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Technical Efficiency and Productivity Analysis in Indonesian Provincial Economies

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Abstract

By using the stochastic frontier methodology, this study investigates the technical efficiency and total factor productivity (TFP) growth in Indonesian provincial economies during the period from 1993 to 2000. In addition to the estimation of provincial technical efficiency, factors that contribute to technical inefficiency are also examined and the TFP growth is decomposed into technological progress, the scale component and the change in technical efficiency. The results reveal that average technical efficiency is only around 50%. Our results reveal that the mean years of schooling and sectoral differences affected technical efficiency. The TFP grew, on average, in the range from 1.65% to 5.43% with an average growth of 3.59%. In twenty out of twenty six provinces the TFP growth was driven by efficiency changes while in four provinces the TFP growth was driven by technological progress. Further, we note that the Asian crisis affected the TFP growth and the western provinces suffered from the crisis more than the eastern provinces.

Keywords: Technical Efficiency, TFP, Indonesia.
JEL Classification: D24, R11

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1. Introduction

The Stochastic Frontier approach to estimate technical efficiency is based on the idea that an economic unit may operate below its production frontier due to pure errors and some uncontrollable factors. The study of frontier begins with Farrell (1957) who suggested that efficiency could be measured by comparing the realized output with the attainable maximum output. Later on, Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) independently proposed stochastic frontier models. Traditionally, stochastic frontier models have been used to estimate technical efficiency in micro units, e.g., firms, agricultural farms, etc. But recently this methodology is also used to estimate regional efficiencies. Nishimizu and Page (1982) perhaps can be thought of as the pioneers in studying regional efficiencies. They estimated total productivity growth, technological progress and technical efficiency change in Yugoslavia during 1965-1978 and observed that in the first five years, technical efficiency increased, but for the following five years it decreased. They noted that this change was due to production atmosphere changes between the two five-year periods. Using stochastic frontier and panel data of seventeen market and seven planned economies between 1978-1980, Moroney and Lovell (1997) claimed that planned economy countries are less efficient than Western countries. For seventeen Spanish regions, Gumbau (1998) estimated regional technical efficiencies using panel data for the period 1986-1991 and concluded that technical efficiency in those regions is between 81 % and 89 % and varies over time. Wu (2000) employed the stochastic frontier model to estimate technical efficiency and productivity of twenty seven Chinese provinces between 1981 and 1995 and concluded that China's economic reforms signified improvement in technical efficiencies. Puig-Junoy (2001) showed that technical efficiency in 48 contiguous U.S. states range from 45.3% and 99.3% over the period 1970-1983. Brock (2001) estimated technical efficiency for the same region in the period 1977-1986 and claimed that the average technical efficiency is 90%. Recently, Sharma, Sylwester and Margono (2003) estimated technical efficiency and total factor productivity growth in fifty U.S. states from 1977 to 2000 and found that, on average, technical efficiency is around 75%. Other studies on regional technical efficiencies that use different methods include Osiewalski, Koop, and Steel (2000) and Maudos, Pastor and Serrano (2000). Osiewalski et al. (2000) examined productivity disparity between Poland and other Western economies using a Bayesian stochastic frontier. They claimed that at the beginning of Poland's reforms its economy exhibited low technical efficiency. Maudos et al. (2000) employed Data Envelopment Analysis to estimate efficiency in Spanish regions using panel data from 1964 to 1993 and they observed that efficiency varies across sectors and time.

Productivity, a measurement of an economy, is basically defined as the ratio of output and inputs. Productivity can be evaluated at various levels - economy, industry, and company. At the economy level, output is measured by Gross Domestic Product (GDP). Productivity can be measured as labor productivity which is defined as output per employee or capital productivity which is defined as output per unit of capital. An alternative measure is total factor productivity (TFP). In growth accounting approach TFP is defined as the difference between output growth and input growth. In recent years, there has been numerous research devoted to TFP and TFP growth. The comparison of economic performance at country levels has been discussed widely. World Bank (1993) reports that different countries conduct their economies in different ways. Edwards (1998) compared TFP growth of developed and developing countries. He concludes that the degree of openness in trade along with per capita income and human capital play an important role in TFP. A different approach of estimating TFP growth assuming that production technology is allowed to fall under the frontier can be done via stochastic frontier. Inspired by Nishimizu and Page (1982) and Kalirajan, Obwona and Zao (1996), Wu (2000) estimated productivity growth in China's regional economies using frontier approach and found that TFP increased steadily after the reforms in the late of 1980s. Sharma et al. (2003) estimated TFP growth in fifty U.S. States from 1977 to 2000 and noted that the average TFP growth was 1.1%. More recently, Han, Kalirajan and Singh (2004) compared TFP growth in East Asia and OECD countries over the period 1970-1990. They found that the lowest TFP growth was -11.0% (1980-1985) and the highest TFP growth was 8.0% (1985-1990). Under constant return to scale, Wu (2000) notes that TFP growth is the sum of changes in technological progress and technical efficiency. In general, as noted by Kumbhakar and Lovell (2000, p.281), TFP is the sum of the changes in technological progress, technical efficiency and a scale factor. However, under constant returns to scale, the scale factor reduces to zero.

By using stochastic frontier model at the macro level the above studies specify an aggregate production for entire regions. However, this specification is not uncommon at the macro level where researchers have used economywide production function to investigate productivity differences across space and time. By using an economywide production function, Solow (1957) decomposed the U.S. output growth into productivity growth and into increases in inputs. Similar results for other countries are discussed by Barro and Sala-I-Martin (1995, chapter 10). Further, to explain the differences in worker productivity across the world, Hall and Jones (1999) decomposed the output differences across countries to differences in productivity and differences in input quantities.

Economists have viewed the economic growth from several different perspectives. One of them is the growth accounting approach, which measures the contribution of labor growth, capital accumulation and productivity in economic growth. Technical change, on the other hand, can be used to estimate productivity. Productivity becomes the cornerstone in explaining economic growth since the empirical work shows that capital and labor growth cannot sustain in the long run, but productivity can (Senhadji, 2000). Krugman (1994) suggested that East Asian economic growth was due to accumulation in capital rather than productivity growth. Krugman's claim was further supported by Young (1995) who also noted negative productivity growth in manufacturing sector. On the other hand, by using growth accounting for a large set of countries Collins and Bosworth (1996) observed positive total productivity growth for Eastern Asian economies. However, the disadvantage of Solow (1957) approach is that it fails to capture the individual contributions of technological progress and efficiency gains on productivity. The individual contributions of the two are important. Efficiency gains are not sustainable without technological progress since they cannot recur once the frontier is reached. Therefore, an advantage of using stochastic frontier model to macroeconomic data is that it can help us understand why productivity changes over time.

Even though all of Indonesian provinces are under the same political and economic system, it is suspected that there are differences in growth, efficiency as well as its determinants among those provinces. The diversity of provincial economies raises questions whether their efficiencies also vary. With a spirit of Indonesian diversity in provincial level. This paper is intended to analyze provincial technical efficiencies using panel data of 26 Indonesian provincial economies over the period 1993-2000. Next, the determinants of provincial technical efficiency and the total factor productivity growth of provincial economies are also examined.

The paper is organized as follows. Indonesian economy is reviewed briefly in Section 2. Section 3 is devoted to methodological issues. Section 4 explains the data used in this study. In section 5 and 6, we present estimates of technical efficiency and total factor productivity. Finally, Section 7 concludes this study.

2. Indonesian Economy

Indonesia is a large country with great regional diversity. The territory of Indonesia is divided into 31 autonomous provinces. The number of provinces has fluctuated recently, due to reform movement and decentralization. Since five new provinces have already been formed in the last two years, for the purpose of this study, they are combined with the provinces where they were located earlier. Thus, the analysis is based on 26 provinces, excluding East Timor which declared its independence in 1999. They are: (1) Aceh, (2) North Sumatra, (3) West Sumatra, (4) Riau, (5) Jambi, (6) South Sumatera, (7) Bengkulu, (8) Lampung, (9) Jakarta, (10) West Java, (11) Central Java, (12) Yogyakarta, (13) East Java, (14) West Kalimantan, (15) Central Kalimantan , (16) South Kalimantan, (17) East Kalimantan, (18) North Sulawesi, (19) Central Sulawesi, (20) South Sulawesi, (21) Southeast Sulawesi, (22) Bali, (23) West Nusa Tenggara, (24) East Nusa Tenggara, (25) Maluku, (26) and Irian Jaya.

The country is composed of more than 13,000 islands, of which around 6,000 are inhabited. The most important islands are Java, Sulawesi, Sumatra, Kalimantan, and Irian Jaya. The last three islands cover almost 75% of the Indonesian area. However, the population distribution in Indonesia is very uneven. According to the 2000 census, Java with 6% of the land area holds about 60 % percent of population and Sumatra accounts for 24% of land area and holds 20% of the population. On the other hand, other big islands such as Sulawesi, Kalimantan and Irian Jaya which account for more than 50% of total land area are inhabited by less than 20% of the population. Java dominates Indonesian economy by contributing more than 40% of GDP (Central Bureau of Statistics, 2002). If it is combined with Sumatra, the contribution of the GDP is more than 75% of Indonesia’s total GDP. By contrast, Irian Jaya, portion of New Guinea, with 163,000 square miles which is about one fifth of Indonesian area shares only 2 % in GDP and in population.

As one would expect, the regional economies are not much different than the national economy. The provincial level economies not only suffered from the crisis but also were affected by the fact that natural endowment is uneven among regions. The uneven distribution of population and natural resources causes disparity in economic growth and regional incomes. Substantial diversity in economy is reflected by provincial GDP. For the year 2000 the lowest per capita provincial GDP was 1,610,942 rupiahs (approximately US $ 184.32) for East Nusa Tenggara while the highest was 29,662,899 rupiahs (US $ 3,393.92) for East Kalimantan. Moreover, per capita provincial GDP of the four poorest provinces combined, i.e., East Nusa Tenggara, Maluku, West Nusa Tenggara, and Bengkulu is not more than 50% of the wealthiest province (Central Bureau of Statistics, 2002). Even though the Indonesian economy at the national level showed rapid economic growth over the past three decades (except for the last four years), there exist large inter-regional variations in the growth rate and their income levels. In 1999, four provinces exhibited decreasing provincial GDP, namely Maluku (-24.3%), Aceh (-4.19%), and Irian Jaya (-3.48%), and Jakarta (-0.29 %). On the other hand, five provinces grew more than 3.2%.

Provincial economies in Indonesia are closely related to spatial differences in the location of agriculture, industries and services. Investment in industries is higher in the west of the country and in provinces rich in oil and natural liquid gas (LNG) such as Riau and Aceh. In Java, investment is mainly in manufacturing, whereas in Irian Jaya it is in extractive industry such as timber. Bali, Yogyakarta and Jakarta are provinces that economically depend on services and tourism. Provinces in Kalimantan Island heavily depend upon natural resource-based industry like forestry. Nearly all manufacturing in the eastern part of Indonesia involve either the processing of local primary products such as tropical fruits or coconuts or a product for localized markets. In addition to that, as mentioned earlier, the population distribution in Indonesia is very uneven. For that reason, it is not surprising if regional economies among provinces are very diverse.

Since the provincial economies are so different, it is worth investigating technical efficiencies and its determinants. This will help to examine how far each province is off the production frontier in each period and how quick each province can reach the frontier.

Decomposing the total factor productivity growth at the provincial levels into its components will help to identify the cause of growth for each province, i.e., whether provincial economic growth is due to a technological progress or due to a change in technical efficiency.

3. Methodology

Consider a production function of panel data:

$$y_{it} = f(x_{jit}; a)\exp(e_{it}) \tag{1}$$

where $i = 1, 2, 3, \ldots, I$ represents the cross sectional units, $t = 1, 2, 3, \ldots, T$ represent time periods. y_{it} is the output of the ith unit at time t, x_{jit} is the jth input, $j = 1,2,3,\ldots, J$, and a is a vector of unknown parameters. The error term e_{it} is divided into two components: v and u, i.e., $e_{it} = v_{it} - u_{it}$, where v_{it} is the random error and u_{it} captures the inefficiency. The random error, v_{it}, is assumed to be independently and identically distributed as normal with mean = 0 and variance = s_v^2, and we assume that u_{it} follows a truncated normal distribution with m as the mode, i.e., $u_{it} \sim N^+(m, s_u^2)$. Battese and Coelli (1988) extended the work of Jondrow et al. (1982) to the case of panel data assuming that technical efficiency is time invariant. In practice it seems natural to relax the assumption that technical efficiency is time invariant. For that reason, we follow Battese and Coelli (1992) where technical efficiency varies over time[1]. They define u_{it} to accommodate time-varying assumption as follows:

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[1] Besides the Battese and Coelli (1992) specification of time varying technical efficiency, there are other specification also, e.g., Cornwell, Schmidt and Sickles (1990) proposed $h = g_1 + g_2 t + g_3 t^2$ and Kumbhakar (1990) proposed $h = [1 + \exp(g_1 t + g_2 t^2)]$ among others.

$$u_{it} = h_t u_i \tag{2}$$

where $h_t = \exp\{-d(t-T)\}$ and d is a parameter to be estimated. Battese and Coelli (1992) note that if $d > 0$, technical efficiency rises at a decreasing rate, if $d < 0$ technical efficiency declines at an increasing rate, and if $d = 0$ the technical efficiency remains the same. Following Battese and Coelli (1992), we estimate technical efficiency by the minimum mean-square-error predictor, i.e.,

$$\begin{aligned} TE_{it} &= E[\exp(-u_{it}) \mid e_i] \\ &= \left[\frac{1-\Phi(h_t s_* - (m_{*i} / s_*))}{1-\Phi(-(m_{*i} / s_*))} \right] \exp\{-h_t m_{*i} + 0.5 h_t^2 s_*^2\} \end{aligned} \tag{3}$$

where

$$m_{*i} = \frac{m s_v^2 - h' e_i s_u^2}{s_v^2 + h'h s_u^2}, \tag{4}$$

$$s_*^2 = \frac{s_u^2 s_v^2}{s_v^2 + h'h s_u^2}, \tag{5}$$

$h' = (h_1\, h_2\, h_3\, h_4 \cdots h_T)$ and $\Phi(\bullet)$ is the standard normal cumulative distribution.

Specifically, in this study we use a translog production function with two inputs, capital, *k*, and labor, *l*, i.e.,

$$\begin{aligned}\ln(y_{it}) = {} & a_0 + a_k \ln k_{it} + a_l \ln l_{it} + a_t t \\ & + \frac{1}{2}\left[a_{kk} (\ln k_{it})^2 + a_{ll} (\ln l_{it})^2 + a_{tt} t^2 \right] \\ & + a_{kl} \ln k_{it} \ln l_{it} + a_{kt} t \ln k_{it} + a_{lt} t \ln l_{it} \\ & + v_{it} - u_{it},\end{aligned} \tag{6}$$

where $i = 1, 2, 3, \ldots, 26$ and $t = 1, 2, 3, 4, \ldots, 8$ represent province and time respectively.

To investigate the factors which contribute to the technical inefficiencies we estimate the following model:

$$TIE_{it} = b_0 + b_1 z_{1it} + b_2 z_{2it} + b_3 z_{3it} + ... + b_n z_{nit} + x_{it} \tag{7}$$

where TIE_{it} is technical inefficiency of province i at period t, $z_{1it,} z_{2it,} z_{3it,} \ldots, z_{nit,}$ are n independent variables, $b_1, b_2, b_3, \ldots, b_n$ are the parameters to be estimated and x_{it} the error terms, assumed to be independently and identically distributed with mean = 0 and variance = s_x^2.

Kumbhakar and Lovell (2000, p:281) note that total factor productivity (TFP) growth, denoted by $\dot{TFP}$, can be decomposed into three components: rate of technological change, a scale component and a change in technical efficiency. A rate of technological progress can be estimated by:

$$\begin{aligned} TP &= \frac{\partial \ln(y_{it})}{\partial t} \\ &= a_t + a_{tt}t + a_{kt} \ln k_{it} + a_{lt} \ln l_{it}. \end{aligned} \qquad (8)$$

Technological progress can be interpreted as the shifts of the production frontier over time.

A scale component is defined as:

$$\begin{aligned} SC &= (e-1)\sum_j \left(\frac{e_j}{e}\right)\dot{x}_j \\ &= (e-1)\left(\frac{e_k}{e}\dot{k} + \frac{e_l}{e}\dot{l}\right), \end{aligned} \qquad (9)$$

where e_k and e_l are the elasticities of output with respect to capital and labor, respectively, $e = e_l + e_k$ and dot over variable denotes the rate of its change. The elasticity of output with respect to capital is estimated by

$$e_k = a_k + a_{kk} \ln k_{it} + a_{kl} \ln l_{it} + a_{kt}t, \qquad (10)$$

and the elasticity of output with respect to labor is estimated by

$$e_l = a_l + a_{ll} \ln l_{it} + a_{kl} \ln k_{it} + a_{lt}t. \qquad (11)$$

For our case, change in technical efficiency is estimated by

$$\begin{aligned} \dot{TE} &= -\frac{\partial u_{it}}{\partial t} \\ &= d \exp\{-d(t-T)\}u_i. \end{aligned} \qquad (12)$$

The technical efficiency changes can be interpreted as the rate at which entity moves towards or away from production frontier. Thus, $\dot{TFP}$ is given by

$$\dot{TFP} = TP + SC + \dot{TE}\,. \tag{13}$$

4. Data

The data on provincial output y; capital k; and labor l for 26 provinces from 1993 to 2000 are obtained from Central Bureau of Statistics Indonesia. Due to unavailability of the capital data, capital formation is used for k. Output and capital formation are in 1993 constant prices. Further, due to unavailability of the data, labor is measured by the number of people 15 years of age and over who work 35 hours or more per week. Next, to investigate the factors which affect technical efficiency, we consider mean years of schooling, inflation, region and sectoral differences across provinces. Mean years of schooling is defined as the average number of years people spend in school. Region is a binary variable which takes value 1 if a province belongs to the western part of Indonesia, otherwise 0. Sectoral differences are accounted also by dummy variables. A dummy variable takes a value 1 if a province falls into a certain sectoral category. Sectoral categories considered in this case are: Agriculture, Mining and Quarrying, Manufacturing and Others. A province is classified into sectoral category based on the biggest sectoral contribution to its provincial GDP. All of these variables are also obtained from the Central Bureau of Statistics, Indonesia.

5. Technical Efficiency

Model (6) is estimated by the maximum likelihood method using FRONTIER 4.1 software (Coelli, 1996)[2] where u_{it} follows truncated normal distribution with mean = m and variance = s_u^2, and the time varying set up of u_{it} is specified in equation (2). Parameter estimates of the model are shown in Table 1. We note a_t is positive and statistically significant, i.e., technological progress improved over time. It is interesting to note that the parameter estimates for capital and labor are positive, but only labor is significant. It can be inferred that labor is more crucial than capital in determining output in Indonesian provincial economies.

Table 1 is here

The estimates of technical efficiencies from equation (3) are reported in Table 2. Table 2 reveals that the average technical efficiency of Indonesian provincial economies over the period from 1993 to 2000 is 50.63 %. Thus, on average, technical inefficiency caused actual production to fall below maximum potential production by slightly less than 50%. This is lower than the average technical efficiency of Spanish regions which are between 81% and 85% (Gumbau, 1998) and of the U.S. states which is around 67% (Sharma et al., 2003). The average efficiency steadily increased from 46.7% in 1993 to 54.5% in 2000. The minimum efficiency for East Nusa Tenggara in 1993 is 21.92%, whereas the maximum efficiency for East Kalimantan in 2000 is 98.33%. As expected,

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[2] The authors would like to thank to Tim Coelli for providing Frontier 4.1

Table 2 is here

the average (over time) efficiency among provinces varies. For East and West Nusa Tenggara the average efficiencies are the lowest i.e., 26.27% and 27.72% whereas for East Kalimantan the average efficiency is the highest i.e., 98.17%. It is worth noting that in terms of provincial output, East and West Nusa Tenggara contributed only 1.52% to the national GDP and are ranked 18 and 23 among 26 provinces,. Although East Kalimantan has the highest efficiency, its contribution to the national GDP is small, only 6.19%. In contrast, five provinces in Java (Jakarta, East Java, Central Java, West Java, and Yogyakarta) which contribute 68.12% to the national GDP, their efficiencies are less than 80%. These findings reveal that provinces with larger outputs do not necessarily have higher efficiencies.

Furthermore, our estimates indicate that only nine provinces have technical efficiencies more than 50%. All of them are located on the west side of the country. It is well known that there is a significant difference in economic growth between western and eastern regions. The eastern part of the country is widely regarded as lagging far behind the western part (particularly Java) in economic development. The eastern part of Indonesia is comprised of thirteen provinces namely East Kalimantan, South Kalimantan, Central Kalimantan, West Kalimantan, North Sulawesi, Central Sulawesi, South Sulawesi, Southeast Sulawesi, Maluku, Irian Jaya, East Nusa Tenggara, West Nusa Tenggara and Bali. Table 2 reveals that among thirteen provinces with low level of technical efficiency, nine of them are in the eastern part of the country. In addition, it can be inferred from the results that except for East Kalimantan, the average (over time and over provinces) technical efficiency of eastern provinces is below 50%. Further, note that four out of five provinces in Java, which are West Java, East Java, Cental Java and Jakarta, are among the seven most technically efficient provinces in the country. However, the three most technically efficient provinces are East Kalimantan, Riau and Aceh, and these provinces are known for an abundance of natural resources such as oil and timber.

Next, we observe that the Indonesian provincial technical efficiencies show a tendency to converge over time. This is tested by $b-$convergence introduced by Baumol (1986), i.e. we estimate the following regression:

$$\ln\left(\frac{TE_l}{TE_0}\right)=q_0+q_1\ln(TE_0)+w \tag{14}$$

where TE_0 and TE_l are the first and the last period average (over provinces) technical efficiency respectively and w is the random error term. If q_1 is negative and statistically significant, than it can be inferred that $b-$convergence exists (Baumol, 1986). Our results reveal that q_0 and q_1 are 0.3909 and – 0.4319 with standard errors 0.009 and 0.019 respectively. Since q_1 is negative and highly significant, we conclude that the technical efficiencies of Indonesian regions converge over the period 1993-2000. Wu (2000) concluded that the technical efficiencies converged quickly by 1995 in Chinese provinces. Moreover, Gumbau (2000) also observed convergence in Spanish regions.

5.1 Determinants of Technical Inefficiency

There are various factors e.g., socio-economic, demographic and regional responsible for technical efficiencies to be different across provinces. In this study the factors considered are: inflation, mean years of schooling, regional location, and sectoral differences. A positive relationship is expected between mean years of schooling and technical efficiency. Moreover, since the western provinces are more developed, the provinces in this region are expected to be more efficient than the less developed eastern provinces. Regarding the sign of sectoral differences, there is no a-priori judgment whether they affect the technical inefficiency positively or negatively. Due to unavailability of the mean years of schooling data for every year the factors of inefficiency are only investigated for the years 1996 and 1999. The parameter estimates obtained for the year 1996, 1999 and 1996 and 1999 are reported in Table 3. We note that except for the coefficient of inflation all other coefficient estimates are almost the same in both periods. Coefficients of mean years of schooling and sectoral differences are significant at less than 5% level of significance, whereas the coefficients of both inflation and regional effects are not significant. The inefficiency is affected negatively by the mean years of schooling, i.e., mean years of schooling enhance the provincial technical efficiencies. Although the regional effect coefficient is not significant, the negative sign of this estimate indicates that the provinces in the eastern region are more inefficient than those in the western part. In the case of sectoral differences all sector effects are significant. The magnitude of the estimates

Table 3 is here

reveals that agricultural provinces are more inefficient than mining and quarrying and Manufacturing provinces. The combined data of two periods also reveals the same result, i.e., mean years of schooling and sectoral differences are significant.

6. Total Factor Productivity Growth

Productivity and its growth are essential because they determine the real standard of living that can be achieved by citizens in a certain province. Note that the total factor productivity (TFP) growth is the sum of technological change, a scale component, and change in efficiency (equation 10).

This decomposition of total factor productivity change into technical efficiency change and technological change makes it possible to understand whether regions have improved their productivity levels simply through a more efficient use of existing technology or through technological progress. Estimates of annual provincial TFP growth together with the average growth of technological progress (TP), scale component (SC) and technical efficiency (TE) are summarized in Table 4. From Table 4, we note that during 1993-2000, in twenty out of twenty six provinces the efficiency change is larger than the technological progress, and in four provinces it is smaller. Thus, we conclude that in most provinces, the TFP growth was driven by changes in technical efficiency, and in only four provinces (Aceh, Riau, Jakarta, and East Kalimantan) the TFP growth was driven by technological progress. The average TFP growth was 3.59% and in thirteen provinces TFP grew above the average. Among these thirteen provinces, six of

Table 4 is here

them are in the eastern part of the country. Further, the results indicate that before 1997 there were four provinces with negative TFP growth which are: Aceh in 1994, West Java in 1994 to 1996, Central Java in 1994 and 1997 and East Java in 1995 and 1996. The lowest TFP growth during the study period (1994 – 2000) was in West Java in 1996 which is -6.15% and the highest was in Jakarta in 1998 (10.58%). However, on average, TFP growth among all provinces during this period ranged from 1.65% to 5.43%. It is interesting to note that provinces with high technical efficiencies do not necessarily have high TFP growth. For example, technical efficiency in Aceh, on average, is 83% but during the same period, TFP grew only 1.65%. Central Java's average technical efficiency is 64%, but its TFP growth is the lowest among provinces which is 1.32%. On the contrary, some provinces with low technical efficiencies had high TFP growth, e.g., Bengkulu with technical efficiency only 32.9% grew by 4.33%, Irian Jaya's TFP grew 4.65 % but the province was only 49.1% technically efficient.

The average provincial technological progress ranged from -0.06% to 3.57%. Only one province has the technological progress negative, i.e., technological recess throughout the period which is East Nusa Tenggara. However, the average TFP growth for this province was 4.51%. Interestingly, Jakarta, with average TFP growth of 5.13%, was the only province where the average technological progress was above 3.0% which was the highest among all provinces. This average was higher than the national average which was only 1.17%. Other interesting fact is that East Kalimantan which had the highest technical efficiency (98.2% in Table 2) also had the high technological progress (2.89%) but the TFP only grew 3.03%.

Provincial scale component demonstrates that, on average, almost all provinces underwent negative changes. The data indicates that for all provinces both capital and labor increased over time which means that $\dot{x}$ in equation (7) is always positive. As a result, the negative of the scale component in total factor productivity growth was due to the total elasticity (*e*) being less than unity. Thus, negative scale component indicates that the corresponding provinces exhibit decreasing return to scale. This conclusion is supported by the fact that total elasticitities of output (*e*) in Table 4 are less than one.

The effects of Asian crisis (that hit Indonesia in 1997) on provincial TFP are noticeable. We note that the western provinces were affected more than the eastern ones, i.e., the TFP for most of the western provinces dropped more than eastern provinces. TFP declined in nineteen out of twenty six provinces from 1998 to 1999. However, TFP recovered in 2000 for some of the provinces. For example the TFP in North Sumatra decreased from 6.86% in 1998 to 1.22% in 1999 and increased to 2.81% in 2000. In South Sumatra TFP decreased from 6.91% in 1998 to 3.70% in 1999 and increased to 3.97% in 2000. In some provinces TFP decreased significantly over the period 1998 to 2000. In Lampung, TFP declined from 7.05% in 1998 to 3.48% in 2000. TFP growth also slowed down in Jakarta, from 10.58% in 1998 to just 5.17% in 2000. West Java and Yogyakarta also recorded drop in TFP growth from 1998 to 2000. The largest drop in TFP growth was noted in East Java, where it dropped more than 7.5% (from 9.92% in 1998 to 2.08% in 2000). Some of the eastern provinces exhibit the same reaction to the crisis, although the decrease was not as large as in western provinces. TFP in East Nusa Tenggara and West Kalimantan dropped slightly from 5.23% and 5.38% in 1998 to 4.18% and 4.58% in 2000, respectively. Small downturn in TFP growth is also noted in

Central Sulawesi (from 5.21% in 1998 to 4.44% in 2000), South Sulawesi (from 4.12% in 1998 to 3.83% in 2000) and Southeast Sulawesi (from 5.70% in 1998 to 5.27% in 2000). The largest drop in TFP in eastern provinces is in South Kalimantan, from 6.45% in 1998 to 2.05% in 2000.

6. 1. Output Elasticities

It is useful to examine how much output will increase when the level of input increases. Note that elasticity of output with respect to capital e_k and elasticity of output with respect to labor e_l are computed at the mean input levels. The elasticities of output at the mean values together with their variances for each province are reported in Table 5.

Table 5 is here

The output elasticities of capital and labor vary across provinces. For example, the output elasticity with respect to capital ranges from 0.2888 for East Nusa Tenggara to 0.7685 for Jakarta, and the output elasticity with respect to labor varies from 0.0758 for Jakarta to 0.5890 for Bengkulu. Total output elasticity defined as the sum of the output elasticity of capital and labor also varies from a low of 0.6768 for East Java to 0.9450 for Central Kalimantan and 0.9359 for East Kalimantan. It means that in the provincial economy, if capital and labor increases by 1%, the output or provincial GDP will increase by 0.68% - 0.94% depending upon the province under consideration. As for elasticities of output with respect to capital and labor, our results are confirmed with the economic profiles of provinces. In the eastern provinces (most of these are agricultural provinces reflected by their sectoral provincial GDP, Central Bureau of Statistic, 2000) e_l's are greater than

e_k's i.e., East and West Nusa Tenggara , Maluku, North and Central Sulawesi. This finding is supported by the fact that in most developing countries, the agricultural sector is characterized as labor intensive rather than capital intensive. Moreover, for some eastern provinces such as East Kalimantan, South Sulawesi, Irian Jaya, e_k's are greater than e_l's since these provinces have non-agricultural economies. However, in five provinces, i.e., Aceh, West Sumatra, Yogyakarta, Bali and South Kalimantan the e_k's are almost equal to the e_l's. Perhaps, this is due to the fact that in these five provinces, the contribution of the two biggest sectors usually are labor and capital intensive and their shares to GDP are approximately the same. For example in 2000, the shares of agricultural (labor intensive) and mining and quarrying (capital intensive) in Aceh were 30.36% and 31.56 % respectively. We conclude that in general, e_k (the average of all provinces is 0.4895) is greater than e_l (the average of all provinces is 0.3251). At the 5 % level of significance all elasticities of capital are significant and almost all elasticities of labor except North Sumatra, Jakarta, West Java, Central java, East Java and East Kalimantan are significant. Furthermore, all provinces but seven (which are North Sumatra, South Sumatra, Lampung, East Java, Central Java, West Java and South Sulawesi) exhibit constant returns to scale.

7. Conclusion

This study investigates the technical efficiency and total factor productivity analysis in Indonesian provincial economies during 1993-2000. The average technical efficiency during this period was slightly above 50% which is lower than average technical efficiency of Spanish regions which is 80.99% (Gumbau, 2000) and also lower than the U.S. states which is 75.95% (Sharma et al., 2003). We note that mean years of schooling and sectoral differences affected technical efficiency. Similar results have been found by Sharma et al. (2003) for the case of U.S. They concluded that sectoral differences and human capital, measured by people who have college degree is associated with technical efficiency in U.S.

In the case of total factor productivity growth, we conclude that across provinces, TFP grew, on average, in the range of 1.65% to 5.43%, with an average growth of 3.59%. These results are higher than those of Spanish regions where between 1964-1993 the TFP grew 0.83% to 1.65% (Gumbau, 2000) and also higher than the U.S. states where TFP grew between –0.09% and 1.52% for the period 1978-2000. (Sharma, et al., 2003). In twenty out of twenty six provinces the TFP growth was driven by efficiency changes , while in four provinces the TFP growth was driven by technological progress.

The impact of Asian crisis is reflected in provincial economies via TFP. We observe that the western provinces suffer from the crisis more than the eastern provinces, i.e., during the Asian crisis (1977-1999) the TFP for most of the western provinces decreased more than eastern provinces. TFP declined in nineteen out of twenty six provinces from 1998 to 1999. Although, in general, for most provinces the TFP also decreased from 1999 to 2000 but it did increase for some provinces in 2000.

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Table1: Parameter Estimates of Production Function

Variable	Parameter	Estimate	Std.Error
Intercept	a_0	-4.3719**	0.9956
ln K	a_k	0.1292	0.6897
ln L	a_l	1.9095**	0.7151
T	a_t	0.0713	0.0819
0.5(ln K)^2	a_{kk}	0.1520**	0.0347
0.5(ln L)^2	a_{ll}	0.0323	0.1252
0.5T^2	a_{tt}	0.0026	0.0057
(ln K)(ln L)	a_{kl}	-0.1329	0.0761
T(ln K)	a_{kt}	0.0123	0.0076
T(ln L)	a_{lt}	-0.0135	0.0092
	s_u^2	0.0368*	0.0072
	g	0.8520**	0.0584
	m	0.3541**	0.0933
	d	0.0360*	0.0163

note: * indicates significance at 5% level of significance
** indicates significance at 1% level of significance

Table 2. Provincial Technical Efficiency

Province	1993	1994	1995	1996	1997	1998	1999	2000	Average	Rank
Aceh	0.81239	0.81836	0.82417	0.82981	0.83529	0.84061	0.84578	0.85079	0.83215	3
North Sumatra	0.56132	0.57288	0.58427	0.59546	0.60646	0.61727	0.62788	0.63829	0.60048	8
West Sumatra	0.42528	0.43832	0.45128	0.46414	0.47690	0.48954	0.50205	0.51442	0.47024	11
Riau	0.94562	0.94748	0.94928	0.95101	0.95269	0.95432	0.95589	0.95741	0.95171	2
Jambi	0.32172	0.33487	0.34807	0.36129	0.37453	0.38775	0.40095	0.41411	0.36791	20
South Sumatra	0.42322	0.43627	0.44925	0.46213	0.47490	0.48756	0.50010	0.51249	0.46824	12
Bengkulu	0.28370	0.29661	0.30962	0.32272	0.33588	0.34908	0.36230	0.37554	0.32943	22
Lampung	0.29292	0.30591	0.31898	0.33212	0.34531	0.35853	0.37176	0.38499	0.33882	21
Jakarta	0.59047	0.60156	0.61246	0.62315	0.63365	0.64394	0.65403	0.66392	0.62790	7
West Java	0.74176	0.74962	0.75728	0.76475	0.77203	0.77911	0.78601	0.79272	0.76791	4
Central Java	0.60923	0.61998	0.63054	0.64089	0.65104	0.66099	0.67072	0.68025	0.64546	6
Yogyakarta	0.34601	0.35923	0.37246	0.38568	0.39889	0.41205	0.42516	0.43821	0.39221	18
East Java	0.66000	0.66975	0.67930	0.68864	0.69777	0.70669	0.71541	0.72392	0.69269	5
Bali	0.45243	0.46528	0.47803	0.49066	0.50316	0.51551	0.52772	0.53978	0.49657	9
West NusaTenggara	0.23302	0.24533	0.25782	0.27047	0.28326	0.29617	0.30918	0.32227	0.27719	25
East NusaTenggara	0.21921	0.23129	0.24357	0.25603	0.26866	0.28143	0.29433	0.30733	0.26273	26
West Kalimantan	0.37563	0.38885	0.40204	0.41519	0.42829	0.44132	0.45426	0.46710	0.42159	17
Central Kalimantan	0.33546	0.34866	0.36189	0.37512	0.38834	0.40154	0.41469	0.42779	0.38169	19
South Kalimantan	0.42205	0.43511	0.44809	0.46098	0.47377	0.48644	0.49898	0.51139	0.46710	13
East Kalimantan	0.97935	0.98007	0.98076	0.98143	0.98208	0.98271	0.98331	0.98389	0.98170	1
North Sulawesi	0.39082	0.40401	0.41715	0.43024	0.44325	0.45618	0.46901	0.48172	0.43655	15
Central Sulawesi	0.27383	0.28666	0.29960	0.31263	0.32574	0.33891	0.35212	0.36535	0.31936	23
South Sulawesi	0.39351	0.40669	0.41983	0.43290	0.44590	0.45880	0.47161	0.48430	0.43919	14
Southeast Sulawesi	0.23579	0.24814	0.26067	0.27335	0.28617	0.29910	0.31213	0.32524	0.28007	24
Maluku	0.37833	0.39155	0.40473	0.41788	0.43096	0.44397	0.45689	0.46971	0.42425	16
Irian Jaya	0.44702	0.45992	0.47271	0.48539	0.49794	0.51036	0.52263	0.53475	0.49134	10
Average	0.46731	0.47855	0.48976	0.50093	0.51203	0.52307	0.53403	0.54491	0.50633	

Table 3: Technical Inefficiency Analysis

Variable	1996		1999		1996 and 1999	
	Estimates	Std. Errors	Estimates	Std. Errors	Estimates	Std. Errors
Inflation (%)	0.0084	0.0160	-0.0053	0.0082	-0.0029	0.0058
Schooling (Year)	-0.1011*	0.0286	-0.1003*	0.0280	-0.0998*	0.0178
Region	-0.0263	0.0510	-0.0279	0.0497	-0.0234	0.0322
Agriculture	1.2349*	0.1983	1.3029*	0.1896	1.2887*	0.1224
Mining and Quarrying	0.8784*	0.2009	0.9644*	0.1918	0.9404*	0.1245
Manufacturing	0.9150*	0.1846	0.9877*	0.1708	0.9726*	0.1119
Others	1.2250*	0.2411	1.2809*	0.2327	1.2671*	0.1518

Note: * significant at 1 % level of significance

Table 4: Provincial TFP Growth

Province	1994	1995	1996	1997	1998	1999	2000	Average Growth of			
								TFP	TP	SC	TE
Aceh	-0.02	1.13	0.40	1.47	2.60	3.17	2.82	1.65	1.09	-0.09	0.65
North Sumatra	3.13	0.49	1.72	4.04	6.86	1.22	2.81	2.90	1.29	-0.18	1.79
West Sumatra	3.34	3.15	2.68	3.16	4.84	5.34	4.00	3.79	1.19	-0.06	2.65
Riau	0.91	2.02	1.32	5.15	1.98	2.47	2.21	2.29	2.11	0.00	0.18
Jambi	3.54	4.55	3.53	4.70	5.38	5.34	4.20	4.46	0.84	0.11	3.51
South Sumatra	2.32	3.02	2.59	3.54	6.91	3.70	3.97	3.72	1.45	-0.40	2.67
Bengkulu	4.46	4.31	3.91	5.38	4.24	4.17	3.82	4.33	0.40	0.02	3.90
Lampung	4.61	2.01	2.28	4.40	7.05	4.94	3.48	4.11	0.61	-0.30	3.80
Jakarta	2.51	3.58	3.64	4.97	10.58	5.46	5.17	5.13	3.57	-0.08	1.64
West Java	-0.57	-0.40	-6.15	6.26	5.95	2.83	1.34	1.32	0.87	-0.48	0.93
Central Java	-1.39	0.69	-0.54	3.48	4.90	5.46	0.75	1.91	0.26	0.10	1.54
Yogyakarta	3.27	4.10	3.63	4.18	5.78	3.78	4.16	4.13	1.02	-0.18	3.29
East Java	0.67	-0.35	-0.98	0.96	9.92	3.98	2.08	2.32	0.76	0.27	1.29
Bali	2.32	3.00	2.76	3.82	5.51	4.19	3.85	3.64	1.17	0.01	2.46
West NusaTenggara	3.92	4.34	3.71	4.25	0.92	7.80	5.49	4.35	0.61	-0.77	4.51
East NusaTenggara	4.17	4.60	3.46	5.27	5.23	4.66	4.18	4.51	-0.06	-0.13	4.70
West Kalimantan	2.62	2.45	3.14	3.69	5.38	4.73	4.58	3.80	1.43	-0.67	3.03
Central Kalimantan	5.29	5.04	4.93	5.34	6.01	5.40	5.99	5.43	2.18	-0.14	3.38
South Kalimantan	2.54	3.28	2.54	1.74	6.45	3.83	2.05	3.20	1.10	-0.57	2.67
East Kalimantan	2.42	2.73	2.90	4.49	2.38	3.06	3.23	3.03	2.89	0.07	0.07
North Sulawesi	3.25	3.12	2.25	3.60	4.85	4.01	3.02	3.44	0.53	0.00	2.91
Central Sulawesi	3.78	4.62	4.19	4.65	5.21	4.55	4.44	4.49	0.65	-0.17	4.01
South Sulawesi	0.18	3.18	1.26	1.90	4.12	3.93	3.83	2.63	0.86	-1.12	2.89
Southeast Sulawesi	4.78	5.15	4.85	5.01	5.70	5.50	5.27	5.18	0.90	-0.20	4.47
Maluku	3.35	3.59	3.20	4.32	4.48	0.79	1.04	2.97	0.18	-0.23	3.01
Irian Jaya	3.95	4.09	4.20	4.39	5.32	5.82	4.78	4.65	2.47	-0.32	2.50
Indonesia	2.67	2.98	2.36	4.01	5.33	4.24	3.56	3.59	1.17	-0.21	2.63

Table 5: Elasticities of Output

Province	e_k	$SE(e_k)$	e_l	$SE(e_l)$	e	$SE(e)$
Aceh	0.4313	0.0146	0.4388	0.1413	0.8701*	0.0786
North Sumatra	0.4944	0.0190	0.2928	0.1554	0.7872	0.0933
West Sumatra	0.4440	0.0150	0.4157	0.1430	0.8597*	0.0804
Riau	0.5720	0.0177	0.3161	0.1472	0.8880*	0.0934
Jambi	0.3932	0.0139	0.5078	0.1364	0.9010*	0.0740
South Sumatra	0.5017	0.0171	0.3198	0.1497	0.8215	0.0895
Bengkulu	0.3382	0.0134	0.5890	0.1318	0.9272*	0.0725
Lampung	0.3930	0.0163	0.4192	0.1514	0.8121	0.0870
Jakarta	0.7685	0.0236	0.0758	0.1680	0.8442*	0.1604
West Java	0.4839	0.0302	0.2007	0.1806	0.6846	0.1075
Central Java	0.4080	0.0308	0.2734	0.1872	0.6814	0.1083
Yogyakarta	0.4167	0.0144	0.4543	0.1409	0.8710*	0.0781
East Java	0.4742	0.0314	0.2026	0.1836	0.6768	0.1084
Bali	0.4409	0.0148	0.4275	0.1418	0.8684*	0.0791
West NusaTenggara	0.3755	0.0141	0.4824	0.1426	0.8580*	0.0807
East NusaTenggara	0.2888	0.0140	0.5557	0.1473	0.8445*	0.0914
West Kalimantan	0.4727	0.0154	0.3978	0.1426	0.8705*	0.0808
Central Kalimantan	0.5373	0.0187	0.4077	0.1430	0.9450*	0.0815
South Kalimantan	0.4296	0.0145	0.4471	0.1404	0.8767*	0.0776
East Kalimantan	0.6445	0.0218	0.2914	0.1554	0.9359*	0.1087
North Sulawesi	0.3513	0.0133	0.5373	0.1375	0.8886*	0.0773
Central Sulawesi	0.3598	0.0134	0.5480	0.1348	0.9078*	0.0740
South Sulawesi	0.4246	0.0164	0.3915	0.1502	0.8160	0.0860
Southeast Sulawesi	0.3782	0.0143	0.5557	0.1323	0.9339*	0.0697
Maluku	0.3660	0.0136	0.5483	0.1341	0.9142*	0.0728
Irian Jaya	0.5798	0.0194	0.3545	0.1474	0.9343*	0.0912
Indonesia	0.4895	0.0173	0.3251	0.1506	0.8146*	0.0892

Note: $e = e_k + e_l$, * indicates constant returns to scale at the 5% level of significance.