
Estimation of Regional Growth Convergence in BRICs: Using the Polarization Index¹

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1. Introduction

Can lower-income regions converge into higher-income regions in a country during a high-growth period? Developed countries have regional convergence across states in the period of economic rapid growth. The United States has clear evidence of regional convergence since the 1840s (Barro and Sala-i-Martin, 1992). There is evidence of regional convergence in the United Kingdom, France, Japan, Germany, Italy, and Spain since the 1950s (Barro and Sala-i-Martin, 2004). Canada has seen regional convergence since the 1960s (Coulombe and Lee, 1995). And Persson (1997) finds convergence in Sweden since the 1910s.

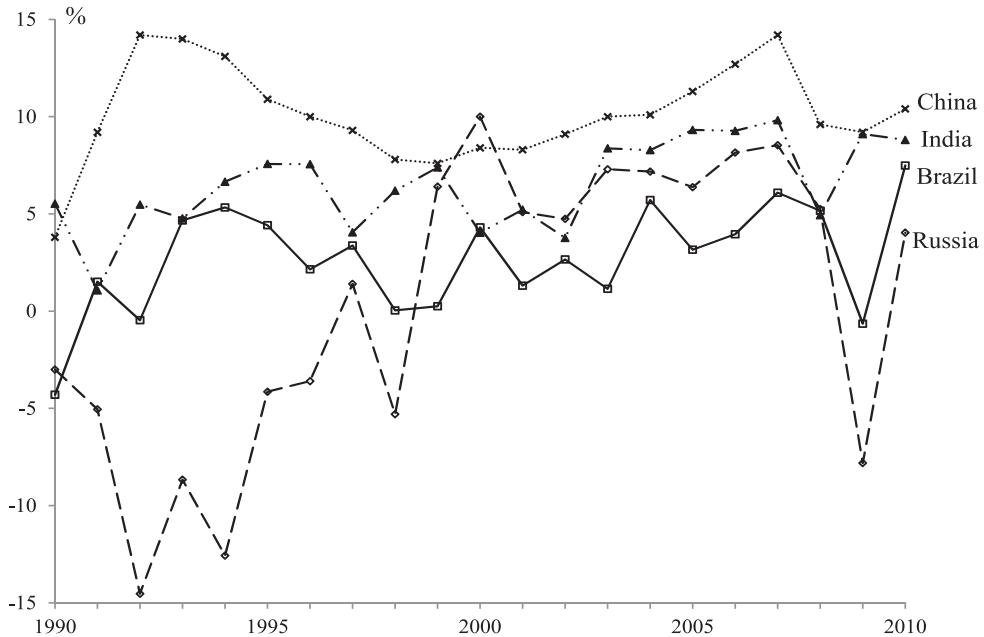
BRICs have experienced rapid economic growth in the 2000s, except for the world recession. China is continuing with more than an 8% growth rate in the 2000s. India experienced 8% or 9% from 2003 to 2010 excluding 2008. Russia achieved more than 4% because of occurring and export of natural resources in the 2000s. The annual growth rate of Brazil is 3.3% during the 2000s. These rates are not so high and not so low (Figure 1). As a result, the BRICs' PPP-based GNI accounted for a quarter of the world's in 2010.²

Not all regions in a country have experienced high economic growth, because BRICs have large regional disparities in their large, diverse states. BRICs account for a 29% surface area share in the world in square kilometers. And BRICs include some lower-income regions such as the northern region and northeastern region in Brazil, the North Caucasian Federal District of Russia, the eastern region in India, and the western area in China. If lower-income regions tend to grow faster than high-income regions in per-capita terms, the welfare of BRICs and the world economy can increase.

Numerous studies have investigated regional convergence across all the states in BRICs. Azzoni (2001) shows that Brazil has β -convergence for the period of 1948 to 1995. Aiyar (2001) finds conditional convergence across 19 Indian states since the 1970s. And previous studies find σ -convergence and β -convergence from 1987 to 1993 in China (Chen and Fleisher, 1996; Jian et al., 1996).

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² The BRICs' GDP accounted for 18% of the world GDP in 2010. The data are from the World Bank. (<http://data.worldbank.org/>)

Figure 1: Annual GDP Growth Rate in BRICs, 1990–2010

Source: World Bank website:

(<http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/countries/1W?display=default>).

Quah (1993a) points out problems of β -convergence, which employs a cross-section regression approach. For example, if we have no sigma convergence, we can find results of β -convergence (Galton's Fallacy). Furthermore, β -convergence has the problems of econometrical methodology and data reliability (Iwaisako, 2000, pp. 67-72). So Quah (1993b) proposes a distribution approach that uses kernel density and the Markov transition. Previous studies employ Quah's framework to analyze convergence. Brazilian states, which are surrounded by higher-income states, tend to transit higher-income classes (Mossi et al., 2003). Russian federal subjects have one convergence club for the period of 1994 to 2004, and Chinese provinces have two convergence clubs from 1978 to 2004 (Herzfeld, 2008). Bandyopadhyay (2011) shows two convergence clubs using kernel density between 1965 and 1997. Kar et al. (2010) find a tendency towards the two modes in the ergodic distribution using the data of 21 major Indian states for the period of 1993 to 2005.

However, this distribution approach has methodological problems. The empirical results depend on the periods of analysis using the Markov transition, not the robust study from previous studies on Chinese convergences. Sakamoto and Islam (2008) studying the period from 1978 to 2003 and Herrerías et al. (2010) using data for the period of 1978 to 2005 find one convergence club in China. Herzfeld (2008) analyzing the period of 1978 to 2004, He and Zhang (2006) focusing on 1985 to 2004, and Bhalla et al. (2003) employing the data period of 1978 to 1997 show two convergence clubs in China.

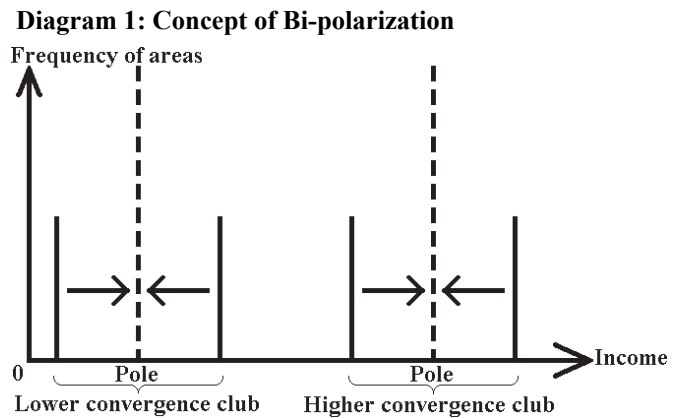
This paper analyzes regional economic growth convergence across all the states in BRICs, using the polarization index. The polarization index does not use time series data but cross-section data. The polarization index can measure bi-polarization in various years, and this index can supplement the distribution approach.

The paper is organized as follows. Section 2 presents the polarization index methods. Section 3 discusses the data issues. Section 4 provides empirical results. The final section offers some concluding remarks.

2. Methods

The paper uses three polarization indexes: the Esteban and Ray index (*ER*), the Foster and Wolfson index (*FW*), and the Tsui and Wang index (*TW*).

The polarization index measures the “disappearing middle class.” Diagram 1 shows the concept of bi-polarization. First, there are four income classes, the highest, the higher middle, the lower middle, and the lowest. Second, the higher-middle-income class grows faster than the highest-income class, and these classes converge into the high-income pole. This convergence means a higher convergence club. And the lowest- and lower-middle-income classes also converge into the low-income pole. This convergence means a lower convergence club. Finally, these twin poles make the middle class disappear. An increase in the value of the polarization index means bi-polarization in a country, when we divide into two groups across areas.



2.1. Esteban and Ray index

Esteban and Ray (1994) say that polarization depends on alienation in society, and that identification influences alienation. The Esteban and Ray index (*ER*) is defined as follows:

$$ER = \sum_{i=1}^n \sum_{j=1}^n \pi_i^{1+\alpha} \pi_j |\mu_i - \mu_j|, \quad (1)$$

where n is the number of groups; μ_i is the average income of i group, and we normalize average total income to 1; $|\mu_i - \mu_j|$ means dissimilarity; π_i , which means identification, is the population share of i group; and α is sensitivity to polarization, where $0 \leq \alpha \leq 1.6$, and we set α at 1.5.

It is noted that we divide all states into two groups to estimate bi-polarization in a country,

$n = 2$. These two groups are the high-economy states group and the low-economy states group.

There remains an unsettled question with regard to the Esteban and Ray index as to how to divide into two groups. Aghevil and Mehran (1981) show that a limit of two groups equals the average income of the total population. And the new index advanced by Esteban, Gradin, and Ray (2007) divides into two groups based on average income. Therefore, the parameter for dividing into two groups is the average real GDP per capita for all states.

2.2. Foster and Wolfson index

Wolfson (1994) and Foster and Wolfson (2010) focus on the “disappearing middle class,” and they discuss the relationship between the polarization curve and the Lorenz curve. The Foster and Wolfson index (FW) is defined as follows:

$$FW = 4 \left\{ 0.5 - L(0.5) - \frac{Gini}{2} \right\} / \frac{m}{\mu}, \quad (2)$$

where $L(0.5)$ is the income share of the poorest 50% of the population; m is median income; and μ is mean total income. The FW index means twice the area surrounded by the Lorenz curve and tangent line at m .

The paper defines m as the median of per capita income and μ as the mean total per capita income because we analyze bi-polarization of GDP per capita across all states.

2.3. Tsui and Wang index

Wang and Tsui (2000) developed the FW index. They generalized the FW index to satisfy the two partial ordering axioms of increased spread and increased bi-polarity. The Tsui and Wang index (TW) is expressed as follows:

$$TW = \frac{\theta}{N} \sum_{i=1}^n \pi_i \left| \frac{\mu_i - m}{m} \right|^r, \quad (3)$$

where θ is a positive constant scalar, and we set θ at 1; N is the total population; and $r \in (0,1)$, and the paper sets $r = 0.5$.

3. Data

The paper focuses on the trend of regional growth bi-polarity across states in Brazil, Russia, India, and China. We use the population data and real GDP of the states. GDP data are more reliable and useful than capital stock data.

The sample of Brazil covers 20 states in 1947–66, 70, 75, 80, and 85–2007. The 20 states are Alagoas, Amazonas, Bahia, Ceará, Espírito Santo, Goiás and Distrito Federal and Tocantins, Maranhão, Mato Grosso and Mato Grosso do Sul, Minas Gerais, Pará, Paraíba, Paraná, Pernambuco, Piauí, Rio de Janeiro, Rio Grande do Norte, Rio Grande do Sul, Santa Catarina, São

Table 1: GDP Per-capita of Brazilian States

States	1947	1950	1960	1970	1980	1990	2000	2007
Alagoas	0.449	0.404	0.448	0.399	0.395	0.413	0.384	0.410
Amazonas	1.030	0.725	0.832	0.671	0.899	1.271	1.035	0.883
Bahia	0.469	0.407	0.500	0.473	0.542	0.556	0.569	0.554
Ceará	0.308	0.404	0.415	0.307	0.346	0.373	0.432	0.430
Espirito Santo	0.688	0.790	0.621	0.685	0.857	0.936	1.072	1.220
Goiás + Distrito Federal + Tocantins	0.425	0.503	0.476	0.746	1.017	0.791	1.008	1.304
Maranhão	0.265	0.258	0.312	0.256	0.251	0.238	0.251	0.359
Mato Grosso + Mato Grosso do Sul	0.742	0.617	0.784	0.635	0.784	0.693	0.851	0.961
Minas Gerais	0.755	0.709	0.692	0.671	0.840	0.867	0.915	0.871
Pará	0.614	0.463	0.627	0.472	0.531	0.611	0.471	0.484
Paraíba	0.407	0.448	0.497	0.278	0.282	0.388	0.414	0.433
Paraná	1.041	1.197	1.059	0.730	0.906	1.102	1.064	1.094
Pernambuco	0.628	0.591	0.593	0.525	0.492	0.548	0.567	0.516
Piauí	0.349	0.213	0.229	0.204	0.209	0.255	0.289	0.328
Rio de Janeiro	2.122	2.112	1.794	1.726	1.456	1.244	1.477	1.342
Rio Grande do Norte	0.501	0.485	0.542	0.322	0.395	0.437	0.516	0.529
Rio Grande do Sul	1.250	1.122	1.138	1.202	1.215	1.306	1.289	1.134
Santa Catarina	1.009	0.809	0.852	0.860	1.070	1.207	1.221	1.231
São Paulo	1.871	1.979	1.890	2.066	1.776	1.721	1.544	1.542
Sergipe	0.267	0.230	0.454	0.446	0.402	0.566	0.512	0.591
Average	0.759	0.723	0.738	0.684	0.733	0.776	0.794	0.794

Note: The figure = GDP share to total GDP / population share to total population. The parameter for dividing into the high-economy group and the low-economy group is the average real GDP per capita for all states. We exclude Acre, Amapá, Rondônia, and Roraima from our analysis because of missing data. The paper unifies Goiás, Distrito Federal, and Tocantins into one state, and furthermore, Mato Grosso and Mato Grosso do Sul are unified.

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Data for Russia are 79 federal subjects from 1997 to 2009. The real per capita GDP is defined as the 1994 value price. The data come from the Federal State Statistics Service⁴ and *Regiony Rossii 1998* (Goskomstat Rossii, 1998). The Arkhangelsk Region includes Nenets Autonomous District. And the Tyumen Region includes Khanty-Mansi Autonomous Okrug-Ugra and the Yamalo-Nenets Autonomous District. The Chechen Republic is excluded because of missing data (Table 2).

India divided some states in the 2000s. The paper unites 21 states from 1980/81–2007/08. The 21 states are Andhra Pradesh, Arunachal Pradesh, Assam, Bihār and Jharkhand, Goa, Gujarat, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh and Chhattisgarh, Maharashtra, Manipur,

³ <http://www.ibge.gov.br/home/>

⁴ <http://www.gks.ru/wps/wcm/connect/rosstat/rosstatsite/main/>

Table 2: GDP Per-capita of Russian Federal Subjects (in 1 billion rubles)

Federal subjects	1994	2009	Federal subjects	1994	2009
Belgorod Region	2.9	18.1	Republic of Bashkortostan	3.5	19.4
Bryansk Region	2.3	11.5	The Republic of Mari El	2.2	7.5
Vladimir Region	2.6	11.8	Republic of Mordovia	2.0	13.4
Voronezh Region	2.4	11.5	The Republic of Tatarstan	3.3	24.0
Ivanovo Region	2.1	8.6	Udmurt Republic	3.2	12.7
Kaluga Region	2.8	13.8	Chuvash Republic	2.2	8.2
Kostroma Region	2.9	11.5	Perm	4.5	22.4
Kursk Region	2.8	16.1	Kirov Region	2.7	10.1
Lipetsk Region	3.8	16.1	Nizhny Novgorod Region	4.0	16.7
Moscow Region	2.9	16.1	Orenburg Region	3.6	18.3
Orel	2.4	12.6	Penza Region	2.0	10.4
Ryazan Region	3.2	13.6	Samara Region	5.2	20.6
Smolensk Region	2.9	14.6	Saratov Region	2.9	18.4
Tambov Region	2.2	12.7	Ulyanovsk Region	3.2	12.4
Tver Region	2.9	13.3	Kurgan Region	2.5	10.9
Tula Region	2.7	12.4	Sverdlovsk Region	4.2	21.4
Yaroslavl Region	4.3	18.7	Tyumen Region	23.8	203.7
Moscow	6.0	40.3	Chelyabinsk Region	3.8	17.7
Republic of Karelia	4.3	12.9	Altai Republic	1.9	8.5
Komi Republic	5.6	25.9	The Republic of Buryatia	3.6	12.8
Arkhangelsk Region	4.1	29.4	The Republic of Tuva	1.8	5.3
Vologda Region	4.6	17.3	The Republic of Khakassia	4.1	11.0
Kaliningrad Region	2.5	14.5	Altai Territory	2.2	10.5
Leningrad Region	3.0	21.2	Trans-Baikal Territory	3.3	13.8
Murmansk Region	5.3	16.8	Krasnoyarsk Territory	5.0	25.0
Novgorod Region	2.5	14.7	Irkutsk Region	4.4	20.1
Pskov Region	2.2	8.7	Kemerovo Region	4.4	20.1
St. Petersburg	3.5	23.9	Novosibirsk Region	3.2	17.9
Republic of Adygea	1.6	8.4	Omsk Region	3.1	19.6
Republic of Kalmykia	1.3	5.1	Tomsk Region	4.1	19.0
Krasnodar Territory	2.3	13.7	The Republic of Sakha (Yakutia)	7.9	34.8
Astrakhan Region	2.1	11.8	Kamchatka	5.4	18.6
Volgograd Region	3.2	12.9	Primorsky Krai	3.3	15.3
Rostov Region	2.1	13.7	Khabarovsk Territory	3.8	23.4
Dagestan Republic	1.0	6.5	Amur Region	4.2	17.6
Republic of Ingushetia	0.9	1.7	Magadan Region	7.1	24.0
Kabardino-Balkar Republic	1.1	9.0	Sakhalin Region	4.6	37.1
Karachay-Cherkessia	1.6	9.5	Jewish Autonomous Region	2.8	9.2
Republic of North Ossetia-Alania	1.3	7.6	Chukotka Autonomous District	4.6	77.7
Stavropol Territory	2.5	12.0	Average	3.5	18.7

Note: The Arkhangelsk Region includes the Nenets Autonomous District. And the Tyumen Region includes Khanty-Mansi Autonomous Okrug-Ugra and the Yamalo-Nenets Autonomous District. The Chechen Republic is excluded because of missing data. The parameter for dividing into the high-economy group and the low-economy group is the average real GDP per capita for all states.

Table 3: GDP Per-capita of Indian States (in 100 thousand rupees)

	1980/81	1985/86	1990/91	1995/96	2000/01	2005/06	2007/08
Andhra Pradesh	602	675	779	901	1139	1473	1738
Arunachal Pradesh	460	618	788	1034	1044	1333	1520
Assam	512	594	618	653	664	778	860
Bihar	371	428	480	411	716	790	982
Goa	119	119	177	218	283	384	443
Gujarat	737	838	1018	1356	1458	2225	2657
Himachal Pradesh	631	669	844	996	1259	1612	1844
Karnataka	548	599	744	943	1232	1602	1898
Kerala	608	631	758	980	1195	1648	1989
Madhya Pradesh + Chhattisgarh	552	586	714	769	828	989	1072
Maharashtra	796	891	1140	1487	1665	2200	2560
Manipur	491	559	619	650	738	902	960
Meghalaya	599	639	801	865	1036	1302	1408
Orissa	454	505	499	602	649	895	1040
Punjab	945	1148	1303	1466	1723	1928	2125
Rajasthan	478	527	755	817	928	1132	1310
Tamil Nadu	587	714	880	1136	1439	1825	2089
Uttar Pradesh + Uttarakhand	440	476	571	605	665	755	839
West Bengal	541	593	665	825	1056	1329	1525
Delhi	1539	1761	2075	2137	2660	3358	4105
Puducherry	1099	1177	1270	1224	2431	2678	3987
Average	624	702	833	956	1181	1483	1760

Note: The parameter for dividing into the high-economy group and the low-economy group is the average real GDP per capita for all states.

Meghalaya, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and Uttarakhand, West Bengal, Delhi, and Puducherry. Haryana, Jammu & Kashmir, Jharkhand, Mizoram, Nagaland, Sikkim, Tripura, A & N Islands, Chandigarh, D & N Haveli, Daman & Diu, and Lakshadweep are excluded because of lacking data for the period of 1980/81–2007/08. We use the 1993/94 value real GDP. The data come from the Ministry of Statistics and Programme Implementation (Table 3).⁵

There are 30 provinces, which are Beijing, Tianjin, Hebei, Shanxi, Neimengu, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shangdong, Henan, Hubei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Xizang, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang, during 1952 to 2010. Hainan is excluded because of missing data from 1952 to 1977. The real GDP is the 1979 value (Table 4). The data are mainly from the *Data of Gross Domestic Product of China 1952–2004* (National Bureau of Statistics, Department of National Accounts, 2007), and the *China Statistical Yearbook* (National Bureau of Statistics, various years). The paper modified the population registered by the police (*hukou renkou*) to the residual population (*changzhu renkou*) based on Hoshino (2011). The population registered by the police does not reflect migration from inland to coastal areas, and GDP per capita has large biases.

⁵ <http://www.mospi.gov.in/>

Table 4: GDP Per-capita of Chinese Provinces (in 100 thousand yuan)

	1952	1960	1970	1980	1990	2000	2010
Beijing	14	75	88	152	286	654	1437
Tianjin	31	71	76	134	229	606	1929
Hebei	13	20	22	39	80	244	674
Shanxi	13	31	27	40	79	187	549
Neimengu	18	33	26	35	83	209	988
Liaoning	18	57	43	76	148	345	1081
Jilin	18	33	31	42	93	220	712
Heilongjiang	32	55	47	62	109	230	649
Shanghai	55	131	142	279	484	1286	2731
Jiangsu	18	20	26	49	130	446	1436
Zhejiang	13	20	21	43	113	409	1140
Anhui	16	19	23	26	59	160	487
Fujian	12	21	19	33	82	289	847
Jiangxi	18	24	24	32	65	155	457
Shangdong	10	14	19	37	83	281	903
Henan	12	15	18	28	60	164	508
Hubei	14	24	23	40	83	217	682
Hunan	12	20	21	32	59	147	461
Guangdong	17	24	28	45	125	381	1052
Guangxi	7	13	15	25	41	115	356
Chongqing	12	19	17	30	62	175	604
Sichuan	11	14	16	31	62	155	509
Guizhou	9	17	13	20	41	85	262
Yunnan	9	16	17	24	57	125	308
Xizang	12	22	26	48	74	188	520
Shaanxi	10	19	21	33	74	179	599
Gansu	13	16	22	38	75	171	472
Qinghai	12	30	30	44	74	145	421
Ningxia	10	21	26	40	81	159	423
Xinjiang	19	35	26	37	89	185	417
Average	16	31	32	53	106	277	787

Note: We excluded Hainan because of missing data from 1952 to 1977.

4. Results

This study calculated the three polarization indexes, ER, FW, and TW, from all the BRICs states' GDP per capita data sets: Brazil (1947–66, 70, 75, 80, and 85–2007), Russia (1994–2009), India (1980–2008), and China (1952–2010).

We now show regional sigma convergence across all the states in BRICs (Figure 2). σ -convergences are calculated from the standard deviation.

We find that only Brazil has σ -convergence among BRICs. Brazil has a downward trend for the period of the 1960s, 1990s, and 2000s. Russia rose sharply in the second half of the 1990s. Russia has σ -divergence. India stabilized in the 1980s and 1990s, and then went up during the late 2000s. China has had an overall upward trend since the 1950s. In particular, China increased

sharply and steadily in the period of the Cultural Revolution and the 1990s. It is noted that China has declined steadily since 2005.

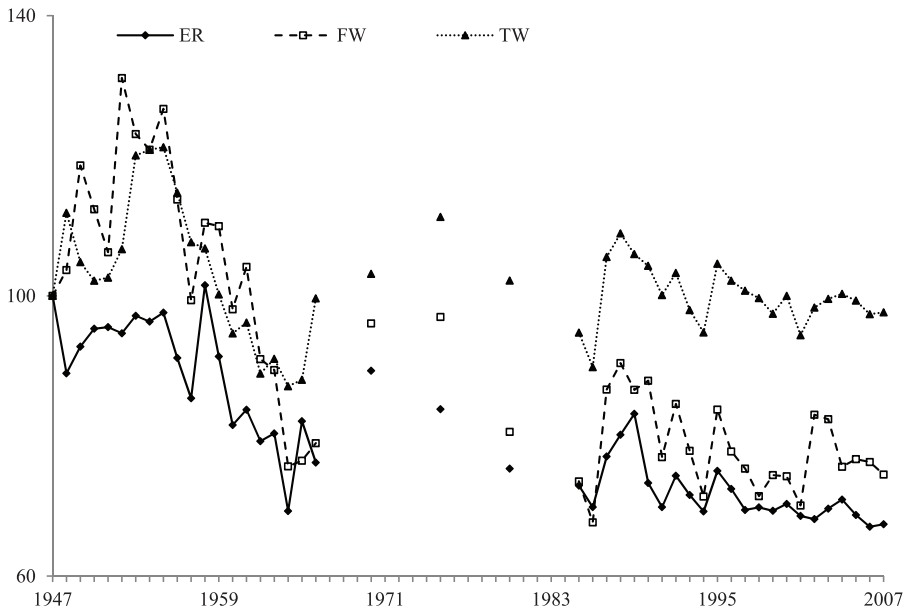
Figure 2: σ -Convergence in BRICs



Source: Author's calculation.

Note: We use the natural logarithm of per capita GDP.

Figure 3: Bi-polarization in Brazil



Source: Author's calculation.

Note: 1947=100.

Table 5: Average Annual GDP Growth Rate in BRICs

	1960s	1970s	1980s	1990s	2000s
Brazil	5.9	8.5	3.0	1.7	3.3
Russia	5.1	3.5	1.7	-4.9	5.5
India	6.7	2.9	5.7	5.6	7.2
China	3.0	7.4	9.8	10.0	10.3

Source: The figures are based on the World Bank website:

(<http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/countries/1W?display=default>). The data of Russia in the 1960s, 1970s, and 1980s are based on Kuboniwa and Ponomarenko (2000).

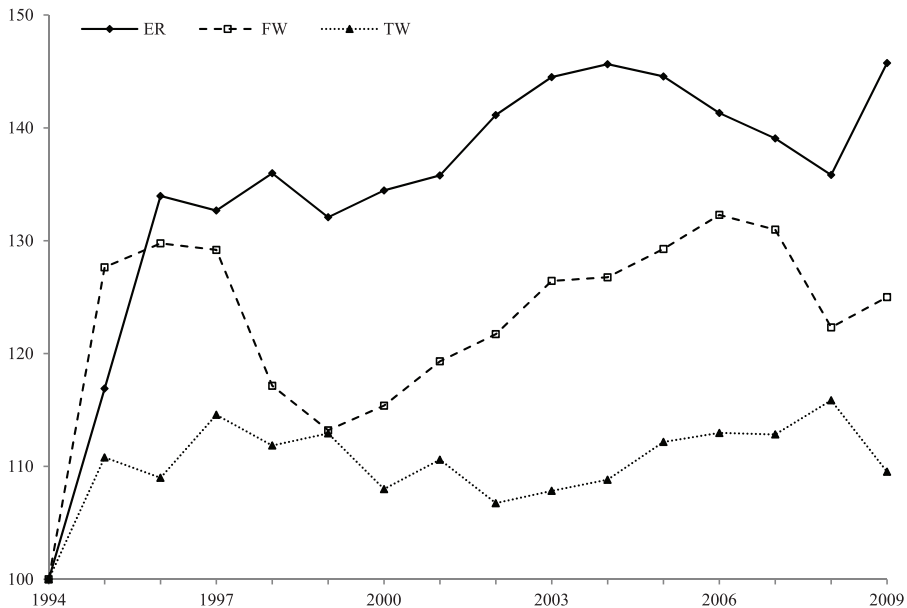
Note: The figure is a percentage of the arithmetic mean annual real GDP growth rate. The figure for Russia in the 1960s is the arithmetic mean of this rate from 1962 to 1969.

These results suggest that Brazil has probably not bi-polarized, and that Russia, India, and China have bi-polarized.

Figure 3 shows that the three polarization indexes, ER, FW, and TW, have an overall downward trend in Brazil. Since the 1950s. Brazil converged and uni-polarized across all the states in the 1990s and 2000s. Why did Brazil have one polarization?

Brazil is different from Russia, India, and China in growth rate terms (Table 5). Brazil started regional development program and tax preference system since the 1960s. Brazil had a high economic growth rate of 8.5% in the 1970s. The poor northern area converged into the rich southern area in Brazil from the 1980s. The growth rate of Brazil is 3.3% in the 2000s. “Avanca

Figure 4: Bi-polarization in Russia



Source: Author’s calculation.

Note: 1994=100.

Brazil” plan reformed rural-urban gap, labor, culture, environment and so on. The relationship between the convergence and growth rate of Brazil is similar to that of developed countries.

In Russia, the three polarization indexes rise rapidly from 1994 to 1997 (Figure 4). And the three indexes show an overall upward trend in the 2000s. Russia bi-polarizes during economic transition and the period of rapid economic growth.

Russia initiated radical economic transition and faced economic crisis during the 1990s. Highest-economy federal subjects and lower-middle-economy federal subjects were damaged by this transition and crisis. In the 2000s, some high-income areas such as Khanty-Mansi and Yamalo-Nenets have increased with the occurrence of oil and gas. However, the middle-income area did not converge into the high-income area. As a result, Russia has been forming two convergence clubs.

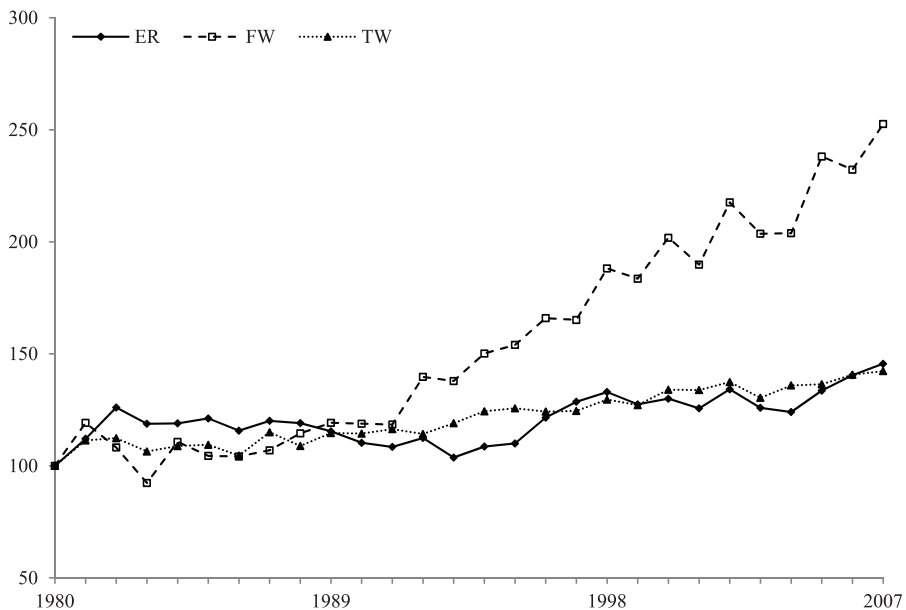
India has clearly bi-polarized. The three polarization indexes increased sharply from 1991 (Figure 5).

India started economic liberalization in 1991. The southern area, with its accumulation of IT and finance industry, has converged into the western area. But the northern and eastern area has remained a poor economy. India has been forming two convergence clubs during the economic liberalization policy.

China also definitely bi-polarized during economic transition. Figure 6 shows that the three polarization indexes had an overall upward trend from 1979.

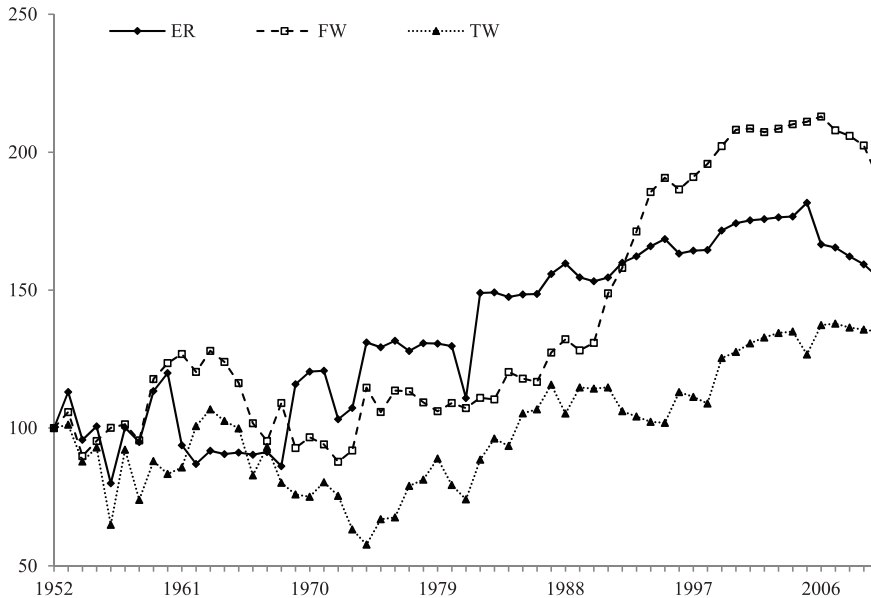
China launched the Reform and Opening Up policy in 1978. The coastal area has converged

Figure 5: Bi-polarization in India



Source: Author’s calculation.

Note: 1994=100.

Figure 6: Bi-polarization in China

Source: Author's calculation.

Note: 1952=100.

into developed areas such as Beijing, Shanghai, and Tianjin. Most inland areas have experienced low economic growth. Therefore, China has been forming two convergence clubs during economic transition.

Russia, India, and China have steadily bi-polarized and have been forming two convergence clubs during economic transition and the high-growth period. Most low-income states have experienced low economic growth, because these states do not enjoy sufficient economic transition policy or economic liberalization policy.

5. Conclusion

This paper analyzes regional growth convergence across states in BRICs. β -convergence has some methodological problems, and the results depend on the period of analysis using the Markov transition. We use three polarization indexes, which are the Esteban and Ray index (*ER*), the Foster and Wolfson index (*FW*), and the Tsui and Wang index (*TW*).

The empirical results are as follows: (1) Brazil does not have a bi-polarized trend across states, but has σ -convergence because the poor northern states converged into the rich southern states. (2) Russia, India, and China bi-polarized steadily and have been forming two convergence clubs during economic transition, because most low-income states have experienced low economic growth.

BRICs do not have a common trend of regional convergence. Brazil is different from Russia, India, and China, because Brazil launched rapid economic growth in the 1970s and its growth rate

stabilized from 1% to 6% in the 2000s. Russia, India, and China cannot diminish their large regional disparities. Bi-polarization means the creation of twin peaks and two convergence clubs in a country.

The results suggest two points. The first is that Russia, India, and China cannot follow the path of developed countries. Barro and Sala-i-Martin (2004) show that the United Kingdom, France, United States, Japan, Germany, Italy, and Spain have regional σ -convergence across states in the period of economic rapid growth.

The second suggestion is that only Brazil has a trend of regional convergence among BRICs. Although Russia, India, and China have experienced high economic growth since the reform of the economic system, these countries do not have regional convergence in our results. These three countries should learn from Brazil's experience of regional development.

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