RESEARCH ARTICLE

THE CONTRIBUTION OF TECHNOLOGY ON INDONESIAN ECONOMY:
NATIONAL, SECTORAL AND SPATIAL PERSPECTIVES.

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Abstract

This paper reports a research that aimed to analysis the contribution of technology on Indonesian economy at national, sectoral and spatial perspectives. Growth accounting decomposition technique was employed to calculate the contribution of factors production in the economy. The results showed that, on average, technology contribution to Indonesian economy, in term of TFP growth, was too small (8.79%) if compared to the TFP growth of other countries, especially in the developed countries. Even if compared with the contribution of other factors contribution, such as capital (74.1%) and labor (17.1%). Sectorally, the contribution of technology on Indonesian economy varied among sector. The highest and gave positive contribution were Other Services (72.6%) and Manufacturing (52.6%). The lowest and gave negative contribution were Agriculture (-55.1%) and Financial, Rental and Corporate Services (-38.7%). Spatially, the contribution of technology on Indonesian economy also varied. The highest and gave positive contribution were the Island of Java (47.9%) and Bali-Nusa Tenggara Island (30.4%). The lowest and gave negative contributions were Maluku-Papua Islands (-95.4%) and Kalimantan Island (-24.7%)

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accelerated to over 4–6% in recent years; Indonesian economy grows on average at 5.06 per cent per year at period between 1967- 2011 (Prihawantoro, et al, 2013).

Economic growth is the increase in the inflation-adjusted market value of the goods and services produced by an economy over time. It is conventionally measured as the percent rate of increase in real gross domestic product, or real GDP, usually in per capita terms. Growth is usually calculated in real terms to eliminate the distorting effect of inflation on the price of goods produced. Measurement of economic growth uses national income accounting (Bjork, G, J., 1999).

Economic growth has traditionally been attributed to the accumulation of human and physical capital and the increase in productivity arising from technological innovation (Lucas, R. E. 1988). Before industrialization technological progress resulted in an increase in the population, which was kept in check by food supply and other resources, which acted to limit per capita income, a condition known as the Malthusian trap (Galor, O, 2005; Clark, G., 2007). The rapid economic growth that occurred during the Industrial Revolution was remarkable because it was in excess of population growth, providing an escape from the Malthusian trap (Clark, G., 2007). Countries that industrialized eventually saw their population growth slow-down, a phenomenon known as the demographic transition. Most of the economic growth in the 20th century was due to increased output per unit of labor, materials, energy, and land (less input per widget). The balance of the growth in output has come from using more inputs. Both of these changes increase output. The increased output included more of the same goods produced previously and new goods and services (Kendrick, J. W. 1961). During the Industrial Revolution, mechanization began to replace hand methods in manufacturing, and new processes streamlined production of chemicals, iron, steel, and other products (Landes, D. S., 1969). Machine tools made the economical production of metal parts possible, so that parts could be interchangeable (Hounshell, D. A., 1984).

In Ricardian economics, the theory of production and the theory of growth are based on the theory or law of variable proportions, whereby increasing either of the factors of production (labor or capital), while holding the other constant and assuming no technological change, will increase output, but at a diminishing rate that eventually will approach zero. These concepts have their origins in Thomas Malthus’s theorizing about agriculture. Malthus’s examples included the number of seeds harvested relative to the number of seeds planted (capital) on a plot of land and the size of the harvest from a plot of land versus the number of workers employed (Bjork, G, J., 1999). Solow, R, M., (1956) and Swan, T. W., (1956) developed what eventually became the main model used in growth economics in the 1950s. This model assumes that there are diminishing returns to capital and labor. Capital accumulates through investment, but its level or stock continually decreases due to depreciation. Due to the diminishing returns to capital, with increases in capital/worker and absent technological progress, economic output/worker eventually reaches a point where capital per worker and economic output/worker remains constant because annual investment in capital equals annual depreciation. The Solow-Swan model is considered an exogenous growth model because it does not explain why countries invest different shares of GDP in capital nor why technology improves over time. Instead the rate of investment and the rate of technological progress are exogenous. The value of the model is that it predicts the pattern of economic growth once these two rates are specified. Its failure to explain the determinants of these rates is one of its limitations.

Unsatisfied with the assumption of exogenous technological progress in the Solow-Swan model, economists worked to endogenize technology in the 1980s. They developed the endogenous growth theory that includes a mathematical explanation of technological advancement (Lucas, 1988). This model also incorporated a new concept of human capital, the skills and knowledge that make workers productive. Unlike physical capital, human capital has increasing rates of return. Research done in this area has focused on what increases human capital, for instance education or technological change, for example innovation (Helpman, E., 2004). Three sources of economic growth were capital accumulation growth, labour growth and technological progress.

Solow’s (1957) paper was a landmark in the development of growth accounting. It was not the first paper to make an explicit decomposition of the sources of growth into contributions from factor inputs and from output per unit of total input. This had been done several times since the pioneering paper by Fabricant (1954), and with more detail, by Abramovitz (1956), and Kendrick (1961). But it was Solow (1957) that put the growth economics into growth accounting making clear its interpretation in terms of the distinction between shifts of and moves along the aggregate production function. Another major development in the practice of growth accounting was the publication of Jorgenson and Griliches (1967). These authors made revisions to the crude measure of TFP that reduced it from
1.6 to 0.1 per cent per year for the United States during 1945-1965. They focused on the measurement of capital services and produced a much more sophisticated index of capital input growth while also correcting labour quality for changes in education in a conceptually similar way to Denison (1962).

Previous research on technology contribution, using growth accounting method that have been published, among others, by Carré et al., (1975) on France, Ohkawa and Rosovsky (1972) on Japan, and Matthews et al. (1982) for the UK together with a succession of papers from the study of the United States culminating in Abramovitz and David (2001). As further useable historical national income accounts have become available, the country coverage of long-run historical growth accounting has expanded and papers in this tradition continue to be published. In recent years, these have included Schulze (2007) on Austria-Hungary, Lains (2003) on Portugal, and Prados de la Escosura and Roses (2007) on Spain.

Employing growth accounting method, the objective of this paper is to analysis on the contribution of technology on Indonesian economy at national, sectoral and spatial perspectives.

**Method of Analysis**:  
The method for calculating TFP, as a measure of technology contribution, in this research was growth accounting method. This method has been used in many countries to calculate TFP. So the results can easily be compared with other countries. Using the production function of Cobb-Douglas, as:

$$Q_t = A_t F_t (K_t, L_t)$$

where $Q_t$ is output in year-$t$, $K_t$ is Capital and $L_t$ is Labor. Hananto Sigit (2004) calculated TFP with formulating trans-log production function as:

$$\ln Q_t = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \beta_1 (\ln K_t)^2 + \beta_2 \ln K_t \ln L_t$$

$$+ \frac{1}{2} \beta_3 (\ln L_t)^2 + \beta_4 T \ln K_t + \beta_5 T \ln L_t + \frac{1}{2} \beta_6 T^2$$

If equation (2), differentiated toward time, then:

$$Q_t^* = \alpha_0 + \alpha_1 K_t^* + \alpha_2 L_t^* + \beta_1 (\ln K_t)^* K_t* + \beta_2 (K_t^* \ln L_t + L_t^* \ln K_t)$$

$$+ \beta_3 (\ln L_t^*) L_t^* + \beta_4 (T K_t^* + \ln K_t^*) + \beta_5 (T L_t^* + \ln L_t) + \beta_6 T$$

Equation (3) is a growth equation. Start notations, *, indicate a continuous growth. Equation (3) can be rewritten as

$$Q_t^* = TFP_t^* + S_t K_t^* + S_t L_t^*$$

Based on equation (4), the value of TFP can be calculated. As the equation (4) is a continuous equation, but the values needed are discrit TFP then the equation of TFP growth reformulated as:

$$TFPG_t = \frac{1}{2} [(TFP_t^* + TFP_{t-1}^*)]$$

$$= (\ln Q_t - \ln Q_{t-1}) - \frac{1}{2} (S_t + S_{t-1})(\ln K_t - \ln K_{t-1})$$

$$- \frac{1}{2} (S_t + S_{t-1})(\ln L_t - \ln L_{t-1})$$

With the equation (5), the TFP growth at year can easily be calculated.

Data needed for this study were: 1. Gross Domestic Product and/or Gross Regional Domestic Product, 2. Capital Stock, 3. Labour, 4. Wage/Salary, and 5. Depreciation. Data adjusted by excluding indirect tax, so data of GDP and GRDP are data at factors cost. For national analysis data are available for the year of 1967-2011, for sectoral analysis data are available for the year of 1977-2007 and for spatial analysis data are available for year 2002-2010.

After data adjustment process, steps in calculation TFP growth using growth accounting method are as follows:

1. Calculate labor income share year-$t$ (LIS$_t$) with formula:

$$LIS_t = \frac{Wage/Salary at year-t}{GDP year-t}$$

2. Calculate average labor income share at year-$t$ (LISA$_t$):

$$LISA_t = \frac{1}{2} (LIS_t + LIS_{t-1})$$

where:

LIS$_t$ = Labor income share at year-$t$

LIS$_{t-1}$ = Labor income share at year $t-1$

3. Calculate capital income share at year-$t$ (KIS$_t$) with formula:

$$KIS_t = 1 - LIS_t$$
4. Calculate average capital income share at year- t (KISA):

\[ KISA_t = \frac{1}{2} (KIS_t + KIS_{t-1}) \]  \hspace{1cm} (9)

where:

- \( KIS_t \) = Capital income share at year-t
- \( KIS_{t-1} \) = Capital income share at year- t-1

5. Calculate the rate of economic growth at year-t (EG):

\[ EG_t = \frac{ln GDP_t - ln GDP_{t-1}}{ln GDP_t} \times 100 \]  \hspace{1cm} (10a)

where:

- \( GDP_t \) = GDP at constant price at year-t
- \( GDP_{t-1} \) = GDP at constant price at year- t-1

For sectoral calculation:

\[ SG_i = \frac{(ln VAi_i - ln VAi_{i,t})}{ln VAi_t} \times 100 \]  \hspace{1cm} (10b)

where:

- \( VAi_i \) = Value-Added sector i at constant price at year-t
- \( VAi_{i,t} \) = Value-Added sector i at constant price at year- t-1

6. Calculate the rate of capital stock growth at year -t (KG):

\[ KG_t = (ln K_t - ln K_{t-1}) \times 100 \]  \hspace{1cm} (11)

where:

- \( K_t \) = Capital stock at year-t
- \( K_{t-1} \) = Capital stock at year- t-1

7. Calculate weighted average the growth rate of capital stock at year- t (KGA):

\[ KGA_t = \frac{1}{2} (KIS_t + KIS_{t-1}) \times (ln K_t - ln K_{t-1}) \times 100 \]  \hspace{1cm} (12)

8. Calculate the growth rate of labor at year-t (LG):

\[ LG_t = (ln L_t - ln L_{t-1}) \times 100 \]  \hspace{1cm} (13)

where:

- \( L_t \) = Labor at year-t
- \( L_{t-1} \) = Labor at year- t-1

9. Calculate weighted average of the labor growth at year-t (LGA):

\[ LGA_t = \frac{1}{2} (LIS_t + LIS_{t-1}) \times (ln L_t - ln L_{t-1}) \times 100 \]  \hspace{1cm} (14)

10. The growth rate of TFP at year-t (TFPG) can be calculated as follow:

\[ TFP_{t-1} = EG_t - KGA_t - LGA_t \]  \hspace{1cm} (15)

Further more, contribution of factors such as labor, capital and TFP on economic growth are calculated as:

11. Contribution of capital = \[ \frac{Equation (12)}{Equation (10)} \times 100 \]  \hspace{1cm} (16)

12. Contribution of labor = \[ \frac{Equation (14)}{Equation (10)} \times 100 \]  \hspace{1cm} (17)

13. Contribution of TFP = \[ \frac{Equation (15)}{Equation (10)} \times 100 \]  \hspace{1cm} (18)

**Results and Discussion:-**

Table 1: presents the contribution of factors production in Indonesian economy at national level. On average Indonesian economy grows at 5.06 per cent per year for period 1976 to 2011. The highest economic growth happened at oil boom phase (7.62%) that occurred between 1976-1981. Negative growth happened at multi-crisis phase (-1.03%) that occurred between 1997-2001. Technology contribution, indicated by TFP, nationally was only 08.79 per cent. It was too small compared to the contribution of technology on American economy (26 % average from 1979-1979), and at private business reached 52 per cent in raverage at period 1948-1996 as well as other advanced countries (Hulten, 2000). In Austria, Schulze (2007) found that technology contribution was 14.4 per cent in period of 1870-1890 and 30.5 per cent in 1891-1910. Broadberry (1998) reported that technology contribution to German economy was 32.3 per cent for the period of 1871-1991 and 33.5 per cent in period of 1892-1111. Craft (1995) and Mattews et al (1982) reported that contribution of technology on Great Britain economy was, on average for period 1700-1913, 33.9 per cent. In Italy Rossi et al (1992) reported that TFP growth was 32.2 per cent for period of 1920-1973. As Kranzt and Schon (2007) reported, the contribution of technology on Sweden economy was 22.3 per cent in the period of 1850-1973. This small percentage of technology contribution on Indonesian economy were also confirmed by other studies. For instance, Aswicahyono et.al. (1996) found that the TFP growth in the manufacturing sector was only positive for the periods 1976-1981, 1982-1985, and 1986-1991, findings which
were also confirmed by Abimanyu (1995) and Osada (1994). It is also too small compared to contribution of labour (17.1%) and capital (74.1%). In recession phase, the contribution of technology on Indonesian economy was, even, negative (-95.36%). The highest contribution of technology in Indonesian economy occurred in multi-crisis phase (74.32%) because of negative economic growth, followed by economic revitalization phase (26.3%) and oil-boom phase (8.45%).

| Phase            | Year       | PDB Growth | Contribution to PDB Growth (%) |
|------------------|------------|------------|--------------------------------|
|                  |            | Capital    | Labour | TFP                  |
| Oil Boom         | 1976-1981  | 7.62 (100%)| 72.46  | 19.09 | 8.45 |
| Recession        | 1982-1986  | 4.24 (100%)| 161.42 | 33.94 | -95.36 |
| Deregulation     | 1987-1996  | 6.67 (100%)| 72.15  | 17.05 | 10.80 |
| Multi-crisis     | 1997-2001  | -1.03 (100%)| 21.86  | 3.82 | 74.32 |
| Economic Revitalization | 2002-2011 | 5.38 (100%)| 59.62  | 14.08 | 26.30 |
| Indonesia        | 1976-2011  | 5.06 (100%)| 74.13  | 17.07 | 8.79 |

**Source:** Prihawantoro, S., et al (2013).

| Sector                              | PDB Growth | Contribution to PDB Growth (%) |
|-------------------------------------|------------|--------------------------------|
|                                     |            | Capital | Labour | TFP                  |
| Agriculture                         | 3.14 (100%)| 4.51 (143.6%) | 0.36 (11.5%) | -1.73 (-55.1%) |
| Mining and Quarrying                | 1.48 (100%)| -0.17 (-11.5%) | 1.51 (102.0%) | 0.14 (9.5%) |
| Manufacturing                       | 8.26 (100%)| 2.57 (31.1%)  | 1.35 (16.3%)  | 4.34 (52.6%) |
| Electricity, Gas and Drinking Water | 9.87 (100%)| 7.09 (71.8%)  | 3.08 (31.2%)  | -0.30 (-3.0%) |
| Construction                        | 6.30 (100%)| -0.21 (-3.3%) | 6.21 (98.7%)  | 0.29 (4.6%) |
| Trade, Hotel and Restaurant         | 4.94 (100%)| 5.29 (107.1%) | 0.95 (19.2%)  | -1.30 (-26.3%) |
| Transportation and Communication    | 7.77 (100%)| 3.63 (46.7%)  | 1.85 (23.8%)  | 2.29 (29.5%) |
| Financial, Rental and Corporate Services | 7.02 (100%)| 6.22 (88.6%)  | 3.52 (50.1%)  | -2.71 (-38.7%) |
| Other Services                      | 3.98 (100%)| -1.57 (-39.4%) | 2.66 (66.7%)  | 2.89 (72.6%) |
| Indonesia                           | 5.08 (100%)| 2.79 (74.13%) | 0.73 (17.07)  | 1.56 (8.79) |

**Source:** Prihawantoro, S., et al (2009).

Sectorally, the contribution of technology on Indonesian economy for period of 1977-2007 is presented in Table 2. The highest contribution was occurred at Other Services (72.6%), followed by Manufacturing (52.6%) and Transportation and Communication (29.5%). Negative contribution occurred in Agriculture (-55.1%), followed by Financial, Rental and Corporate Service (-38.7%), Trade, Hotel and Restaurant (-26.3%) and Electricity, Gas and Drinking Water (-3.0%). In terms of the TFP by industry, Timmer (1999) estimated that TFP performance varied greatly across industries. During the period 1975-1981, TFP growth rates ranged from very high (12%) in the wood industry to low (-5%) for chemicals. In 1982-1985, the basic metals industry performed best (14%), while TFP in nonmetallic minerals slumped (-8%). The log export ban seems to have had an adverse impact on efficiency in the
wood industry, with TFP growth becoming negative (-2%). The period 1986-90 showed annual TFP growth rates of over 5 per cent for all industries except chemicals. Furthermore, between 1991 and 1995, TFP levels appeared to be rising very rapidly particularly for food, beverages, tobacco and the metal product and machinery industries, while there was a marked slump in the basic metal industry. Therefore, all industries - except chemicals and non-metallic minerals - experienced a TFP growth of at least 2 per cent between 1975 and 1995. The low level of TFP growth in the area of non-metallic minerals (especially cement manufacturing) was perhaps due to government regulations aimed at improving efficiency levels in this industry.

Table 3: Contribution of Factors Production on Indonesian Economy, Regional Dimension, 2002-2010.

| Region/Island       | PDB Growth | Contribution to PDB Growth (%) |
|---------------------|------------|--------------------------------|
|                     |            | Capital | Labour | TFP    |
| Sumatera            | 4.57 (100) | 2.88 (63.0) | 0.88 (19.3) | 0.81 (17.7) |
| Java                | 5.42 (100) | 2.30 (42.5) | 0.52 (9.6) | 2.60 (47.9) |
| Kalimantan          | 3.65 (100) | 3.92 (107.3) | 0.64 (17.4) | -0.90 (-24.7) |
| Sulawesi            | 6.41 (100) | 3.69 (57.5) | 1.11 (17.4) | 1.61 (25.1) |
| Bali-Nusa Tenggara | 5.01 (100) | 2.51 (50.2) | 0.97 (19.4) | 1.73 (30.4) |
| Maluku-Papua        | 3.42 (100) | 4.65 (135.9) | 2.03 (59.5) | -3.26 (-95.4) |
| Indonesia           | 5.08 (100) | 2.79 (74.13) | 0.73 (17.07) | 1.56 (8.79) |

Source: Prihawantoro, S., et al., (2013).

Table 3: provides results at regional perspective, based on 6 big Island aggregations. Technology contribution on Indonesian economy was 8.79%. Technology contribution varies among Island; there were positive contribution and negative contributions. There were two Islands in which the contributions of technology were negative, namely in Kalimantan (-0.24.7%) and in Maluku-Papua (-95.4%). Island with positive technological contributions were Sumatera (17.7%), Java (47.9%), Sulawesi (25.1%) and Bali-Nusa Tenggara (30.4%). Java Island had the highest of percentage in technology contribution on Indonesia economy. It is followed by Bali-Nusa Tenggara (30.4%), Sulawesi (25.1%) and Sumatera (17.7%). But, on average, the contribution of technology in Indonesian economy still very small.

Conclusion:

From the results and discussion, it could be concluded that, firstly, the contribution of technology on Indonesian economy (8.79%) was relatively small compared to the contribution of technology on developed countries. It also small compared to the contribution other factors of production, such as capital (74.13%) and labor (17.7%). Secondly, the contribution of technology on Indonesian economy sectorally varied from negative to positive. Negative contribution was given by Agriculture (-55.1%), Financial, Rental and Corporate Service (-38.7%), Trade, Hotel and Restaurant (-26.3%) and Electricity, Gas and Drinking Water (-3.0%). Positive contribution was given by Other Services (72.6%), Manufacturing (52.6%), Transportation and Communication (29.5%), Mining and Quarrying (9.5%) and Construction (4.6%). Thirdly, spatially the contribution of technology on Indonesian economy also varied among Islands. Maluku-Papua Island give negative contribution (-95.4%) as well as Kalimantan Island (-24.7%). Other Island that contributes positively was Java Island (47.9%), Bali-Nusa Tenggara Island (30.4%), Sulawesi Island (25.1%) and Sumatera Island (17.7%).
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