

Generalized Delta Convergence Analysis of Regional Economic Growth Based on 1952–2008 Chinese Provincial Level Empirical Results

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Generalized Delta Convergence Analysis of Regional Economic Growth Based on 1952-2008 Chinese Provincial Level Empirical Results

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1. *Introduction*

China has maintained an incredibly rapid economic growth rate for more than 30 years since its reform and openness. But the diversities of growth speed among provinces did not just happen in recent years but have been for quiet some time. Therefore we try to analyze these disparities in the aspects of convergence or divergence in both space and time dimensions for long-run term even since the Communist Revolution in 1952.

As early as 1950s, a lot of authors began to consider the degree of economic growth divergence or convergence across countries, regions or economic systems. Solow (1956) accounts that the growth of per capita income tends to be inversely related to its starting level, which is later named as “absolute convergence” or “unconditional convergence”. Practically, the researches of the convergent objectives are various, and so are the empirical results. Barro et al., (1992) and Sala-i-Martin (1996) have built models within or across some developed countries, like the states of America, the prefectures of Japan and the countries of European Communities. On the contrary, Baumol et al., (1988) focus on low-income countries. Barro et al., (1990, 1995) and Mankiw et al., (1992) set their analyses all over the world. The quantitative convergence points depend on the way and the research objectives chosen by the experts.

Even though foreign economists and scholars had been interested in the convergence issues for

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The writer is solely responsible for the consequences of this article.

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many decades, it was not until the end of last century that the convergence debate of China had captured the attentions of mainstream. A large number of Chinese convergence or divergence literatures have emerged since the 1990s. Representatively, Cai et al., (2001), Shen et al., (2002), Lin et al., (2003) claim that there is no absolute convergence in China, but conditional convergence exists. If we treat 1990 as a critical line, the pre-phase samples (from 1978 to 1990) of Chinese provincial show conditional convergence (See Wei, 1997), and even show some degree of absolute convergence characteristics. But the later phase of samples show obviously weaken convergence even somewhat divergent trend (See Liu, 2001). Lin et al., (2010, 2011a, 2011b) develop the β -convergence method, using the panel data of provinces of China, to describe the degree of disparity in China. But we rarely find empirical research using more than two methods of δ -convergence to analyze the Chinese economic growth convergence for long term.

2. δ -convergence method

δ -Convergence means the deviation of per capita income trends to decline over time (Wang, 2004). Dalton, H. (1920) offers a set of principles to comprehend shifts in an income distribution, thereby providing a more compelling theoretical basis for understanding relationships with incomes. Dalton proposed the condition that if there is an income transfer from one richer to one poorer, so long as that transfer does not reverse the ranking of the two, it will results in greater equity in social level (Dalton, 1920). This principle has come to be known as the Pigou-Dalton principle (see, e.g., Amartya Sen, 1973). The major δ -convergence index, broadly speaking, usually include Relative Mean Deviation (*RMD*), Gini Coefficient, Coefficient of Variation (*CV*), Herfidhal-Hirshman coefficients (*HHI*), Theil coefficients (*TEC*), Mean Logarithm Deviation (*MLD*) and so on.

$$MD = \frac{\sum_{i=1}^n \sum_{j=1}^n |y_i - y_j|}{n(n-1)} \quad (1)$$

$$RMD = \frac{\sum_{i=1}^n \sum_{j=1}^n |y_i - y_j|}{(n-1) \sum_{i=1}^n y_i} \quad (2)$$

$$RMD = \frac{MD}{\bar{Y}} \quad (3)$$

Where, y_i , y_j represents the exact quantity of indicator in region i , j separately.

The *RMD* indicator quantifies the mean difference in comparison to the size of the mean but it is a dimensionless measurement. Worth mentioning, the *RMD* indicator equals to twice the Gini coefficient which is defined in terms of the Lorenz curve. But one disadvantage of the *RMD* indicator is that the *RMD* indicator can not reflect the effect of Pigou-Dalton income transfer.

The indicator combined of the *HHI* and *TEC* ratio is a better solution to this problem. *HHI* and *TEC* are usually used as a measure of the firm size in relation to the industry and are also

used as indicators of accessibility and closeness among these rivals. Mathematically, HHI is a convex function under the influence of large share, but TEC is a concave function under the influence of small share. Here we use the combination of them as an approach to calculate the contribution share of each local economy to the Chinese national economic growth (e.g. GDP, Consumption, etc.) and as an indicator of the disequilibrium in pitch among these regions.

$$HHI = \sum_{i=1}^n s_i^2, \quad s_i = \frac{f_i}{F}, \quad F = \sum_{i=1}^n f_i \quad (4)$$

$$TEC = \sum_{i=1}^n s_i \log(s_i) \quad (5)$$

Where, f_i represents quantity of indicator in region i , F represents the total quantity of the economic system.

The combination of the HHI ratio and TEC ratio considers both sides of the indicator trends. If HHI stands still but TEC is increasing over the time, it means the transfer effects mainly happen among large share regions. On the contrary, if TEC is steady but HHI is increasing over the time, the transfer effects mainly happen among small share regions.

But HHI and TEC method also has its limitation that the statistical results will be sensitive to the sample groups how we divided into. Let us take China as an example, the results of HHI and TEC method must be different when we set the regions into East-Middle-West level groups, 31-provincial level groups, or more than hundreds of city level groups, when we all aim at the same research objective, the convergent degree of the whole country.

Comparatively speaking, MLD indicator use the discrepancy of the mean logarithmic and logarithmic mean to combat this object quantity influence.

$$MLD = \log\left(\frac{1}{n} \sum_{i=1}^n f_i\right) - \frac{1}{n} \sum_{i=1}^n \log(f_i) \quad (6)$$

But HHI , TEC and MLD have one corresponding disadvantage is these three indexes are zero-homogeneous. That is to say, the indicators can not reflect when all the regions in the system increase (or decrease) the same proportion.

Other broad delta methods to measure the unbalanced degree within one economy system are as followings:

$$\delta^2 = \frac{1}{n} \sum_{i=1}^n \left(\log y_{it} - \frac{1}{n} \sum_{i=1}^n \log y_{it} \right) \quad (7)$$

$$CV = \frac{\delta}{\bar{Y}} \quad (8)$$

Where, y_{it} represents the quantity of indicator in region i , when time t .

δ^2 -coefficient indicator also can describe the transfer effects but can not distinguish these effects happened from the developed regions or developing regions. In the following empirical analysis, we will choose δ^2 -coefficient as one representative method.

Coefficient of Variation (CV) is an evolution of δ^2 -coefficient measurement, which eliminates the scale differences among sample groups by taking the mean into consideration. Usually, Coefficient of Variation is used to settle the scale-variance among countries or economies.

3. *Empirical result comparisons*

The assumption of convergence hypothesis is based on three premises. First, marginal benefit of capital diminishes; second, homo-preferences exist within economies and technical conditions progress gradually; third, productive factors flow freely among the economies (See Lu et al., 2004). Actually China basically satisfies all these hypotheses. Especially after the Reforms in late 1970s, China alters its resource allocation method to market-oriented way. Inter-regional competitions around the relevant elements are increasingly fierce.

3.1 *Data Specification*

According to common sense, there have been three peaks of social revolution and economic rapid growth periods in the last half century, coinciding with the Great Famine of the late 1950s, the Cultural Revolution of the late 1960s and 1970s, and the phase of openness and global integration since the late 1990s. We choose two representative time points as split lines, namely, 1978 and 1994. And because most provinces omit the import and export data before 1978, and because domestic commercial trade dominates in that Planning Economy period, we introduce total retail sales of consumer goods as a substitute indicator to EX_{it} (Net Export), named Con_{it} .

Here we use data from *A Sixty Years Statistical Compendium for New China* and *China year book*. As Chong Qing was separated from Si Chuan Province as a municipality in 1997, we still count the date of Chong Qing and Si Chuan as one unit in the whole sample period in our empirical analyses. And after cancelling the samples of Hai Nan Province and Tibet Province, which are seriously data omitting in the past-1978 phase, we still have 28 provinces and municipalities for analyses.

3.2 *Special δ -Convergence Analysis Results*

δ -convergence analysis describes the deviation of indicator trends over time. To measure the income and disposable income deviations, we use the provincial level data comparisons of per capita GDP, per capita second industry plus third industry, and per capita consumption. The innovation point here is we introduce an indice of per capita regional second industry plus third industry, which measures the disparities caused by industry structure change. Then we bring in the concept of the indexes of finance department development disequilibrium, education department unbalance, the infrastructure investment and total social fixed assets investment differ-

ences, as well as the opening degree. To compare these indexes with GDP growth separately, we can simply figure out how the productivity factors or economic departments take the participation in divergence of regional growth. Still, there are other influence factors, like human capital stock, investment rate, unemployment rate, marketing degree (See Cai et al., 2000), as well as exchange rate fluctuation, price indices fluctuation and other variables, but these indicators we included in analyses have covered main disparity impacts.

According to Equation (7), we get the descriptive statistic results in Table 1 and get the fifty-seven-year long-run trends of each index from Figure 1 to Figure 7 using equation (4) and (5).

From Table 1 and Figure 1, we find the δ^2 -convergence coefficients of industry structure are pretty larger than GDP and consumption. And the curves of industry structure and GDP are gourd-shaped as time goes on. The degree of the diversity expands progressively faster since 1980s. Although there is a trough during 1960 and 1980, the gaps of these indicators widened after the Reform and Openness, and reached to the peak in 2008. Resources, geography, support from policies etc., lots of forces practiced, which are the internal cause of industry structure reform. We can not omit the traces of the policy effects, which changed the industry structure and efficiency significantly with a lot of state-owned companies being bankrupted; bundles of worker were laid off; but numerous private small and middle sized firms were set up. Therefore, the industry unbalance and reform may play a crucial role quietly in China's gradualism economic reform. On the other hand, for long-run term, per capital consumption seems smooth compared with other two curves among provinces and municipalities. The consumption curve has a nearly similar trend with the industry structure until 1990s, after that, they also split up. But even more interesting is that the consumption curve does not coincide with GDP shape, or they are contrasted. We are wondering whether the growth of GDP in China is not raised by consumption but investment. During the long-run term, the disparity of regional per capita income waves and reaches to the peak around 2000, mainly during 2002 to 2005. In recent years, especially after 2005, the coefficients of consumption show rainbow downward trends, so do GDP coefficients. The diversities of income disparity were under control during these years, though the effects of industry structure reform in regions were enlarged in the same time.

3.3 *HHI-TEC Analysis Results*

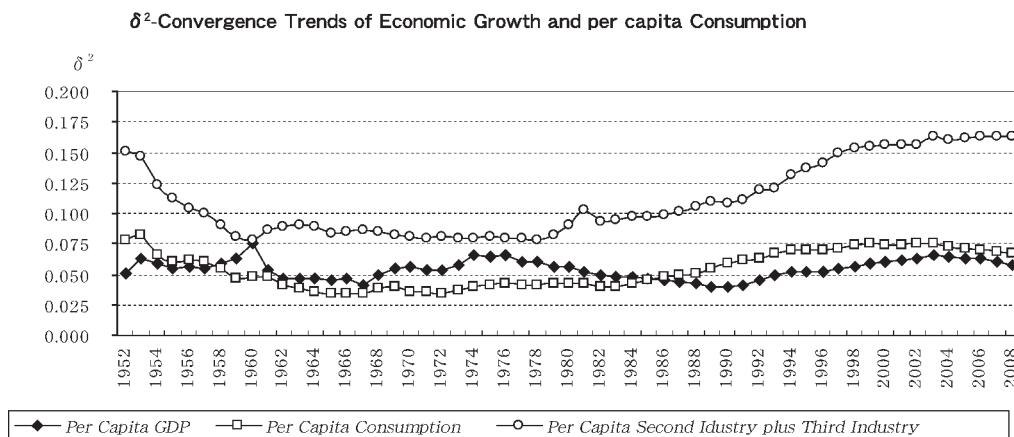
We have already got that if *HHI* stand still but *TEC* is increasing over the time, it means the transfer effects mainly happen among large share regions. On the contrary, if *TEC* is steady but *HHI* is increasing over the time, the transfer effects mainly happen among small share regions.

The bench mark of each group is GDP. We use the trends of GDP as a comparison reference while we analyze other factors. First, we will analyze the effect of the reform of industry structure (See Figure 2). Here we name the indicator of the second industry output plus the third

Table 1: The fifty-seven years δ^2 -convergence indicators

Year	GDP	Consumption	Industry	Year	GDP	Consumption	Industry	Year	GDP	Consumption	Industry
1952	0.0504	0.0778	0.1502	1971	0.0530	0.0355	0.0791	1990	0.0391	0.0588	0.1086
1953	0.0630	0.0828	0.1470	1972	0.0541	0.0348	0.0804	1991	0.0417	0.0619	0.1111
1954	0.0594	0.0664	0.1228	1973	0.0578	0.0366	0.0797	1992	0.0448	0.0635	0.1192
1955	0.0546	0.0604	0.1127	1974	0.0661	0.0403	0.0796	1993	0.0496	0.0675	0.1202
1956	0.0561	0.0621	0.1040	1975	0.0644	0.0415	0.0804	1994	0.0526	0.0702	0.1319
1957	0.0541	0.0606	0.0995	1976	0.0654	0.0430	0.0789	1995	0.0526	0.0697	0.1376
1958	0.0585	0.0551	0.0901	1977	0.0606	0.0413	0.0797	1996	0.0525	0.0702	0.1412
1959	0.0636	0.0465	0.0813	1978	0.0604	0.0416	0.0780	1997	0.0549	0.0712	0.1497
1960	0.0755	0.0478	0.0778	1979	0.0559	0.0429	0.0818	1998	0.0568	0.0737	0.1528
1961	0.0540	0.0484	0.0859	1980	0.0567	0.0426	0.0906	1999	0.0589	0.0751	0.1542
1962	0.0460	0.0418	0.0891	1981	0.0517	0.0419	0.1028	2000	0.0606	0.0738	0.1556
1963	0.0460	0.0378	0.0903	1982	0.0487	0.0394	0.0935	2001	0.0622	0.0747	0.1566
1964	0.0471	0.0350	0.0897	1983	0.0478	0.0403	0.0942	2002	0.0636	0.0751	0.1566
1965	0.0446	0.0345	0.0833	1984	0.0474	0.0424	0.0968	2003	0.0656	0.0751	0.1625
1966	0.0469	0.0342	0.0843	1985	0.0471	0.0455	0.0978	2004	0.0648	0.0731	0.1605
1967	0.0410	0.0340	0.0866	1986	0.0458	0.0474	0.0982	2005	0.0631	0.0708	0.1614
1968	0.0500	0.0385	0.0844	1987	0.0444	0.0493	0.1015	2006	0.0624	0.0703	0.1631
1969	0.0553	0.0395	0.0821	1988	0.0428	0.0511	0.1048	2007	0.0603	0.0689	0.1634
1970	0.0568	0.0360	0.0804	1989	0.0404	0.0548	0.1092	2008	0.0570	0.0673	0.1630

Sources: A Sixty Years Statistical Compendium for New China and China year book.

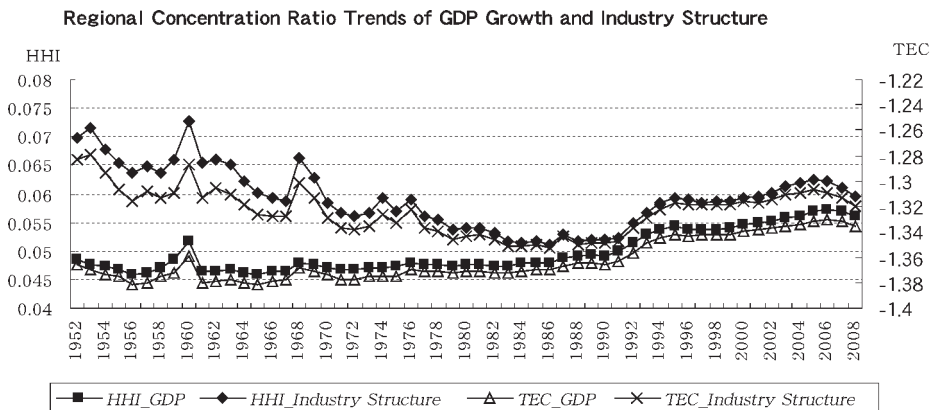


Sources: A Sixty Years Statistical Compendium for New China and China year book.

Figure1: The fifty-seven years special δ -convergence indicator trends

industry output “Industry Structure”. Then we compare this indicator with GDP. From Figure 2, we can see, both the GDP trend and Industry Structure trend are similar when using *HHI* and *TEC* methods. The regional concentration effects of GDP and Industry Structure are similar among the faster developing regions and lower developing regions. In other words, during the macro economy fast growth phase, both the richer and the poorer regions develop fast, during the macro environment lower growth phase, both the richer and the poorer regions slow down its

growth speed. That result coincides with economic cycle theory. As we discussed above, the similar trend with GDP reflects the industry structure reform plays a crucial role in China's economy rapid growth. The *HHI* value of GDP is larger and more fluctuant before 1980s, regional concentration is obvious in this phase. Then it reaches to a trough during 1980s. After that, the Reform and Openness has spread the regional disparities again since 1990s. Compared with GDP, the volatility of Industry Structure concentration is smaller. Obviously, The *TEC* of industry structure trend is fluctuating with the *HHI* value of GDP. So are the relationship of the other two curves. That is to say, the impulses of GDP growth in richer regions are pushed forward by the reform and development in poor regions, vice verse.



Sources: A Sixty Years Statistical Compendium for New China and China year book.

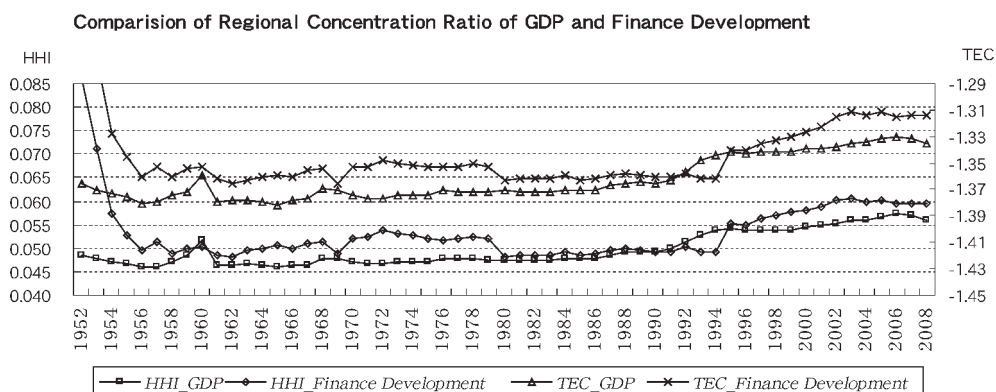
Figure2: regional concentration ratio trends of GDP growth and industry structure

Here we choose two development indicators: financial indicator and education indicator.

Because the major financing method in China, mostly in 1950s-1990s, is indirect, we use the total sum of bank deposit and bank loan as the financial development indicator for the whole sample period.

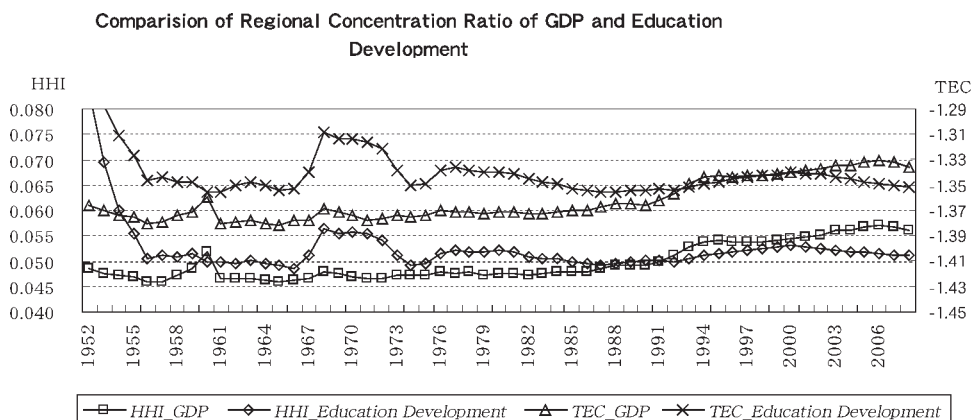
In Figure 3, the finance development trends are similar when using *HHI* and *TEC* methods. That is to say, the regional financial development speed and direction of the richer regions and poorer regions happen in the same phase. Whether fifty-seven years' similar trends are con-
sistency, we need more information to do the further casual analysis.

During the whole analysis phase, fifty- seven years, the fluctuated violent results appears in 1950s, when the structure organization, market supervision and regulation, and control system of Chinese financial sector are imperfect; and after 1994, when financial system reform has achieved. And we can obviously find that the similar concentration trends of disparities of finance develop-



Sources: A Sixty Years Statistical Compendium for New China and China year book.

Figure3: comparison of regional concentration ratio of GDP and finance development

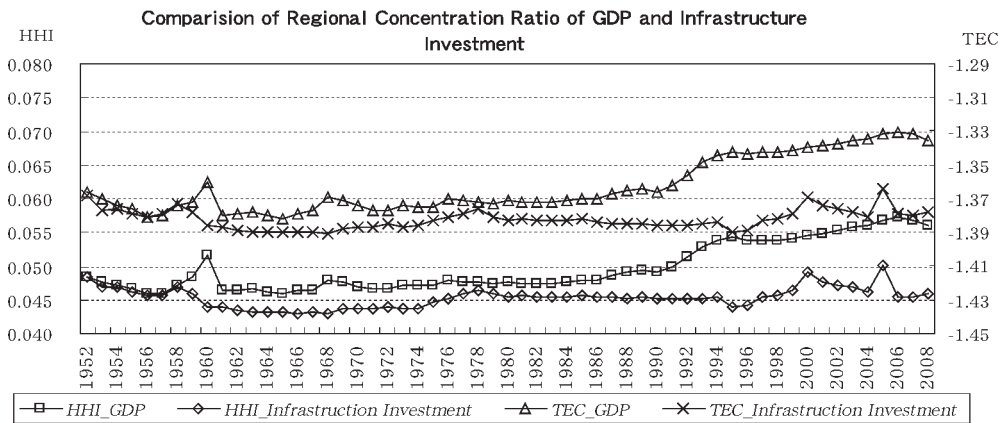


Sources: A Sixty Years Statistical Compendium for New China and China year book.

Figure4: comparison of regional concentration ratio of GDP and education development

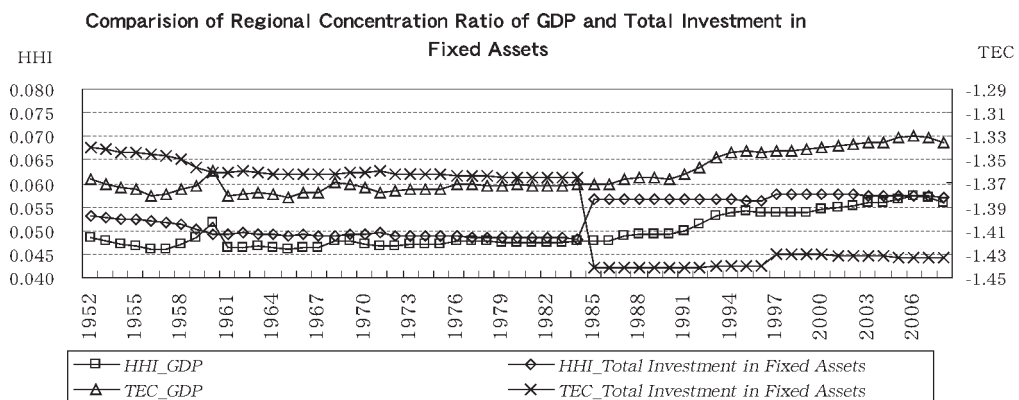
ment and GDP since 1980s. The ever present possibility of casual effect between these two is referred by a lot of scholars, but this kind of comparisons is the first.

Also, the *HHI* and *TEC* results of education development trend to be smooth and interlaced with GDP (See Figure 4). We employ the sum of high education student number and secondary education student number as education development indicator. The most violently fluctuated results come out before 1978, when the reform of the educational system is still in exploration. After that, the differences of education levels among the richer regions and poor regions decrease. Then the GDP growth does. But the causal effect between education development and GDP still needs more information.



Sources: A Sixty Years Statistical Compendium for New China and China year book.

Figure5: comparison of regional concentration ratio of GDP and infrastructure investment



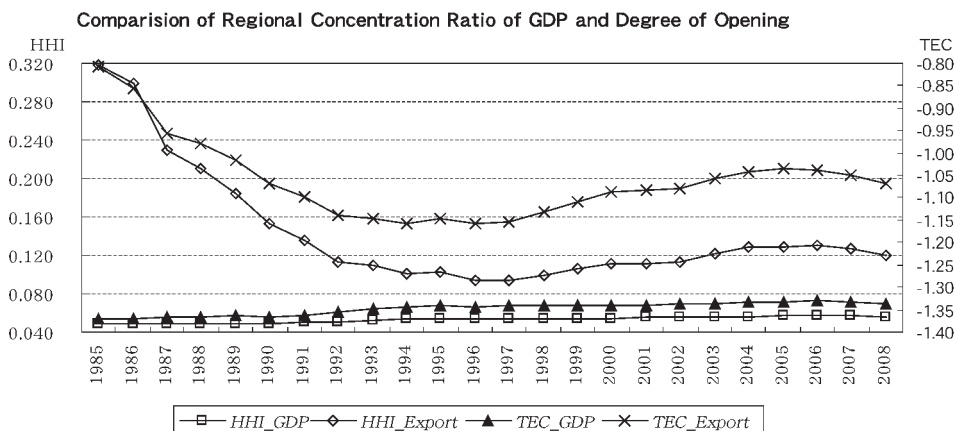
Sources: A Sixty Years Statistical Compendium for New China and China year book.

Figure6: comparison of regional concentration ratio of GDP and total investment in fixed assets

Compared with the above figures, the infrastructure investment in Figure 5 seems smooth. We use the sum of railway length and high way length in operation to measure this indicator. To certain extends the infrastructure investment degree and development speed in each region are harmonious. But this balance has been broken since 1990s.

The total investment in fixed assets has a break in 1984. After that, more investments flood into richer area. And since 1984, the trends of GDP and the trends of total investment in fixed assets each goes his way.

Since the Reform and Openness, China becomes a big export country. Therefore, we study the Degree of Opening using total imports and exports from 1985 (Figure 7). The absolute values of



Sources: A Sixty Years Statistical Compendium for New China and China year book.

Figure7: comparison of regional concentration ratio of GDP and degree of opening

Opening of *HHI* and *TEC* are larger than all the above indicators, which is reasonable. The export amount varies widely among regions. Like Guangdong Province, Zhejiang Province etc, they are big export provinces. But this fluctuation goes low in 1990s, but enlarger since then, though not so fluctuate in new century.

4. Conclusion

Our empirical results illustrate the existence of economic growth disparities in whole country level in fifty-seven years. The fluctuation of each indicator is different. Some disparity gaps among regions widened but some reduced. Only using generalized δ -convergence analyses can describe the disparity degree and disparity trend in each phase; even can distinguish the convergence or divergence trend. But it has its own disadvantage, the dimension is limited. We need other information and methods to go further study and get more detail conclusion about Chinese disparity and convergence problem.

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