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ANALYSIS OF SECTORAL EFFICIENCY AND THE RESPONSE OF REGIONAL POLICY

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Abstract

This paper analyzes the contribution of capital and labor on sectoral performance in Indonesia. Using stochastic frontier production function, this paper found the aggregate share of capital and labor is 0.20 and 0.34 respectively; representing the dominance of labor. The highest three technical efficiency is Mining sector (88.65%), Manufacture (70.47%) and Financial (65.93%), while the lowest one is Electric, Gas and Water (25.38%).

Keywords: efficiency, stochastic frontier, productivity, Indonesia.

JEL Classification: D24, J24, O18

¹ Authors are researcher on BRE – Directorate of Economic Research and Monetary Policy, Bank Indonesia. The views on this paper are solely of the author and not necessarily represent the views of Bank Indonesia. Authors thank to KKBI, who participate on this research, and also to other researcher in BRE, for valuable discussion and comments. E-mail: majidikram@bi.go.id, andry@bi.go.id, inanurmalia@bi.go.id, donni@bi.go.id

I. INTRODUCTION

The growth of Gross Domestic Product (GDP) is one of domestic economic development indicator. GDP can be viewed from three approaches; expenditure, sectoral, and income. The Central Bureau of Statistics (BPS) has actually calculated the GDP; unfortunately they publish GDP growth only from the expenditure and sectoral sides. There are nine sectors which contribute to GDP growth, namely Agriculture, Mining, Manufacturing, Electricity Gas and Water, Construction, Trade Hotel and Restaurant, Transportation and Telecommunications, Finance, and Other services.

On income approach, Tjahyono (2007) analyzed the impact of the quality and the efficiency of input factors on output, both in national and regional level. He concluded the technology adoption is equal across regions and the technical efficiency (TE) is time varying in Indonesia. However, these studies neither explained specifically the sectoral efficiency in regional level, nor the dynamics of regional efficiency across periods. It is necessary to know which sectors in each region have the highest growth over the years. On the other hand, we should identify the sector with low efficiency; hence need regional policy to support their development.

From sectoral approach, the regional economic structure can be distinguished into two; the region with similar sectoral economic structure with the national economy, and the region with high dependency on particular sectors (e.g. Mining and Agriculture). The changes in regional economic growth that affect the national economic growth, depends on the performance of each sector in the region, particularly their major sector. In addition, the change of economic growth, will affect the economic cycle both in regional and national.

This information is vital for local government to determine their priority to achieve the economic resilience on their region. Considering the purpose of development is to achieve sustainable economic growth, therefore it is necessary to identify the sectoral dynamics to formulate the right targeted regional policy.

This study will also beneficial for investors and bank industry. Investors can decide their investment target by looking at the sectoral efficiency and its dynamics. Investors will certainly prioritize investment in the most efficient sector. From the banking side, this study will assist the sectoral allocation of the loan. A more efficient sector will absolutely be a priority for the bank.

The first purpose of this study is to analyze the input factors that encourage the growth of national economy. Second is to measure the sectoral efficiency at national and regional level. Third is to analyze if there are changes in the sectoral efficiency over time. Fourth is to provide policy recommendations for local government to maintain resilience and to obtain the sustainable regional economic growth.

The second part of the paper reviews the theory and the literature study on sectoral efficiency. The next part will review the methodology, econometric models, and data. In the fourth section we present the estimation result and analysis. The fifth part provides conclusions and suggestions, and closes the presentation.

II. THEORY

Frontier analysis refers to the Solow-Swan model, which is based on the concept of Cobb-Douglas production function. Solow-Swan² model is widely referred in exogenous growth theory; one of the approaches to the theory of long-run economic growth.

Solow-Swan model² has been adopted by many economists and continuously developed by some experts such as Mankiw-Romer Model-Weil (MRW Model) who internalize human capital into the model. Bernanke and Guryanak also developed a MRW models by presenting learning by doing through the balance growth path. In addition, Barro-Mankiw-Sala I Martin (2001) also contributed by introducing the role of financial market in stimulating the economic growth. These models are using the assumption that the growth of technological progress is exogenous; hence they are included on exogenous growth category.

2.1. Solow-Swan Model and Measurement of Efficiency

Solow-Swan model basically reflects a closed economy. This closed economy produces one type of goods using labor and capital stock as the input factors. Solow-Swan model is a combination of neoclassical supply-side and Keynesian demand-side, in which technological progress and saving rate are assumed to be exogenous. In addition, government is excluded, leaving only the household and corporate sectors. In the corporate sector, there are several companies with similar technology. The prices of production factors are more flexible to ensure full utilization, while the output price is constant.

Cobb-Douglas production function expressed that the output is affected by the input, in which the capital stock and labor are the main components. Therefore, the Solow-Swan Model also focuses on the capital stock and labor as the input factors plus technological factor.

Nevertheless, the Solow-Swan models cannot present the level of efficiency in the use of input factors. Farrell (1957) classifies efficiency into two categories, technical efficiency (TE) and allocative efficiency (AE). Technical efficiency (TE) measures the maximum output one can obtain using available input, whereas the allocative efficiency (AE) measure the efficiency by using input in an optimal proportions and available input price.

2 Mankiw, N. Gregory, David Romer, and David N. Weil, "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 1956

Furthermore, we can use parametric and non-parametric data to estimate the fully efficient production function. Data Envelopment Analysis (DEA) is a measurement method that uses non-parametric data, while the Stochastic Frontier method is a measurement method that uses parametric data, developed among others by Aigner, Lovell, and Schmidt (1977).

2.2. Stochastic Frontier Model

Stochastic frontier model was not only developed by Aigner, Lovell and Schmidt (1977), but also by Meeusen and Van den Broeck (1977), Cornwell, Schmidt and Sickles (1990), and Kumbhakar (1990). Basically, stochastic frontier illustrates maximum output that can be generated from the input factors. Actual output will be exactly on the frontier line, when the input factors are used efficiently. Otherwise, the actual output will be inside the frontier. The greater difference between the frontier and the actual, the more inefficient the input factor utilization.

The gap can be narrowed or widened over time. These changes can be caused by the increasing of efficiency in input usage or the frontier shifting due to the technological improvement. Hence, there are three factors that influence output: the efficiency change of input factors usage, the changes in technology, and the changes in input factors.

The basic model of this approach is Solow-Swan based on the Cobb-Douglas production function with stock of capital and labor as the input. Cobb-Douglas production function can be expressed as:

$$Y_{it} = A_i K_{it}^{\beta_{1it}} L_{it}^{\beta_{2it}} \quad (1)$$

Where Y_{it} is the output of the province i at period t , K_{it} expresses province capital stock, L_{it} expresses province labor, A_i expresses technological progress, β_{1it} expresses *output* elasticity to capital, and β_{2it} expresses *output* elasticity to labor

On Equation (1), we add two types of composite error: one-sided non-negative error term that measures the inefficiency in input factors usage (various factors under firm's control) and two-sided error term that measures all factors beyond the firm's control. Aigner, Lovell, Schmidt (1977) developed Stochastic frontier function model which significantly contributed to econometric model and estimated the technical efficiency of firm or economic sector. Stochastic frontier includes two random components, one of them is the technical inefficiency and the other is a random error. Furthermore, Schmidt and Sickles (1984) developed a model of stochastic frontier production function with panel data as presented below:

$$y_{it} = \alpha + X'_{it}\beta + v_{it} - u_{it} \quad (2)$$

y_{it} is output, X is input, v is statistical noise, and $u > 0$ is a firm effect representing technical inefficiency. Equation (2) can be simplified as follow:

$$y_{it} = \alpha_i + X'_{it}\beta + v_{it} \quad (3)$$

Where $\alpha_i = \alpha - u_{it}$

Equation (3) is a standard form on panel data literatures, and β can be estimated with standard methods, such as GLS (Generalized Least Square) or Hausmann and Taylor instrumental variables estimator. We can also estimate using the MLE (Maximum Likelihood Estimator) with assumption of particular distribution for one side error u_{it} in equation (2).

Schmidt and Sickles applied panel model above on airline sample data during 1970-1977 (prior deregulation) under assumption of Cobb-Douglas technology. Schmidt and Sickles used and compare the GLS and MLE method (assuming half normal distribution for the firm effects). They also use Wu-Hausmann specification error and test the null hypothesis: firm-specific effects are not correlated with its regressor.

The advantage of using panel data is we can choose whether to use a particular distribution assumption for v and u or use the assumption that technical inefficiency is not correlated with the input. This assumption is testable. Nevertheless, the major benefits come primarily from the assumption that firm effects are constant over time.

Several studies use aggregated data, hence does not necessarily work on individual firms data. Senhadji (2000) among others measured the total factor productivity (TFP) in several countries using the Solow model and compare TFP between developing and developed countries. Koop, Osiewalski, and Steel (1997) applied stochastic frontier model using Bayesian analysis to decompose the output growth into input change, technological change and efficiency change in developing countries.

III. METHODOLOGY

This study uses quantitative method in measuring the efficiency of Indonesia's economy. There are two different methods to apply, first, the stochastic frontier model with panel data, to analyzethe effect of input factor on sectoral growth based on the Cobb-Douglas production function and to analyzethe efficiency levels. Empirically we use special software FRONTIER program 4.1 developed by Coelli (1996). This program use FORTRAN language to insert mathematical specification into the stochastic frontier models.

For frontier analysis, we use the data of Gross Domestic Product, real Gross Regional Domestic Product, capital stock, and labor. The frequency of the data is annual, covering periods of 1985 to 2009, providing us 25 years in total. In addition, the cross section

No	Sector
1	Agricultural
2	Mining sector
3	Manufacturing
4	Electricity, Gas, and Water
5	Construction
6	Trade, Hotel and Restaurant
7	Transport and Telecommunications
8	Financial
9	Service

identifier is nine sectors of the economy (Table 1). In total, the number of sample data is 225.

We refer to the Solow-Swan model with the basic Cobb-Douglas production function.

Recall Equation (1), the function to estimate is $Y_{it} = A_t K_{it}^{\beta_{1,it}} L_{it}^{\beta_{2,it}}$. Where Y_{it} is GDP or real regional GDP of province i to time t ; K_{it} is capital stock of province i to time t ; L_{it} is labor of province i to time t ; A_t is similar to $Ae^{\xi t}$, where ξ measures the rate of technical progress; $\beta_{1,it}$ is the level of output elasticity to capital; and $\beta_{2,it}$ the level of output elasticity to labor.

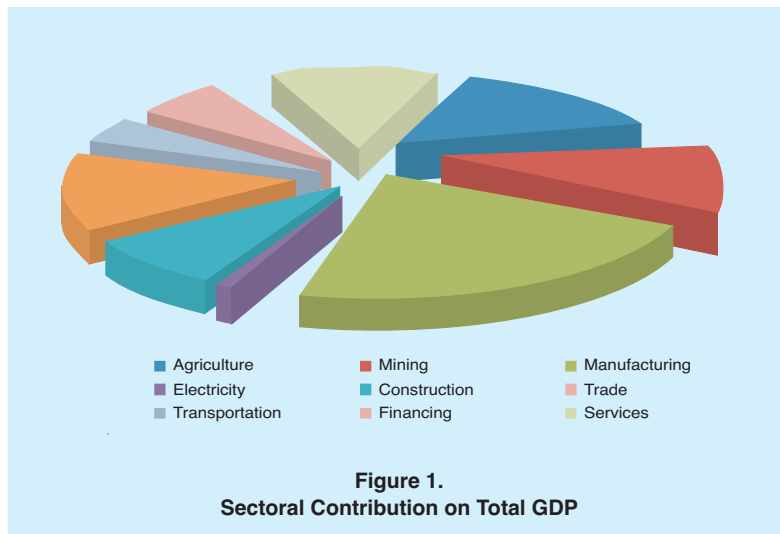
We apply this model on several provinces, including North Sumatera, South Sumatera, West Java, Central Java, East Java, Bali, South Kalimantan, and South Sulawesi.

IV. RESULTS AND ANALYSIS

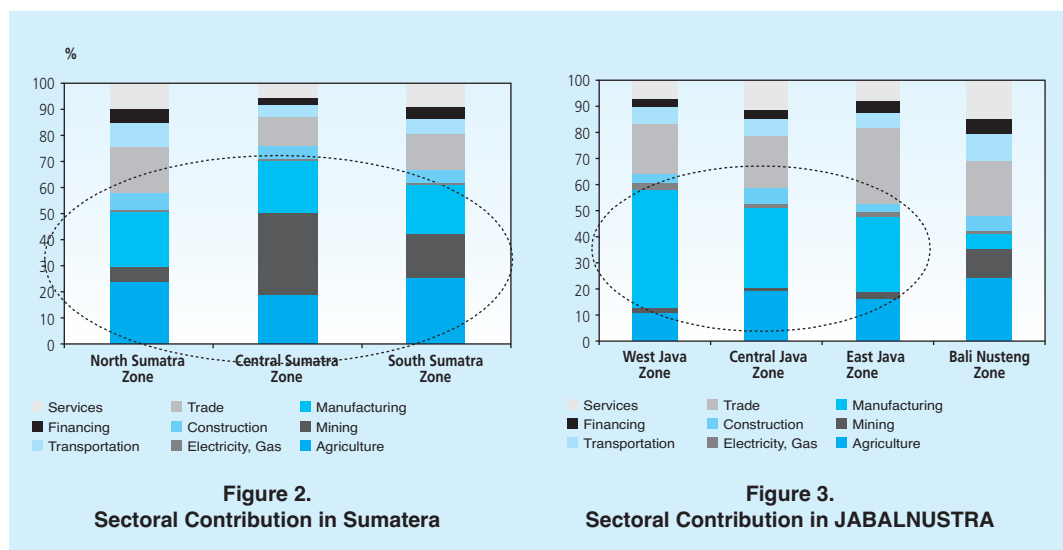
4.1. Sectoral Economic Profile in Regional and National Level

The GDP growth is contributed by nine sectors. Four major sectors with the total contribution of 68.2% are Manufacturing, Trade Hotel and Restaurant, Agriculture, and Mining sector with the individual share of 27.8%, 15.5%, 14.5%, and 10.4% respectively. With this significant contribution, the movement of total GDP growth will depends mainly on these four sectors.

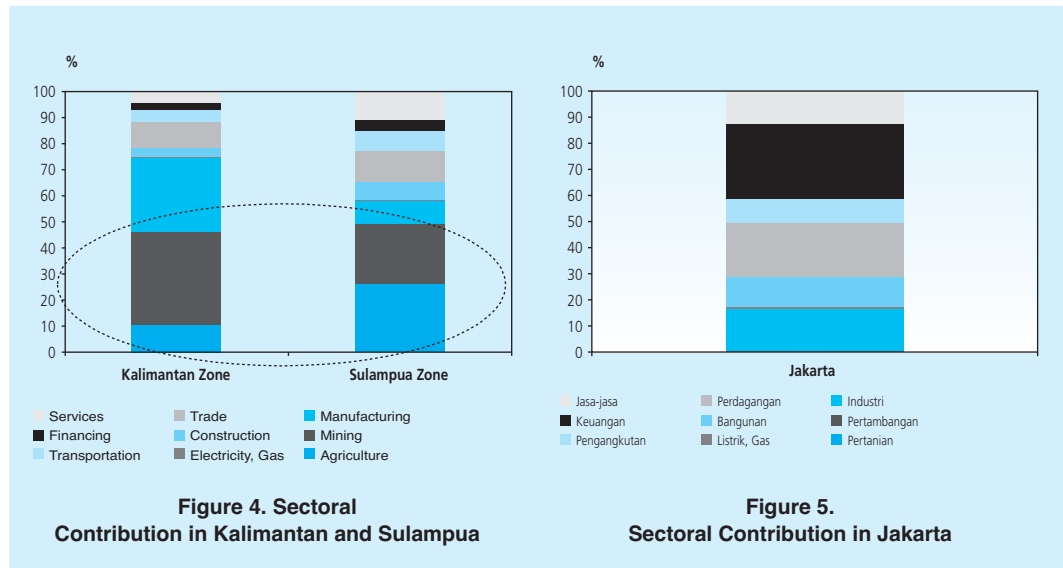
The regional economic growth contributes variously to national growth. Some regional growths coincide with the national growth, and some are even higher than the national level. However, there are regions with lower growth than the national. The different growth between regional and national may arise from different sectoral economic structure. This occur in Riau,



NAD, East Kalimantan and Jakarta, where the economy of these regions rely on specific sectors, such as Mining for Riau, Aceh, and East Kalimantan, and financial sector for Jakarta. Nationally, the contribution of these sectors is minor relative to other sectors. Figure 2 to Figure 5 describe the sectoral contribution in the region³.



³ Region consists of several provinces, Sumatera (all provinces in Sumatra, Riau Islands, and Bangka Belitung); JABALNUSTRA (the provinces on Java Island, Bali, Nusa Tenggara except DKI Jakarta) Jakarta, and KALI_SULAMPUIA (all provinces in Kalimantan island, Sulawesi, Maluku and Papua)

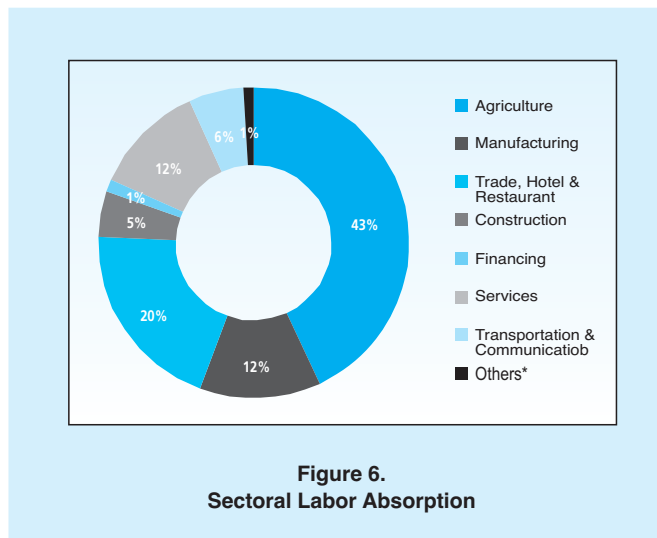


Among all sectors, the majority of labor in Indonesia (the average from 2000- 2009) is absorbed in agricultural sector (43%), Sector Trade, Hotel and Restaurant (20%), and Service (12%). See below.

Table 2.
Sectoral Labor Absorption (in percent)

Sector	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Agriculture	45.28	43.77	44.34	46.38	43.33	43.97	42.05	41.24	40.30	39.68
Manufacturing	12.96	13.31	13.21	12.39	11.81	12.72	12.46	12.38	12.24	12.24
Construction	3.89	4.23	4.66	4.37	4.84	4.86	4.92	5.26	5.30	5.24
Trade, Hotel and Restaurant	20.58	19.24	19.42	18.59	20.40	19.06	20.13	20.57	20.69	20.93
Transport and Telecommunication	5.07	4.90	5.10	5.32	5.85	6.02	5.93	5.96	6.03	5.84
Finance	0.98	1.24	1.08	1.41	1.20	1.22	1.41	1.40	1.42	1.42
Services	10.66	12.12	11.30	10.60	11.22	10.99	11.90	12.03	12.77	13.35
Other*	0.58	1.20	0.88	0.95	1.35	1.17	1.21	1.17	1.24	1.33

Source: Sakernas, BPS
Note: *) Other sector includes Mining, Electric, Gas and Water.



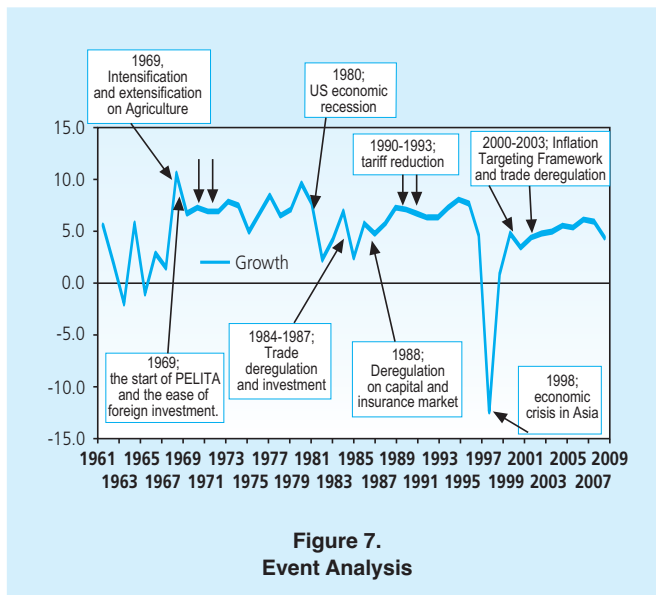
4.2. Indonesian Economic Policy and the Impact of World Shock on Sectoral Developments

Sectoral developments in Indonesia can not be separated from the economic policy during the regime of Orde Baru and the dynamics of the external economy. The economic policy of Orde Baru is based on the trilogy of development; a dynamic national stability, high economic development, and equitable distribution of development and its results. The implementation of development at that time was divided into five-year development patterns or so-called Five-year Development (Pelita) which began in 1969 (Bappenas, 1969 - 1998).

On the other hand, the dynamics of world economy also affected the sectoral development in Indonesia. The oil boom in 1970s and the US recession in 1980 bring significant impact on exports and imports performance of oil-gas and non- oil-gas. Changes in import-export performance trigger sectoral fluctuations, including Mining and Manufacturing (textile, wood products). Meanwhile, the economic crisis in 1997-1998 reduced the performance of almost all sectors.

In the next section we present the analysis of stochastic frontier models and the sectoral efficiency both at national and regional level.

Table 3. Indonesia's Economic Policy		
PELITA	TARGET	POLICY
I (1969-1974)	The central point of development is Agriculture (food production), supported by clothing, infrastructure, and other sectors to support Agriculture.	Focus on policies to boost rice production (agricultural intensification) and infrastructure improvements, as well as the ease of investment
II (1974-1979)	Availability of food, clothing, housing, and infrastructure	Continuity of agricultural intensification and extensification, ease on Mining investment
III (1979 – 1984)	Focus on equity (world economic recession , 1980)	the policies for Industrial development
IV (1984 – 1989)	The agricultural sector towards food self-sufficiency and industrial development that can produce own machine	the policy of bank liberalization, Pakto 1988
V (1989-1994)	Food self-sufficiency and industrial development	Deregulation on trade policy (1992)
VI (1994-1998)	Food self-sufficiency and industrial development	-
RPJM	-	The era of low cost carrier in air transport



4.3. Analysis of Stochastic Frontier

By using panel data, we will outline the aggregate elasticity of input factor, while the level of efficiency will be analyzed on sectoral level. Generally, the level of sectoral efficiency changes over time or time varying, with an increasing trend.

4.3.1. Input Factor Analysis at National Level

This study emphasizes the role of input factors on producing the output, without analyzing their quality. This is consistent with the Neo Classic theory, which considers only the accumulation of input factor (capital stock and labor). The empirical results of Stochastic Frontier with Maximum Likelihood Estimator (MLE) method is:

$$\log Y = 3.43 + 0.20 \log K + 0.34 \log L$$

(0.28)*** (0.03)*** (0.04)***

$$\hat{\sigma}_s^2 = 0.10, \quad \hat{\gamma} = 0.97, \quad \hat{\mu} = 0.47, \quad \hat{\eta} = 0.02$$

$$\text{Log (likelihood)} = 309.37$$

The above is a result from panel data regression with nine economic sectors during 1985-2009. Nationally, the elasticity of capital and labor are 0.20 and 0.34 respectively, with a fairly high significance level (). These are consistent with Tjahjono and Anugrah (2006) that the role of labor is greater than the capital stock for Indonesian economy.

The labor elasticity of 0.34 indicates a 1% increase of labor will increase the output by 0.34%. Meanwhile, an increase of 1 unit of capital will increase output by 0.2 units, which mean to increase 1 unit of output require 5 additional units of capital. On the other hand, the Incremental Capital Output Ratio (ICOR) during 2008-2009 is 4-5, which represents the needs of 4-5 additional units of capital to increase the output by 1 unit.

4.3.2. Regional Input Factor Analysis

The results of regional input factor analysis are presented in Table 5.1. Depends on the characteristic of regional economy, the proportion of capital stock and labor factor varies across region.

Table 4.
Estimation Result of Regional Stochastic Frontier

Variable	National	Jabar	Jateng	Jatim	Bali
Constant	3.43***	4.80***	3.57**	9.29**	7.57**
Capital	0.20***	0.56***	0.45***	0.19**	0.37**
Labor	0.34***	0.04	0.42***	0.47**	0.21**
σ^2	0.1	3.3	1.49	0.23	1.76
γ	0.97	0.98	0.97	0.81	0.93
μ	0.47	-1.05	-2.41	0.87	1.72
η	0.02	0.007	0.02	0.007	0.003

Variable	Sumut	Sumsel	Sulsel	Kalsel
Constant	1.54**	25.44***	10.71*	7.23**
Capital	0.65***	0.17***	0.17*	0.46**
Labor	0.19***	0.10***	0.36*	0.24**
σ^2	7.06	1.52	0.98	0.98
γ	0.99	0.99	0.98	0.97
μ	-5.29	2.46	1.55	1.96
η	0.00	0.00	0.406	0.001

*) significant at $\alpha = 10\%$, **) significant at $\alpha = 5\%$, ***) significant at $\alpha = 1\%$

From the empirical test results above, the capital and the labor elasticity of output is positive for all regions. The positive sign of parameter $\hat{\eta}$ indicates the technical efficiency will increase over time. It also indicates an increasing efficiency level of production input over the observation period.

The results for East Java and South Sulawesi are similar with the national result, where the contribution of labor is dominant over the capital stock. However, in contrast to the national results, in West Java, Central Java, Denpasar, North Sumatera, South Sumatera and South Kalimantan, the capital stock contributes more than the labor.

Possible reason is the contribution of capital intensive sectors on these regions. In West Java, the contribution of Manufacturing is high⁴, while in South Kalimantan⁵ the Mining sector

4 Analysis of Efficiency Levels and Sectoral Business Cycle in West Java.

5 Analysis of Efficiency Levels and Sectoral Business Cycle in South Kalimantan.

dominates. In South Sumatera, the highest sectoral contribution is Mining, Manufacturing, and Electricity, Gas and Water⁶.

4.3.3. Sectoral Efficiency Analysis in National Level

Battese and Coelli (1992) stated that if the parameter $\hat{\eta}$ is positive, the technical efficiency will increase over time, likewise, the technical efficiency will decrease when η is negative. On national level, the estimated $\hat{\eta}$ is 0.02, which indicates an increase of sectoral efficiency during the period of observation.

In agricultural, the average level of efficiency is 53.08% with an increasing trend for the last 25 years (See Figure 8). The improvement in agricultural sector and the use of more efficient labor contribute to this increasing technical efficiency.

In Mining sector, the average level of efficiency is 88.65% during 1985-2009 (See Figure 9). This is the highest among all sectors. This high technical efficiency is possibly explained with the usage of more efficient Mining equipment, which is included in capital stock.

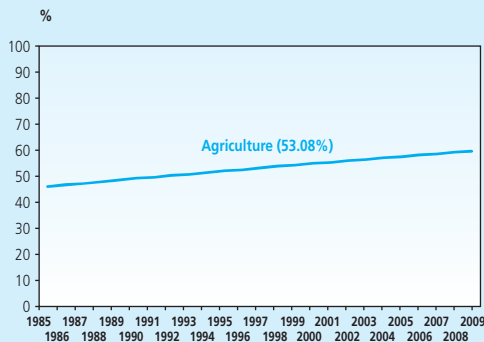


Figure 8.
Technical efficiency on Agriculture

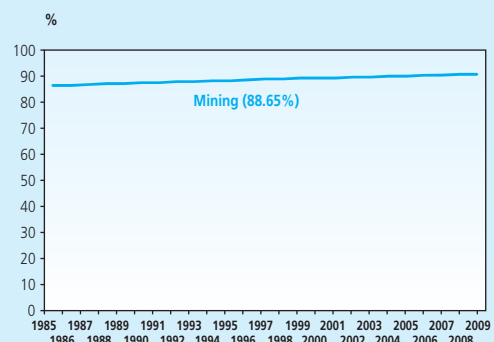


Figure 9.
Technical efficiency on Mining sector

The growing Manufacturing sector in Indonesia also records an increase of efficiency level. On average, the efficiency level of Manufacturing is 70.47% in the last 25 years. This is the second highest after Mining sector. Possible explanation for this fairly high efficiency is the higher skills of the labor; hence more efficient, and the use of more efficient equipment.

Meanwhile, the Electricity, Gas and Water record the average level of technical efficiency by 25.38%, which is the lowest among sectors during 1985-2009. Though increases over

⁶ Analysis of Efficiency Levels and Sectoral Business Cycle in South Sumatera.

time, the low efficiency level of this sector is possibly caused by the less efficient of its production equipment.

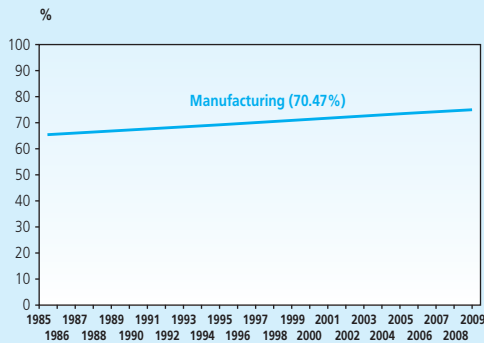


Figure 10.
Technical efficiency on Manufacturing

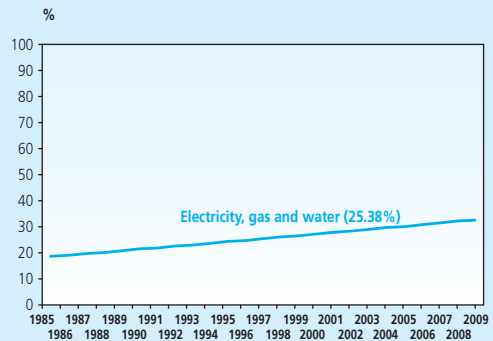


Figure 11.
Technical efficiency on Electric, Gas and Water

The average level of technical efficiency on Construction also increases over time. The technical efficiency in this sector is averagely 55.17% for the last 25 years. The efficiency increase in this sector is relatively higher as illustrated with steeper line in Figure 12.

Trading, Hotels and Restaurants records 58.50% of efficiency level for the same period; similar with the Construction sector. The efficiency level in this sector is also changing over time with a positive trend. The more efficient the labor, the higher the technical efficiency of this sector.

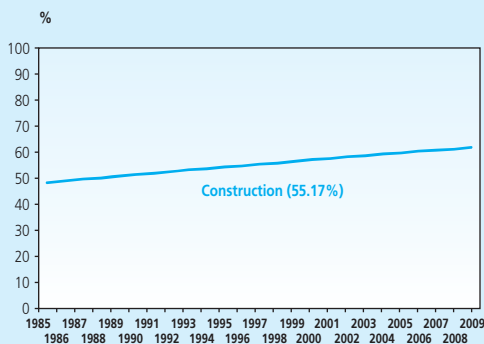


Figure 12.
Technical efficiency on Construction

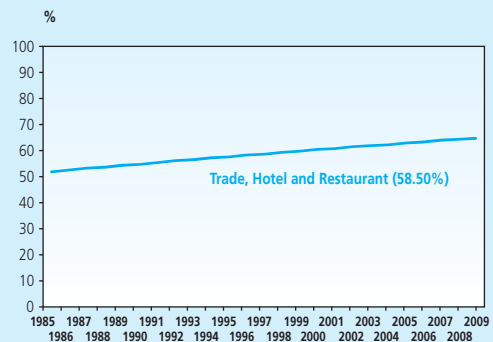


Figure 13. Technical efficiency Sector on Trade, Hotel and Restaurant

The efficiency level of Transport and Telecommunication changes over time with a positive trend. However, the average efficiency level is quite low, 43.40% during 1985-2009. The use of inefficient supporting equipment on Transport is possible reason for its low efficiency.

In financial sector, the average level of efficiency during the period 1985-2009 is 65.93%. Several financial policies including banking policy of Pakto 1988 increase the performance of this sector. In addition, the labor of this sector tends to be more efficient. Over time, the efficiency of Financial sector also increases.

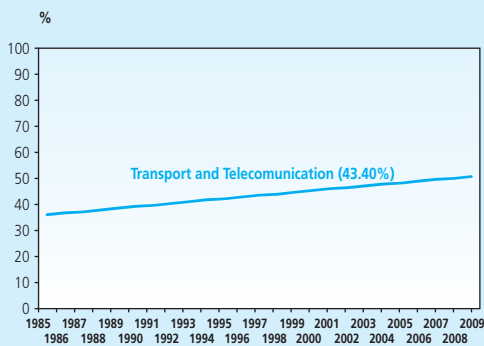


Figure 14. Technical efficiency on Transport and Telecommunication

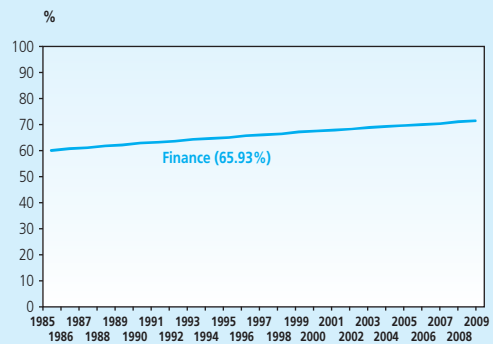


Figure 15. Technical efficiency on Financial Sector

Service sector also records a change in technical efficiency over time, with a positive trend. However, the average level of efficiency for this sector is low, 43.99%, for the last 25 years. Considering its changes rate, the technical efficiency of this sector increases rapidly, as indicated by steeper line in Figure 16.

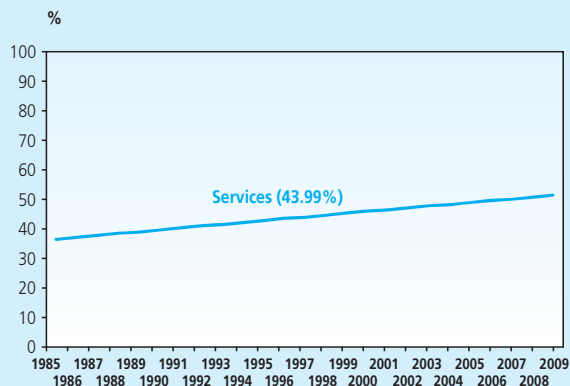


Figure 16. Technical efficiency on Service Sector

4.3.4. Analysis of Sectoral Efficiency at Regional Level

The value of technical efficiency for each sector in each region is presented in Table 5 below.

Sector	National	Jabar	Jateng	Jatim	Bali
Agriculture	53%	76%	77%	44%	0,1%
Mining	89%	95%	94%	45%	0,01%
Manufacturing	70%	67%	81%	44%	0,05%
Electricity, Gas and Water	25%	4%	17%	57%	0,00%
Construction	55%	45%	88%	23%	0,03%
Trade, Hotel and Restaurant	58%	56%	69%	54%	0,1%
Transport and Telecommunication	43%	16%	39%	21%	0,04%
Finance	66%	12%	77%	9%	0,03%
Services	44%	13%	28%	12%	0,05%

Sector	Sumut	Sumsel	Sulsel	Kalsel
Agriculture	76%	13%	64%	8%
Mining	96%	32%	50%	5%
Manufacturing	67%	14%	62%	4%
Electricity, Gas and Water	6%	0,5%	200%	4%
Construction	89%	8%	100%	3%
Trade, Hotel and Restaurant	58%	9%	88%	2%
Transport and Telecommunication	29%	3%	100%	2%
Finance	28%	5%	133%	1%
Services	15%	5%	5%	0,3%

Generally, the largest efficiency level is for Mining sector in national level as well as in some regions. West Java, Central Java, and North Sumatra record efficiency level above 90%. This indicates the use of input (capital and labor) to produce output in this sector has been optimal relative to other sectors.

Electricity, Gas, and Water records the lowest level of efficiency, nationally and in several region including West Java, Central Java, North Sumatra, and South Sumatra. Possible explanation is the over use of capital stock in producing inadequate output. East Java and South Sulawesi are the opposite cases where the EGW sector record the largest technical

efficiency; hence most efficient. Furthermore, In East Java⁷ the amount of labor has been considered to be optimal.

V. CONCLUSION

Since the regime of Orde Baru, the government has been trying to encourage the sectoral growth as a part of the overall economic development. Some fundamental policies have improved the sectoral performance, including intensification and extensification policy, which has increased the growth on Agricultural sector, especially food which contribute 60%. In financial sector, the enactment of Pakto 1988 and its continuous policy package had raised the financial sector performance, originated from banking. In Manufacturing, the policy, which focuses on the clothes availability and supported by industrial regulation, particularly on investment, has increased the TPT performance.

This paper provides two important findings. *First*, with additional information on the technical efficiency of input, the stochastic frontier model is better than the Solow-Swan model. The estimated shares of capital stock and labor are 0.20 and 0.34 respectively. This indicates the labor dominates of the use of capital stock in Indonesia's economy.

Second, all sectors experienced an increase of technical efficiency during period of 1985-2009. The Mining sector on average has the highest technical efficiency (88.65%), followed by Manufacturing sector (70.47%) and Financial sector (65.93%). While the Electricity, Gas, and Water recorded the lowest average efficiency by 25.38%, for the last 25 years.

These two findings require the government role to raise the level of efficiency especially in some sectors with low efficiency such as Electricity, Gas, and Water. Since the government dominate this sector, it is important to provide incentives for the state owned company to increase their efficiency.

This research calls for further research by examining the quality of input factor for each sector, such as human capital and the term structure of the capital. In addition, it is also important to include the sectoral Total Factor Productivity (TFP).

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APPENDIX: SPENCER CURVE

Spencer Moving Average is generally used as a data smoothing process, to display the underlying pattern (signal) while reducing the random fluctuation (noise). Spencer (1904) proposed a method to remove trends from time series data by using moving average line. Spencer formulated 15 periods moving average, with negative weight for the end of period. The Spencer Curve is particularly calculated based on the 5x5x4x4 moving average, which is the 4 periods moving average of original data is processed using 4 periods moving average, then 5 periods moving average and finally another 5 periods moving average by assigning weights of $-3/4$, $3/4$, 1 , $3/4$, and $-3/4$.

The following steps show how the Spencer Curve is formed:

1. Determine 4 periods moving average. The general form is as follows:

$$MA4_1 = (x_1 + x_2 + x_3 + x_4) / 4$$

$$MA4_2 = (x_2 + x_3 + x_4 + x_5) / 4$$

⋮

$$MA4_i = (x_i + x_{i+1} + x_{i+2} + x_{i+3}) / 4$$

Which $MA4_i$ is the moving average for 4 periods and x_i is the value of i time series data.

2. Determine the 4 periods moving average using $MA4$ data.

The general form is as follows:

$$MA4_4_i = (MA4_i + MA4_{i+1} + MA4_{i+2} + MA4_{i+3}) / 4$$

Or:

$$MA4_4_i = (x_i + 2x_{i+1} + 3x_{i+2} + 4x_{i+3} + 3x_{i+4} + 2x_{i+5} + x_{i+6}) / 4$$

Where $MA4_4_i$ is the moving average for 4 periods from $MA4$ data.

3. Determining the 5 periods Moving Average using $MA4_4$ data.

The general form is as follows:

$$MA5_4_4_i = (MA4_4_i + MA4_4_{i+1} + MA4_4_{i+2} + MA4_4_{i+3} + MA4_4_{i+4}) / 5$$

Or:

$$MA5_4_4_i = (x_i + 3x_{i+1} + 6x_{i+2} + 10x_{i+3} + 13x_{i+4} + 14x_{i+5} + 13x_{i+6} + 10x_{i+7} + 6x_{i+8} + 3x_{i+9} + x_{i+10}) / 80$$

Where $MA5-4-4_i$ is the moving average for 4 periods from $MA4_4$ data

4. Determining the 5 periods Moving Average using $MA5_4_4$ weighted data.

The general form is as follows:

$$MA_Spencer_i = (- 3/4) MA5_4_4_i + (3/4) MA5_4_4_{i+1} + (3/4) MA5_4_4_{i+2} + (3/4) MA5_4_4_{i+3} + (3/4) MA5_4_4_{i+4}$$

Or:

$$MA_Spencer_i = (- 3/320) x_i + (- 6/320) x_{i+1} + (- 5/320) x_{i+2} + (3/320) x_{i+3} + (21/320) x_{i+4} + (46/320) x_{i+5} + (67/320) x_{i+6} + (74/320) x_{i+7} + (67/320) x_{i+8} + (46/320) x_{i+9} + (21/320) x_{i+10} + (3/320) x_{i+11} + (- 5/320) x_{i+12} + (- 6/320) x_{i+13} + (- 13/320) x_{i+14}$$

The graph below shows the weighting in smoothing process on Spencer Moving Average method.

