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**Conference Paper**

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56th Congress of the European Regional Science Association: "Cities & Regions: Smart, Sustainable, Inclusive?", 23-26 August 2016, Vienna, Austria

**Provided in Cooperation with:**

European Regional Science Association (ERSA)

*Suggested Citation:* Kataoka, Mitsuhiro (2016) : Interprovincial efficiency differentials in Indonesia's pre- and post-crisis economy, 56th Congress of the European Regional Science Association: "Cities & Regions: Smart, Sustainable, Inclusive?", 23-26 August 2016, Vienna, Austria, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/174655>

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# Interprovincial efficiency differentials in Indonesia's pre-and post-crisis economy

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*Running head: Provincial efficiency differentials*

We measure the role of efficiency factors in Indonesia's pre-and post-crisis interprovincial income inequality, by referring to Cheng and Li's (2006) inequality decomposition technique. Their technique presents that the interprovincial income inequality consists of the sum of the corresponding Theil second index components and their interactions when the decomposition variable is expressed multiplicatively by two terms. To incorporate efficiency factors into inequality analysis, we estimated the production frontier and efficiency score of each province, by using data envelopment analysis (hereinafter referred to as DEA).

Using the annual observations of 26 contiguous provincial output and input factors from 1990 to 2010, we found that the narrowing interprovincial income inequality was mainly due to the narrowing inequality both in the pure technical inefficiency and in scale inefficiency.

*Keywords:* Technical efficiency, regional inequality, inequality decomposition, Indonesia

JEL classification code: R11, R12, R58

## 1. INTRODUCTION

Rapid economic growth is inevitably uneven in its subnational impact levels and thus significantly affects the income gap across subnational regions. Some regions—usually those with better connections to the international economy with the presence of rich mining enclaves, good market-oriented governance, agglomeration effects—gain the higher income. In particular, the large East Asian economies such as China, Indonesia, Malaysia, Thailand, and Vietnam have been facing these issues. Hill (2002) describes significant interregional income gaps between the coastal and inland regions in China, between West and East Malaysia, between Bangkok and the rest of the country in Thailand, and between the northern and southern parts of Vietnam.

On account of nation's size, insular geography, the world's fourth most population size, and its rich endowment of natural resources, Indonesia consists of the widely different socioeconomic sub-national regions: the nation's largest urban agglomeration province (Jakarta), the resource-rich provinces (Ache, Riau, East Kalimantan, and Papua), the internationally well-known tourist destinations (Bali and Yogyakarta), the emerging manufacturing cluster provinces (West and Central Java), and the labor-intensive agricultural provinces (the rest of provinces) (Kataoka 2012). Given extraordinary diversities, the nation is beset by a serious resource imbalance and income inequality among provinces.

To address this issue, the Indonesian government has implemented various policies, including Five-Year Development Plans (REPELITA, Rencana Pembangunan Lima Tahun), interregional fiscal transfer programs by presidential instruction (IMPRES, Instruksi Presiden), and programs promoting internal migration (Transmigrasi), and has established integrated economic development zones (Kawasan Pengembangan Ekonomi Terpadu) (Kataoka and Wibowo, 2014). Furthermore, Indonesia has been going through major changes in its intergovernmental system since 1999 by adopting a much more decentralized regime, widely termed fiscal decentralization (Wibowo, 2015) so that the gap of resource allocation among regions can be more narrowed. However, outcomes are still far below the target level, as the nation faces the serious resource imbalances across provinces. Java constitutes 6% of Indonesia's total land area but has almost 60% of its economic activity (Hill 2000).

Since Esmara's (1975) pioneering work, interregional income inequality in Indonesia has frequently become a subject of theoretical discussions and empirical economic research, given the aforementioned resource imbalances. (See other studies such as Islam and Khan (1986), Garcia and Soelistianingsih (1988), Azis (1990), Akita and Lukman (1995), Akita et al. (1999), Hill (2000), Akita (2003), and Kataoka (2010). Several studies examined the factors for interregional income inequality, employing the various inequality measures and factor decomposition techniques. One treatment of income inequality decomposition is to analyze the factors with GDP by income sources, such as sectoral per capita GDP in each region (See Akita and Lukman 1995, Akita and Alisjahbana 2002, Akita 2003, and Kataoka 2010). Another treatment is to analyze the factors with expenditure data by household head subgroups, such as province, location, educational attainment, gender, and age (See Akita et al. 1999, Akita and Miyata 2008, and Hayashi et. Al. 2014). However,

to the best of our knowledge, the economic performance to the income gap across subnational regions has been infrequently examined in Indonesia for no apparent reason.

We measure efficiency factors in the interprovincial income inequality in Indonesia's pre-and post-crisis period, by referring to Cheng and Li's (2006) inequality decomposition technique. They proposed the interpretive additive inequality decomposition of Theil's second index by causal factors when the decomposition variable is expressed multiplicatively by two terms.<sup>1</sup> To incorporate efficiency factors into inequality analysis, we estimated the production frontier and efficiency score of each observation point. To construct the frontier and estimate the efficiency scores, we utilize the linear programming method commonly called data envelopment analysis (hereinafter referred to as DEA) (also Coelli et al., 1998 for applications). The remainder of this paper is organized as follows: In the next section, we describe the method and data used in this study. Then, we describe the empirical results and, finally, present our conclusions.

## **2. METHOD AND DATA**

### **2.1. DEA application to multiplicative income decomposition**

DEA is a widely-used non-parametric linear programming method for assessing the efficiency and productivity of decision-making units (DMUs), using inputs to produce outputs. (Coelli et al., 1998; Paul and Kourouche 2008; Barros et al. 2011; Sibiano and Agasisti 2013 ; Tsolas 2013). DEA empirically derives a frontier that follows the peak performers and envelops the remainder. The frontier connects all the relatively best DMUs in the observed data and thus represents the theoretically possible maximum production that a DMU can achieve at any level of input.

Two versions of DEA models, Charnes, Cooper, and Rhodes (CCR) model (1978) and Banker, Charnes, Cooper (BCC) model (1984), are used by assuming (1) constant returns to scale (CRS) where all DMUs operate at optimal scale and (2) variable returns to scale (VRS) where all DMUs operate at maximum level, but not necessarily at optimal scale. Imperfect competition, government regulation, financial constraints, and other factors can cause DMUs not to operate at their optimal sizes. At a given size, several factors in managerial underperformance can cause DMUs operate below at their maximum level. Each DMU is assigned an efficiency score between zero and unity (efficient: score = 1; inefficient: score < 1).

The efficiency score measured by the BCC model is known as pure technical efficiency (hereinafter referred to as PE) while the efficiency score measured by the CCR model is known as overall technical efficiency (hereinafter referred to as OE). PE assesses performance without considering scale effects, whereas OE considers the input/output configuration and size of operations. Differences between two scores for a particular unit indicate scale inefficiency.

The SE measures the optimality of the DMU's size. Inappropriate DMU's size (i.e., too large

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<sup>1</sup> Their method improves Duro and Esteban's (1998) inequality decomposition in which terms can take positive or negative values, although a strict Theil index maintains a non-negative value for its property. Moreover, negative decomposition values are hardly interpretive, contributing to overall inequality.

or too small) may be a cause of scale inefficiency that takes the form of either increasing returns to scale (IRS) or decreasing returns to scale (DRS). A DMU, exhibiting IRS, has a suboptimum scale size while a DMU, exhibiting DRS, operates at supraoptimum scale size. A DMU is scale efficient if it operates at CRS. In subnational economies, either scale economies (or IRS) or diseconomies (or DRS) may exist. Based on the IRS assumption, doubling all inputs should lead to more than a doubling of output in terms or higher rates of regional development. IRS is due to their small size of production, which may be essential to enhance their efficiency by selecting a scaling up strategy that is increasing their scale of operations. The reverse can be true for the DRS assumption (Halkis and Tzeremes 2010).

DEA models have two orientations: input-oriented and output-oriented. The former minimizes DMU's levels of inputs and maintains the same level of output while the latter maximizes DMU's outputs while keeping inputs constant. We treat a province as a DMU and used the output-oriented model in order to take into account given province-specific resource endowment and presence of the scale economies (or diseconomies) in Indonesia's provinces. The nation is beset by an uneven resource endowment among regions and several provinces are given a fixed quantity of resources and asked to produce as much output as possible.

Each province  $i$  ( $i = 1, \dots, n$ ) uses  $j$  inputs  $X_{ij}$  ( $j = 1, \dots, m$ ) to produce GDP  $Y_i$ . In the output-oriented DEA model,  $Y_{si}$  and  $Y_{ei}$  are province  $i$ 's projected GDP without pure technical inefficiency and scale inefficiency, respectively. Figure 1 depicts piecewise-linear frontiers assembled by five observed provinces A–E. The diagonal passing through BC represents the CRS frontier, whereas ABCE represents the VRS frontier. All provinces except D are efficient under VRS, and only a straight line passing through BC is efficient under CRS. D1 and D2 are projected under VRS and CRS, respectively. D1, the projections of unit D on the VRS efficient frontier, is between C and E. DMU C and E are called the Reference Set (or peers) of DMU D. The reference set of a given DMU consists of the list of efficient DMUs which performance was used to calculate the efficiency of the given DMU.

We can run the dual form of linear programming in the output-oriented VRS model to obtain the PE score of each province  $i$ , expressed as  $(Y_i/Y_{si})$ .

$$\begin{aligned}
 & \text{Max}_{\theta_i, z_i} \theta_i \\
 & \text{s.t. } \theta \cdot Y \leq \sum_{i=1}^n z_i Y_i \\
 & \quad \sum_{i=1}^n z_i X_{ij} \leq X_j \quad (j = 1, \dots, m) \\
 & \quad z_i \geq 0 \\
 & \quad \sum_{i=1}^n z_i = 1 \quad (i = 1, \dots, n)
 \end{aligned} \tag{1}$$

where  $(1/\theta)$  shows the PE score and  $z$  is a weight of each province and take a non-negative value.

<sup>2</sup> Removing the last constraint, we can obtain the OE scores  $(Y_i/Y_{ei})$  under the CRS assumption. Dividing OE by PE, we can then obtain the SE score  $(Y_{si}/Y_{ei})$  as follows:

$$OE_i (= Y_i/Y_{ei}) = (Y_i/Y_{si}) \cdot (Y_{si}/Y_{ei}) = PE_i \cdot SE_i \tag{2}$$

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<sup>2</sup> We slightly change the notations of Cheng and Li (2006) for improving its clarification.

We decompose the per capita GDP in province  $i$  to causal elements.  $P$  and  $L$  are variables of population and labor force and per capita GDP  $y$  is expressed as

$$y_i (= Y_i / P_i) = (L_i / P_i) \cdot (Y_i / L_i) = l_i \cdot x_i, \quad (3)$$

where  $l$  and  $x$  are variables of labor participation rate and labor productivity. Below the frontier level, labor productivity is decomposed as:

$$x_i = [Y_{ei} / L_i \cdot (Y_{si} / Y_{ei} \cdot Y_i / Y_{si})] = x_{ei} \cdot OE_i, \quad (4)$$

where  $x_{ei} (= Y_e / L)$  indicates pure labor productivity of a production unit after eliminating all its total inefficiency. It is affected by the per capita level of physical and human capital and technological progress.

## 2.2. Inequality decomposition method

Let  $\mu_y$ ,  $\mu_l$ , and  $\mu_x$  be the provincial mean values of per capita GDP,  $\mu_y [ = (1/n) \sum y_i ]$ , and its corresponding two multiplicative elements. Interprovincial inequality of per capita GDP is measured by the Theil second index as:

$$T(y) = 1/n \sum_{i=1}^n \ln (\mu_y / y_i) [T(y) \geq 0]. \quad (5)$$

Substituting Equation (3) into Equation (5) and multiplying the quotient inside the natural logarithm  $(\mu_l \cdot \mu_x / \mu_l \cdot \mu_x)$  yields

$$\begin{aligned} T(y) &= (1/n) \sum_{i=1}^n \ln [\mu_l / l_i \cdot \mu_x / x_i \cdot \mu / (\mu_l \cdot \mu_x)] \\ &= (1/n) \sum_{i=1}^n \ln (\mu_l / l_i) + (1/n) \sum_{i=1}^n \ln (\mu_x / x_i) + \ln [\mu / (\mu_l \cdot \mu_x)], \end{aligned} \quad (6)$$

where the first and second additive terms of the right-hand side are strict Theil second indexes with non-negative values.<sup>3</sup> We rewrite Equation (6) as

$$T(y) = T(l) + T(x) + \ln [\mu_y / (\mu_l \cdot \mu_x)]. \quad (7)$$

Focusing on the third term on Equation (7), we express the covariance of  $l_i$  and  $x_i$  ( $cov(l, x)$ ) as follows:

$$cov(l, x) = (1/n) \sum_{i=1}^n (l_i - \mu_l) (x_i - \mu_x) = \mu - \mu_l \cdot \mu_x. \quad (8)$$

Dividing both sides by  $(\mu_l \cdot \mu_x)$ , we get

$$\mu / (\mu_l \cdot \mu_x) = cov(l, x) / (\mu_l \cdot \mu_x) + 1. \quad (9)$$

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<sup>3</sup> Theil first and second indexes are the distance function that measures the divergence between the two shares. The difference between two indexes is essentially the weighting of this divergence. Their structure requires that the weights be given by share in weighted by the numerator of the variables inside the natural logarithm (Gisbert 2001). Quotients inside the natural logarithm of the first and second terms in Equation (6) are expressed as follows.

$$(\mu_l / l_i) = [(1/n) / (l_i / \sum l_i)]$$

$$(\mu_x / x_i) = [(1/n) / (x_i / \sum x_i)].$$

Each term is weighted by the total number of provinces  $(1/n)$ , and satisfies the Theil second index property.

Substituting Equations (9) into Equation (7), we obtain

$$T(y) = T(l) + T(x) + \ln [\text{cov}(l, x) / (\mu_l \cdot \mu_x) + I] = T(l) + T(x) + I(l, x), \quad (10)$$

where  $I(l, x) = \ln[\mu / (\mu_l \cdot \mu_x)]$  is the interaction term that can be positive, negative, or zero if the element variables are correlated positively, correlated negatively, or not correlated.

We derive inequality decompositions in labour productivity and the OE score, using Equations (4) and (2).

$$T(x) = T(x_e) + T(OE) + I(x_e, OE) \quad (11)$$

$$T(OE) = T(PE) + T(SE) + I(PE, SE) \quad (12)$$

## 2.3 Data

We use GDP, factor inputs (labour, physical, and human capital), and the population of 26 contiguous Indonesian provinces for 1990–2010.<sup>4</sup> The data of provincial output are sourced from Gross Regional Domestic Product of Provinces in Indonesia by Industry (Badan Pusat Statistik, hereafter referred to as ‘BPS’, various years a). The population data are sourced from Population Census (BPS, various years b) and Intercensal Population Census Indonesia (BPS, various years c). The data of provincial labor force are sourced from Labour Force Situation in Indonesia (BPS, various years d). This data series also presents labor force an employment by education attainment. Average period of education of labour force is used as a proxy variable for human capital, weighted by the provincial labour force’s share of education attainment. Data on capital stock have not been officially published in Indonesia; therefore, this study uses provincial data on physical capital stock from Kataoka (2014).

Table 1, exhibiting the statistical summary employed in this study, indicate that the Indonesian provinces are widely different in terms of socioeconomic development. Provinces located in Java Island, such as Jakarta, West and East Java, show the highest value of GDP, capital, labor, average years of education and population, respectively, in both years of 1990 and 2010. The reverse is true for the resource-poor off-Java provinces, such as Bengkulu, Southeast Sulawesi, West Nusa Tenggara, and Maluku.

With regard to per capita income and labor productivity, one of major resource-rich provinces, East Kalimantan, demonstrates the highest values in 1990; however, in 2010, Jakarta, the nation’s largest urban agglomeration province that specializes in knowledge-intensive sectors, shows the highest. This is one of major evidence demonstrating the structural change of the

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<sup>4</sup> Political reforms after the economic crisis in 1998 increased the number of provinces from 27 to 34. Until now, no effort has been made to adjust historical data to account for these changes; therefore, we consider only 26 provinces, aggregating data on the new and existing provinces for each year. The eight newly established provinces are as follows: North Maluku (Maluku, 1999), West Papua (Papua, 1999), Banten (West Java, 2000), Bangka-Belitung (South Sumatra, 2000), Gorontalo (North Sulawesi, 2000), the Riau Islands (Riau, 2002), West Sulawesi (South Sulawesi, 2004), and North Kalimantan (East Kalimantan, 2012). Within parentheses are the original province and the year in which the new province was established.

leading sector in Indonesia. Besides, the internationally well-known resort island, province of Bali, keeps the highest labor participation rates.

DEA efficiency analysis can be influenced by the presence of outliers. We confirm that no maximum/minimum GDP values are in fact outliers at the 0.01 significance level, employing by Smirnov-Grubbs test.

### 3. EMPIRICAL RESULTS

#### 3.1 DEA application to per capital income: productivity and efficiency

We measure economic performance of 26 provinces for 1990–2010, employing the output-oriented DEA model. Table 2 summarizes each province's efficiency scores in the first and last observation years and the corresponding annual change with provincial average. The return to scale (RTS) and reference sets<sup>5</sup> are also shown. There are several interesting findings to be noted.

First, the observation that the mean values of OE scores 0.509 in 1990 indicates that the provinces could have increased output values by 49.1% on provincial average without increasing any inputs. In other words, they could produce only 50.9% of maximum output level at the optimal scale. The increase in average OE score to 0.771 in 2010 indicates the improvement in overall efficiencies that were contributed by both improvement in input/output configuration and production scale efficiencies. Note that two-sample t-tests confirms that means are significantly different at the 0.01 level.

Second, the majority of Indonesia's provinces faces considerably serious overall technically inefficiency in 1990 although six of twenty-six provinces, which consist of off-Java resource-rich provinces and Java provinces, are efficient (OE = 1.000). Most provinces with below half of mean values are the remote resource-poor off-Java provinces, such as Bengkulu (0.184), West Nusa Tenggara (0.187), Central Sulawesi (0.187), Jambi (0.191), and East Nusa Tenggara (0.210). Among the aforementioned inefficient provinces, Bengkulu became efficient in 2010 and other inefficient provinces have enjoyed the higher efficiency growth (West Nusa Tenggara 4.9%, Central Sulawesi 6.9%, Jambi 6.9%, East Nusa Tenggara 5.5%). On the contrary, several resource-rich off-Java provinces with relatively higher values or the unity scores in 1990 show the negative growth rates (Aceh -1.2%, Riau -0.8%, and Papua -1.8%). This may infer the resource curse thesis, indicating that strong correlation between natural resource abundance and poor economic growth. Each efficiency score shows the strong negative correlation between the scores in 1990 and the corresponding annual growth rates (OE -0.879, PE -0.926, SE -0.855). This observed convergence in OE could say something in advance to our key research questions.

Third, observing the provinces by RTS, the numbers of provinces exhibiting IRS (DRS)

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<sup>5</sup> The reference set of a DMU is composed of efficient units with a similar level of input and output mix. The best practice by which an inefficient unit can improve through reference set or peers which are 100% efficient. It is that an inefficient unit's reference set contains the efficient units which have the most similar input/output orientation to itself and they should therefore provide examples of good operating practice for it to emulate.



decreased (increased) from eighteen (two) in 1990 to fifteen (five) in 2010 although provinces exhibiting CRS (i.e., overall technically efficient provinces) that operate in the most productive scale size (MPSS), remain unchanged at six. The overall technically inefficient provinces exhibiting IRS (DRS) have the opportunities to become more efficient through growth (through the separation from the existing provinces). In 2010, among the eight original provinces consisting newly separated provinces, only Maluku experienced DRS. This provincial separation under the decentralization process for those provinces follow the economic rationalities. Among other seven provinces, only Papua exhibits IRS and lower SE scores (0.557). This indicates that there is adequate scale economy unexploited; therefore, Papua's provincial separation is not motivated by the efficiency-maximizing behavior. The rest of provinces<sup>6</sup> showed considerably high scale efficiency, ranging between 0.942 and 1.000. This indicates that there is little scale economy unexploited; therefore, those provincial separations are considerably acceptable.

Fourth, resource-rich provinces have more reference sets of provinces than non-resource rich provinces do. In 1990, as reference sets, provinces of Aceh, Papua, and East Kalimantan that are resource-rich provinces, are referred by fifteen, ten, six, and one inefficient provinces, respectively. West Java, East Java and Southeast Sulawesi that are non-resource-rich provinces are all referred by six inefficient provinces. In 2010, South Kalimantan, East Kalimantan, and Papua that are the resource-rich provinces are referred by have fifteen, twelve, and seven inefficient provinces, respectively. West Java, Bengkulu, East Nusa Tenggara, and East Java have seven, six, four and one sets, respectively. Although East Nusa Tenggara and Bengkulu are the first and froth lowest per capita GDP off-Java provinces, several inefficient provinces refer those as role models. On the other hand, Jakarta has no referring sets despite of its highest income. This finding shows its specific characteristics as no provinces refer to Jakarta for a good operating performance.

### **3.2. Decomposing interprovincial income inequality in Indonesia**

Figures 2–4 show the inequality decomposition in per capita GDP, labor productivity, and overall technical efficiency, derived from Equations (10) and (12) for 1990–2010, respectively.

Figure 2 shows how interprovincial income inequalities are affected by labor participation and labor productivity. The interprovincial income inequality decreased from 0.331 in 1990 to 0.220 in 2010. This deceasing trend is consistent with other existing inequality studies based on regional income sources, such as Akita and Lukman (1995) and Kataoka (2010). The results are reasonable against the financial crises: Asian Financial Crisis in 1997/98 and Global Financial Crisis in 2007/08. In 1998, the inequality largely declined by 3.3%, which was the highest since 1995 because the impacts of the 1998 economic crisis, differed by region, were much more severe in the relatively higher income Java-Bali region than in other regions (Akita and Alisjahbana 2002). In 2008, the inequality moderately declined by 2.5%, which was not as serious as in the former crisis because Indonesia's provincial economies archived relatively sound growth with about 5.5% on average.

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<sup>6</sup> Those seven are Riau, South Sumatra, West Java, East Kalimantan, North Sulawesi, and South Sulawesi.

In decomposition, those are largely affected by the decline in labor productivity from 0.403 to 0.212 while effects of labor participation are very small. This finding is logically similar to the results obtained by Duro and Esteban (1998) and Goerlich (2001), since the values of all non-productivity variables range between 0 and 1 whereas productivity values exceed the unity. The interaction terms take small negative values with a slight upward trend to the small positive value closing to zero. As interaction terms are not standardized, the calculated correlation coefficients are between  $-0.484$  in 1990 and  $-0.072$  in 2010. This insufficiently supports the general assumption: higher-productivity provinces have less labor-intensive agricultural employment opportunities.

Besides, international evidence shows that tourism is more labor-intensive than other non-agricultural sectors (Ashely et al. 2007). Although the detailed data are not presented in this paper, the two highest labor participation provinces in 1990, Bali (56.3%) and Yogyakarta (54.5%), have the lower values than a half of the provincial productivity mean (BPS, various years c).

Figure 3 shows decomposition in labor productivity inequalities. Inequalities in overall technical inefficiency decline from 0.193 in 1990 to 0.028 in 2010 and significantly affected the declining inequality in labor productivity; inequality in pure labor productivity increase slightly from 0.143 to 0.166 with some fluctuations. This indicates that the gap in labor productivity after eliminating overall technical inefficiency, which are affected by per capita physical and human capital and technology, increased continuously across provinces. Their interaction terms take minor positive values between 0.066 in 1990 and 0.018 in 2010.

Figure 4 shows inequality decomposition in overall technical inefficiency. Inequality in pure technical inefficiency and in scale inefficiency declined from 0.127 in 1990 to 0.014 in 2010 and from 0.088 in 1991 to 0.010 in 2009, respectively. Summing up the aforementioned findings, decrease in both inefficiencies is the major driving force of the decreasing interprovincial income inequality.

This finding is different from Cheng and Li's (2006) study in China's post open door policy period that the increasing interprovincial income inequality came from the increasing inequality in the pure labor productivity after the early 1980s. Considering is one of the major DEA's finding at the previous sub-section section that there is a convergence in overall technical efficiency, catchup effects both in performance and size of operations between the resource-poor off-Java provinces and the resource-rich provinces contributes to decrease interprovincial income inequality in Indonesia for 1990-2010.

Additionally, the inequality values in per capital physical capital and human capital that affect those in pure labor productivity and are based on Theil second measures, denoted as  $T(k)$  and  $T(h)$  (Figure 5). Each inequality value in year 1990 is set as 100. Figure 5 shows that the inequalities in per capital physical capital slightly declined and those in per capital human capital remain unchanged. Consequently, as one of the remaining factors, the widening interprovincial technological gaps affected those in pure labor productivity.

#### 4. CONCLUSION

Employing Cheng and Li's (2006) inequality decomposition method, we found that the narrowing interprovincial income inequality in Indonesia's pre- and post-crisis period was mainly due to the narrowing inequality in the overall technical efficiency. In addition, one of major DEA findings emerged that the several resource-poor (resource-rich) off-Java provinces, which were the far overall technical inefficient (efficient) in 1990, have the higher (lower) annual growth rates in overall technical efficiency. Those aforementioned findings indicate that a convergence effects both in performance and size of operations contributes to decrease interprovincial income inequality.

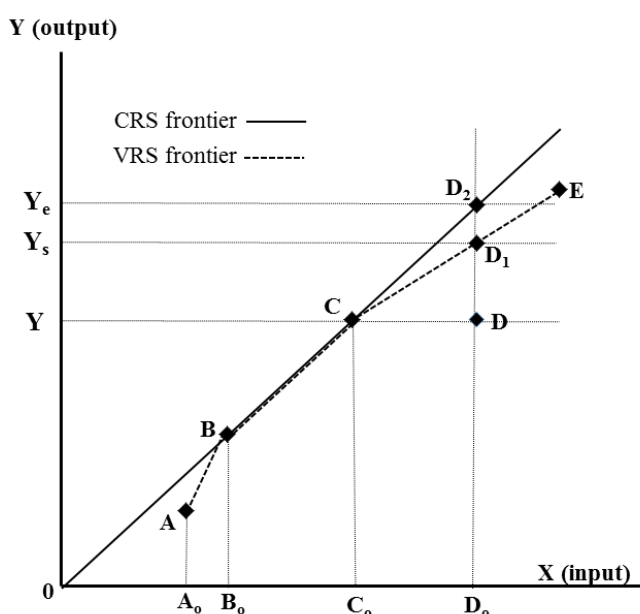
Our work has several potential extensions. First, we can detect the factors affecting the pure technical efficiency scores related to province-specific factors such as R&D expense, infrastructure investment, interprovincial linkage, employing Tobit regression analysis. Tobit regression analysis is an appropriate method of which the dependent variable is made a censored variable with limits at zero and unity as efficiency scores range between 0 and 1 (see Cooper et al., 2007; Coelli et al., 1999; Fried et al., 1999). The second extension is to measures the productivity change over time, employing DEA-based Malmquist productivity index. This index can be multiplicatively decomposed into two components: one measuring the technical change and the other measuring the frontier shift (efficiency change). The applications of those empirical studies could contribute to further discussions and understanding of policy implications.

#### REFERENCES

- Akita, T. and Lukman, R. Affandi (1995) 'Interregional inequalities in Indonesia: a sectoral decomposition analysis for 1975–1992', *Bulletin of Indonesian Economic Studies* 31 (2): 61–81.
- Akita et al, (1999) 'Inequality in the distribution of household expenditures in Indonesia: a Theil decomposition analysis', *The Developing Economies* 37 (2): 197–221.
- Akita, T. and Alisjahbana, A. Salsiah (2002) 'Regional income inequality in Indonesia and the initial impact of the economic crisis', *Bulletin of Indonesian Economic Studies* 38 (2): 201–222.
- Akita, T. (2003) 'Decomposing regional income inequality in China and Indonesia using two-stage nested Theil decomposition method', *The Annals of Regional Science* 37: 55–77.
- Akita, T. and S. Miyata, 2008. Urbanization, educational expansion, and expenditures inequality in Indonesia in 1996, 1999, and 2002. *Journal of Asia Pacific Economy*, **13**(3), pp. 147–67.
- Ashley, C., 2007 *The Role of the Tourism Sector in Expanding Economic Opportunity*, Economic Opportunities Series, Harvard University, Boston.
- Azis, Iwan J. (1990) 'Inpres' role in the reduction of interregional disparity', *Asian Economic Journal* 4 (2): 1–27.
- Banker, R. D., Charnes, A., and Cooper, W. W. (1984). "Models for estimating technical and scale efficiencies in data envelopment analysis." *Manage. Sci.*, 30(9), 1078 – 1092.
- Barros, C. P., L. Botti, et al. (2011). "Managerial Efficiency and Hospitality Industry: The Portuguese Case." *Applied Economics* 43(22-24): 2895-2905.
- BPS (Central Bureau of Statistics) (various years a) *Gross Regional Domestic Product of Provinces in Indonesia by Industrial Origin*, Jakarta.
- (various years b) *Labor Force Situation in Indonesia*, Jakarta.
- (various years c) *The Intercensal Population Surveys*, Jakarta.

- (various years d) Population Census, Jakarta.
- Charnes, A., Clark, C. T., Cooper, W. W., and Golany, B. (1985). "A developmental study of data envelopment analysis in measuring the efficiency of maintenance units in the US Air Forces." *Ann. Oper. Res.*, 2(1), 95 – 112.
- Cheng, Y.-S. and S.-K. Li, 2006. Income inequality and efficiency: A decomposition approach and applications to China. *Economics Letters*, 91(1), pp. 8–14.
- Coelli, T. J., Prasada, R. and Battese, G. E. (1998) *An Introduction to Efficiency and Productivity Analysis*, Kluwer Academic Publishers, Boston.
- Cooper, W. W., Seiford, L. M., and Tone, T. (2007). *Data envelopment analysis: A comprehensive text with models, applications, references and DEA-solver software*, Springer Science and Business Media, Inc, New York.
- Duro, J. A. and J. Esteban, 1998. Factor decomposition of cross-country income inequality, 1960–1990. *Economics Letters*, 60(3), pp. 269–75.
- Esmara, H. (1975) 'Regional income disparities', *Bulletin of Indonesian Economic Studies* 11 (1): 41–57.
- Garcia, J. G. and L. Soelistianingsih (1998). 'Why Do Differences in Provincial Incomes Persist in Indonesia?' *Bulletin of Indonesian Economic Studies* 34(1): 95-120.
- Gisbert, G. F. J., 2001. On factor decomposition of cross-country income inequality: Some extensions and qualifications. *Economics Letters*, 70(3), pp. 303–309.
- Hayashi, M., M. Katoka, and T. Akita, 2014. Expenditure inequality in Indonesia, 2008-2010: A spatial decomposition analysis and the role of education. *Asian Economic Journal*, 28(4), pp. 389–411.
- Hill, H. (2000) *The Indonesian Economy*, Cambridge University Press, Cambridge, MA.
- Hill, H., 2002, Spatial disparities in developing East Asia: a survey, *Asian-Pacific Economic Literature* vol. 16, 10-35.
- Hill, H., 2008, Globalization, inequality, and local-level dynamics: Indonesia and the Philippines. *Asian Economic Policy Review*, 3, pp. 42–61.
- Islam, I. and Khan, H. (1986) 'Spatial patterns of inequality and poverty in Indonesia', *Bulletin of Indonesian Economic Studies* 22 (2): 80–102.
- Ji, Y. and C. Lee (2010). "Data envelopment analysis." *Stata Journal* 10(2): 267-280.
- Kataoka, M., 2013 Capital Stock Estimates by Province and Interprovincial Distribution in Indonesia, *Asian Economic Journal* 27(4): 409–428.
- Kataoka, M., 2012, Economic growth and interregional resource allocation in Indonesia. *Studies in Regional Science*, 42(4), pp. 911–20.
- Kataoka, M., 2010, Factor decomposition of interregional income inequality before and after Indonesia's economic crisis, *Studies in Regional Science*, 40(4), pp. 1061–1072.
- Kataoka, M., and W., Kodrat 2014, Decentralization and Spatial Allocation Policy of Public Investment in Indonesia and Japan, *Working Papers in Economics and Development Studies (WoPEDS)*, Department of Economics, Padjadjaran University, Bandung, Indonesia.
- Sibiano, P. and T. Agasisti (2013). "Efficiency and heterogeneity of public spending in education among Italian regions." *Journal of Public Affairs* (14723891) 13(1): 12-22.
- Tsolas, I. E. (2013). "Modeling Profitability and Stock Market Performance of Listed Construction Firms on the Athens Exchange: Two-Stage DEA Approach." *Journal of Construction Engineering & Management* 139(1): 111-119.
- Theil, H. 1967. *Economics and Information Theory*. Amsterdam: North-Holland.
- Tsui, K. 1993. Decomposition of China's Regional Inequalities. *Journal of Comparative Economics* 17(3), 600–627.
- Wibowo, K., 2005. Basic Strategies for the role of Indonesian Central-local Government In Poverty Alleviation Programs, *Working Papers in Economics and Development Studies (WoPEDS)* 200503, Department of Economics, Padjadjaran University.

**Figure 1 Technical and scale efficiency and return to scale**



**Table 1. Descriptive statistics of input and output variables (Unit: %)**

1990

Variables	Mean	S.D.	Maximum		Minimum	
			Value	Province	Value	Province
GDP (Triillion Rp.)	34.2	44.6	154.0	Jakarta	3.2	Bengkulu
Capital (Triillion Rp.)	59.5	101.9	450.3	Jakarta	3.0	Southeast Sulawesi
Labor (Million)	3.0	4.2	15.8	East Java	0.5	Southeast Sulawesi
Average years of education	5.6	1.0	9.0	Jakarta	4.1	West Nusa Tenggara
Population (Million)	6.7	9.3	35.6	West Java	1.2	Bengkulu
per capita GDP (Million Rp.)	5.8	6.1	25.6	East Kalimantan	1.4	East Nusa Tenggara
Labor productivity (Million Rp.)	14.4	16.9	64.7	East Kalimantan	2.7	East Nusa Tenggara
Labor participation rate	0.436	0.058	0.563	Bali	0.308	Riau

2010

Variables	Mean	S.D.	Maximum		Minimum	
			Value	Province	Value	Province
GDP (Triillion Rp.)	85.5	116.4	410.8	West Java	7.3	Maluku
Capital (Triillion Rp.)	185.0	285.8	1,311.9	Jakarta	10.7	Bengkulu
Labor (Million)	4.5	5.9	24.2	West Java	0.9	Bengkulu
Average years of education	7.9	1.0	10.4	Jakarta	5.3	Papua
Population (Million)	9.1	12.3	53.7	West Java	1.7	Bengkulu
per capita GDP (Million Rp.)	9.4	8.4	41.2	Jakarta	2.7	East Nusa Tenggara
Labor productivity (Million Rp.)	19.1	16.5	75.0	Jakarta	5.9	East Nusa Tenggara
Labor participation rate	0.488	0.038	0.577	Bali	0.423	Maluku

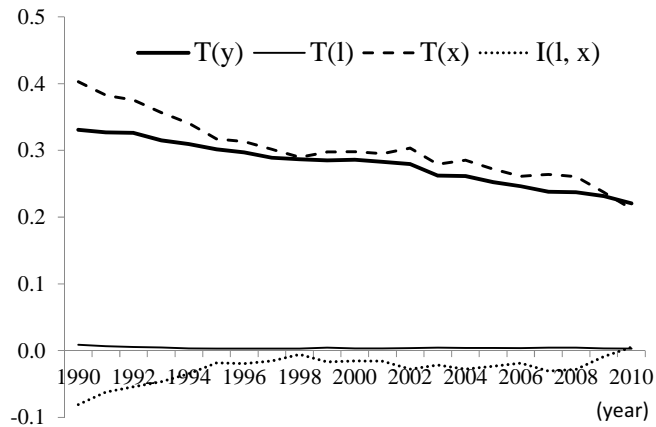
Sources: Gross Regional Domestic Product of Provinces in Indonesia by Industrial Origin (BPS, various years a), Population Census (BPS, various years d), Labor Force Situation in Indonesia (BPS, various years c), and Kataoka (2014).

**Table 2 Summary of DEA results: Efficiency scores with annual changes, RTS, and reference sets for each province in 1990 and 2010**

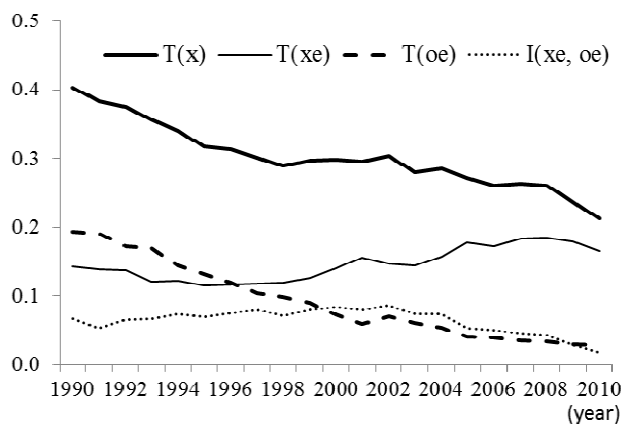
Province	1990						2010						Annual Growth (%)		
	Efficiency scores			Reference sets			Efficiency scores			Reference sets					
	OTE	PTE	SE	RTS	a*	Reference sets (Weight)	OTE	PTE	SE	RTS	a*	Reference sets (Weight)	OTE	PTE	SE
1 Aceh	1.000	1.000	1.000	CRS	15	1(1.000)	0.780	0.787	0.992	DRS	0	17 (0.142), 18 (0.858)	-1.2	-1.1	0.0
2 N. Sumatra	0.624	0.664	0.940	DRS	0	9 (0.205), 1 (0.795)	0.946	0.951	0.995	IRS	0	9 (0.091), 17 (0.740), 18 (0.168)	2.0	1.7	0.3
3 Riau*	1.000	1.000	1.000	CRS	1	3(1.000)	0.841	0.852	0.987	IRS	0	17 (0.755), 10 (0.148), 26 (0.041), 13 (0.057)	-0.8	-0.8	-0.1
4 W. Sumatra	0.325	0.334	0.974	DRS	0	9 (0.011), 1 (0.989)	0.781	0.785	0.994	DRS	0	17 (0.235), 18 (0.765)	4.3	4.2	0.1
5 Jambi	0.191	0.238	0.805	IRS	0	1 (0.294), 22 (0.512), 17 (0.194)	0.777	0.778	1.000	CRS	0	18 (0.632), 6 (0.368)	6.9	5.8	1.0
6 Bengkulu	0.184	0.849	0.217	IRS	0	22 (0.995), 17 (0.005)	1.000	1.000	1.000	CRS	6	6(1.000)	8.4	0.8	7.5
7 S. Sumatra*	0.582	0.604	0.964	IRS	0	9 (0.138), 26 (0.116), 1 (0.074), 17 (0.672)	0.668	0.709	0.942	IRS	0	17 (0.396), 9 (0.113), 26 (0.208), 18 (0.283)	0.7	0.8	-0.1
8 Lampung	0.387	0.494	0.784	IRS	0	1 (0.543), 13 (0.012), 26 (0.445)	0.748	0.779	0.960	IRS	0	18 (0.831), 9 (0.054), 24 (0.115)	3.2	2.2	1.0
9 W. Java*	1.000	1.000	1.000	CRS	6	9(1.000)	1.000	1.000	1.000	CRS	7	9(1.000)	0.0	0.0	0.0
10 Jakarta	1.000	1.000	1.000	CRS	0	10(1.000)	1.000	1.000	1.000	CRS	1	10(1.000)	0.0	0.0	0.0
11 C. Java	0.800	0.816	0.980	IRS	0	13 (0.627), 1 (0.268), 26 (0.106)	0.879	0.907	0.969	IRS	0	9 (0.484), 26 (0.04), 24 (0.476)	0.4	0.5	-0.1
12 Yogyakarta	0.224	0.254	0.883	IRS	0	1 (0.714), 9 (0.014), 26 (0.262), 13 (0.01)	0.510	0.513	0.995	DRS	0	17 (0.129), 18 (0.871)	4.0	3.4	0.6
13 E. Java	1.000	1.000	1.000	CRS	6	13(1.000)	0.968	1.000	0.968	IRS	1	13(1.000)	-0.2	0.0	-0.2
14 Bali	0.264	0.342	0.772	IRS	0	1 (0.486), 9 (0.018), 26 (0.478), 13 (0.017)	0.774	0.783	0.988	DRS	0	17 (0.077), 18 (0.923)	5.3	4.0	1.2
15 W. Kalimantan	0.318	0.608	0.522	IRS	0	3 (0.009), 9 (0.056), 26 (0.895), 17 (0.04)	0.521	0.650	0.802	IRS	0	17 (0.114), 9 (0.017), 26 (0.443), 18 (0.426)	2.4	0.3	2.1
16 C. Kalimantan	0.320	0.540	0.593	IRS	0	1 (0.018), 22 (0.788), 17 (0.193)	0.407	0.869	0.468	IRS	0	17 (0.099), 26 (0.134), 6 (0.767)	1.2	2.3	-1.1
17 E. Kalimantan*	1.000	1.000	1.000	CRS	7	17(1.000)	1.000	1.000	1.000	CRS	12	17(1.000)	0.0	0.0	0.0
18 S. Kalimantan	0.313	0.322	0.970	IRS	0	1 (0.637), 22 (0.061), 26 (0.302)	1.000	1.000	1.000	CRS	15	18(1.000)	5.7	5.5	0.1
19 N. Sulawesi*	0.279	0.294	0.949	IRS	0	1 (0.383), 26 (0.617)	0.766	0.773	0.991	IRS	0	18 (0.603), 17 (0.056), 6 (0.341)	4.9	4.7	0.2
20 C. Sulawesi	0.187	0.286	0.653	IRS	0	1 (0.223), 22 (0.734), 17 (0.043)	0.753	0.838	0.899	IRS	0	18 (0.259), 6 (0.62), 17 (0.052), 26 (0.069)	6.9	5.3	1.5
21 S. Sulawesi*	0.401	0.501	0.800	IRS	0	1 (0.528), 13 (0.041), 26 (0.432)	0.849	0.878	0.967	IRS	0	9 (0.089), 18 (0.87), 24 (0.041)	3.6	2.7	0.9
22 SE. Sulawesi	0.364	1.000	0.364	IRS	6	22(1.000)	0.600	0.620	0.969	IRS	0	18 (0.136), 17 (0.072), 6 (0.792)	2.4	-2.3	4.8
23 W. Nusa Tenggara	0.187	1.000	0.187	IRS	0	23(1.000)	0.506	0.664	0.763	IRS	0	9 (0.014), 24 (0.331), 26 (0.257), 18 (0.398)	4.9	-1.9	6.9
24 E. Nusa Tenggara	0.210	0.239	0.878	IRS	0	1 (0.295), 13 (0.002), 26 (0.703)	0.652	1.000	0.652	IRS	4	24(1.000)	5.5	7.1	-1.4
25 Maluku*	0.268	0.445	0.602	IRS	0	1 (0.064), 22 (0.777), 17 (0.159)	0.772	0.773	0.998	DRS	0	6 (0.951), 18 (0.049)	5.2	2.7	2.4
26 Papua*	0.818	1.000	0.818	IRS	10	26(1.000)	0.557	1.000	0.557	IRS	7	26(1.000)	-1.8	0.0	-1.8
Mean	0.509	0.647	0.794				0.771	0.843	0.918				2.0	1.3	0.7
SD	0.316	0.299	0.240				0.174	0.137	0.144				-2.8	-3.7	-2.4
Maximum	1.000	1.000	1.000				1.000	1.000	1.000				8.4	7.1	7.5
Minimum	0.184	0.238	0.187				0.407	0.513	0.468				-1.8	-2.3	-1.8
# of efficient provinces	6	9	6				5	8	6						
# of provinces by RTS	IRS: 18	CRS: 6	DRS: 2				IRS: 15	CRS: 6	DRS: 5						

a\* : Number of times that each provinces is a peer for another.

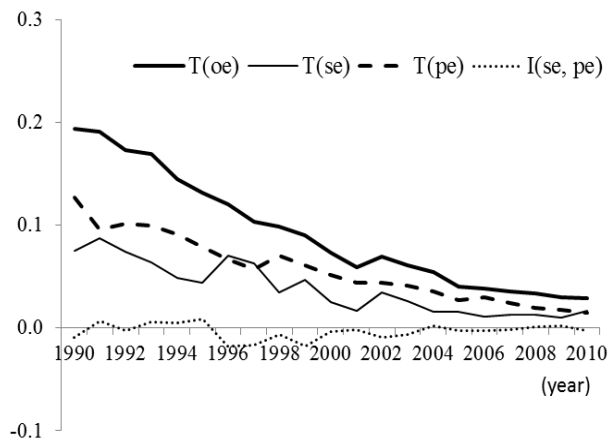
**Figure 2. Decomposition of inequality in per capita GDP.**



**Figure 3. Decomposition of inequality in labor productivity.**



**Figure 4. Decomposition of inequality in overall technical efficiency.**



**Figure 5. Interprovincial inequalities in pure labor productivity, per capita physical capital, and human capital.**

