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Decomposing regional income inequality in China and Indonesia using two-stage nested Theil decomposition method

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Abstract. The objective of this paper is to present an inequality decomposition method, the two-stage nested Theil decomposition method, which is an extension of the ordinary one-stage Theil decomposition method. The method is analogous to a two-stage nested design in the analysis of variance (ANOVA). It considers the three-level hierarchical structure of a country: region-province-district, and decomposes overall regional inequality, as measured by Theil indices based on district-level mean incomes, into three components: the between-region, between-province, and within-province inequality components. The within-province component is a weighted-average of within-province income inequalities for each province, while the between-province component is a weighted-average of between-province income inequalities within each region. The method uses a district as the underlying regional unit to measure regional income inequality, rather than a province, and thus can analyze the contribution of within-province inequalities as well as between-province and between-region inequalities to the overall regional income inequality in a coherent framework. This paper applies the two-stage nested Theil decomposition method to district-level income and population data in China and Indonesia and explores factors determining regional income inequality in China and Indonesia.

JEL classification: O15, C8

1. Introduction

As pointed out by Metwally and Jensen (1973), the measure of regional income inequality based on regional mean incomes relative to the national mean income fails to explain either the dispersion of individual incomes nationally or the dispersion of incomes within regions. It is quite possible for the measure to decrease over time (i.e., a convergence in regional mean incomes), while the

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dispersion of actual incomes may be experiencing the opposite trend. Despite this technical problem, however, there have been a number of studies that measure regional income inequality based on regional mean incomes, using such inequality indices as the weighted coefficient of variation (Williamson 1965), Theil entropy indices (Theil 1967) and the variance of log-income.[1] This is attributable mainly to the paucity of data on individual incomes within each region versus the availability of data on regional mean incomes.

This paper presents an inequality decomposition method, the two-stage nested Theil decomposition method, which is an extension of the ordinary one-stage Theil decomposition method.[2] The method is analogous to a two-stage nested design in the analysis of variance (ANOVA).[3] It considers the three-level hierarchical structure of a country: region-province-district as shown in Fig. 1, and decomposes the overall regional inequality, as measured by a Theil index based on district-level mean incomes, into three components: the between-region, between-province, and within-province inequality components. It should be noted that the method relies on per capita GDP to measure regional income inequality; thus it does not solve the intrinsic problem mentioned above. However, it uses a district as the underlying regional unit to measure regional income inequality, rather than a province, the unit used by the majority of previous studies. By using the district as the underlying regional unit, this study can analyze the contribution of within-province inequalities as well as between-province and between-region inequalities to the overall regional income inequality in a coherent framework.

In this paper, I chose China and Indonesia as case studies, since in these two countries, district-level GDP and population data are available for some years, and their within-province inequalities seem to have been more prominent than between-province inequalities.

The paper is organized as follows. The next section presents the two-stage nested Theil decomposition method, while Sect. 3 discusses the data used in the inequality decomposition analysis. Section 4 then applies the two-stage nested Theil decomposition method to district-level GDP and population data in China and Indonesia and explores factors determining regional income inequality. Finally, Sect. 4 provides the summary of the findings and some policy implications.

2. Decomposition of Theil inequality indices: Two-stage nested Theil decomposition method

The Theil inequality decomposition method is based on two Theil inequality indices (T and L). Theil indices are additively decomposable and satisfy several desirable properties as a measure of regional income inequality, i.e., mean independence, population-size independence, and the Pigou-Dalton principle of transfers (Bourguignon 1979; Shorrocks 1980). An inequality index is said to be additively decomposable if total inequality can be written as the sum

[1] For example, Akita and Lukman (1995), Akita et al. (1999), Chen and Fleisher (1996), Daniere (1996), Das and Barua (1996), Esmara (1975), Gilbert and Goodman (1976), Green (1969), Jensen (1969), Mathur (1983), Mutlu (1991), Tabuchi (1988), Tsui (1991, 1993, 1996), Uppal and Budiono (1986), Wei and Ma (1996), Zheng (1997).

[2] For the one-stage decomposition of Theil indices, see, for example, Anand (1983).

[3] For a two-stage nested design in ANOVA, see, for example, Montgomery (1984).

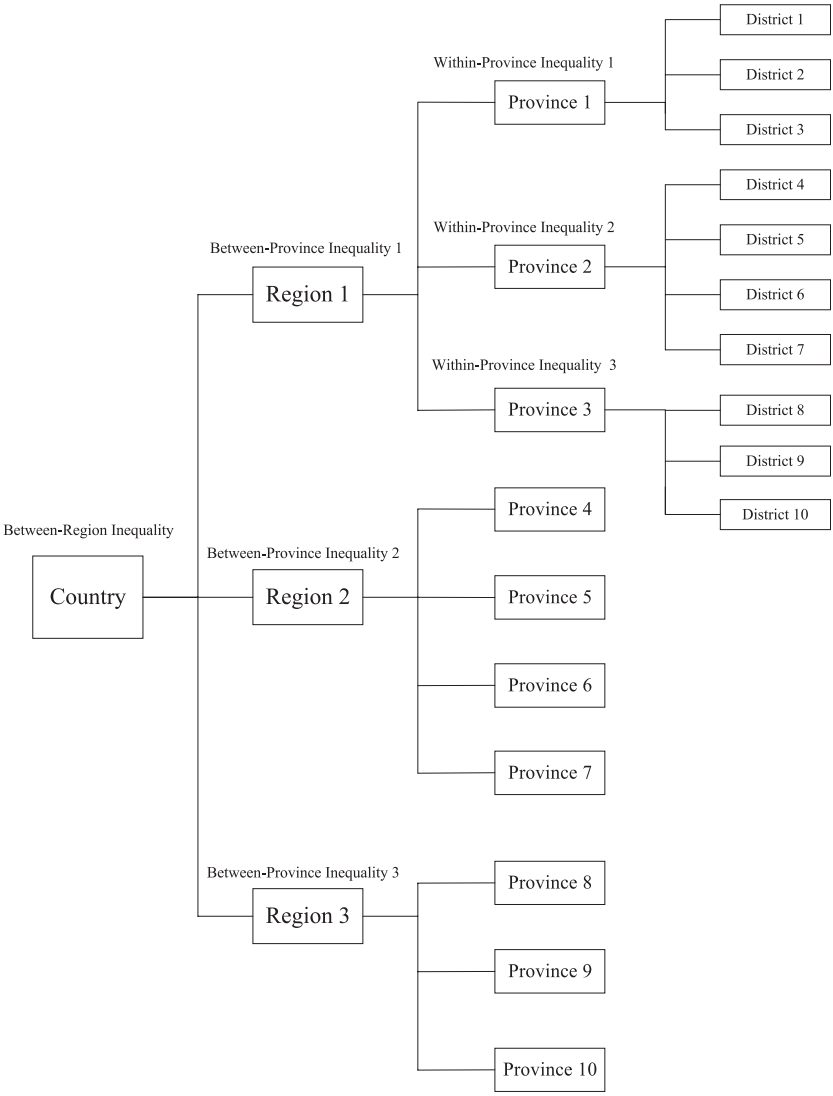


Fig. 1. Three-level hierarchical structure region-province-district

of between-group and within-group inequalities. Mean independence implies that the index remains unchanged if every region's income is changed by the same proportion, while population-size independence means that the index remains unchanged if the number of people in each region is changed by the same proportion, i.e., the index depends only on the relative population frequencies at each region, not the absolute population frequencies. Finally, the Pigou-Dalton principle of transfers implies that any income transfer from a richer to a poorer region that does not reverse their relative ranks in income reduces the value of the index.

This section first presents the ordinary one-stage Theil inequality decom-

position method and then develops the two-stage nested Theil decomposition method as an extension of the one-stage Theil decomposition method. There are numerous studies that used the one-stage Theil decomposition method to analyze factors determining income inequality. But most studies applied the method to analyzing inter-personal or inter-household income inequality.[4]

2.1. *One-stage Theil decomposition method*

Consider the following hierarchical structure of a country: region-province. Using a province as the underlying regional unit, overall regional income inequality can be measured by the following Theil index (Theil index T).

$$T_p = \sum_i \sum_j \left(\frac{Y_{ij}}{Y}\right) \log\left(\frac{Y_{ij}/Y}{N_{ij}/N}\right) \tag{1}$$

where Y_{ij} is the income of province j in region i,

Y is the total income of all provinces $\left(=\sum_i \sum_j Y_{ij}\right)$,

N_{ij} is the population of province j in region i, and

N is the total population of all provinces $\left(=\sum_i \sum_j N_{ij}\right)$.

If we define T_{pi} as follows to measure between-province income inequality for region i,

$$T_{pi} = \sum_j \left(\frac{Y_{ij}}{Y_i}\right) \log\left(\frac{Y_{ij}/Y_i}{N_{ij}/N_i}\right) \tag{2}$$

then Theil index T in Eq. (1) can be decomposed into

$$\begin{aligned} T_p &= \sum_i \left(\frac{Y_i}{Y}\right) T_{pi} + \sum_i \left(\frac{Y_i}{Y}\right) \log\left(\frac{Y_i/Y}{N_i/N}\right) \\ &= \sum_i \left(\frac{Y_i}{Y}\right) T_{pi} + T_{BR} \\ &= T_{WR} + T_{BR} \end{aligned} \tag{3}$$

where Y_i is the total income of region i $\left(=\sum_j Y_{ij}\right)$,

N_i is the total population of region i $\left(=\sum_j N_{ij}\right)$, and

[4] See, for example, Akita and Lukman (1999), Akita et al. (1999), Ching (1991), Estudillo (1997), Glewwe (1986), Ikemoto (1985), Jenkins (1995), Mookherjee and Shorrocks (1982), Tsakloglou (1993), and Tsui (1993).

$T_{BR} = \sum_i \left(\frac{Y_i}{Y}\right) \log\left(\frac{Y_i/Y}{N_i/N}\right)$ measures income inequality between regions.

Equation (3) is the ordinary one-stage Theil inequality decomposition, in which the overall income inequality T_p is the sum of the within-region component (T_{WR}) and the between-region component (T_{BR}), and the within-region component is a weighted average of the between-province income inequalities for each region (T_{pi}).

The Theil index T_p as defined by Eq. (1) employs income shares as weights. Therefore, it is more sensitive to changes in richer provinces. Another Theil index, Theil index L, which is defined as follows, uses population shares as weights; thus it is more sensitive to changes in poorer provinces.

$$L_p = \sum_i \sum_j \left(\frac{N_{ij}}{N}\right) \log\left(\frac{N_{ij}/N}{Y_{ij}/Y}\right) \tag{4}$$

Theil index L in Eq. (4) can also be decomposed into two components.

$$L_p = \sum_i \left(\frac{N_i}{N}\right) L_{pi} + L_{BR}$$

$$= L_{WR} + L_{BR}.$$

2.2. *Two-stage nested Theil decomposition method*

Next, we consider the following hierarchical structure of a country: region-province-district. In this case, by using a district as the underlying regional unit, overall regional income inequality can be measured by the following Theil index (Theil index T).

$$T_d = \sum_i \sum_j \sum_k \left(\frac{y_{ijk}}{Y}\right) \log\left(\frac{y_{ijk}/Y}{n_{ijk}/N}\right), \tag{5}$$

where y_{ijk} is the income of district k in province j in region i,

Y is the total income of all districts $\left(=\sum_i \sum_j \sum_k y_{ijk}\right)$,

n_{ijk} is the population of district k in province j in region i, and

N is the total population of all districts $\left(=\sum_i \sum_j \sum_k n_{ijk}\right)$.

If we define T_{di} as follows to measure between-district income inequality for region i,

$$T_{di} = \sum_j \sum_k \left(\frac{y_{ijk}}{Y_i}\right) \log\left(\frac{y_{ijk}/Y_i}{n_{ijk}/N_i}\right), \tag{6}$$

then T_d in Eq. (5) will be decomposed into

$$T_d = \sum_i \left(\frac{Y_i}{Y}\right) T_{di} + \sum_i \left(\frac{Y_i}{Y}\right) \log\left(\frac{Y_i/Y}{N_i/N}\right)$$

$$= \sum_i \left(\frac{Y_i}{Y}\right) T_{di} + T_{BR} \tag{7}$$

where Y_i is the total income of region i $\left(=\sum_j \sum_k y_{ijk}\right)$,

N_i is the total population of region i $\left(=\sum_j \sum_k n_{ijk}\right)$, and

$T_{BR} = \sum_i \left(\frac{Y_i}{Y}\right) \log\left(\frac{Y_i/Y}{N_i/N}\right)$ measures income inequality between regions.

Therefore, the overall regional income inequality T_d is the sum of the within-region component and the between-region component.

Next, if we define T_{ij} as follows to measure within-province income inequality for province j in region i,

$$T_{ij} = \sum_k \left(\frac{y_{ijk}}{Y_{ij}}\right) \log\left(\frac{y_{ijk}/Y_{ij}}{n_{ijk}/N_{ij}}\right)$$

then T_{di} in Eq. (6) can be further decomposed into

$$T_{di} = \sum_j \left(\frac{Y_{ij}}{Y_i}\right) T_{ij} + \sum_j \left(\frac{Y_{ij}}{Y_i}\right) \log\left(\frac{Y_{ij}/Y_i}{N_{ij}/N_i}\right)$$

$$= \sum_j \left(\frac{Y_{ij}}{Y_i}\right) T_{ij} + T_{pi} \tag{8}$$

where Y_{ij} is the total income of province j in region i $\left(=\sum_k y_{ijk}\right)$,

N_{ij} is the total population of province j in region i $\left(=\sum_k n_{ijk}\right)$, and

$T_{pi} = \sum_j \left(\frac{Y_{ij}}{Y_i}\right) \log\left(\frac{Y_{ij}/Y_i}{N_{ij}/N_i}\right)$ measures income inequality between provinces in region i (same as Eq. (2)).

By substituting T_{di} in Eq. (8) into Eq. (7), we obtain

$$T_d = \sum_i \left(\frac{Y_i}{Y}\right) \left[\sum_j \left(\frac{Y_{ij}}{Y_i}\right) T_{ij} + T_{pi}\right] + T_{BR}$$

$$= \sum_i \sum_j \left(\frac{Y_{ij}}{Y}\right) T_{ij} + \sum_i \left(\frac{Y_i}{Y}\right) T_{pi} + T_{BR}$$

$$= T_{WP} + T_{BP} + T_{BR}. \tag{9}$$

Equation (9) is the two-stage Theil inequality decomposition equation, in which the overall regional income inequality is decomposed into the within-province component (T_{WP}), the between-province component (T_{BP}), and the between-region component (T_{BR}). The within-province component is a weighted average of within-province income inequalities (T_{ij}), while the between-province component is a weighted average of between-province income inequalities (T_{pi}). It should be noted that T_{BP} in Eq. (9) is the same as T_{WR} in Eq. (3).

In the region-province-district framework, Theil index L is defined as:

$$L_d = \sum_i \sum_j \sum_k \left(\frac{n_{ijk}}{N}\right) \log\left(\frac{n_{ijk}/N}{y_{ijk}/Y}\right) \tag{10}$$

Theil index L in Eq. (10) can also be decomposed into three components.

$$L_d = \sum_i \sum_j \left(\frac{N_{ij}}{N}\right) L_{ij} + \sum_i \left(\frac{N_i}{N}\right) L_{di} + L_{BR}$$

$$= L_{WP} + L_{BP} + L_{BR}.$$

It should be noted that inequality figures based on provincial income and population data are comparable to the sum of the between-province and between-region inequality components in the two-stage nested Theil decomposition analysis (compare Eq. (3) with Eq. (9)).

3. The data

This section describes the data used in a one-stage decomposition analysis and a two-stage nested decomposition analysis in China and Indonesia.

3.1. China

A one-stage decomposition analysis for China uses provincial GDP and population data from the *China Statistical Yearbook* (Chinese State Statistical Bureau, various issues), whereas a two-stage nested decomposition analysis relies on district-level GDP and population data from a database compiled by a Japanese research institute (Soken) under the editorial supervision of the Chinese State Statistical Bureau (Soken 2000).[5] The study period for the one-stage analysis is 1990–1997, but the two-stage analysis is conducted only for 1997. It should be noted that regional income inequalities are measured using current price GDP data; thus care should be taken in analyzing the changes in regional income inequality over time.

China is divided into four regions: Western Region, Central Region, Eastern Region, and Northeastern Region. Western Region includes Sichuan,

[5] This database is based on various provincial Statistical Yearbooks and covers all provinces in China. It should be noted that districts in this study refer to cities, districts, and autonomous provinces within each province.

Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. Central Region includes Jiangxi, Shanxi, Anhui, Henan, Hunan, and Hubei. Eastern Region includes Fujian, Guangdong, Guangxi, Hainan, Zhejiang, Jiangsu, Shanghai, Shandong, Hebei, Beijing, and Tianjin. Finally, Northeastern Region includes Heilongjiang, Jilin, Liaoning, and Neimenggu (Inner Mongolia).

For the purpose of geographical convenience in these one-stage and two-stage inequality decomposition analyses, the following separate administrative units have been subsumed into its contiguous province: Shanghai into Jiangsu province; Beijing and Tianjin into Hebei province; and Hainan into Guangdong province.

3.2. Indonesia

A one-stage decomposition analysis for Indonesia uses provincial GDP and population data from the *Gross Regional Domestic Product of Provinces in Indonesia* (Central Bureau of Statistics, various issues), whereas a two-stage nested decomposition analysis employs district-level GDP and population data from the *Gross Regional Domestic Product of Regencies/Municipalities in Indonesia* (Central Bureau of Statistics 1998). Provincial and district-level GDP figures are all in constant 1993 prices. The study period for the one-stage analysis is 1993–1997, but the two-stage analysis is conducted only for 1996.

In this study, Indonesia is divided into five regions: Sumatra, Java-Bali, Kalimantan, Sulawesi, and Others. Sumatra includes DI Aceh, North Sumatra, West Sumatra, Riau, Jambi, South Sumatra, Bengkulu, and Lampung. Java-Bali includes DKI Jakarta, West Java, Central Java, DI Yogyakarta, East Java, and Bali. Kalimantan includes West Kalimantan, Central Kalimantan, South Kalimantan, and East Kalimantan. Sulawesi includes North Sulawesi, Central Sulawesi, South Sulawesi, and Southeast Sulawesi. Finally, Others are West Nusatenggara, East Nusatenggara, East Timor, Maluku, and Irian Jaya.

4. Results: Decomposing regional income inequality in China and Indonesia

This section applies the two-stage nested Theil decomposition method to district-level GDP and population data in China and Indonesia. In addition, as a prelude to the two-stage nested Theil decomposition analysis, the results of a one-stage Theil decomposition analysis based on province-level GDP and population data are presented first.

4.1. One-stage Theil inequality decomposition analysis

4.1.1. China

Figure 2 presents the results of the one-stage Theil decomposition analysis by Theil index T for China (see also Table A1 in the Appendix). It is apparent that the overall regional inequality as measured by provincial per capita GDP increased significantly (from 0.057 in 1990 to 0.088 in 1994). But, after 1994, it became stable at around 0.085.

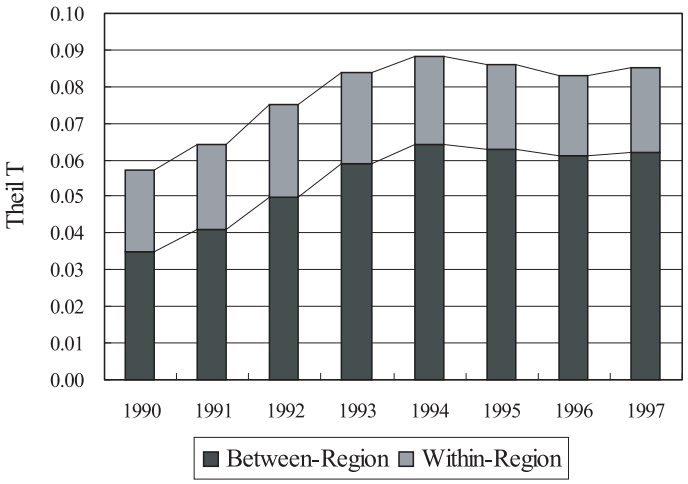


Fig. 2. One-stage inequality decomposition by Theil index T for China 1990–1997

Decomposition of the overall regional inequality into the between-region and within-region components reveals that a significant increase in overall regional income inequality between 1990 and 1994 is due entirely to an increase in the between-region component (from 0.035 to 0.064); in contrast, the within-region component was quite stable between 1990 and 1994. Thus, the percentage contribution of the between-region component increased from 61 percent in 1990 to 73% in 1994. In other words, income disparity between the four regions became increasingly significant in overall regional inequality as calculated using provincial per capita GDP.

Between 1990 and 1997, Eastern Region had the highest per capita GDP, followed in diminishing order by Northeastern Region, Central Region, and Western Region. A large increase in the between-region inequality component between 1990 and 1994 was due to a relative decrease in the per capita GDP of Western, Central, and Northeastern Regions. It should be noted that while Central Region recorded a rise in per capita GDP relative to Eastern Region after 1994, Northeastern Region experienced a further decrease in per capita GDP, signifying the so-called 'Northeast Phenomenon', which refers to the sluggish economic condition of northeastern provinces due to their high dependence on inefficient state-owned heavy industries.

Though the within-region component was relatively stable between 1990 and 1997, each within-region inequality exhibited a distinct movement over the period. The within-region inequality of Eastern Region revealed a slight decreasing trend, indicating that economic activities gradually extended throughout an increasing number of districts of the Eastern provinces as the regional economy expanded under the reform and open-door policies. However, the within-region inequality was still the highest among the four regions in 1997 at 0.034.

In contrast to Eastern Region, the within-region inequality of Western Region exhibited an increasing trend. In 1990, it was only 0.014, but it gradually increased and became the second highest after Eastern Region at 0.027 in 1997. On the other hand, the within-region inequality of Central Region

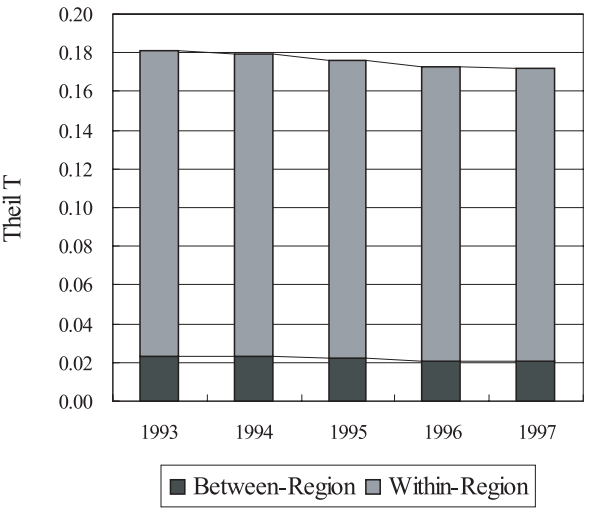


Fig. 3. One-stage inequality decomposition by Theil index T for Indonesia including mining sectors 1993–1997

remained stable at a very low level, indicating that Central Region had managed a balanced regional economic growth even under the reform and open-door policies. Finally, the within-region inequality of Northeastern Region fluctuated significantly. Until 1994 (with the exception of 1993), Northeastern Region had the second highest level of within-region inequality, but in 1995 it was supplanted by Western Region.

4.1.2. Indonesia

The results of the one-stage Theil decomposition analysis for Indonesia are presented in Figs. 3 and 4; the former includes while the latter excludes the oil and gas sectors (see also Tables A2 and A3 in the Appendix).[6] When the oil and gas sectors are included, overall regional inequality exhibited a slight decreasing trend (from 0.181 in 1993 to 0.172 in 1997); however, after excluding the oil and gas sectors, it exhibited a slight increasing trend. This reflects the declining importance of the oil and gas sectors in regional economic development in Indonesia. The share of the oil and gas sectors in total national GDP decreased from 10 percent in 1993 to 8% in 1997, and while Indonesia as a whole achieved a per capita GDP growth of more than 5%, the oil-rich provinces of Aceh, Riau, and East Kalimantan exhibited either declining or only slightly increasing per capita GDP as measured in constant 1993 prices during this period.

[6] We should note that regional GDP indicates the income generated within a region, rather than the income received by the region's inhabitants. Often, much of the value-added generated by a resource-rich region through extraction activities does not trickle down to the inhabitants but instead is transferred to other regions or countries. For this reason, like previous studies on regional income disparities in Indonesia, we exclude the oil and gas sectors in the estimation of regional income inequality; the oil and gas sectors include oil/gas mining, oil refining, and LNG.

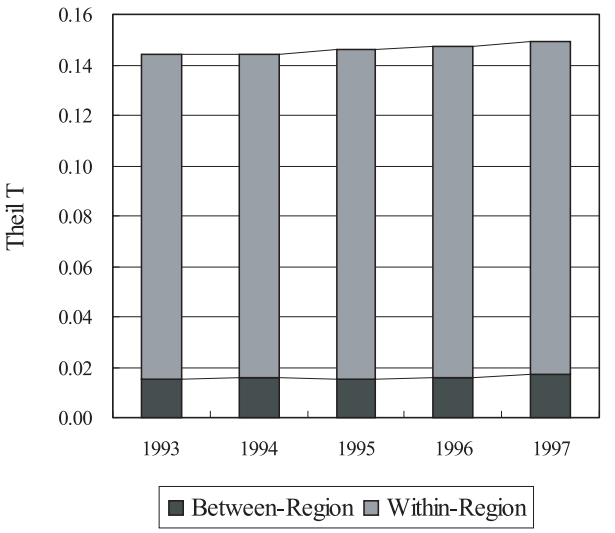


Fig. 4. One-stage inequality decomposition by Theil index T for Indonesia excluding mining sectors 1993–1997

According to the one-stage decomposition analysis, the within-region component, as measured by the Theil index T, contributed to about 88% of the overall regional inequality, whether including or excluding the oil and gas sectors. This is in sharp contrast to China in which the analogous contribution was 27% (see Fig. 2). After excluding the oil and gas sectors, Indonesia's between-region inequality was 0.017 in 1997, which is much lower than China's (0.062). However, Indonesia's within-region inequality component amounted to 0.132 in 1997, which is six times higher than China's within-region component (0.023). Table A3 in the Appendix indicates that Indonesia's relatively large within-region component is due mainly to a very high level of within-region inequality in the Java-Bali region, which is, in turn, due to Jakarta's very high per capita GDP relative to the other provinces in the Java-Bali region.[7] Java-Bali's within-region inequality, in fact, accounted for 75 percent of the overall regional inequality in provincial GDP.

After excluding the oil and gas sectors, Kalimantan exhibited a downward trend in within-region inequality during 1993–1997 (from 0.085 to 0.069) while the other regions exhibited an upward trend. Much slower growth in per capita GDP in East Kalimantan, the richest province in Kalimantan, relative to the other Kalimantan provinces, seems to have contributed to this downward trend. In contrast to Kalimantan, Sumatra experienced a significant increase in its within-region inequality over the period (from 0.024 to 0.032). This seems to be attributable to a much higher per capita GDP growth rate in

[7] As in China, in which Shanghai is subsumed into Jiangsu province, if Jakarta is subsumed into West Java, overall regional inequality is reduced substantially to 0.060 in 1997 due to the decrease in the within-region inequality component (from 0.132 to 0.043). But, the within-region component still accounts for 72% of the overall regional inequality and is much larger than China's within-region component.

North Sumatra, the richest province in Sumatra after excluding the oil and gas sectors, than the other Sumatra provinces. Finally, while Sulawesi's within-region inequality exhibited a slight increasing trend, it remained at a very low level, which is indicative of Sulawesi's balanced regional development based on the agricultural sector, which accounts for more than 30% of total GDP in Sulawesi.

4.2. Two-stage nested Theil inequality decomposition analysis

4.2.1. China

Figure 5 presents the results of the two-stage nested decomposition analysis for China in 1997 (see also Table A4 in the Appendix). It should be noted that the between-province component in the two-stage decomposition analysis is comparable with the within-region component in the one-stage Theil decomposition analysis.

According to the two-stage decomposition analysis, overall regional income inequality was 0.238 as measured by the Theil index T and 0.216 as measured by the Theil index L. Decomposition of the overall regional inequality into the within-province, between-province, and between-region components by

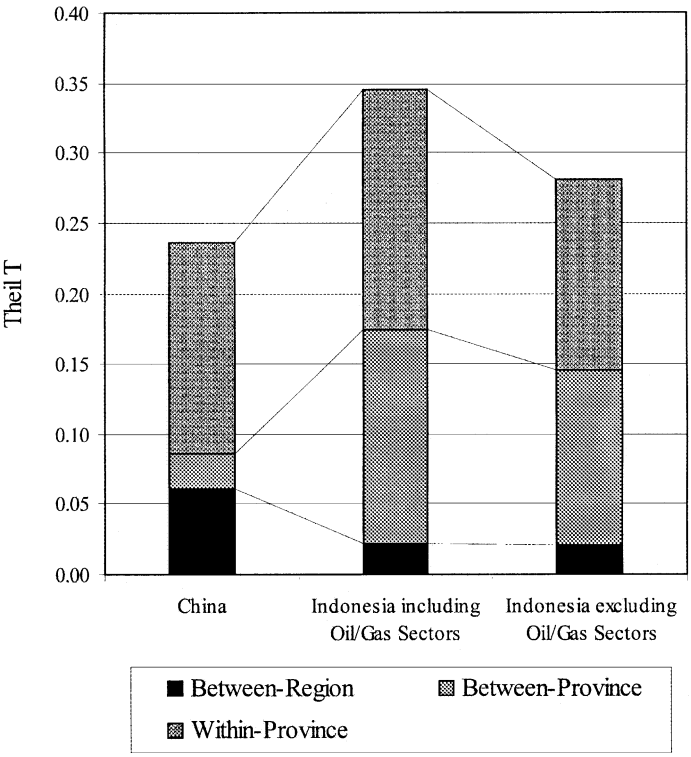


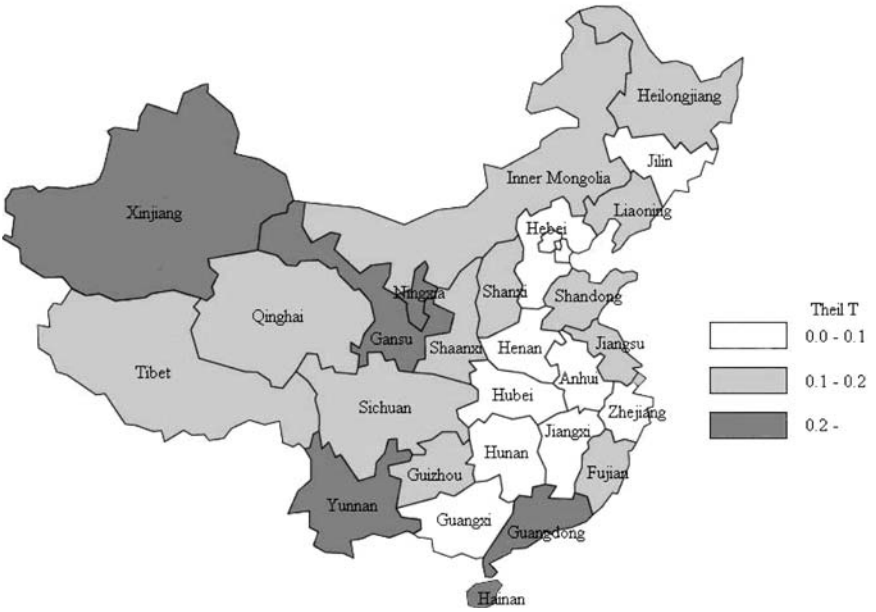
Fig. 5. Two-stage nested inequality decomposition for China and Indonesia

the Theil index T indicates, however, that 64% of the overall inequality was due to the within-province component. The between-province and between-region components accounted for, respectively, 10 and 26% of the overall inequality.

Between-region inequality. It is said that the reform and open-door policies favoring coastal eastern provinces have contributed to increasing income disparity between the coastal and inland areas. There is, in fact, a large disparity in per capita GDP between the four regions. In particular, the per capita GDP of Eastern Region was 2.3 times higher than that of Western Region. However, the two-stage decomposition analysis indicates that the within-region component (i.e., the sum of the within-province and between-province components) was much more significant than the between-region component, accounting for about 74% (64% plus 10%) of overall regional inequality.

Between-province inequalities. Among the four regions, Eastern Region had the highest level of between-province inequality in per capita GDP at 0.028 by Theil T, accounting for 6.4% of overall regional inequality. This was followed by Northeastern Region, Western Region, and Central Region. If we compare the two-stage decomposition results with the one-stage decomposition results, Central Region had a much higher level of between-province inequality in the two-stage decomposition analysis (0.015 vs. 0.006). This seems attributable to a much higher per capita GDP in Hubei using the two-stage decomposition analysis.

Within-province inequalities. Map 1 exhibits within-province inequalities in



Map 1. Within-province inequalities in China

China. Among Western provinces, Yunnan had the highest level of within-province inequality at 0.326 as measured by the Theil index T. This is followed by Xinjiang and Gansu. Provinces in Central Region were much more evenly distributed in terms of per capita GDP than provinces in Western Region. According to the Theil index T, Shanxi had the highest level of within-province inequality in Central Region, but the figure is still lower than the lowest level of within-province inequality in Western Region, which was recorded by Sichuan. This suggests that Central Region has so far achieved a very balanced regional development, not only across provinces but also within provinces.

There are large variations in within-province inequalities in Eastern Region. Guangdong registered the highest level of within-province inequality at 0.398 as measured by the Theil index T, accounting for 18% of overall regional inequality. This was followed by Jiangsu, Shandong, and Fujian. Guangdong, in fact, had the highest level of within-province inequality in all of China. On the other hand, the lowest level of within-province inequality in Eastern Region was recorded by Zhejiang at 0.057, which ranked among the lowest in China. These observations suggest that each province in Eastern Region has had a distinct pattern of provincial economic development under the reform and open-door policies. At the district level in Guangdong, the highest per capita GDP was more than 40 times higher than the lowest in the province. In Jiangsu, the ratio between the highest per capita GDP (Shanghai) and the lowest was 8.7; in Zhejiang, the ratio was merely 3.7. It should be noted that together with the region's between-province inequality, Eastern Region contributed to about a half of the overall regional inequality.

Among provinces in Northeastern Region, Heilongjiang had the highest within-province inequality at 0.144 as measured by the Theil index T, which was followed by Liaoning, Inner Mongolia, and Jilin. However, according to the Theil index L, Liaoning had the highest level of inequality, followed by Heilongjiang. This comes from the fact that higher per capita GDP districts tended to have larger GDP shares in Heilongjiang *vis-a-vis* Liaoning.

4.2.2. Indonesia

Figure 5 also presents the results of the two-stage nested decomposition analysis for Indonesia in 1996, including and excluding the oil and gas sectors (see Tables A5 and A6 in the Appendix, respectively). Since the two-stage decomposition analysis uses district-level data from the *Gross Regional Domestic Product of Regencies/Municipalities in Indonesia*, provincial GDP figures in Tables A5 and A6 are different from provincial GDP figures from the *Gross Regional Domestic Product of Provinces in Indonesia* used in the one-stage decomposition analysis. Thus, estimates of between-region and between-province inequalities in Tables A5 and A6 are different from their counterparts in the one-stage decomposition analysis.

Since the oil and gas sectors' direct contribution to regional welfare is minimal as most of the revenues are transferred to the central government or other countries, this section focuses on the results based on per capita GDP after excluding the oil and gas sectors (see Footnote 6). Unless noted otherwise, the results are based on the Theil index T. The conclusion would not change significantly if the Theil index L were used instead.

Overall regional inequality as measured by the Theil index T in per capita GDP, including and excluding the oil and gas sectors, was 0.345 and 0.281, respectively. After excluding the oil and gas sectors, the within-province component accounted for 49% of the overall regional inequality in district-level per capita GDP, whereas the between-province and between-region inequality components contributed to 44% and 7%, respectively, of the overall regional inequality.[8]

Between-region inequality. Reducing income disparities between rich western and poor eastern regions has been one of the main policy issues in Indonesia. It is true that even after the oil and gas sectors are excluded, the highest per capita GDP, registered by Kalimantan, was 2.6 times higher than the lowest per capita GDP in Others, which include Nusatenggara provinces, Maluku, and Irian Jaya. However, the between-region inequality was only 0.021, accounting for merely 7% of the overall regional inequality. Java-Bali region registered the second highest per capita GDP, but this is due mostly to the existence of Jakarta, the richest province.

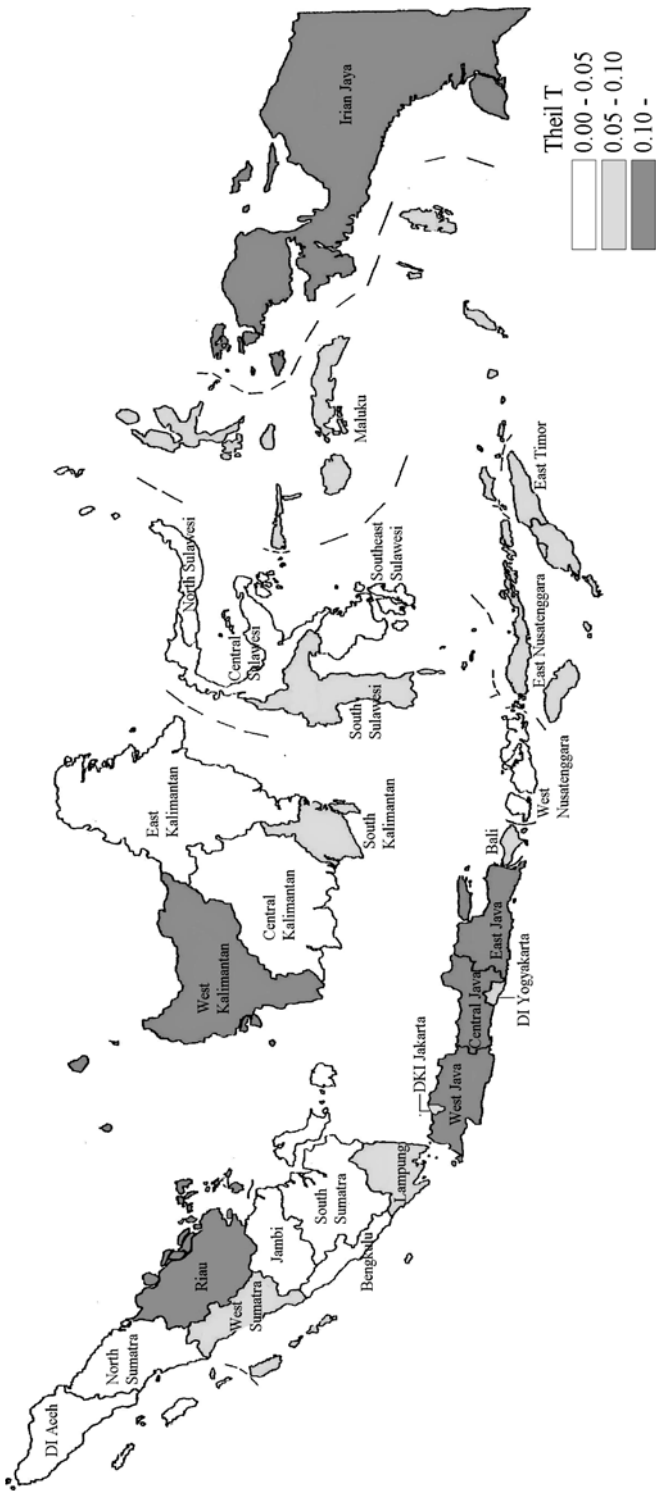
Between-province inequalities. Among the five regions, Java-Bali had the highest between-province inequality at 0.169 as measured by Theil T, accounting for 40% of the overall regional inequality. This is followed by Kalimantan, Others, Sumatra, and Sulawesi. Java-Bali's very high level of between-province inequality is attributable to Jakarta's primacy in per capita GDP. Jakarta's per capita GDP was more than 5 times higher than the lowest per capita GDP recorded by Central Java.

Within-province inequalities. Map 2 shows within-province inequalities in Indonesia. Within Sumatra, Riau had the highest level of within-province inequality at 0.274 as measured by the Theil index T. This is followed by West Sumatra and Lampung. The main reason why Riau had a very high level of inequality is the existence of Batam Island, which is located just 20 km southeast of Singapore and has received special treatment from the central government as an export-oriented industrial zone. Batam's per capita GDP far exceeded other districts' per capita GDP after excluding oil and gas in Riau. With the exception of Riau, Sumatra provinces overall had relatively low within-province inequalities ranging from 0.014 to 0.087.

Among Java-Bali provinces, East Java had the highest level of within-province inequality at 0.358, accounting for 20.6% of the overall regional inequality as measured in district per capita GDP. East Java's very high inequality is due to the existence of a few very rich districts: urban Kediri, urban Surabaya, and Gresik. Though its population size is not large, urban Kediri's per capita GDP was higher than Central Jakarta's per capita GDP; in fact, it had the highest per capita GDP in Indonesia.

Within Java-Bali, the second highest level of within-province inequality

[8] If Jakarta is subsumed into West Java, the between-province inequality component (equivalent to the within-region inequality component in the one-stage decomposition method) decreases to 0.041, while the within-province inequality component increases to 0.219. The within-province inequality component now accounts for 78% of the overall income inequality, while the between-province inequality component accounts for 15%.



Map 2. Within-province inequalities in Indonesia

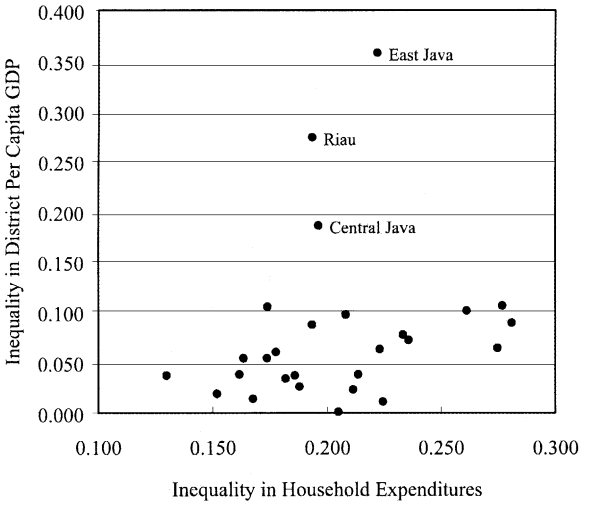


Fig. 6. Inequalities in per capita GDP and household expenditure within each province

was registered by Central Java at 0.186, in which Kudus and urban Semarang had relatively high per capita GDP. West Java had the third highest level of inequality, but it was much lower than Central Java and East Java. This comes from the fact that unlike Central Java and East Java, which include the primary cities of Semarang and Surabaya, respectively, West Java districts are very uniformly developed and do not include any dominant cities.[9]

Among Kalimantan provinces, West Kalimantan registered the highest within-province inequality at 0.105, in which urban Pontianak had the highest per capita GDP. It is interesting to observe that while East Kalimantan had a very high per capita GDP, its within-province inequality is one of the lowest in Indonesia after the oil and gas sectors are excluded.

Within Sulawesi, South Sulawesi had the highest level of within-province inequality at 0.072 due to the existence of Ujung Pandang, the richest district in Sulawesi region. Sulawesi, however, had a very even distribution of income not only across provinces but also within provinces. Finally, within Others, Irian Jaya had the highest level of within-province inequality at 0.106, in which Jaya Pura had the highest per capita GDP.

In order to analyze how the distribution of GDP within each province compares to the distribution of household expenditure within each province, Fig. 6 plots the relationship between within-province inequalities in per capita GDP estimated by this study (on the vertical axis) and within-province inequalities in household expenditure estimated by Akita and Szeto (2000) based on the 1996 National Socio-Economic Survey (on the horizontal axis). No significant relationship exists between them, as the simple correlation coefficient is only 0.21. In general, inequalities based on per capita GDP are much lower than inequalities based on household expenditures, indicating that large inequalities still exist between households within each district.

[9] It should be noted that Jakarta is a separate province and does not belong to West Java.

5. Concluding remarks

The paper presented an inequality decomposition method, the two-stage nested Theil inequality decomposition method, as an extension of the ordinary one-stage Theil inequality decomposition method. The method uses a district as the underlying regional unit, rather than a province, to measure regional inequality in per capita GDP; thus, it can analyze within-province inequalities as well as between-region and between-province inequalities in a coherent framework. Though the method cannot solve the intrinsic problem that the measure of regional inequality based on per capita GDP fails to explain the dispersion of incomes within the underlying regional unit, it provides a much clearer picture of regional inequalities at a more granular level within a country, especially in such large, developing countries as China and Indonesia.

Given unequal distribution of natural resources and transportation facilities, some regional income disparities are inevitable from the perspective of efficiency. China and Indonesia are still at a relatively early stage of economic development, and thus income-enhancing economic activities tend to have concentrated in a few districts in each province in order to take advantage of agglomeration economies. In fact, the results of this study show that very high levels of regional income inequality still exist among the districts of China and Indonesia.

Applying the two-stage nested decomposition method to district-level GDP and population data reveals that in China, the within-province component accounted for 64 percent of the overall regional inequality, while in Indonesia, it accounted for about a half of the overall regional inequality. Thus, within-province inequalities are much more prominent than between-region and between-province inequalities, at least in these two countries. These observations suggest that policy makers should look not only at between-region or between-province inequalities but also within-province inequalities to formulate better regional policies.

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Appendix

Table A1. One-stage inequality decomposition by Theil index T for China 1990–1997

Regions	1990	1991	1992	1993	1994	1995	1996	1997
Western region	0.014	0.017	0.019	0.022	0.026	0.027	0.025	0.027
Central region	0.008	0.010	0.008	0.008	0.006	0.005	0.005	0.006
Eastern region	0.037	0.036	0.040	0.037	0.034	0.032	0.032	0.034
Northeastern region	0.024	0.025	0.027	0.039	0.033	0.026	0.023	0.024
Within-region	0.022	0.023	0.025	0.025	0.024	0.023	0.022	0.023
(% Contribution to total)	(38.6)	(35.9)	(33.3)	(29.8)	(27.3)	(26.7)	(26.5)	(27.1)
Between-region	0.035	0.041	0.050	0.059	0.064	0.063	0.061	0.062
(% Contribution to total)	(61.4)	(64.1)	(66.7)	(70.2)	(72.7)	(73.3)	(73.5)	(72.9)
Total	0.057	0.064	0.075	0.084	0.088	0.086	0.083	0.085

Table A2. One-stage inequality decomposition by Theil T for Indonesia including mining sectors 1993–1997

Regions	1993	1994	1995	1996	1997
Sumatra	0.138	0.127	0.118	0.107	0.106
Java-Bali	0.157	0.159	0.161	0.161	0.162
Kalimantan	0.278	0.276	0.253	0.239	0.225
Sulawesi	0.002	0.003	0.003	0.004	0.005
Others	0.175	0.170	0.195	0.204	0.199
Within-region	0.158	0.156	0.154	0.152	0.151
(% Contribution to total)	(87.3)	(87.2)	(87.5)	(87.9)	(87.8)
Between-region	0.023	0.023	0.022	0.021	0.021
(% Contribution to total)	(12.7)	(12.8)	(12.5)	(12.1)	(12.2)
Total	0.181	0.179	0.176	0.173	0.172

Table A3. One-stage inequality decomposition by Theil T for Indonesia excluding mining sectors 1993–1997

Regions	1993	1994	1995	1996	1997
Sumatra	0.024	0.026	0.028	0.027	0.032
Java-Bali	0.169	0.169	0.170	0.171	0.172
Kalimantan	0.085	0.076	0.077	0.073	0.069
Sulawesi	0.002	0.003	0.003	0.004	0.005
Others	0.161	0.153	0.183	0.194	0.188
Within-region	0.129	0.128	0.131	0.131	0.132
(% Contribution to total)	(89.6)	(88.9)	(89.7)	(89.1)	(88.6)
Between-region	0.015	0.016	0.015	0.016	0.017
(% Contribution to total)	(10.4)	(11.1)	(10.3)	(10.9)	(11.4)
Total	0.144	0.144	0.146	0.147	0.149

Table A4. Two-stage nested inequality decomposition for China in 1997

Regions provinces[a]	Theil T		Theil L		GDP share	Population share	Per capita GDP (in yuan)
		Contrib. to total[b]		Contrib. to total[b]			
Western region (105)	0.025	1.5%	0.026	2.8%	14.0%	23.2%	3,891.2
1 Sichuan (20)	0.110	2.8%	0.102	4.5%	6.1%	9.5%	4,119.2
2 Guizhou (9)	0.133	0.6%	0.115	1.6%	1.1%	3.0%	2,324.7
3 Yunnan (17)	0.326	3.0%	0.281	4.3%	2.2%	3.3%	4,222.3
4 Tibet (7)	0.173	0.1%	0.156	0.2%	0.1%	0.2%	3,158.3
5 Shaanxi (10)	0.113	0.8%	0.112	1.5%	1.8%	2.9%	3,916.3
6 Gansu (14)	0.273	1.2%	0.258	2.5%	1.0%	2.1%	3,132.9
7 Qinghai (8)	0.139	0.1%	0.126	0.2%	0.2%	0.4%	3,394.8
8 Ningxia (4)	0.253	0.3%	0.239	0.5%	0.3%	0.4%	3,979.6
9 Xinjiang (16)	0.308	1.8%	0.282	1.9%	1.4%	1.4%	6,193.5
Central region (81)	0.015	1.4%	0.014	1.9%	21.0%	28.3%	4,793.5
1 Jiangxi (11)	0.087	0.8%	0.076	1.2%	2.0%	3.3%	3,900.3
2 Shanxi (11)	0.100	0.8%	0.096	1.2%	1.9%	2.6%	4,731.0
3 Anhui (16)	0.048	0.7%	0.046	1.1%	3.4%	5.1%	4,370.3
4 Henan (17)	0.073	1.6%	0.069	2.5%	5.3%	7.6%	4,479.3
5 Hunan (14)	0.056	0.9%	0.055	1.4%	3.8%	5.3%	4,626.5
6 Hubei (12)	0.093	1.8%	0.094	1.9%	4.6%	4.3%	6,762.8
Eastern region (101)	0.028	6.4%	0.031	5.6%	53.7%	38.0%	9,116.0
1 Fujian (9)	0.105	1.7%	0.095	1.2%	3.9%	2.7%	9,268.5
2 Guangdong (22)	0.398	18.0%	0.320	9.6%	10.6%	6.4%	10,674.0
3 Guangxi (15)	0.077	0.9%	0.075	1.3%	2.8%	3.8%	4,667.9
4 Zhejiang (11)	0.057	1.5%	0.063	1.1%	6.0%	3.7%	10,488.3
5 Jiangsu (14)	0.195	10.5%	0.212	6.9%	12.6%	7.0%	11,691.0
6 Shandong (17)	0.131	4.7%	0.136	4.6%	8.5%	7.3%	7,569.8
7 Hebei (13)	0.092	3.7%	0.093	3.1%	9.4%	7.2%	8,393.9
Northeastern region (48)	0.026	1.3%	0.027	1.3%	11.4%	10.6%	6,888.6
1 Inner Mongolia (12)	0.100	0.6%	0.101	0.9%	1.4%	1.9%	4,622.2
2 Jilin (9)	0.039	0.3%	0.040	0.4%	1.9%	2.2%	5,693.9
3 Heilongjiang (13)	0.144	2.1%	0.110	1.6%	3.4%	3.1%	6,991.5
4 Liaoning (14)	0.136	2.7%	0.153	2.4%	4.7%	3.4%	8,827.7
Within-province	0.150	63.8%	0.127	59.4%			
Between-province	0.025	10.5%	0.025	11.5%			
Between-region	0.061	25.7%	0.062	29.1%			
Total (316)	0.235	100.0%	0.214	100.0%	100.0%	100.0%	6,448.3

[a] Number in parentheses is the number of districts.
[b] Contribution to the overall regional inequality (in %).

Table A5. Two-stage nested inequality decomposition for Indonesia in 1996 including oil and gas sectors

Regions provinces[a]	Theil T		Theil L		GDP share	Population share	Per capita GDP[c] (in 1000 Rp)
		Contrib. to total[b]		Contrib. to total[b]			
Sumatra (73)	0.110	6.8%	0.102	7.7%	21.4%	21.1%	2,097.6
1 DI Aceh (10)	0.310	2.5%	0.293	2.1%	2.8%	2.0%	2,909.3
2 North Sumatra (17)	0.036	0.6%	0.037	0.8%	5.8%	5.7%	2,092.6
3 West Sumatra (14)	0.087	0.5%	0.081	0.7%	1.9%	2.2%	1,743.2
4 Riau (7)	0.346	4.9%	0.415	3.1%	4.9%	2.1%	4,937.5
5 Jambi (6)	0.038	0.1%	0.038	0.2%	0.8%	1.2%	1,293.0
6 South Sumatra (10)	0.052	0.5%	0.052	0.7%	3.2%	3.7%	1,756.1
7 Bengkulu (4)	0.014	0.0%	0.015	0.0%	0.4%	0.7%	1,226.6
8 Lampung (5)	0.060	0.3%	0.052	0.7%	1.7%	3.4%	1,021.2
Java-Bali (116)	0.159	28.3%	0.119	25.7%	61.3%	60.2%	2,108.2
1 DKI Jakarta (5)	0.089	4.2%	0.077	1.3%	16.1%	4.7%	7,062.9
2 West Java (25)	0.104	5.3%	0.098	7.1%	17.7%	20.2%	1,807.0
3 Central Java (35)	0.214	6.2%	0.181	9.8%	10.0%	15.1%	1,369.2
4 D I Yogyakarta (5)	0.064	0.2%	0.057	0.3%	1.3%	1.5%	1,753.8
5 East Java (37)	0.358	15.1%	0.266	16.4%	14.6%	17.2%	1,752.5
6 Bali (9)	0.097	0.5%	0.087	0.5%	1.8%	1.5%	2,466.7
Kalimantan (29)	0.251	6.7%	0.226	4.4%	9.2%	5.5%	3,483.9
1 West Kalimantan (7)	0.105	0.5%	0.099	0.7%	1.7%	1.9%	1,851.4
2 Central Kalimantan (6)	0.038	0.1%	0.038	0.1%	1.0%	0.9%	2,378.1
3 South Kalimantan (10)	0.053	0.2%	0.054	0.3%	1.5%	1.5%	2,020.4
4 East Kalimantan (6)	0.155	2.3%	0.172	0.8%	5.1%	1.2%	8,542.4
Sulawesi (38)	0.006	0.1%	0.006	0.2%	4.2%	7.1%	1,219.3
1 North Sulawesi (7)	0.038	0.1%	0.036	0.2%	0.9%	1.4%	1,410.9
2 Central Sulawesi (4)	0.001	0.0%	0.001	0.0%	0.5%	1.0%	1,108.0
3 South Sulawesi (23)	0.072	0.5%	0.067	0.9%	2.3%	3.9%	1,238.8
4 Southeast Sulawesi (4)	0.011	0.0%	0.010	0.0%	0.4%	0.8%	949.9
Others (47)	0.202	2.3%	0.177	4.0%	4.0%	6.2%	1,324.1
1 West Nusatenggara (7)	0.023	0.1%	0.023	0.2%	0.8%	1.9%	861.8
2 East Nusatenggara (12)	0.063	0.1%	0.059	0.4%	0.7%	1.8%	738.7
3 East Timor (13)	0.077	0.0%	0.073	0.1%	0.2%	0.4%	766.5
4 Maluku (5)	0.053	0.1%	0.047	0.2%	0.7%	1.1%	1,386.7
5 Irian Jaya (10)	0.941	4.6%	0.688	2.5%	1.7%	1.0%	3,397.8
Within-province	0.171	49.4%	0.139	49.9%			
Between-province	0.152	44.1%	0.117	42.0%			
Between-region	0.022	6.5%	0.023	8.2%			
Total (303)	0.345	100.0%	0.278	100.0%	100.0%	100.0%	2,069.2

[a] Number in parentheses is the number of districts (i.e., the number of Kabupatens and Kotamadyas).
[b] Contribution to the overall regional inequality (in %).
[c] Per capita GDP figures are in constant 1993 prices.

Table A6. Two-stage nested inequality decomposition for Indonesia in 1996 excluding oil and gas sectors

Regions provinces[a]	Theil T		Theil L		GDP share	Population share	Per capita GDP[c] (in 1000 Rp)
		Contrib. to total[b]		Contrib. to total[b]			
Sumatra (73)	0.028	1.8%	0.029	2.7%	18.3%	21.1%	1,626.9
1 DI Aceh (10)	0.019	0.1%	0.019	0.2%	1.7%	2.0%	1,575.1
2 North Sumatra (17)	0.037	0.8%	0.037	0.9%	6.3%	5.7%	2,053.6
3 West Sumatra (14)	0.087	0.6%	0.081	0.8%	2.1%	2.2%	1,743.2
4 Riau (7)	0.274	2.1%	0.177	1.6%	2.2%	2.1%	1,990.7
5 Jambi (6)	0.037	0.1%	0.037	0.2%	0.8%	1.2%	1,253.6
6 South Sumatra (10)	0.034	0.4%	0.034	0.6%	3.0%	3.7%	1,494.7
7 Bengkulu (4)	0.014	0.0%	0.015	0.1%	0.5%	0.7%	1,226.6
8 Lampung (5)	0.060	0.4%	0.052	0.8%	1.9%	3.4%	1,021.2
Java-Bali (116)	0.169	39.9%	0.126	33.4%	66.2%	60.2%	2,063.0
1 DKI Jakarta (5)	0.089	5.6%	0.077	1.6%	17.8%	4.7%	7,062.9
2 West Java (25)	0.101	6.7%	0.092	8.2%	18.6%	20.2%	1,724.6
3 Central Java (35)	0.186	7.0%	0.155	10.3%	10.5%	15.1%	1,300.9
4 D I Yogyakarta (5)	0.064	0.3%	0.057	0.4%	1.4%	1.5%	1,753.8
5 East Java (37)	0.358	20.6%	0.266	20.2%	16.1%	17.2%	1,751.3
6 Bali (9)	0.097	0.7%	0.087	0.6%	1.9%	1.5%	2,466.7
Kalimantan (29)	0.070	1.9%	0.064	1.6%	7.4%	5.5%	2,553.2
1 West Kalimantan (7)	0.105	0.7%	0.099	0.8%	1.9%	1.9%	1,851.4
2 Central Kalimantan (6)	0.038	0.2%	0.038	0.1%	1.1%	0.9%	2,378.1
3 South Kalimantan (10)	0.054	0.3%	0.055	0.4%	1.6%	1.5%	2,011.3
4 East Kalimantan (6)	0.026	0.3%	0.027	0.2%	2.9%	1.2%	4,413.0
Sulawesi (38)	0.006	0.1%	0.006	0.2%	4.6%	7.1%	1,219.3
1 North Sulawesi (7)	0.038	0.1%	0.036	0.2%	1.0%	1.4%	1,410.9
2 Central Sulawesi (4)	0.001	0.0%	0.001	0.0%	0.6%	1.0%	1,108.0
3 South Sulawesi (23)	0.072	0.7%	0.067	1.2%	2.6%	3.9%	1,238.8
4 Southeast Sulawesi (4)	0.011	0.0%	0.010	0.0%	0.4%	0.8%	949.9
Others (47)	0.049	0.6%	0.048	1.3%	3.4%	6.2%	1,026.5
1 West Nusatenggara (7)	0.023	0.1%	0.023	0.2%	0.9%	1.9%	861.8
2 East Nusatenggara (12)	0.063	0.2%	0.059	0.5%	0.7%	1.8%	738.7
3 East Timor (13)	0.077	0.1%	0.073	0.1%	0.2%	0.4%	766.5
4 Maluku (5)	0.055	0.2%	0.048	0.2%	0.8%	1.1%	1,379.7
5 Irian Jaya (10)	0.106	0.3%	0.125	0.6%	0.9%	1.0%	1,583.3
Within-province	0.136	48.4%	0.115	50.8%			
Between-province	0.124	44.2%	0.089	39.2%			
Between-region	0.021	7.4%	0.023	10.1%			
Total (303)	0.281	100.0%	0.227	100.0%	100.0%	100.0%	1,873.4

[a] Number in parentheses is the number of districts (i.e., the number of Kabupatens and Kotamadyas).
[b] Contribution to the overall regional inequality (in %).
[c] Per capita GDP figures are in constant 1993 prices.