retail trade and repair of household goods	(S)	0.150	0.286	0.237
Wholesale trade and commission trade	(S)	0.072	0.173	0.137
Other Inland transport	(S)	0.124	0.133	0.130
Chemicals and chemical products	(I)	0.091	0.137	0.121
Electricity, gas and water supply	(I)	0.092	0.116	0.108
Education	(S)	0.137	0.084	0.103

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Table 4.4: China's top ten of within shift effect

$(LP^t-LP^{t-1})S^{t-1}$		1987-1996 (average)	1997-2008 (average)	1987-2008 (average)
Agriculture, hunting forestry and fishing	(A)	0.995	0.638	0.791
Basic metals	(I)	0.473	0.617	0.555
Other non-metallic mineral	(I)	0.491	0.460	0.473
Machinery, NEC	(I)	0.470	0.461	0.465
Electrical and optical equipment	(I)	0.397	0.511	0.462
Food, beverages, and tobacco	(I)	0.557	0.348	0.438
Chemicals and chemical products	(I)	0.289	0.466	0.390
Textiles and textile	(I)	0.466	0.236	0.334
Other Inland transport	(S)	0.389	0.291	0.333
Renting of m&eq and other business activities	(S)	0.243	0.375	0.318

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

India

The case of India is not much different from the case of Brazil, in that the agricultural sector and the service sector have highest growth rate of labor productivity (See Table D7 in Appendix D). It can be noticed that there was only a slight improvement of productivity growth before and after trade liberalization policy was introduced. In fact, trade liberalization improved the

performance of some sectors such as post and telecommunications; retail trade and repair of household goods; and whole sale trade and commission trade, while worsening the productivity of other sectors; for example, agriculture; education; and real estate activities.

China

China, who had the best performance of total labor productivity growth, seems to be the only country that has the structural change pattern similar to the conventional pattern of other developed countries. This pattern is, as stated in the introduction part, that there the shift of labor and capital from production of primary goods to manufacturing and later to services. As can be observed in Table B10, the growth rate of agricultural productivity had decline, while those of industrial sector and service sector had improved. By comparing the periods 1987-1996 and 1997-2008, it can be observed that within shift effect was increasing for some sectors, such as basic metal; electrical and optical equipment; chemical products; and mining and quarrying, while some other industrial sectors such as machinery; food, beverage, and tobacco; and textiles had a decreasing labor productivity. During these periods, many sectors in the service sector were gaining an increase in productivity growth. Those sectors such as renting of machinery and equipment; transport equipment; financial intermediation all experienced increasing trend of labor productivity.

4.2.2 Static shift effect

Overall, we can distinguish the results into two similar groups. On one hand, the countries that shared some similarity of static shift effect are Brazil and Russia. In both countries wholesale trade and commission trade, retail trade and repair of household goods, and public administration and defense were within the top 5 sector that had high static shift effect. However, figures in Table 5.1 shows that the labor share growth of these sectors in Brazil had been declining. On the other hand, India and China are another group of countries that shared some similarity. They had quite similar phenomenon of labor movement. The real estate activities, construction, financial intermediation, and wholesale trade and commission trade were top sectors ranked in the top ten ranking of static shift effect.

Brazil

Regarding the static shift effect, Table D2 shows surprising results that the growth rate of labor share of each leading sector in within shift effect had significantly declined (all of them experienced negative growth). The sectors that had positive growth of labor share were the most unproductive sectors; these include retail trade and repair of household goods, public administration and defense, and social security, whole sale trade and commission trade, and

education. Nevertheless, these figures seem to be declining overtime.

Table 5.1: Brazil's top ten of static shift effect

$(S^t - S^{t-1})LP^{t-1}$		1980-1994 (average)	1995-2008 (average)	1980-2008 (average)
Public admin and defense; compulsory social security	(S)	0.194	0.116	0.155
Retail trade and repair of household goods	(S)	0.225	0.064	0.144
Education	(S)	0.108	0.069	0.089
Wholesale trade and commission trade	(S)	0.127	0.029	0.078
Renting of machines & equipments and other business activities	(S)	0.022	0.130	0.076
Health and social work	(S)	0.080	0.057	0.069
Other community, social and personal services	(S)	0.091	0.041	0.066
Other Inland transport	(S)	0.064	0.034	0.049
Hotels and restaurants	(S)	0.064	0.014	0.039
Other supporting of transport activities	(S)	0.029	0.025	0.027

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Table 5.2: Russia's top ten of static shift effect

$(S^t - S^{t-1})LP^{t-1}$		1995-2008 (average)
Wholesale trade and commission trade	(S)	0.712
Retail trade and repair of household goods	(S)	0.336
Public admin and defense; compulsory social security	(S)	0.207
Financial intermediation	(S)	0.081
Electricity, gas and water supply	(I)	0.066
Hotels and restaurants	(S)	0.062
Other supporting of transport activities	(S)	0.042
Renting of machines & equipments and other business activities	(S)	0.030
Sale, maintenance and repair of motor vehicles	(S)	0.028
Other community, social and personal services	(S)	0.024

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Table 5.3: India's top ten of static shift effect

$(S^t - S^{t-1})LP^{t-1}$		1981-1990	1991-2008	1981-2008
		(average)	(average)	(average)
Real estate activities	(S)	0.130	0.470	0.349
Construction	(I)	0.319	0.197	0.241
Financial intermediation	(S)	0.073	0.170	0.135
Retail trade and repair of household goods	(S)	0.120	0.140	0.133
Other Inland transport	(S)	0.064	0.154	0.122
Wholesale trade and commission trade	(S)	0.058	0.141	0.112
Post and telecommunications	(S)	0.003	0.169	0.110
Renting of machines & equipments and other business activities	(S)	0.019	0.147	0.101
Education	(S)	-0.005	0.092	0.058
Transport equipment	(I)	0.016	0.034	0.028

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Table 5.4: China's top ten of static shift effect

$(S^t - S^{t-1})LP^{t-1}$		1987-1996	1997-2008	1987-2008
		(average)	(average)	(average)
Electrical and optical equipment	(I)	0.023	0.357	0.214
Real estate activities	(S)	0.289	0.143	0.206
Wholesale trade and commission trade	(S)	0.259	0.075	0.154
Financial intermediation	(S)	0.229	0.077	0.142
Construction	(I)	0.147	0.101	0.121
Other community, social and personal services	(S)	0.155	0.051	0.096
Hotels and restaurants	(S)	0.074	0.083	0.079
pulp, paper, printing and publishing	(I)	-0.007	0.127	0.070
Electricity, gas and water supply	(I)	0.090	0.048	0.066
Rubber and plastics	(I)	-0.001	0.106	0.060

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Russia's static shift effect

The static shift effect of Russia (shown in Table D5) also reports the high mobility of labor movement in service sector, especially in whole sale trade and commission trade; retail trade and repair of household goods; public administration and defense; and financial intermediation. Surprisingly, there was a declining labor share in most industrial sectors. In addition the declining of labor share in agricultural sector is obvious.

India's static shift effect

With regard to the static shift effect, Table D8 suggests that there was a significant increase of labor share in service sector, including real estate activities; financial intermediation; other inland transport; whole sale trade and commission trade; and post and telecommunications. In contrast, there was an obvious reduction of labor share in construction; mining and quarrying; electricity, gas and water supply; food, beverages, and tobacco; and coke, refined petroleum, and nuclear fuel. The reduction of labor share in agriculture was also obvious over the period.

China's static shift effect

During 1987-1996, the labor share growth was quite high for real estate activities; wholesale trade; and financial intermediation. However, the growth decreased significantly during 1997-2008. The growth of labor share improved the most in electrical and optical equipment during this period. In fact, the electrical and optical equipment sector was a sector that had the best performance over the studied period.

4.2.3 Dynamic shift effect

For the dynamic shift effect, we can see that in Brazil's case, this effect is negative for all sectors. This implies that there is no labor movement to the high growth sectors; and, in fact, the values of the growth rate were very small compared to other countries. For Russia, India, and China, there were similarity as the post and telecommunication, financial intermediation, and construction sectors were ranked within the list of top ten of dynamic shift effect. This implies that there was labor share's growth in parallel with the productivity growth within these sectors.

Brazil's dynamic shift effect

The dynamic shift effect, shown in Table D3, of Brazil shows a negative sign for all sectors, indicating that no labor movement to high productivity sectors.

Russia's dynamic shift effect

For the dynamic shift effect, the results in Table D6 show some positive sign in some sectors. However, we should carefully interpret these results. By closely observing the data, there positive figures are derived from the interaction between the negative increments of labor productivity and labor share. These imply that there were reductions of labor productivity in parallel with the reduction of labor share in construction; financial intermediation; transport equipment; other non-metallic mineral; post and telecommunications; and machinery. The positive interaction prevailed especially after 2003.

India's dynamic shift effect

In India, the dynamic shift effect was significant for financial intermediation, before the trade reform. After the reform post and telecommunications, and renting of machines and equipments had a positive effect. In fact, for these sectors, there was a positive dynamic shift effect, implying that the productivity of these sectors improved with the increase of labor share.

China's dynamic shift effect

Its dynamic shift effect was also positive, indicating that it attracted labor force with the increase of labor productivity. Some other sectors that also had a positive dynamic shift effect include financial intermediation, real estate activities; electricity, gas, and water supply; and other transport equipment.

Table 6.1: Brazil's top ten of dynamic shift effect

$(LP^t-LP^{t-1})(S^t-S^{t-1})$		1980-1994	1995-2008	1980-2008
		(average)	(average)	(average)
Leather, leather and footwear	(I)	-0.0007	-0.0003	-0.0005
Wood and of wood and cork	(I)	-0.0010	-0.0000	-0.0005
Machinery, NEC	(I)	-0.0022	0.0006	-0.0008
Other non-metallic mineral	(I)	-0.0016	-0.0001	-0.0008
Rubber and plastics	(I)	-0.0015	-0.0010	-0.0012
Transport equipment	(I)	-0.0028	-0.0000	-0.0014
Electrical and optical equipment	(I)	-0.0029	-0.0003	-0.0016
Manufacturing NEC; Recycling	(I)	-0.0018	-0.0017	-0.0017
pulp, paper, printing and publishing	(I)	-0.0027	-0.0015	-0.0021
Other Water transport	(S)	-0.0049	-0.0008	-0.0028

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Table 6.2: Russia's top ten of dynamic shift effect

$(LP^t-LP^{t-1})(S^t-S^{t-1})$		1995-2008 (average)
Construction	(I)	0.008
Financial intermediation	(S)	0.007
Transport equipment	(I)	0.003
Other non-metallic mineral	(I)	0.002
Post and telecommunications	(S)	0.001
Machinery, NEC	(I)	0.001
Wood and of wood and cork	(I)	0.000
Rubber and plastics	(I)	0.000
Private households with employed persons	(S)	0.000
Health and social work	(S)	-0.000

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Table 6.3: India's top ten of dynamic shift effect

$(LP^t-LP^{t-1})(S^t-S^{t-1})$		1981-1990 (average)	1991-2008 (average)	1981-2008 (average)
Post and telecommunications	(S)	-0.000	0.020	0.013
Renting of machines & equipments and other business activities	(S)	0.000	0.007	0.005
Education	(S)	0.000	0.001	0.001
Financial intermediation	(S)	0.004	-0.001	0.001
Hotels and restaurants	(S)	-0.001	0.001	0.001
Health and social work	(S)	-0.001	0.001	0.001
Other non-metallic mineral	(I)	-0.000	0.000	0.000
Leather, leather and footwear	(S)	0.000	0.000	0.000
Other Water transport	(S)	0.000	0.000	0.000
Other Air transport	(S)	0.000	0.000	0.000

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

Table 6.4: China's top ten of dynamic shift effect

$(LP^t-LP^{t-1})(S^t-S^{t-1})$		1987-1996 (average)	1997-2008 (average)	1987-2008 (average)
Electrical and optical equipment	(I)	0.006	0.020	0.014
Financial intermediation	(S)	0.004	0.006	0.005
Real estate activities	(S)	0.002	0.007	0.005
Electricity, gas and water supply	(I)	0.001	0.005	0.004
Other Inland transport	(S)	0.001	0.003	0.002
Construction	(I)	0.012	-0.006	0.002
Post and telecommunications	(S)	0.000	0.002	0.001
Transport equipment	(I)	0.005	-0.002	0.001
Other Air transport	(S)	-0.000	0.001	0.000
Sale, maintenance and repair of motor vehicles	(S)	0.000	0.000	0.000

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively.

4.3 Compare the results of BRICs with some OECD countries

In this section, we compare the aggregate results of BRICs with those of some OECD countries. Compared to BRICs, the advanced countries have had poorer growth performance – as suggested by theories and other empirical studies. In table 7, we can observe that during 1980s, among our samples of advanced countries, Japan has highest growth rate of 3.2% (this decade actually marked the last high growth decade of Japan). Other countries, such as France and United Kingdom, grew at average rate of 2%, while the United States grew at only 1%. The 2% growth did not last long for Japan and France, as their growth dropped to 1% after 1980s. In fact, Japan entered a well-known era of bubble economy after 1980s. United Kingdom could maintain the 2% average rate of growth, while the US growth was improving to 1.6%. In 2000s, we can see that growth most countries, except the U.S, decreased further. In contrast to other counterparts, the US showed an improved growth rate. For these advanced countries, the major driving forces of their growth were not different from the BRIC countries. It was the within shift effect that contributed to the total growth the most. The growth of labor share (static shift effect) of U.K decreased over the studied period, and France and U.S's had negative static shift during 2000s, while only in Japan that there was a slight movement of labor. These results may imply that there had been no structural change anymore in advanced countries.

Table 7: Labor productivity decomposition for some OECD countries

	Percentage (% , annual average) of labor productivity growth explained by:			
	Within shift effect	Static shift effect	Dynamic effect	Total
	$\frac{\sum_{i=1}^n S_{i,0} (LP_{i,1} - LP_{i,0})}{LP_0}$	$\frac{\sum_{i=1}^n LP_{i,0} (S_{i,1} - S_{i,0})}{LP_0}$	$\frac{\sum_{i=1}^n (LP_{i,1} - LP_{i,0})(S_{i,1} - S_{i,0})}{LP_0}$	$\frac{\Delta LP}{LP_0}$
	(I)	(II)	(III)	(I+II+III)
France				
1981-1990	1.61	0.60	-0.02	2.18
1991-2000	1.13	0.23	-0.03	1.33
2001-2005	1.01	-0.04	-0.02	0.95
Japan				
1981-1990	2.72	0.47	-0.02	3.18
1991-2000	0.89	0.21	-0.02	1.08
2001-2003	0.02	0.17	-0.02	0.17
United Kingdom				
1981-1990	2.23	-0.02	-0.06	2.14
1991-2000	2.56	-0.20	-0.09	2.26
2001-2005	1.79	-0.37	-0.06	1.35
United States				
1981-1990	0.85	0.36	-0.04	1.17
1991-2000	1.58	0.05	-0.02	1.61
2001-2005	2.72	-0.48	-0.05	2.19

Note: The figures are computed from the 10 sector data.

5. Convergence of labor productivity in BRIC

5.1 Unit root test

In previous section, we have seen that there are some similarities and differences among BRIC countries' structural changes. However, those results merely illustrate the pattern of change using simple decomposition and some descriptive analyses. In this section, we shall address the issue of productivity convergence in the long run among BRIC countries. In these regards, we check for the convergence of each sector itself (the unit root or stationary test); then we check for the cross-country convergence. In fact, one should understand that the term "convergence" implies two different phenomena. On one hand, the convergence of a series implies that the series converge to a certain value or level as time goes by. So, in our sense this should represent the stagnation of those series. On the other hand, the convergence of different series (or sectors in our analysis) to a specific level, as elaborated in growth theory, means that different economies converge and meet each other at some point as time goes by. For now, we are keen to statistically check the stagnation of economic sectors in BRIC countries using the unit root test.

The results of unit root test are shown in Table 8.1-8.3 (we do not perform the unit root test for Russian due to the data has too short time period). Overall, the results show that only some sectors in Brazil, including food, beverage, and tobacco, text tiles, wood, rubber and plastic, non-metallic mineral, electrical and optical equipment, wholesale trade and commission trade, public administration, health and social work, and other community, social and personal services are statistically and significantly converged to some levels. For other countries, there was no convergence in all sectors (in most cases there are increasing trends of labor productivity). These results suggest that among BRIC countries, Brazil's labor productivity in many sectors is stagnant. Unfortunately, these tests of stationarity do not include the information of whether the series have increasing or decreasing trends. Thus, to obtain more useful information, we combine these stationary tests' information and the graphical presentation in Appendix E. The graphs also show that Brazil's labor productivity in each sector volatile dramatically, while the labor productivity in most sectors in other counterparts are mostly increasing.

Table 8.1: Test of convergence of economic sectors in Brazil

Number of periods: 29

Sector		Convergence coefficient	t-stat (McKinnon, 1996)	Optimum lag
1	Agriculture, hunting forestry and fishing	(A) 0.101	2.308	3
2	Mining and quarrying	(I) - 0.005	- 0.151	0
3	Food, beverages, and tobacco	(I) - 0.392***	- 3.726	0
4	Textiles and textile	(I) - 0.459***	- 3.326	4
		(I) - 0.011	- 0.166	0
5	Leather, leather and footwear			
6	Wood and of wood and cork	(I) - 0.534***	- 5.107	3
7	pulp, paper, printing and publishing	(I) - 0.048	- 0.697	0
8	Coke, refined petroleum and nuclear fuel	(I) - 0.121	- 2.008	1
9	Chemicals and chemical products	(I) - 0.010	- 0.220	3
10	Rubber and plastics	(I) - 0.235*	- 2.706	0
11	Other non-metallic mineral	(I) - 0.405***	- 4.002	0
12	Basic metals	(I) - 0.202	- 2.012	0
13	Machinery, NEC	(I) - 0.127	- 1.380	0
14	Electrical and optical equipment	(I) - 0.319*	- 2.848	0
15	Transport equipment	(I) - 0.093	- 1.010	0
16	Manufacturing NEC; Recycling	(I) - 0.198	- 1.886	0
17	Electricity, gas and water supply	(I) - 0.022	- 0.593	0
18	Construction	(I) - 0.418	- 2.004	3
19	Sale, maintenance and repair of motor vehicles	(S) - 0.133	- 1.904	1
20	Wholesale trade and commission trade	(S) - 0.383***	- 6.747	0
21	Retail trade and repair of household goods	(S) - 0.103	- 1.931	1
22	Hotels and restaurants	(S) - 0.032	- 0.425	0
23	Other Inland transport	(S) - 0.325	- 2.219	0
24	Other Water transport	(S) - 0.113	- 0.933	0
25	Other Air transport	(S) - 0.253	- 1.700	0
26	Other supporting of transport activities	(S) - 0.252	- 1.788	0
27	Post and telecommunications	(S) - 0.367	- 2.316	0
28	Financial intermediation	(S) - 0.143	- 1.342	2
29	Real estate activities	(S) - 0.003	- 0.036	0

30	Renting of machines & equipments and other business activities	(S)	- 0.063	- 1.308	1
31	Public admin and defense; compulsory social security	(S)	- 0.484***	- 6.241	0
32	Education	(S)	- 0.476***	- 5.036	1
33	Health and social work	(S)	- 0.515***	- 6.229	0
34	Other community, social and personal services	(S)	- 0.524***	- 6.240	0
35	Private households with employed persons	(S)	N.A	N.A	N.A

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively. *, **, and *** indicate the significance of 1%, 5%, and 10% level, respectively.

Table 8.2: Test of convergence of economic sectors in India

Number of periods: 29

	Sector		Convergence coefficient	t-stat	Optimum lag
1	Agriculture, hunting forestry and fishing	(A)	0.052	0.812	1
2	Mining and quarrying	(I)	- 0.220	- 2.272	0
3	Food, beverages, and tobacco	(I)	- 0.066	- 0.573	0
4	Textiles and textile	(I)	- 0.121	- 1.086	0
5	Leather, leather and footwear	(I)	N.A	N.A	N.A
6	Wood and of wood and cork	(I)	- 0.246	- 1.793	0
7	pulp, paper, printing and publishing	(I)	- 0.265	- 1.949	0
8	Coke, refined petroleum and nuclear fuel	(I)	0.05	0.612	0
9	Chemicals and chemical products	(I)	- 0.348	- 1.312	0
10	Rubber and plastics	(I)	- 0.497	- 2.672	0
11	Other non-metallic mineral	(I)	- 0.037	- 0.699	0
12	Basic metals	(I)	- 0.225	- 1.741	1
13	Machinery, NEC	(I)	- 0.190	- 1.972	1
14	Electrical and optical equipment	(I)	- 0.001	- 0.017	0
15	Transport equipment	(I)	- 0.347	- 2.275	0
16	Manufacturing NEC; Recycling	(I)	- 0.378	- 2.517	0
17	Electricity, gas and water supply	(I)	- 0.177	- 2.242	1
18	Construction	(I)	- 0.214	- 2.758	1
19	Sale, maintenance and repair of motor vehicles	(S)	- 0.109	- 1.123	0

20	Wholesale trade and commission trade	(S)	- 0.124	- 1.696	0
21	Retail trade and repair of household goods	(S)	- 0.088	- 0.958	0
22	Hotels and restaurants	(S)	- 0.209	- 1.621	1
23	Other Inland transport	(S)	- 0.128	- 1.210	0
24	Other Water transport	(S)	N.A	N.A	N.A
25	Other Air transport	(S)	N.A	N.A	N.A
26	Other supporting of transport activities	(S)	N.A	N.A	N.A
27	Post and telecommunications	(S)	0.448	1.971	2
28	Financial intermediation	(S)	- 0.317	- 2.360	1
29	Real estate activities	(S)	- 0.195	- 2.236	1
30	Renting of machines & equipments and other business activities	(S)	- 0.042	- 0.551	0
31	Public admin and defense; compulsory social security	(S)	- 0.013	- 0.237	0
32	Education	(S)	- 0.003	- 0.100	0
33	Health and social work	(S)	0.220	0.946	2
34	Other community, social and personal services	(S)	0.001	0.125	0
35	Private households with employed persons	(S)	N.A	N.A	N.A

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively. *, **, and *** indicate the significance of 1%, 5%, and 10% level, respectively.

Table 8.3: Test of convergence of economic sectors for China

Number of periods: 22

Sector		Convergence coefficient	t-stat	Optimum lag	
1	Agriculture, hunting forestry and fishing	(A)	- 0.093	- 1.051	1
2	Mining and quarrying	(I)	- 0.381	- 3.013	2
3	Food, beverages, and tobacco	(I)	- 0.309	- 1.946	0
4	Textiles and textile	(I)	- 0.569	- 2.848	0
5	Leather, leather and footwear	(I)	- 0.346	- 2.174	1
6	Wood and of wood and cork	(I)	- 0.321	- 1.850	0
7	pulp, paper, printing and publishing	(I)	- 0.467	- 2.436	1
8	Coke, refined petroleum and nuclear fuel	(I)	- 0.669	- 3.042	3
9	Chemicals and chemical products	(I)	- 0.688	- 3.128	3
10	Rubber and plastics	(I)	- 0.276	- 1.630	0

11	Other non-metallic mineral	(I)	0.070	0.642	0
12	Basic metals	(I)	0.072	0.873	2
13	Machinery, NEC	(I)	- 0.116	- 1.349	0
14	Electrical and optical equipment	(I)	0.099	1.462	0
15	Transport equipment	(I)	- 0.200	- 1.483	3
16	Manufacturing NEC; Recycling	(I)	0.673	2.096	4
17	Electricity, gas and water supply	(I)	- 0.292	- 2.396	2
18	Construction	(I)	- 0.213	- 2.838	1
19	Sale, maintenance and repair of motor vehicles	(S)	N.A	N.A	N.A
20	Wholesale trade and commission trade	(S)	0.146	1.445	3
21	Retail trade and repair of household goods	(S)	- 0.053	- 0.504	1
22	Hotels and restaurants	(S)	- 0.361	- 2.412	1
23	Other Inland transport	(S)	0.114	0.368	4
24	Other Water transport	(S)	0.275	1.717	4
25	Other Air transport	(S)	- 0.088	- 0.703	1
26	Other supporting of transport activities	(S)	0.275	1.717	4
27	Post and telecommunications	(S)	- 0.188	- 2.645	1
28	Financial intermediation	(S)	- 0.153	- 0.431	1
29	Real estate activities	(S)	0.131	0.714	2
30	Renting of machines & equipments and other business activities	(S)	- 0.402	- 3.047	4
31	Public admin and defense; compulsory social security	(S)	- 0.295	- 2.736	1
32	Education	(S)	- 0.186	- 1.315	0
33	Health and social work	(S)	- 0.203	- 1.791	0
34	Other community, social and personal services	(S)	0.005	0.068	0
35	Private households with employed persons	(S)	N.A	N.A	N.A

Note: (A), (I), and (S) refers to agricultural, industrial, and service sectors, respectively. *, **, and *** indicate the significance of 1%, 5%, and 10% level, respectively.

5.2 Convergence test

According to the growth theory, in the long run, it is likely that the productivity and per capita income among countries will converge to a specific level (a steady state) (Solow, 1965; Swan, 1965, Barrow and Sala-i-Martin, 1991, 1992; Mankiw et al., 1992). With this theory in mind, some growth economists questioned whether technology converges in the aggregate level across country, or merely between sectors within a country, or across countries within an industry (Bernard and Jones, 1996a, 1996b). In this paper, our research interest stems from these interests. It is about whether there is a convergence across countries within individual industries given the different patterns of structural changes. Thus, we attempt to investigate whether the rates of convergence of individual sectors exist among BRIC and what are the means lead to these convergence. Put in other words, our hypothesis is that although there are some differences on the patterns of structural changes during the transitional periods of BRIC, in the long run, the productivity of all countries should have similar pattern and converge to a steady state level.

To do this, we start by specifying a convergence model. Following Bernard and Jones (1996b) and Boussemart et al. (2006), we assume that for each sector the growth rate of labor productivity in country i at time t ($\Delta \ln LP_{i,t}^k$) depends on the lagged technology gap between the desired and observed level of productivity:

$$\ln(LP_{i,t}^k) - \ln(LP_{i,t-1}^k) = \lambda^k [\ln(LP_{i,t-1}^{*,k}) - \ln(LP_{i,t-1}^k)] + u_{i,t}^k \quad (3)$$

where

$LP_{i,t}^k$ is the actual level of productivity for sector k in country i .

$LP_{i,t}^{*,k}$ is the desired level of productivity for sector k in country i .

λ^k is the sector's adjustment parameter.

$u_{i,t}^k$ is sector specific error term.

k represents sector, i represents country, and t represents time.

Then, we postulate that the desired level of productivity depends on the country's aggregate level of technology and social capacity (this is, in fact, the country's specific effect), which is:

$$LP_{i,t}^{*,k} = A_{i,t}^k \quad (4)$$

where

$A_{i,t}^k$ includes many factors such as technology and the social capability. The “social capability” encompasses many economic factors such as the institutional framework, education level, firms’ organization, openness, and so on.

Substituting Eq.(4) into Eq.(3) and rearranging yields

$$\ln(LP_{i,t}^k) - \ln(LP_{i,t-1}^k) = \lambda^k \ln(A_{i,t-1}^k) - \lambda^k \ln(LP_{i,t-1}^k) + u_{i,t}^k \quad (5)$$

Or we rewrite as

$$\ln(LP_{i,t}^k) - \ln(LP_{i,t-1}^k) = \mu_i - \lambda^k \ln(LP_{i,t-1}^k) + u_{i,t}^k \quad (6)$$

where $\lambda^k \ln(A_{i,t-1}^k) = \mu_i$ which captures the country heterogeneity due to social capability in adapting available technology.

The labor productivity growth of each sector across country in the long-rung can be found by solving the difference equation of Eq.(6) (See Appendix C for the proof), we then yield:

$$\ln(LP_{i,T}^k) - \ln(LP_{i,0}^k) = \alpha^k + \beta^k \ln(LP_{i,0}^k) + v_{i,T}^k \quad (7)$$

where

$$\alpha^k = \mu^k \sum_{m=0}^{T-1} (1 - \lambda^k)^m, \quad \beta^k = -(1 - (1 - \lambda^k)^T), \quad \text{and} \quad v_{i,T}^k = \sum_{m=0}^{T-1} (1 - \lambda^k)^m u_{i,T-m}^k$$

At steady state, we assume that $\mu = \mu_i$ (This means that the technology and social capability are the same in the long run for all countries).

5.2.1 Empirical results of BRICs (35 sectors)

For the estimation of the speed of convergence, we utilize the sector-level data of section 1. However, as the Russian data are available only from 1995-2008, we choose to use this time span for other countries to form a panel data set in our regression analysis. We first regress Eq. (7) for each sector to obtain the value of convergence coefficient (β); then we compute the speed of convergence (λ) deriving from the formula $\beta = -(1 - (1 - \lambda^k)^T)$. The results of β and λ are reported in Table 9. The regression of aggregate level (the last row with label “total”) show that the coefficient of the initial labor productivity (β) has negative sign and is significant at 1% level. This indicates that the aggregated labor productivity of less productive countries is catching up with the more productive countries.

To understand which sectors drive the aggregate convergence, we look at sector specific β^k . The results in Table 9 report the negative signs of β with 5% and 1% significant levels in some sectors, while for the rests there are either insignificant effects or divergence. This implies that there are only some sectors that are the main forces to drive the aggregate labor productivity to converge in the long run. More specifically, agricultural sectors among BRIC seems to diverge, but with insignificant effect. In the industrial sector, there are some divergent effects for wood, pulp, paper, printing and publishing, and coke, refined petroleum and nuclear fuel (with the significant level of 1% and 5% for wood and pulp, paper, printing and publishing, respectively; while there is insignificant convergence effect of chemical and chemical products). In service sector, most sub-sectors are significantly converged, except hotels and restaurants, and financial intermediation whose coefficients are insignificant.

Table 9: OLS estimation of convergence of some economic sectors among BRIC

Number of countries : 4

Number of periods : 12

Observation : 48

	Sector		β	t-stat	λ
30	Renting of machines & equipment and other business activities	(S)	-0.460***	-3.250	0.043
5	Leather, leather and footwear	(I)	-0.413***	-5.225	0.037
27	Post and telecommunications	(S)	-0.346***	-4.975	0.030
20	Wholesale trade and commission trade	(S)	-0.312***	-6.826	0.026
26	Other supporting of transport activities	(S)	-0.303***	-7.368	0.025
31	Public admin and defense; compulsory social security	(S)	-0.290***	-6.621	0.024
24	Other Water transport	(S)	-0.275***	-6.862	0.023
14	Electrical and optical equipment	(I)	-0.252***	-4.510	0.021
29	Real estate activities	(S)	-0.238***	-6.213	0.019
25	Other Air transport	(S)	-0.229***	-4.888	0.018
15	Transport equipment	(I)	-0.197***	-2.798	0.016
23	Other Inland transport	(S)	-0.193***	-4.074	0.015
33	Health and social work	(S)	-0.188***	-4.405	0.015
4	Textiles and textile	(I)	-0.173***	-3.916	0.014
21	Retail trade and repair of household goods	(S)	-0.171***	-8.440	0.013
16	Manufacturing NEC; Recycling	(I)	-0.170***	-4.768	0.013

10	Rubber and plastics	(I)	-0.165***	-4.378	0.013
12	Basic metals	(I)	-0.159**	-2.288	0.012
11	Other non-metallic mineral	(I)	-0.153***	-2.637	0.012
32	Education	(S)	-0.148***	-4.474	0.011
34	Other community, social and personal services	(S)	-0.141***	-7.029	0.011
2	Mining and quarrying	(I)	-0.137***	-3.389	0.010
13	Machinery, NEC	(I)	-0.118**	-2.099	0.009
18	Construction	(I)	-0.111***	-2.738	0.008
19	Sale, maintenance and repair of motor vehicles	(S)	-0.109**	-2.316	0.008
17	Electricity, gas and water supply	(I)	-0.106*	-1.931	0.008
22	Hotels and restaurants	(S)	-0.103	-1.673	0.008
3	Food, beverages, and tobacco	(I)	-0.086**	-2.483	0.006
9	Chemicals and chemical products	(I)	-0.057	-0.935	0.004
28	Financial intermediation	(S)	-0.056	-0.849	0.004
8	Coke, refined petroleum and nuclear fuel	(I)	0.023	0.315	-0.002
1	Agriculture, hunting forestry and fishing	(A)	0.029	0.909	-0.002
7	pulp, paper, printing and publishing	(I)	0.082	1.949	-0.006
6	Wood and of wood and cork	(I)	0.155	3.956	-0.010
35	Private households with employed persons	(S)	N.A	N.A	N.A
	Total		-0.149	-4.390	0.011

Note: *, **, and *** indicate the significance of 1%, 5%, and 10% level, respectively. This table is ranked by the highest to lowest speed of convergence (the λ column).

As regards to the speed of convergence (λ), the annual rates of convergence in different sectors (that are statistically significant) range from 0.6% (of food, beverage, and tobacco) to 4.3% (of renting of machines & equipment and other business activities). It can be observed that most service sectors have higher annual speeds of convergence than those of industrial sectors. These results confirm our findings of the decomposition analysis that service sectors grow faster than industrial sectors in Brazil, Russian, and India (except China).

5.2.2 Empirical results of BRICs and some OECD countries (10 sectors)

Apart from 35 sectors' labor productivity of BRICs, we also test the convergence of 10 sectors. The purpose of doing so is to compare the results with OECD countries (this is due to only 10 sector data of OECD are available). The estimated results of BRICs' and four OECDs' 10 sectors are reported in Table 10.1 and Table 10.2, respectively.

Table 10.1: OLS estimation of convergence of 10 sectors among BRICs

Number of countries: 4, Number of periods: 14, Observation: 56

Sector		β	t-stat	λ
8 Finance, Insurance, and Real Estate	(S)	-0.428***	-6.201	0.039
7 Transport, Storage, and Communication	(S)	-0.299***	-6.280	0.025
6 Wholesale and Retail Trade, Hotels and Restaurants	(S)	-0.203***	-6.719	0.016
9 Community, Social and Personal Services	(S)	-0.196***	-5.336	0.015
10 Government Services	(S)	-0.137***	-7.965	0.010
2 Mining and Quarrying	(I)	-0.137***	-3.389	0.010
5 Construction	(I)	-0.111***	-2.738	0.008
4 Public Utilities	(I)	-0.106*	-1.931	0.008
3 Manufacturing	(I)	-0.087*	-1.807	0.007
1 Agriculture, Forestry, and Fishing	(A)	0.029	0.909	-0.002
Total		-0.149***	-4.390	0.011

Note: *, **, and *** indicate the significance of 1%, 5%, and 10% level, respectively. This table is ranked by the highest to lowest speed of convergence (the λ column).

Another point to consider for the comparability, we choose the time span of 14 year for OECDs (as BRICs' time span is only 14 years). Accordingly, we choose to estimate the convergence coefficient using the period from 1970-83. This time period is preferable because we can compare our estimated results with the study of Bernard and Jones (1996b), which covers the period 1970-1987.

For BRICs, the results after merging to 10 sectors obviously show that all sub-sectors in service sector have the highest speed of convergence, following by those related to industrial sector, and no convergence for agriculture. The difference from the disaggregated sector analysis is that financial-related sector becomes the sector with highest speed of convergence. Other sectors' ranks are slightly different to the previous estimation. In contrast to BRICs, the convergence results of the OECD countries are somehow mixed. Mining has highest speed of convergence, following by financial sectors, construction and so on (as shown in Table 10.2). Surprisingly, agriculture also seems to converge among four OECD countries, while trade and

manufacturing do not converge. Comparing the OECDs' results to BRICs, we can see that many sectors in BRICs have higher speed of convergence than those of OECDs. This implies that in BRICs, the less developed countries (these could be China and India) are growing at high rate and are quickly catching up with the more developed nations.

Table 10.2: OLS estimation of convergence of 10 sectors among four OECD countries

Number of countries: 4, Number of periods: 14 (1970-1983), Observation: 56

Sector		β	t-stat	λ
2 Mining and Quarrying	(I)	-0.176***	-3.907	0.014
8 Finance, Insurance, and Real Estate	(S)	-0.169***	-6.985	0.013
5 Construction	(I)	-0.076***	-5.149	0.006
1 Agriculture, Forestry, and Fishing	(A)	-0.076***	-3.075	0.006
4 Public Utilities	(I)	-0.069***	-3.193	0.005
7 Transport, Storage, and Communication	(S)	-0.066***	-3.758	0.005
6 Wholesale and Retail Trade, Hotels and Restaurants	(S)	-0.022	-0.526	0.002
3 Manufacturing	(I)	-0.020	-0.873	0.001
10 Government Services	(S)	0.017*	1.840	-0.001
9 Community, Social and Personal Services	(S)	0.033***	4.066	-0.002
Total		-0.041**	-2.159	0.003

Note: *, **, and *** indicate the significance of 1%, 5%, and 10% level, respectively. This table is ranked by the highest to lowest speed of convergence (the λ column).

By comparing our OECDs' results with those of Bernard and Jones (1996b) and Boussemart et al. (2006), we can observe that our results are somehow different to theirs. In the study of Bernard and Jones (1996b), mining, manufacturing, and agricultural do not converge in the long run, while services converge the fastest, following by construction and electricity, gas, and water. In the study of Boussemart et al. (2006), agriculture, finance, textile and leather, and government service sectors do not converge to the leader's productivity. In addition, they found that industrial sectors were the top four that have highest catching up rates. Taken together, it seems to be difficult to make a clear cut conclusion on which sectors actually converge the fastest and contribute to the aggregate convergence. Nevertheless, we can say that these results imply that there might be technology diffusion in most sectors that statistically and significantly converge. In case of our studies, for BRICs, service sectors seem to fall in this category; while for OECDs, there is a mix between industrial and service sector. These could be the consequence of using different data set, different periods, and different sample sizes. Nevertheless, the comparison gives us some information about how sensitive the results could be given different dataset, periods, and sample sizes.

Table 11: Results of productivity convergence of OECD in Bernard and Jones (1996b)

Observation: 14 OECD, period: 1970-1987

Sector	β	t -stat	λ	R^2
Mining	- 0.029	-1.38	0.0364	0.07
Manufacturing	- 0.0262	-1.78	0.0326	0.14
Services	- 0.0244***	-2.85	0.0283	0.56
Construction	- 0.0227**	-2.03	0.0274	0.19
Electricity/gas/water	- 0.0208**	-2.2	0.0246	0.23
Agriculture	- 0.0122	-1.57	0.0134	0.1
Total industry	- 0.0298***	-5.73	0.0385	0.71

Source: Bernard and Jones (1996b)

Note: *, **, and *** indicate the significance of 1%, 5%, and 10% level, respectively.

Table 12: Results of productivity convergence of OECD in Boussemart et al. (2006)

Observation: 14 OECD, period: 1970-1996

Sector	β	t -stat	λ	R^2
Mining	-0.85***	-7.212	0.095	0.839
Machinery and equipment	-0.73***	-3.446	0.065	0.543
Chemicals	-0.687***	-5.31	0.058	0.738
Construction	-0.631***	-2.67	0.050	0.373
Whole sale trade and retail trade	-0.597***	-5.188	0.045	0.729
Food, beverage, and tobacco	-0.513***	-2.856	0.036	0.449
Electricity, gas, and water	-0.505***	-5.944	0.035	0.746
Basic metal products	-0.467***	-3.526	0.031	0.554
Agriculture	-0.452	-1.463	0.030	0.151
Transport, storage and communication	-0.351***	-2.728	0.022	0.383
Financial institutions and insurance	-0.345	-1.548	0.021	0.179
Community, social and personal services	-0.316**	-2.31	0.019	0.308
Textile, wearing apparel and leather	-0.239	-0.923	0.014	0.078
Government services	0.062	0.446	-0.003	0.016

Source: Bernard and Jones (1996b)

Note: *, **, and *** indicate the significance of 1%, 5%, and 10% level, respectively.

These results are taken from the cross-section estimation. They, in fact, derive and estimate a model of catching up between a leader (USA) and the followers (other OECD countries).

6. Conclusion

In this study, we seek to understand the patterns of structural changes, labor productivity growth and convergence in BRIC countries. Initially, we utilize the shift and share analysis to investigate the contribution of within shift, static shift and dynamic shift effects on growth of labor productivity. We then use the convergence tests to check there will be a convergence in each economic sector even with the existing different patterns of structural changes in each country. Our aggregate shift-share decomposition results report that labor productivity growth within sector itself is the main source of aggregate growth, while an effect of labor movement exists (shift effect) but not substantial. Among BRIC, we found that during 1980-2008, China had the highest rate of labor productivity growth, following by India and Russia, while Brazil performed the worst. We then employ the shift-share analysis for the disaggregated level. The results show that BRIC had different pattern of structural changes. Nevertheless, we can observe in general that in Brazil, Russia, and India, most service sectors had high within-sector labor productivity growth (within shift effect) and labor mostly mobile in this sector, while in China, alone, this within-sector growth concentrated in industrial sectors.

In the second part of our analyses, we proceed to the convergence issue, where we want to test whether the cross-country convergence of each sector occurs even with different pattern of structural change. In this part we first check for the stagnation of sectors in each country using a time series' stationary test. It is found that in Brazil some sectors had already stagnated, while for the rests no stagnation prevailed. This is a big hint for us that the convergence of among these countries might prevail. We then proceed with the cross-country test of productivity convergence. We compare BRICs with four OECD countries. Our findings indicate that the coefficients of speed of convergence in BRICs are higher than in OECDs. This confirms the growth theory that less developed countries tend to have faster rate of catching up. Addressing the issue of the sectors that contribute to the aggregate convergence the most, it is found that in BRICs most service sectors that connect to international transaction have high rates of convergence, following by some industrial sectors, while agricultural sector is diverged. In contrast, in four OECD countries, there are mixtures of industrial and service sectors that have high rate of convergence. However, the sectors that do not converge are trade and manufacturing. This could imply that the international practices, management know-how, and technology in some service sectors spill to BRICs and help these countries develop quickly.

But our results are not yielded without confusion; we find that, in 10 sector analysis of BRICs, financial sector (which include financial intermediation, insurance, and real estate) has highest speed of convergence. However, when we look at the disaggregated 35 sectors; it is found that financial intermediation does not converge. These findings indicate that there is technology spill over in insurance and real estate, but not through the financial system in BRICs.

Thus, it might be a hint that there would not be technology spillover through financial intermediation, even with the current integrated financial system.

In conclusion, from our analyses, we find that among BRICs, there are different patterns of structural change. In most countries, except China, services have high growth rate of labor productivity. While most countries in BRIC rely on service sectors for aggregate growth, China has relied on industrial sectors in its transitional period. Nevertheless even with different patterns of structural changes, it is likely that in the long run the labor productivity of BRIC would converge and this convergence shall be driven by the service sectors.

7. References

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Appendix A

Table A1: 10 economic sectors of some OECD countries

1	Agriculture, Forestry and Fishing	Agriculture
2	Mining and Quarrying	Industry
3	Manufacturing	Industry
4	Public Utility	Industry
5	Construction	Industry
6	Wholesale and Retail Trade, Hotels and Restaurants	Service
7	Transport, Storage, and Communication	Service
8	Finance, Insurance, and Real Estate	Service
9	Community, Social and Personal Services	Service
10	Government Services	Service

Appendix B

Proof of labor productivity decomposition

Following previous literature, the aggregate growth of labor productivity can be decomposed into three separate effects:

$$\begin{aligned}
 \text{growth}(LP) &= \frac{LP_1 - LP_0}{LP_0} \quad \text{or} \\
 \frac{LP_1 - LP_0}{LP_0} &= \frac{\overbrace{\sum_{i=1}^n S_{i,0} (LP_{i,1} - LP_{i,0})}^{\text{Within shift effect}} + \overbrace{\sum_{i=1}^n LP_{i,0} (S_{i,1} - S_{i,0})}^{\text{Static shift effect}} + \overbrace{\sum_{i=1}^n (LP_{i,1} - LP_{i,0})(S_{i,1} - S_{i,0})}^{\text{dynamic shift effect}}}{LP_0}
 \end{aligned} \tag{B.1}$$

Or simply write

$$\frac{\Delta LP}{LP_0} = \frac{\sum_{i=1}^n LP_{i,0} \Delta S_i + \sum_{i=1}^n S_{i,0} \Delta LP_i + \sum_{i=1}^n \Delta LP_i \Delta S_i}{LP_0} \tag{B.2}$$

Where

LP is labor productivity.

S_i is the share of industry i in total employment.

Subscript 0 represents base year.

Subscript 1 represents final year;

Methods of proofs

Step 1: Proof that $LP = \sum_{i=1}^n [LP_i \cdot S_i]$

Proof

$$\begin{aligned}
 \frac{Y}{L} &= \frac{Y_1 + Y_2 + \dots + Y_n}{\sum L_i} = \frac{Y_1}{\sum L_i} + \frac{Y_2}{\sum L_i} + \dots + \frac{Y_n}{\sum L_i} \\
 &= \frac{Y_1}{L_1} \cdot \left(\frac{L_1}{\sum L_i} \right) + \frac{Y_2}{L_2} \cdot \left(\frac{L_2}{\sum L_i} \right) + \dots + \frac{Y_n}{L_n} \cdot \left(\frac{L_n}{\sum L_i} \right) \\
 &= \sum_{i=1}^n \left[\frac{Y_i}{L_i} \cdot \frac{L_i}{\sum L_i} \right] = \sum_{i=1}^n [LP_i \cdot S_i] \tag{B.3}
 \end{aligned}$$

■ End of Proof

Step 2: Proof that $\Delta LP = \sum_{i=1}^n LP_{i,0} \Delta S_i + \sum_{i=1}^n S_{i,0} \Delta LP_i + \sum_{i=1}^n \Delta LP_i \Delta S_i$

Proof:

For the exposition purpose, let

$$Z_i = LP_i \cdot S_i. \tag{B.4}$$

This means that $LP = \sum_{i=1}^n [LP_i \cdot S_i] = \sum_{i=1}^n [Z_i]$

If we rewrite (B.4) as a function of time t , we have $Z_{i,(t)} = LP_{i,(t)} \cdot S_{i,(t)}$

When t changes from $t_0 \rightarrow t_1$ by Δt , then Z , LP , and S also change from Z_0 , LP_0 , and S_0 to Z_1 , LP_1 , and S_1 by ΔZ , ΔLP , and ΔS , respectively. Thus, we can write

$$\Delta Z = Z_1 - Z_0 \quad \text{or} \quad Z_1 = Z_0 + \Delta Z \tag{B.5.1}$$

$$\Delta LP = LP_1 - LP_0 \quad \text{or} \quad LP_1 = LP_0 + \Delta LP \tag{B.5.2}$$

$$\Delta S = S_1 - S_0 \quad \text{or} \quad S_1 = S_0 + \Delta S \tag{B.5.3}$$

Substitute (B.5.1), (B.5.2), and (B.5.3) into (B.4), we yield

$$Z_{i,0} + \Delta Z_i = (LP_{i,0} + \Delta LP_i) \cdot (S_{i,0} + \Delta S_i)$$

$$\Delta Z_i = (LP_{i,0} + \Delta LP_i) \cdot (S_{i,0} + \Delta S_i) - Z_{i,0}$$

$$\Delta Z_i = (LP_{i,0} + \Delta LP_i) \cdot (S_{i,0} + \Delta S_i) - LP_{i,0} \cdot S_{i,0}$$

$$\Delta Z_i = LP_{i,0} \cdot \Delta S_i + S_{i,0} \cdot \Delta LP_i + \Delta LP_i \cdot \Delta S_i$$

Therefore,

$$\sum_{i=1}^n \Delta Z_i = \sum_{i=1}^n LP_{i,0} \Delta S_i + \sum_{i=1}^n S_{i,0} \Delta LP_i + \sum_{i=1}^n \Delta LP_i \Delta S_i$$

And that

$$\Delta LP = \sum_{i=1}^n LP_{i,0} \Delta S_i + \sum_{i=1}^n S_{i,0} \Delta LP_i + \sum_{i=1}^n \Delta LP_i \Delta S_i \quad (\text{B.6})$$

■End of Proof

Step 3

Divide both sides of (B.6) by LP_0 , we have growth rate of labor productivity as (2)

$$\frac{\Delta LP}{LP_0} = \frac{\sum_{i=1}^n LP_{i,0} \Delta S_i + \sum_{i=1}^n S_{i,0} \Delta LP_i + \sum_{i=1}^n \Delta LP_i \Delta S_i}{LP_0}$$

Appendix C

In the text, we have equation (6) as

$$\ln(LP_{i,t}^k) - \ln(LP_{i,t-1}^k) = \mu_i - \lambda^k \ln(LP_{i,t-1}^k) + u_{i,t}^k \quad (6)$$

where $\lambda^k \ln(LP_{i,t-1}^k) = \mu_i$ which captures the country heterogeneity due to social capability in adapting available technology.

For simplicity, we drop the super script k and the subscript i , and write Eq.(6) as

$$\ln(LP_t) - \ln(LP_{t-1}) = \mu - \lambda \ln(LP_{t-1}) + u_t$$

$$\text{Or } \ln(LP_t) = \mu + (1 - \lambda) \ln(LP_{t-1}) + u_t \quad (C.1)$$

This implies that for period 1, we have

$$\ln(LP_1) = \mu + (1 - \lambda) \ln(LP_0) + u_1$$

For period 2, we have

$$\begin{aligned} \ln(LP_2) &= \mu + (1 - \lambda) \ln(LP_1) + u_2 = \mu + (1 - \lambda) [\mu + (1 - \lambda) \ln(LP_0) + u_1] + u_2 \\ &= \mu + \mu(1 - \lambda) + (1 - \lambda)^2 \ln(LP_0) + (1 - \lambda)u_1 + u_2 \end{aligned}$$

For period 3, we have

$$\ln(LP_3) = \mu [1 + (1 - \lambda) + (1 - \lambda)^2] + (1 - \lambda)^3 \ln(LP_0) + (1 - \lambda)^2 u_1 + (1 - \lambda)u_2 + u_3$$

Repeating the iteration, for time $T > 0$, we yield

$$\ln(LP_T) = \mu \sum_{m=0}^{T-1} (1 - \lambda)^m + (1 - \lambda)^T \ln(LP_0) + \sum_{m=0}^{T-1} (1 - \lambda)^m u_{T-m} \quad (C.2)$$

Putting superscript and subscript back and subtracting both sides of Eq.(4.2) by $\ln(LP_0)$, we yield

$$\ln(LP_{i,T}^k) - \ln(LP_{i,0}^k) = \mu \sum_{m=0}^{T-1} (1 - \lambda^k)^m - (1 - (1 - \lambda^k)^T) \ln(LP_{i,0}^k) + \sum_{m=0}^{T-1} (1 - \lambda^k)^m u_{i,T-m}^k \quad (C.3)$$

Or we write Eq. (C.3) as

$$\ln(LP_{i,T}^k) - \ln(LP_{i,0}^k) = \alpha^k + \beta^k \ln(LP_{i,0}^k) + v_{i,T}^k \quad (\text{C.4})$$

where

$$\alpha^k = \mu^k \sum_{m=0}^{T-1} (1 - \lambda^k)^m, \quad \beta^k = -(1 - (1 - \lambda^k)^T), \quad \text{and} \quad v_{i,t}^k = \sum_{m=0}^{T-1} (1 - \lambda^k)^m u_{i,T-m}^k$$

At steady state, we assume that $\mu = \mu_i$ (This means that the technology and social capability are the same in the long run for all countries).

Appendix D

Brazil's structural change and labor productivity

Table D1: Brazil's within shift effect

	1980-1994 (average)	1995-2008 (average)	1980-2008 (average)
Agriculture, hunting forestry and fishing	0.149	0.306	0.228
Real estate activities	-0.010	0.249	0.120
Electricity, gas and water supply	0.118	0.088	0.103
Chemicals and chemical products	-0.046	0.144	0.049
Hotels and restaurants	-0.079	0.173	0.047
Mining and quarrying	0.038	0.035	0.037
Post and telecommunications	0.000	0.018	0.009
Transport equipment	-0.029	0.040	0.006
pulp, paper, printing and publishing	-0.028	0.032	0.002
Machinery, NEC	-0.023	0.023	0.000
Manufacturing NEC; Recycling	-0.019	0.015	-0.002
Other Air transport	0.000	-0.010	-0.005
Other Water transport	0.000	-0.010	-0.005
Coke, refined petroleum and nuclear fuel	-0.015	0.004	-0.006
Wood and of wood and cork	-0.010	-0.002	-0.006
Other non-metallic mineral	-0.016	0.003	-0.006
Leather, leather and footwear	-0.007	-0.008	-0.007
Basic metals	-0.044	0.017	-0.013
Financial intermediation	-0.225	0.198	-0.013

Electrical and optical equipment	-0.030	0.002	-0.014
Rubber and plastics	-0.015	-0.015	-0.015
Other supporting of transport activities	0.000	-0.032	-0.016
Textiles and textile	-0.047	-0.011	-0.029
Other Inland transport	0.001	-0.059	-0.029
Other community, social and personal services	-0.060	-0.003	-0.031
Health and social work	-0.053	-0.013	-0.033
Food, beverages, and tobacco	-0.060	-0.007	-0.034
Sale, maintenance and repair of motor vehicles	-0.085	0.001	-0.042
Construction	-0.027	-0.058	-0.043
Wholesale trade and commission trade	-0.156	0.059	-0.048
Education	-0.071	-0.079	-0.075
Public admin and defense; compulsory social security	-0.127	-0.056	-0.092
Renting of m&eq and other business activities	-0.172	-0.084	-0.128
Retail trade and repair of household goods	-0.277	0.006	-0.135
Private households with employed persons			
Total	-1.420	0.968	-0.226

Source: Groningen Growth for Development Center (2013)

Table D2: Brazil's static shift effect

	1980-1994 (average)	1995-2008 (average)	1980-2008 (average)
Public admin and defense; compulsory social security	0.194	0.116	0.155
Retail trade and repair of household goods	0.225	0.064	0.144
Education	0.108	0.069	0.089
Wholesale trade and commission trade	0.127	0.029	0.078
Renting of m&eq and other business activities	0.022	0.130	0.076
Health and social work	0.080	0.057	0.069
Other community, social and personal services	0.091	0.041	0.066
Other Inland transport	0.064	0.034	0.049
Hotels and restaurants	0.064	0.014	0.039
Other supporting of transport activities	0.029	0.025	0.027
Coke, refined petroleum and nuclear fuel	0.003	0.050	0.027
Transport equipment	0.006	0.037	0.022
Sale, maintenance and repair of motor vehicles	0.069	-0.027	0.021

Post and telecommunications	0.017	0.021	0.019
Food, beverages, and tobacco	0.013	0.016	0.015
Machinery, NEC	0.005	0.022	0.013
Basic metals	0.010	0.016	0.013
Electrical and optical equipment	0.007	0.013	0.010
Other Water transport	0.006	0.005	0.005
Other Air transport	0.008	0.001	0.005
Rubber and plastics	0.003	0.005	0.004
Other non-metallic mineral	0.004	-0.001	0.001
Leather, leather and footwear	0.002	0.000	0.001
Manufacturing NEC; Recycling	0.004	-0.004	0.000
Wood and of wood and cork	0.002	-0.006	-0.002
Textiles and textile	0.011	-0.019	-0.004
pulp, paper, printing and publishing	0.006	-0.017	-0.006
Mining and quarrying	-0.017	-0.012	-0.014
Chemicals and chemical products	0.010	-0.040	-0.015
Electricity, gas and water supply	-0.047	-0.042	-0.044
Real estate activities	0.019	-0.111	-0.046
Financial intermediation	0.029	-0.126	-0.048
Construction	-0.166	0.063	-0.051
Agriculture, hunting forestry and fishing	-0.120	-0.170	-0.145
Private households with employed persons			
Total	0.888	0.255	0.572

Source: Groningen Growth for Development Center (2013)

Table D3: Brazil's dynamic shift effect

	1980-1994 (average)	1995-2008 (average)	1980-2008 (average)
Leather, leather and footwear	-0.0007	-0.0003	-0.0005
Wood and of wood and cork	-0.0010	-0.0000	-0.0005
Machinery, NEC	-0.0022	0.0006	-0.0008
Other non-metallic mineral	-0.0016	-0.0001	-0.0008
Rubber and plastics	-0.0015	-0.0010	-0.0012
Transport equipment	-0.0028	-0.0000	-0.0014
Electrical and optical equipment	-0.0029	-0.0003	-0.0016

Manufacturing NEC; Recycling	-0.0018	-0.0017	-0.0017
pulp, paper, printing and publishing	-0.0027	-0.0015	-0.0021
Other Water transport	-0.0049	-0.0008	-0.0028
Sale, maintenance and repair of motor vehicles	-0.0078	0.0017	-0.0031
Mining and quarrying	-0.0048	-0.0018	-0.0033
Basic metals	-0.0043	-0.0032	-0.0037
Other Air transport	-0.0073	-0.0004	-0.0038
Textiles and textile	-0.0046	-0.0035	-0.0040
Food, beverages, and tobacco	-0.0058	-0.0029	-0.0044
Hotels and restaurants	-0.0073	-0.0032	-0.0053
Health and social work	-0.0093	-0.0012	-0.0053
Other community, social and personal services	-0.0105	-0.0014	-0.0060
Construction	-0.0108	-0.0023	-0.0065
Chemicals and chemical products	-0.0045	-0.0097	-0.0071
Post and telecommunications	-0.0149	0.0001	-0.0074
Wholesale trade and commission trade	-0.0144	-0.0024	-0.0084
Education	-0.0125	-0.0047	-0.0086
Renting of m&eq and other business activities	-0.0167	-0.0012	-0.0089
Coke, refined petroleum and nuclear fuel	-0.0014	-0.0181	-0.0098
Public admin and defense; compulsory social security	-0.0224	-0.0009	-0.0117
Electricity, gas and water supply	-0.0135	-0.0123	-0.0129
Other supporting of transport activities	-0.0253	-0.0005	-0.0129
Retail trade and repair of household goods	-0.0255	-0.0012	-0.0133
Financial intermediation	-0.0218	-0.0101	-0.0159
Real estate activities	-0.0154	-0.0186	-0.0170
Agriculture, hunting forestry and fishing	-0.0251	-0.0157	-0.0204
Other Inland transport	-0.0564	-0.0001	-0.0282
Private households with employed persons			
Total	-0.3642	-0.1190	-0.2416

Source: Groningen Growth for Development Center (2013)

Russia's structural change and labor productivity

Table D4: Russia's within shift effect

$(LP^T - LP^0)S^0$	1995-2008 (average)
Renting of m&eq and other business activities	0.727
Real estate activities	0.313
Construction	0.250
Mining and quarrying	0.247
Wholesale trade and commission trade	0.189
Other Inland transport	0.166
Financial intermediation	0.158
Agriculture, hunting forestry and fishing	0.139
Food, beverages, and tobacco	0.134
Post and telecommunications	0.134
Basic metals	0.123
Chemicals and chemical products	0.069
Electrical and optical equipment	0.065
Other supporting of transport activities	0.054
Retail trade and repair of household goods	0.050
Machinery, NEC	0.050
Coke, refined petroleum and nuclear fuel	0.045
Other Air transport	0.040
Other non-metallic mineral	0.038
pulp, paper, printing and publishing	0.031
Other Water transport	0.025
Sale, maintenance and repair of motor vehicles	0.023
Rubber and plastics	0.022
Textiles and textile	0.016
Wood and of wood and cork	0.008
Education	0.007
Leather, leather and footwear	0.005
Other community, social and personal services	0.002
Health and social work	0.002

Transport equipment	0.000
Private households with employed persons	0.000
Manufacturing NEC; Recycling	-0.008
Hotels and restaurants	-0.010
Electricity, gas and water supply	-0.044
Public admin and defense; compulsory social security	-0.112
Total	2.963

Table D5: Russia's static shift effect

$(S^T - S^0)LP^0$	1995-2008 (average)
Wholesale trade and commission trade	0.712
Retail trade and repair of household goods	0.336
Public admin and defense; compulsory social security	0.207
Financial intermediation	0.081
Electricity, gas and water supply	0.066
Hotels and restaurants	0.062
Other supporting of transport activities	0.042
Renting of m&eq and other business activities	0.030
Sale, maintenance and repair of motor vehicles	0.028
Other community, social and personal services	0.024
Food, beverages, and tobacco	0.010
Manufacturing NEC; Recycling	0.009
Health and social work	0.009
Post and telecommunications	0.009
pulp, paper, printing and publishing	0.008
Rubber and plastics	0.006
Private households with employed persons	0.000
Leather, leather and footwear	-0.003
Wood and of wood and cork	-0.004
Other Inland transport	-0.006
Education	-0.011
Coke, refined petroleum and nuclear fuel	-0.016
Other Air transport	-0.016
Textiles and textile	-0.022

Other Water transport	-0.022
Real estate activities	-0.024
Electrical and optical equipment	-0.030
Chemicals and chemical products	-0.031
Other non-metallic mineral	-0.032
Transport equipment	-0.035
Construction	-0.038
Basic metals	-0.042
Machinery, NEC	-0.059
Mining and quarrying	-0.075
Agriculture, hunting forestry and fishing	-0.107
Total	1.066

Table D6: Russia's dynamic shift effect

$(LP^T-LP^0)(S^T-S^0)$	1995-2008 (average)
Construction	0.008
Financial intermediation	0.007
Transport equipment	0.003
Other non-metallic mineral	0.002
Post and telecommunications	0.001
Machinery, NEC	0.001
Wood and of wood and cork	0.000
Rubber and plastics	0.000
Private households with employed persons	0.000
Health and social work	-0.000
Education	-0.000
Textiles and textile	-0.000
Other community, social and personal services	-0.000
Basic metals	-0.001
Leather, leather and footwear	-0.001
pulp, paper, printing and publishing	-0.002
Other Inland transport	-0.002
Sale, maintenance and repair of motor vehicles	-0.002
Electrical and optical equipment	-0.002
Other Water transport	-0.002

Food, beverages, and tobacco	-0.003
Chemicals and chemical products	-0.003
Other Air transport	-0.003
Coke, refined petroleum and nuclear fuel	-0.003
Manufacturing NEC; Recycling	-0.005
Agriculture, hunting forestry and fishing	-0.005
Electricity, gas and water supply	-0.006
Real estate activities	-0.006
Hotels and restaurants	-0.006
Other supporting of transport activities	-0.008
Mining and quarrying	-0.010
Retail trade and repair of household goods	-0.031
Renting of m&eq and other business activities	-0.033
Public admin and defense; compulsory social security	-0.035
Wholesale trade and commission trade	-0.065
Total	-0.214

India's structural change and labor productivity

Table D7: India's within shift effect

$(LP^T - LP^0)S^0$	1981-1990	1991-2008	1981-2008
	(average)	(average)	(average)
Agriculture, hunting forestry and fishing	0.609	0.472	0.521
Public admin and defense; compulsory social security	0.245	0.320	0.293
Financial intermediation	0.223	0.320	0.285
Post and telecommunications	0.033	0.372	0.251
Retail trade and repair of household goods	0.150	0.286	0.237
Wholesale trade and commission trade	0.072	0.173	0.137
Other Inland transport	0.124	0.133	0.130
Chemicals and chemical products	0.091	0.137	0.121
Electricity, gas and water supply	0.092	0.116	0.108
Education	0.137	0.084	0.103
Basic metals	0.087	0.099	0.095
Renting of m&eq and other business activities	0.033	0.119	0.088
Textiles and textile	0.087	0.081	0.083
Electrical and optical equipment	0.067	0.084	0.078

Food, beverages, and tobacco	0.072	0.079	0.076
Health and social work	0.074	0.067	0.069
Mining and quarrying	0.059	0.067	0.064
Hotels and restaurants	0.038	0.058	0.051
Other community, social and personal services	0.025	0.057	0.045
Coke, refined petroleum and nuclear fuel	0.021	0.054	0.042
Other non-metallic mineral	0.056	0.029	0.039
Transport equipment	0.024	0.025	0.025
Manufacturing NEC; Recycling	-0.001	0.036	0.023
Machinery, NEC	0.027	0.018	0.021
Sale, maintenance and repair of motor vehicles	0.007	0.010	0.009
pulp, paper, printing and publishing	0.037	-0.007	0.009
Construction	-0.161	0.094	0.003
Private households with employed persons	0.005	-0.001	0.001
Leather, leather and footwear	0.000	0.000	0.000
Other Water transport	0.000	0.000	0.000
Other Air transport	0.000	0.000	0.000
Other supporting of transport activities	0.000	0.000	0.000
Rubber and plastics	0.011	-0.006	-0.000
Wood and of wood and cork	-0.029	-0.006	-0.014
Real estate activities	0.159	-0.287	-0.128
Total	2.473	3.081	2.864

Table D8: India's static shift effect

	1981-1990 (average)	1991-2008 (average)	1981-2008 (average)
Real estate activities	0.130	0.470	0.349
Construction	0.319	0.197	0.241
Financial intermediation	0.073	0.170	0.135
Retail trade and repair of household goods	0.120	0.140	0.133
Other Inland transport	0.064	0.154	0.122
Wholesale trade and commission trade	0.058	0.141	0.112
Post and telecommunications	0.003	0.169	0.110
Renting of m&eq and other business activities	0.019	0.147	0.101
Education	-0.005	0.092	0.058
Transport equipment	0.016	0.034	0.028

Electrical and optical equipment	0.050	0.014	0.027
Sale, maintenance and repair of motor vehicles	0.014	0.031	0.025
Chemicals and chemical products	0.031	0.018	0.022
Hotels and restaurants	-0.003	0.035	0.022
Health and social work	-0.008	0.037	0.021
Basic metals	0.001	0.030	0.020
Mining and quarrying	0.079	-0.013	0.020
Machinery, NEC	0.021	0.019	0.020
Rubber and plastics	0.029	0.013	0.019
Manufacturing NEC; Recycling	0.016	0.013	0.014
pulp, paper, printing and publishing	0.002	0.016	0.011
Textiles and textile	-0.031	0.034	0.011
Other community, social and personal services	0.008	0.009	0.009
Other non-metallic mineral	-0.000	0.011	0.007
Electricity, gas and water supply	0.039	-0.013	0.006
Food, beverages, and tobacco	0.019	-0.008	0.002
Private households with employed persons	-0.009	0.008	0.002
Leather, leather and footwear	0.000	0.000	0.000
Other Water transport	0.000	0.000	0.000
Other Air transport	0.000	0.000	0.000
Other supporting of transport activities	0.000	0.000	0.000
Coke, refined petroleum and nuclear fuel	0.023	-0.017	-0.003
Wood and of wood and cork	-0.012	0.000	-0.004
Public admin and defense; compulsory social security	0.011	-0.146	-0.090
Agriculture, hunting forestry and fishing	-0.213	-0.267	-0.248
Total	0.864	1.538	1.297

Table D9: India's dynamic shift effect

	1981-1990 (average)	1991-2008 (average)	1981-2008 (average)
Post and telecommunications	-0.000	0.020	0.013
Renting of m&eq and other business activities	0.000	0.007	0.005
Education	0.000	0.001	0.001
Financial intermediation	0.004	-0.001	0.001
Hotels and restaurants	-0.001	0.001	0.001
Health and social work	-0.001	0.001	0.001

Other non-metallic mineral	-0.000	0.000	0.000
Leather, leather and footwear	0.000	0.000	0.000
Other Water transport	0.000	0.000	0.000
Other Air transport	0.000	0.000	0.000
Other supporting of transport activities	0.000	0.000	0.000
Manufacturing NEC; Recycling	-0.000	-0.000	-0.000
Wood and of wood and cork	-0.001	-0.000	-0.001
Retail trade and repair of household goods	-0.002	0.000	-0.001
Sale, maintenance and repair of motor vehicles	0.000	-0.001	-0.001
Food, beverages, and tobacco	-0.000	-0.001	-0.001
pulp, paper, printing and publishing	-0.002	-0.001	-0.001
Rubber and plastics	0.000	-0.002	-0.001
Chemicals and chemical products	0.000	-0.002	-0.001
Other Inland transport	-0.003	-0.000	-0.001
Private households with employed persons	-0.000	-0.002	-0.001
Mining and quarrying	-0.002	-0.002	-0.002
Wholesale trade and commission trade	-0.001	-0.004	-0.003
Electricity, gas and water supply	0.001	-0.005	-0.003
Basic metals	-0.003	-0.003	-0.003
Transport equipment	-0.005	-0.002	-0.003
Other community, social and personal services	-0.001	-0.005	-0.003
Electrical and optical equipment	0.001	-0.008	-0.005
Coke, refined petroleum and nuclear fuel	0.002	-0.009	-0.005
Agriculture, hunting forestry and fishing	-0.004	-0.007	-0.006
Machinery, NEC	-0.012	-0.009	-0.010
Textiles and textile	-0.004	-0.014	-0.011
Public admin and defense; compulsory social security	-0.005	-0.014	-0.011
Construction	-0.039	0.002	-0.013
Real estate activities	0.002	-0.078	-0.050
Total	-0.076	-0.137	-0.115

China's structural change and labor productivity

Table D10: China's within shift effect

	1987-1996	1997-2008	1987-2008
	(average)	(average)	(average)
Agriculture, hunting forestry and fishing	0.995	0.638	0.791
Basic metals	0.473	0.617	0.555
Other non-metallic mineral	0.491	0.460	0.473
Machinery, NEC	0.470	0.461	0.465
Electrical and optical equipment	0.397	0.511	0.462
Food, beverages, and tobacco	0.557	0.348	0.438
Chemicals and chemical products	0.289	0.466	0.390
Textiles and textile	0.466	0.236	0.334
Other Inland transport	0.389	0.291	0.333
Renting of m&eq and other business activities	0.243	0.375	0.318
Mining and quarrying	0.224	0.382	0.314
Construction	0.295	0.303	0.300
Transport equipment	0.219	0.344	0.291
Financial intermediation	0.163	0.338	0.263
Wholesale trade and commission trade	-0.046	0.455	0.240
Public admin and defense; compulsory social security	0.232	0.210	0.220
Education	0.178	0.171	0.174
Post and telecommunications	0.115	0.206	0.167
Real estate activities	0.026	0.246	0.151
Electricity, gas and water supply	0.010	0.254	0.150
pulp, paper, printing and publishing	0.204	0.051	0.117
Rubber and plastics	0.206	0.040	0.111
Health and social work	0.113	0.095	0.103
Hotels and restaurants	0.071	0.126	0.103
Manufacturing NEC; Recycling	0.069	0.126	0.102
Wood and of wood and cork	0.107	0.038	0.067
Retail trade and repair of household goods	-0.009	0.094	0.050
Leather, leather and footwear	0.107	0.003	0.047
Other supporting of transport activities	0.048	0.046	0.047
Other community, social and personal services	-0.026	0.101	0.047
Other Water transport	0.041	0.040	0.040
Other Air transport	0.013	0.014	0.014

Coke, refined petroleum and nuclear fuel	-0.037	0.050	0.013
Sale, maintenance and repair of motor vehicles	0.000	0.000	0.000
Private households with employed persons			
Total	7.092	8.137	7.689

Table D11: China's static shift effect

	1987-1996 (average)	1997-2008 (average)	1987-2008 (average)
Electrical and optical equipment	0.023	0.357	0.214
Real estate activities	0.289	0.143	0.206
Wholesale trade and commission trade	0.259	0.075	0.154
Financial intermediation	0.229	0.077	0.142
Construction	0.147	0.101	0.121
Other community, social and personal services	0.155	0.051	0.096
Hotels and restaurants	0.074	0.083	0.079
pulp, paper, printing and publishing	-0.007	0.127	0.070
Electricity, gas and water supply	0.090	0.048	0.066
Rubber and plastics	-0.001	0.106	0.060
Transport equipment	0.038	0.066	0.054
Wood and of wood and cork	0.006	0.077	0.046
Food, beverages, and tobacco	-0.020	0.090	0.043
Other Inland transport	0.024	0.053	0.040
Post and telecommunications	0.008	0.061	0.038
Leather, leather and footwear	0.008	0.058	0.036
Retail trade and repair of household goods	0.054	0.015	0.032
Textiles and textile	-0.033	0.074	0.028
Coke, refined petroleum and nuclear fuel	0.073	-0.007	0.027
Chemicals and chemical products	0.061	-0.004	0.024
Education	0.010	0.021	0.017
Public admin and defense; compulsory social security	0.017	0.015	0.016
Other Air transport	0.001	0.008	0.005
Health and social work	-0.013	0.015	0.003
Sale, maintenance and repair of motor vehicles	0.000	0.000	0.000
Other Water transport	0.004	-0.003	-0.000
Other supporting of transport activities	0.004	-0.007	-0.002
Machinery, NEC	-0.078	0.052	-0.003

Basic metals	0.045	-0.050	-0.009
Manufacturing NEC; Recycling	-0.006	-0.017	-0.012
Renting of m&eq and other business activities	-0.047	-0.011	-0.026
Mining and quarrying	0.009	-0.110	-0.059
Other non-metallic mineral	0.000	-0.180	-0.103
Agriculture, hunting forestry and fishing	-0.351	-0.247	-0.292
Private households with employed persons			
Total	1.074	1.140	1.112

Table D12: China's dynamic shift effect

	1987-1996 (average)	1997-2008 (average)	1987-2008 (average)
Electrical and optical equipment	0.006	0.020	0.014
Financial intermediation	0.004	0.006	0.005
Real estate activities	0.002	0.007	0.005
Electricity, gas and water supply	0.001	0.005	0.004
Other Inland transport	0.001	0.003	0.002
Construction	0.012	-0.006	0.002
Post and telecommunications	0.000	0.002	0.001
Transport equipment	0.005	-0.002	0.001
Other Air transport	-0.000	0.001	0.000
Sale, maintenance and repair of motor vehicles	0.000	0.000	0.000
Wood and of wood and cork	0.002	-0.002	-0.000
Hotels and restaurants	-0.003	0.002	-0.000
Retail trade and repair of household goods	-0.002	0.001	-0.000
Other Water transport	-0.001	-0.000	-0.001
Other supporting of transport activities	-0.001	-0.001	-0.001
Wholesale trade and commission trade	-0.009	0.003	-0.002
Coke, refined petroleum and nuclear fuel	-0.002	-0.004	-0.003
Leather, leather and footwear	0.003	-0.008	-0.003
Public admin and defense; compulsory social security	-0.008	-0.002	-0.005
Other community, social and personal services	-0.016	0.003	-0.005
Rubber and plastics	-0.002	-0.007	-0.005
Textiles and textile	-0.011	-0.001	-0.005
Basic metals	0.001	-0.011	-0.005
Chemicals and chemical products	0.006	-0.016	-0.006

Health and social work	-0.017	0.001	-0.007
Mining and quarrying	0.006	-0.018	-0.007
Food, beverages, and tobacco	-0.001	-0.016	-0.010
Manufacturing NEC; Recycling	-0.003	-0.017	-0.011
Education	-0.029	0.001	-0.012
Machinery, NEC	-0.013	-0.013	-0.013
Renting of m&eq and other business activities	-0.021	-0.011	-0.015
pulp, paper, printing and publishing	-0.006	-0.024	-0.016
Agriculture, hunting forestry and fishing	-0.029	-0.019	-0.023
Other non-metallic mineral	0.000	-0.041	-0.023
Private households with employed persons			
Total	-0.121	-0.166	-0.147

Appendix E

Figure E.1 Brazil's labor productivity by sector (unit: local currency/worker)

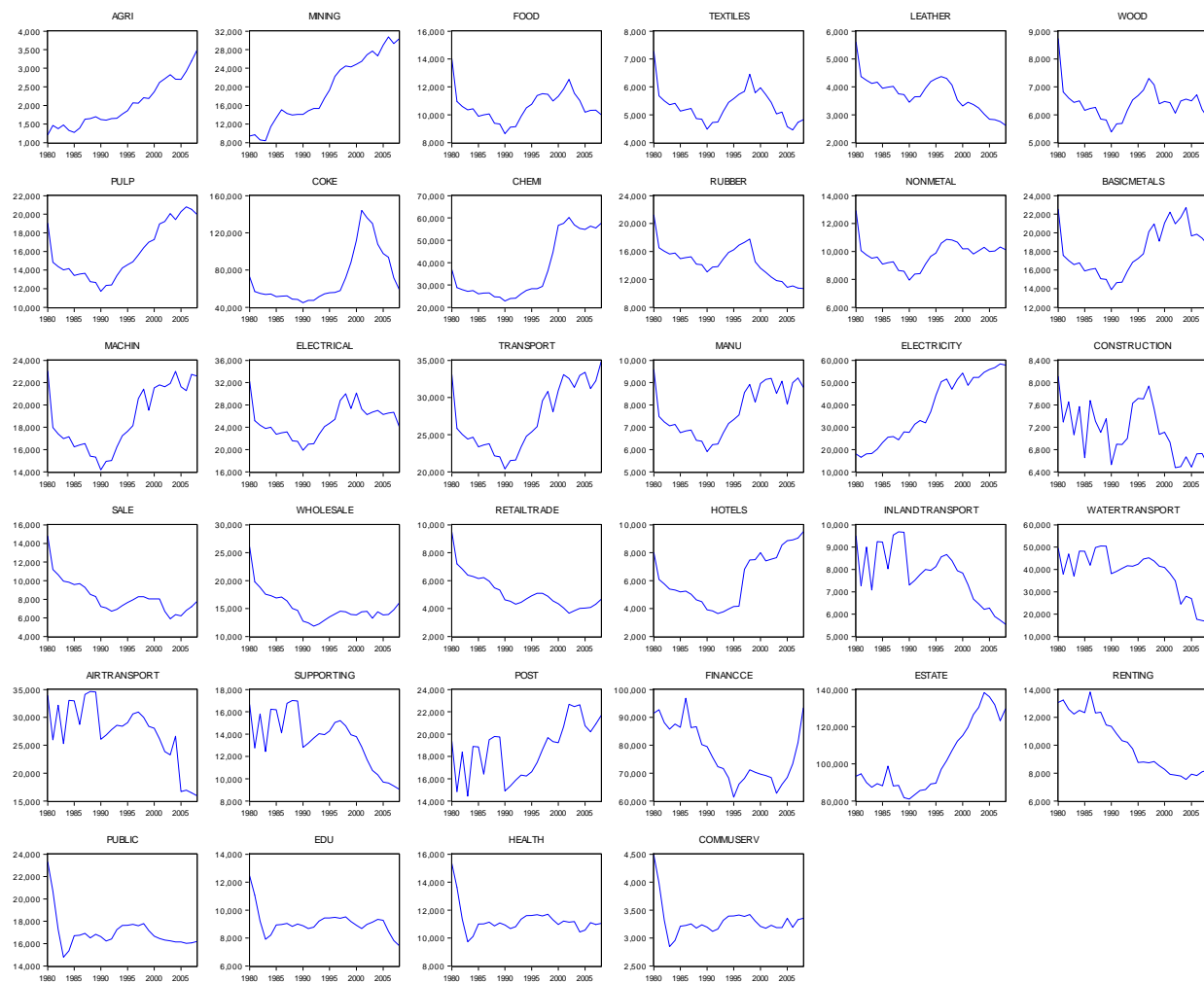


Figure E.2 Russia's labor productivity by sector (unit: local currency/worker)

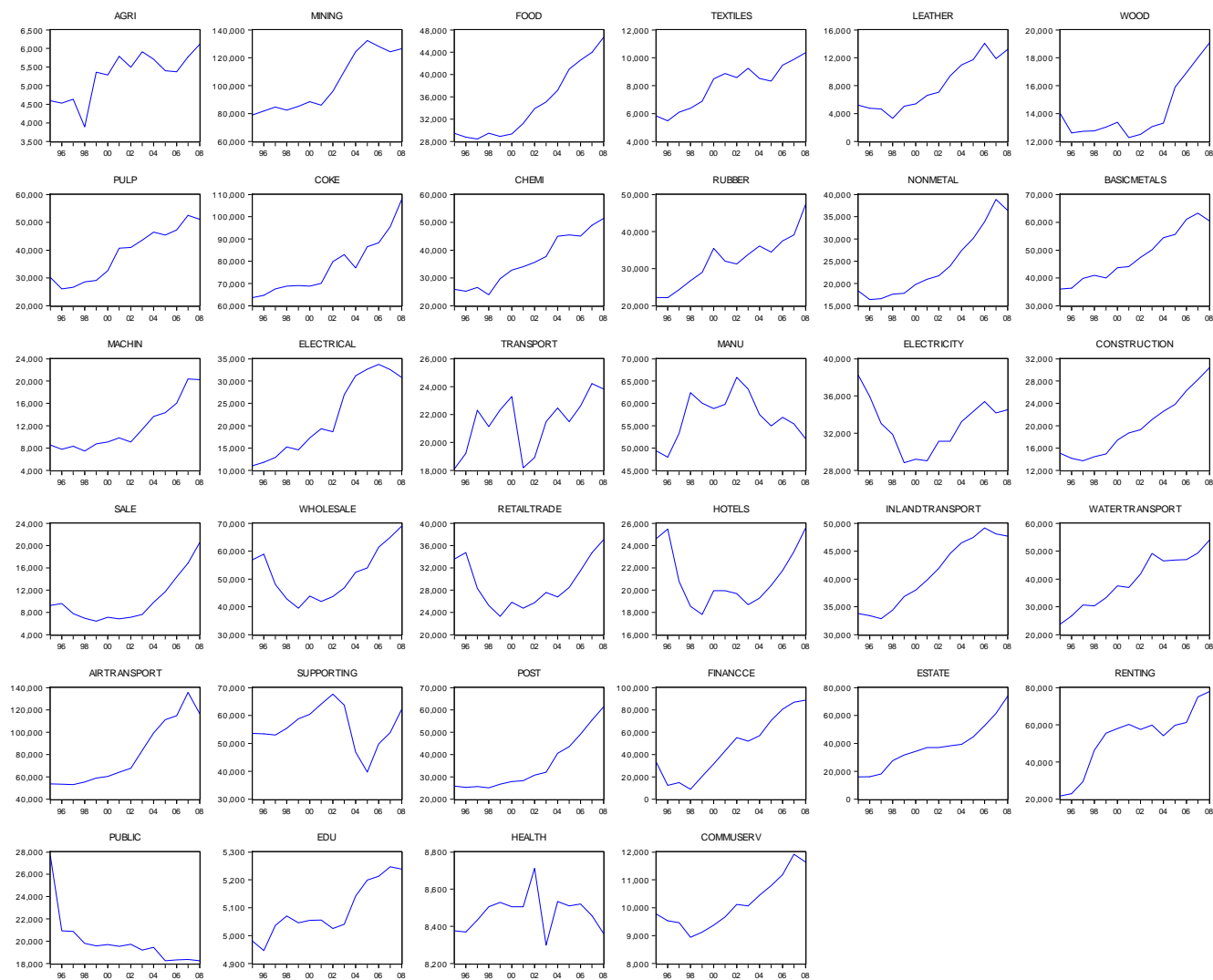


Figure E.3 India's labor productivity by sector (unit: local currency/worker)

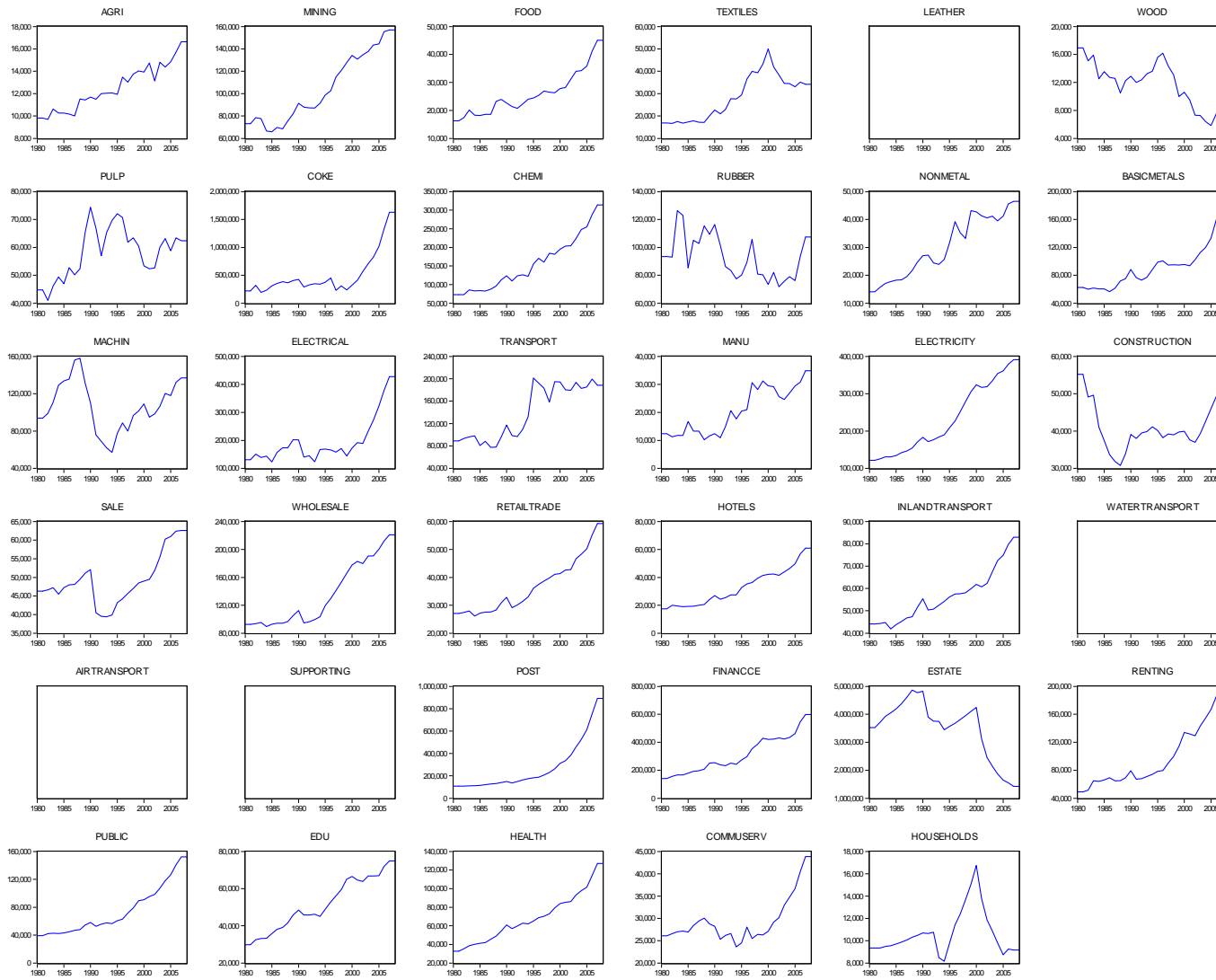
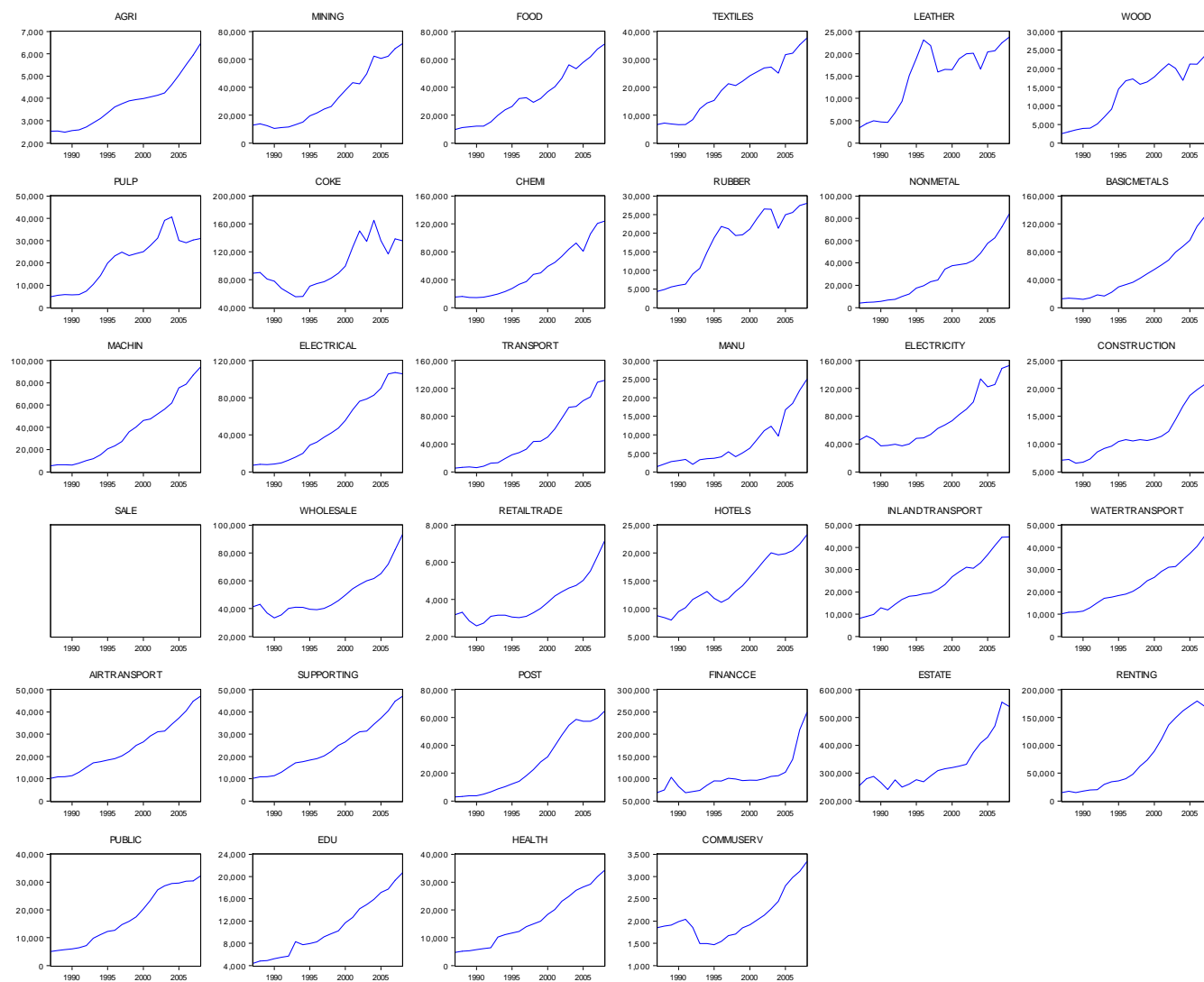


Figure E.4 China's labor productivity by sector (unit: local currency/worker)



Appendix F:

Figure F1: Converged sectors of BRIC

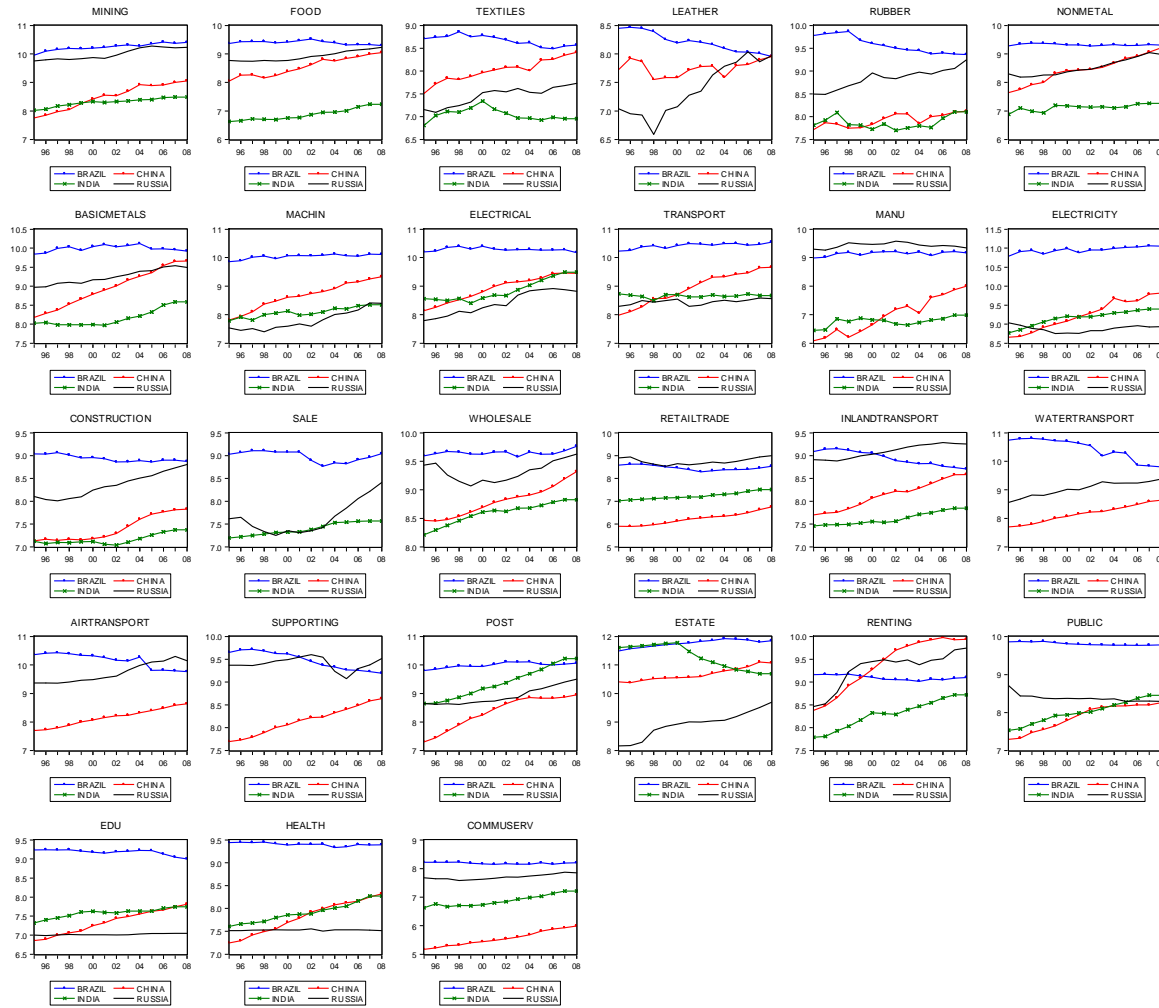


Figure F2: Non-converged sectors of BRIC

