Measuring Economic Growth Differentiation of Emerging Economies Based on Calculation of Theil Index

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Abstract. The purpose of this paper is to select 35 emerging economies from Asian, European, Latin American and African regions as the research objects and use GDP and population data of the years from 1990-2016 to calculate the intragroup Theil indexes within the four individual regions, the interblock Theil index among the four regions, the total Theil index among the emerging economies, then the contribution of intragroup and interblock gap to the total gap in order to measure the economic growth differentiation of the emerging economies. The results indicate that the decreasing total Theil index and the interblock Theil indexes reflect the narrowing trend of output per capita among the emerging economies and among the four regions, the intragroup Theil indexes within the four individual regions that are all lower than Asian region reflect that the gap of output per capita in the Asian region is larger than the other 3 regions; according to the contribution rate, the total gap of output per capita among the emerging economies is mainly affected by the gap among the four regions and the Asian region. It can be concluded that the economic growth differentiation is embodied mainly in the gap among the four regions and in the gap among the Asian economic economies.

Keywords: Theil Index, Economic Growth Differentiation, Emerging Economies

1 Introduction

Theil index is widely applied to the research related to measuring the issues of differentiation in economics, including the income gap, the urban-rural gap, the educational gap, etc. In the test of economic convergence, Theil index which can be used to calculate the gap of output per capita measures the economic growth differentiation among economies. This paper applies calculation of Theil index to the issue of the economic growth to measure the economic growth differentiation of 35 selected emerging economies.

1.1 Selection of Research Objects

This paper selects 35 emerging economies as the research objects and divides them into four regions as follows:
11 from Asian region: China, India, Korea, Thailand, Indonesia, Saudi Arabia, Israel, Malaysia, Pakistan, Philippines and Viet Nam; 9 from European region: Czech, Hungary, Poland, Turkey, Russia, Bulgaria, Romania, Slovakia and Ukraine; 8 from Latin American region: Brazil, Mexico, Argentina, Chile, Columbia, Cuba, Uruguay and Paraguay; 7 from African region: Botswana, Egypt, Morocco, Nigeria, Seychelles, Tunisia and South Africa.

1.2 Resources of Data
The data of the real GDP and population related to the calculation in this paper are from The World Bank World Development Indicator (WDI), the real GDP is calculated at 2010 constant US dollar price.[1-3]

1.3 Related Formula
The Theil index Formula:

$$T = \sum_{i=1}^{I} \frac{P_i}{P} \ln\left( \frac{P_i}{P} \right)$$

(1)

In the formula(1), $I$ represents I areas that are divided into the $i^{th}$ area,……,the $i^{th}$ area $(i \in I)$; $P_i$ represents the total population in the $i^{th}$ area; $P$ represents the total population of $I$ areas; $Y$ represents the total output in the $i^{th}$ area, $Y$ represents the total output of $I$ areas, $T$ represents the Theil index calculating the gap of output per capita among $I$ areas.

As for the measurement of the gap of output per capita, Theil index can be represented by decomposition forms due to its decomposed property. The decomposition formula are the followings:

$$T = T_{ib} + T_u$$

(2)

(2) Includes 2 formula as follows:

$$T_{ib} = \sum_{i=1}^{K} \frac{P_k}{P} \ln\left( \frac{P_k}{P} \right)$$

(3)

$$T_u = \sum_{i=1}^{K} \frac{P_k}{P} \sum_{j=1}^{J} \frac{P_{ij}}{P_k} \ln\left( \frac{P_{ij}/P}{Y_{ij}/Y_k} \right)$$

(4)

Similarly, in the formula(2),(3) and (4), $K$ represents $K$ areas that are divided into $1^{st}$ area,……,the $k^{th}$ area $(k \in K)$, $P_k$ represents the total population in the $k^{th}$ area, $P$ represents the total population of $K$ areas, $Y$ represents the total output in the $k^{th}$ area, $Y$ represents the total output of $K$ areas, $J$ represents $J$ economies that are divided into $1^{st}$ economy,……,the $j^{th}$ economy $(j \in J)$ in the $k^{th}$ area, $P_{ij}$ represents the population of the $j^{th}$ economy in the $k^{th}$ area, $Y_{ij}$ represents the output of the $j^{th}$ economy in the $k^{th}$ area. $T$ that is called the total Theil index and represents the total gap measures the total gap of output per capita among all the economies in all the regions, $T_{ib}$ that is called the interblock Theil index and represents the gap among groups measures the gap of output per capita among $K$ areas, $T_u$ that is called the intragroup Theil index and represents the gap within individual areas measures the gap of output per capita within the $K$ individual areas.

The total Theil index that can be decomposed into the sum of the interblock Theil index and the intergroup Theil indexes represent that the total gap among all the economies in all the regions can be decomposed into the sum of the interblock gap and the intragroup gap. In addition, the decomposition form of Theil index can also calculate the contribution rate of interblock gap and the contribution rate of intragroup gap to the total gap as in the following formula.[4-6]


\[ E_b = \frac{T_b}{T} \]  \hspace{2cm} (5)

\[ E_a = \frac{T_a}{T} \]  \hspace{2cm} (6)

\( E_b \) and \( E_a \) respectively represent the contribution rate of interblock gap and the contribution rate of intragroup gap.

2 Theil Index Calculation of the Selected Emerging Economies

This paper applies the formula to calculating the total Theil index among all the 35 emerging economies and the interblock Theil index among the Asian, European, Latin American and African region and the intragroup Theil indexes within the four individual regions with the data of GDP and population of the years from 1990-2016. On this basis, this paper also calculates the contribution rate of the gap of output per capita among the four regions and the gap of output per capita within the four individual regions to the total gap of output per capita among all the emerging economies and make further analyses on the changing trend of the gap among the four regions and the changing trend of the four individual regions then make a comparison of the influential degree of the gap of the output per capita among the four regions on the total gap of output per capita of all the emerging economies.

The results of the calculation of the Theil indexes and the contribution rate are shown in Table 1.

| Year | Theil index | Total contribution rate (=IGR+IBCR=100%) |
|------|-------------|------------------------------------------|
|      | IGT | IB | TTI | CRG | CRB | ER | AR | LR | FR | AFR |
| 1990 | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.5 | 0.17 | 55 | 0.7 | 2.0 | 58.6 |
| 1991 | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.5 | 0.58 | 97 | 0.7 | 2.0 | 55.7 |
| 1992 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 | 0.5 | 0.77 | 01 | 0.8 | 2.0 | 53.3 |
| 1993 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 | 0.5 | 0.91 | 39 | 0.9 | 2.1 | 51.5 |
| 1994 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 | 0.4 | 1.25 | 34 | 0.9 | 2.3 | 49.0 |
| 1995 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 | 0.4 | 1.54 | 99 | 0.9 | 2.6 | 46.9 |
| 1996 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 | 0.4 | 1.84 | 49 | 0.9 | 2.6 | 45.3 |

Table 1. Calculation results of Theil indexes and contribution rate(1990-2016)(IGT=inter group index, IBT=interblock index, IGR=intergroup contribution rate, IBCR=interblock contribution rate, CRG=contribution rate of intergroup gap, CRB=contribution rate of interblock gap; TTI=total Theil index; ER=European region, AR=Asian region, LAR=Latin American region, African region=AR, AFR=among the four regions; AV=average value)
| Year | Percentages | % |
|------|-------------|---|
| 1997 | 0.0 0.2 0.0 0.0 0.2 0.4 1.99 | 49. |
|      | 09 21 04 12 01 48 % | 35 0.9 2.7 44.9 |
|      | 0.0 0.2 0.0 0.0 0.2 0.4 2.17 | 47. |
|      | 09 02 05 12 00 28 % | 17 1.0 2.7 46.8 |
|      | 0.0 0.1 0.0 0.0 0.1 0.4 2.19 | 48. |
|      | 09 99 05 12 87 11 % | 37 1.1 2.9 45.3 |
|      | 0.0 0.2 0.0 0.0 0.1 0.4 2.08 | 49. |
|      | 09 06 05 12 83 14 % | 69 1.1 2.9 44.2 |
|      | 0.0 0.2 0.0 0.0 0.1 0.4 1.90 | 50. |
|      | 08 04 05 12 73 01 % | 86 1.1 3.0 43.1 |
|      | 0.0 0.2 0.0 0.0 0.1 0.3 1.83 | 52. |
|      | 07 07 05 12 63 94 % | 47 1.1 3.1 41.4 |
|      | 0.0 0.2 0.0 0.0 0.1 0.3 1.73 | 53. |
|      | 07 04 04 12 55 82 % | 39 1.1 3.0 40.7 |
|      | 0.0 0.2 0.0 0.0 0.1 0.3 1.58 | 54. |
|      | 06 03 04 09 52 74 % | 38 1.1 2.3 40.5 |
|      | 0.0 0.2 0.0 0.0 0.1 0.3 1.63 | 55. |
|      | 06 00 04 09 44 63 % | 00 1.1 2.5 39.7 |
|      | 0.0 0.1 0.0 0.0 0.1 0.3 1.61 | 55. |
|      | 06 98 04 09 38 55 % | 92 1.0 2.5 38.8 |
|      | 0.0 0.2 0.0 0.0 0.1 0.3 1.52 | 57. |
|      | 05 01 04 09 30 49 % | 52 1.0 2.6 37.2 |
|      | 0.0 0.2 0.0 0.0 0.1 0.3 1.46 | 59. |
|      | 05 07 04 09 25 49 % | 28 1.0 2.5 35.7 |
|      | 0.0 0.2 0.0 0.0 0.1 0.3 1.80 | 62. |
|      | 06 02 04 08 04 23 % | 58 1.0 2.4 32.0 |
|      | 0.0 0.2 0.0 0.0 0.0 0.3 1.70 | 63. |
|      | 06 02 04 08 99 18 % | 66 1.1 2.3 31.0 |
|      | 0.0 0.2 0.0 0.0 0.0 0.3 1.70 | 65. |
|      | 05 07 04 08 95 18 % | 65 1.1 2.3 29.7 |
|      | 0.0 0.2 0.0 0.0 0.0 0.3 1.72 | 66. |
|      | 05 09 03 08 88 13 % | 62 1.0 2.4 28.1 |
|      | 0.0 0.2 0.0 0.0 0.0 0.3 1.76 | 67. |
|      | 05 09 03 08 88 13 % | 67 1.0 2.4 26.8 |
### Analyses on the Results of the Calculation

#### 3.1 Analyses on the Results of the Calculation of the Theil Indexes

From the total Theil index among all the emerging economies and the Theil index among the European, Asian, Latin American and African regions of the years from 1990-2016 (see Table 1 and Fig.1), both of the two lines reflecting the two Theil indexes demonstrates a decreasing trend and the trend of the two lines is highly consistent with each other. The total Theil index falls from 0.599 to 0.283, a drop of 0.324, the Theil index among the four regions falls from 0.351 to 0.064, a drop of 0.2871 [7-9].

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**Table 1**

| Year | Theil Index | Theil Index | Theil Index | Theil Index |
|------|-------------|-------------|-------------|-------------|
| 2014 | 0.0         | 0.2         | 0.0         | 0.0         |
| 2015 | 0.0         | 0.2         | 0.0         | 0.0         |
| 2016 | 0.0         | 0.2         | 0.0         | 0.0         |
| AV   | 0.0         | 0.2         | 0.0         | 0.0         |

**Fig. 1.** The Theil index among the four regions, the interblock Theil index and the total Theil index (1990-2016)

**Fig. 2.** The Contribution rate of the four regions and the contribution rate among the four regions (1990-2016)
As for the Theil indexes within the four individual regions are concerned, there is some frequent fluctuation for the Theil index of European region, rising from 0.001 to 0.009 in the period from 1990 to 1998 and falling from 0.009 to 0.005 in the period from 1998 to 2008, which shows that the trend first falls then rises in the period from 2009 to 2016. The Theil index of Asian region is relatively stable and keeps within a certain range from 0.20 to 0.25. The Theil index of Latin American region fluctuates a little frequently but the fluctuating range is low, keeping around from 0.003 to 0.004. The Theil index of African region keeps around 0.012 from 1990 to 2004 with the falling trend from 2005 to 2016.

Moreover, as for the intragroup Theil indexes in the major years from 1990 to 2016, the European region, the Latin American region and the African region are all far lower than the Asian region.

3.2 Analyses on the Results of the Calculation of the Contribution Rate

From the contribution rate (see the Table 1 and the Fig.2), the contribution rate among the four regions and the contribution rate of the Asian region account for the major of the total contribution rate and the two contribution rates show the inverse relationship which means that the contribution rate of Asian region rises while the contribution rate among the four regions falls, and vice versa.

The contribution rate of Asian region that accounts for the major of the total contribution rate rises from 38.55% to 71.82% in the period from 1990-2016, especially all over 50% from 2001 reaching the highest rate of 72%. The contribution rate of the European region and Latin American region are both very low, below 2% in the major years. The contribution rate of African region is all over 2%, slightly higher than European region and Latin American region. The contribution rate among the four regions basically maintains an obviously decreasing trend year by year from 58.60% in 1990 to 22.51% in 2016.[10, 11]

Conclusion

According to the analyses on the Theil indexes and the contribution rate using data of GDP and population from the years of 1990 to 2016, in terms of output per capita, this paper draws the conclusions concerning the differentiation of the emerging economies as follows:

As for the analyses on the Theil indexes, the gap among the emerging economies shows a decreasing trend. The gap of Asian region is evidently higher than the other 3 regions, the difference between European region and Latin American region is tiny and African region is slightly larger than European region and Latin American region.

As for the analyses on the contribution rate, the total gap among the emerging economies is mainly affected by the gap among the four regions and the gap of Asian region and slightly affected by the other 3 regions. The influence from the gap among the four regions is getting weaker and from the gap of Asian region getting stronger.

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