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Technology Contribution to the Indonesian Regional Economy

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ABSTRACT

This paper aimed to analyze the contribution of technology to Indonesian regional economy. Growth accounting method was employed using data on GDRP, regional/provincial capital accumulation and regional/provincial employment from during the year of 2002 to 2010. The contribution of factors and technology to Indonesian regional economy were analyzed and presented. The results show that the contribution of technology to Indonesian economy, on average during 2002-2010 at national level, was 24.4 per cent. Spatially, the contribution of technology to Indonesian regional economy varies among Island as well as among provinces within island. The highest contribution of technology was by Java Island (39.77%) followed by Bali-Nusa Tenggara Island (35.39%). The lowest technology contribution was in Kalimantan Island (12.82%). In Java Island, the highest contribution of technology was in the East Java Province (49.63%) and the lowest contribution was in the Special Province of Yogyakarta (28.35%). In Bali-Nusa Tenggara, the highest contribution of technology was in East Nusa Tenggara Province (51.71%), and the lowest contribution was in the Province of Bali (25.89%). In Kalimantan Island, the highest contribution of technology was in West Kalimantan Province (41.91%) and the lowest contribution was in South Kalimantan Province (24.25%).

JEL Classification: O11; O33; P25.

Keywords: Contribution of Technology; Regional Economy; Island; Provinces.

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1. INTRODUCTION

Situated between the Indian and Pacific oceans, Indonesia is the world's largest island country, with more than thirteen thousand islands (United Nations Economic and Social Council, 2012). At 1,904,569 square kilometres (735,358 square miles), Indonesia is the world's 14th-largest country in terms of land area and world's 7th-largest country in terms of combined sea and land area. It has an estimated population of over 260 million people and is the world's fourth most populous country, the most populous Austronesian nation, as well as the most populous Muslim-majority country. The world's most populous island of Java contains more than half of the country's population (World Bank, 2016). Indonesia has 33 provinces, three of which have Special Administrative status, such as Special Province of Aceh, now Nangroe Aceh Darussalam, Special Province of Capital City of Jakarta and Special Province of Yogyakarta. Muchdie (2011) divided Indonesian spatial structure into 6 Big-Island, namely Sumatera: 10 provinces, Java: 6 provinces, Kalimantan: 4 provinces, Bali-Nusa Tenggara Barat: 3 provinces, Sulawesi: 6 provinces and Maluku-Papua: 4 provinces. Its capital and most populous city is Jakarta. The country shares land borders with Papua New Guinea, East Timor, and the eastern part of Malaysia. Other neighboring countries include Singapore, the Philippines, Australia, Palau, and the Indian territory of the Andaman and Nicobar Islands. Despite its large population and densely populated regions, Indonesia has vast areas of wilderness that support the world's second highest level of biodiversity. The country has abundant natural resources like oil and

natural gas, tin, copper and gold. Agriculture mainly produces rice, palm oil, tea, coffee, cacao, medicinal plants, spices and rubber (0EC, 2014).

Indonesia consists of hundreds of distinct native ethnic and linguistic groups. The largest – and politically dominant – ethnic group is the Javanese. A shared identity has developed, defined by a national language, ethnic diversity, religious pluralism within a Muslim-majority population, and a history of colonialism and rebellion against it. Indonesia's national motto, "Bhinneka Tunggal Ika" ("Unity in Diversity" literally, "many, yet one"), articulates the diversity that shapes the country (Hall, 1991). 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 per cent 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, 1999).

The Indonesian economy is the world's 16th largest by nominal GDP and the 8th largest by GDP at PPP, and considered as Emerging markets and Newly industrialized country. As reported by Muchdie (2016), during 1976-2013, on average Indonesian GDP grows at 5.1 per cent per year. There was no spatial change in economic structure in term of GDRB among islands during that period. Even, disparities between Java and the rest of Indonesia became worse and worse. For instance, in 1983, the share of Java Island to Indonesian GDP was 58.19 % and in 2013 has increased to 61.24%. Meanwhile the share of Sumatera Island has decreased from 25.10% in 1983 to 21.15%. Kalimantan Island also experienced decreasing share from 9.63% in 1983 to 8.13% in 2013. The share of Sulawesi Island, Bali-Nusa Tenggara Island and Maluku-Papua Islands experienced in increasing share. In term of growth of GDRB, Sulawesi Island had the highest growth during that period, in average of 6.97%, followed by Maluku-Papua Island (6.02%), Bali-Nusa Tenggara Island, (5.95%), Java Island (5.66%), Kalimantan Island (4.81%) and Sumatera Island (4.79%).

Economic growth has traditionally been attributed to the accumulation of human and physical capital and the increase in productivity arising from technological innovation (Lucas, 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, 2005; Clark, 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, 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, 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, 1969).

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, 1999). Solow, (1956) and Swan (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, 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 & 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 Carre et. al., (1975) on France, Ohkawa & 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 & 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 & Roses (2007) on Spain. Muchdie, et al, (2016) reported a study on the contribution of technology on Indonesian economy both at national and sectoral levels. Employing growth accounting method, the objective of this paper is to report of analysis on the contribution of technology to Indonesian regional economy at Island and Provincial levels.

2. METHODOLOGY

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-Douglass, as:

$$Q_t = A_t\, F\,(K_t\, L_t) \qquad (1)$$

Where Q_t is output in year-t, K_t is Capital and L_t is Labor. TFP with formulating trans-log production function as:

$$\ln Q_t = \ln\alpha_0 + \alpha_t T + \alpha_k \ln K_t + \alpha_l \ln L_t + \tfrac{1}{2}\beta_{kk}(\ln K_t)^2 + \beta_{kl}\ln K_t \ln L_t + \tfrac{1}{2}\beta_{ll}(\ln L_t)^2 + \beta_{kT} T \ln K_t + \beta_{Tl} T \ln L_t + \tfrac{1}{2}\beta_{TT} T^2 \qquad (2)$$

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

$$Q_t^* = \alpha_t + \alpha_k K_t^* + \alpha_l L_t^* + \beta_{kk}(\ln K_t) K_t^* + \beta_{lk}(K_t^* \ln L_t + L_t^* \ln K_t) + \beta_{ll}(\ln L_t) L_t^* + \beta_{kT}(TK_t^* + \ln K_t) + \beta_{lT}(TL_t^* + \ln L_t) + \beta_{TT} T \qquad (3)$$

Equation (3) is a growth equation. Start notasion, *, indicate a continum growth. Equation (3) can be rewritten as:

$$Q_t^* = TFP_t^* + S_k K_t^* + S_l L_t^* \qquad (4)$$

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

$$TFPG_t = \tfrac{1}{2}(TFP_t^* + TFP_{t-1}^*)$$
$$= (\ln Q_t - \ln Q_{t-1}) - \tfrac{1}{2}(S_{kt} + S_{kt-1})(\ln K_t - \ln K_{t-1}) - \tfrac{1}{2}(S_{lt} + S_{lt-1})(\ln L_t - \ln L_{t-1}) \qquad (5)$$

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

Data needed for this study were: 1. Gross Domestic Regional Product, 2. Regional Capital Stock, 3. Regional Labour, 4. Wage/Salary, and 5. Depreciation.

Data are adjusted by excluding indirect tax, so data of GRDP are data at factors cost. For national analysis data are available for the year of 2002-2010, for regional (Islands/Provinces) analysis data are available for year 2002-2010 (Socia Prihawantoro, et al., 2013).

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= Wage/Salary at year- t / GDP year- t (6)

2. Calculate average labor income share at year-t *($LISA_t$)*:

$LISA_t = ½ (LIS_t + LIS_{t-1})$ (7)

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:

$KIS_t = 1 – LIS_t$ (8)

4. Calculate average capital income share at year- t ($KISA_t$):

$KISA_t = ½ (KIS_t + KIS_{t-1})$ (9)

where: KIS_t = Capital income share year-t; KIS_{t-1}= Capital income share year t-1

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

$EG_t = (\ln GDP_t – \ln GD_{t-1}) \times 100$ (10)

where: GDP_t = GDP at constant price at year-t; GDP_{t-1} = GDP at constant price at year t-1

For sectoral calculation:

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

$KG_t = (\ln K_t – \ln K_{t-1}) \times 100$ (11)

where : K_t = Capitak stock at year-t; K_{t-1} = Capital stock at yeat- t-1

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

$KGA_t = ½ (KIS_t + KIS_{t-1}) \times (\ln K_t – \ln K_{t-1}) \times 100$ (12)

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

$LG_t = (\ln L_t – \ln L_{t-1}) \times 100$ (13)

where: L_t = Labor at year-t; L_{t-1} = Labor at year- t-1

9. Calculate weigthed average of the labor growth at year-t (LGA_t) :

$LGA_t = ½ (LIS_t + LIS_{t-1}) \times (\ln L_t – \ln L_{t-1}) \times 100$ (14)

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

$$TFPG_t = EG_t - KGA_t - LGA_t \quad (15)$$

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

$$11.\ \text{Contribution of capital} = \frac{\text{Equation (12)}}{\text{Equation (10)}} \times 100 \quad (16)$$

$$12.\ \text{Contribution of labor} = \frac{\text{Equation (14)}}{\text{Equation (10)}} \times 100 \quad (17)$$

$$13.\ \text{Contribution of TFP} = \frac{\text{Equation (15)}}{\text{Equation (10)}} \times 100 \quad (18)$$

3. RESULTS AND DISCUSSION

On average during 2002-2010, the contribution of technology, in-term of TFP growth, to Indonesian economic growth was 24.40 per cent. This contribution was higher than the contribution of labour (15.11%), but lower than the contribution of capital (64.49%). The dynamics of factors contribution to Indonesian economy is depicted in Figure 1 (left panel). In the year 2002, technology contribution to Indonesian economy was the smallest, but in 2003, the contribution of technology was the same as with capital contribution. In 2004 and 2005, the contribution of technology was the highest among factors in Indonesian economy. But eventually decreasing and reach the lowest in 2009.

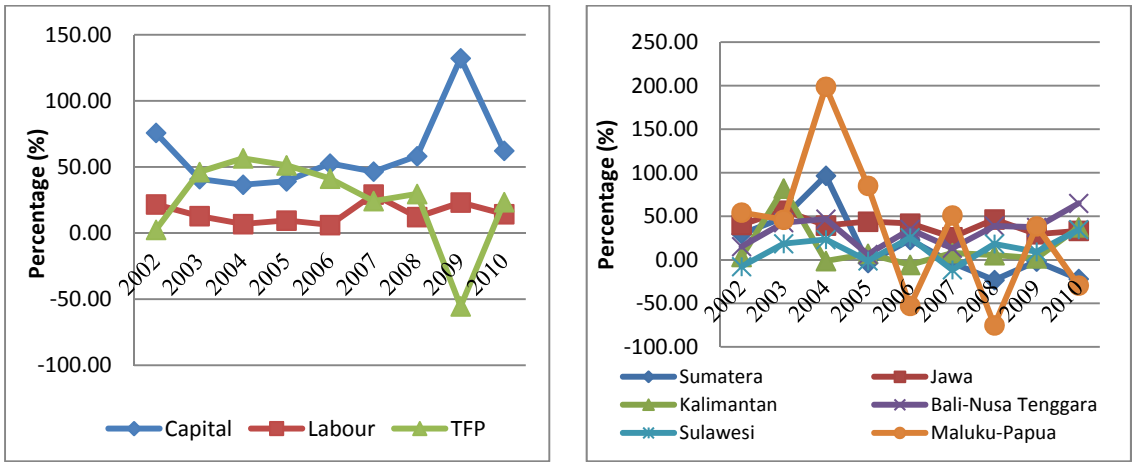

Figure 1.
Factors and Technology Contribution to Indonesian Regional Economy

Spatially among Island, on average during 2002-2010, the highest contribution of technology occurred in Java Island (39,77%) followed by Bali-Nusa Tenggara Island (35.39%), Sumatera Island (16,73%), Maluku-Papua (15.50%), Sulawesi Island (13.72%) and Kalimantan Island (12.82%). Figure 1 (right panel) presents the fluctuation of technology contribution among Island. The highest fluctuation occurred in Maluku-Papua Island. The most consistence and stable contribution of technology occurred in Java Island economy, followed by Bali-Nusa Tenggara Island. In Sumatera Island economy, the contribution of technology to economic growth was the smallest (13.56%) among the contribution of factors of production, such as labour (22.07%) and capital (64.33%). Figure 2 (left panel) depicts the contribution of factors in Sumatera Island economy. In 2003, the contribution of technology was the highest among factors, but the year of 2005, 2007-2010 the contribution of technology was the lowest among factors.

Spatially among provinces in Sumatera Island, 2 provinces gave negative technology contribution, namely Nangro Aceh Darussalam (-32.61%) and the Province of Riau Islands (-4.78%). The province that gave highest technology contribution to the province economy was the Province of West Sumatera (54.38%), followed by Jambi Province (44.89%) and Bengkulu Province (42.93%). In the Province of Lampung, the contribution of technology to

province economy was 31.13 per cent. In North Sumatera Province, the contribution of technology to province economy was 28.17 per cent. In the Province of South Sumatera, the contribution of technology was 27.47 per cent and in Riau Mainland Province was 16.47 per cent.

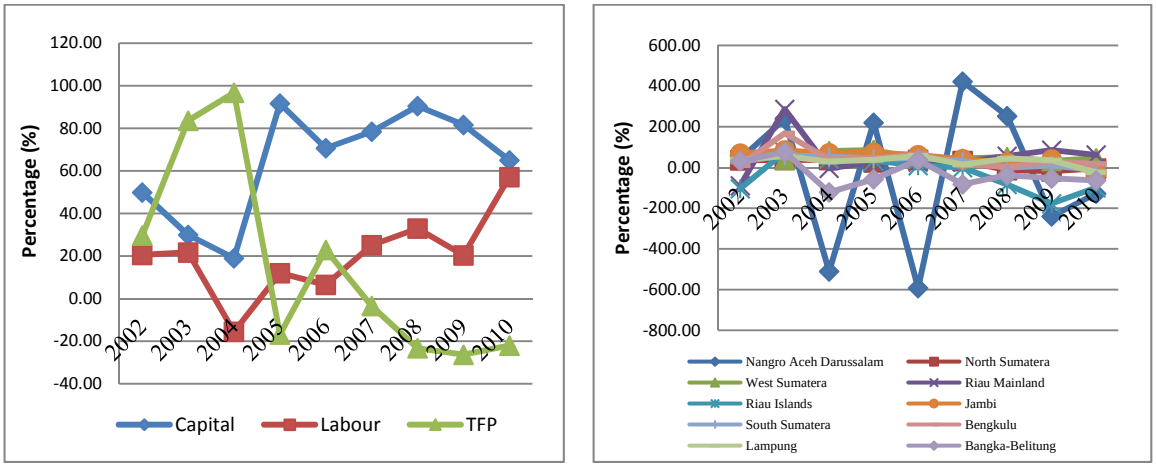

Figure 2.
Factors and Technology Contribution to Sumatera Island Economy

In Bangka-Belitung Province, the contribution of technology to it province economy was the lowest (9.97%) after the Province of Riau Islands and Nangroe Aceh Darussalam. Figure 2 (right panel) presents the graph of technology contribution to the province economy in Sumatera Island. In Java Island economy, the contribution of technology to economic growth was 39.77 per cent; that was lower than the contribution of capital (46.87%), but it was higher than the contribution of labour (13.40%). Figure 3 (left panel) depicts the contribution of factors in Java Island economy. In 2003 and 2008, the contribution of technology was the highest among factors, but the year of 2004-2007 and 2009-2010 the contribution of technology was the lowest among factors.

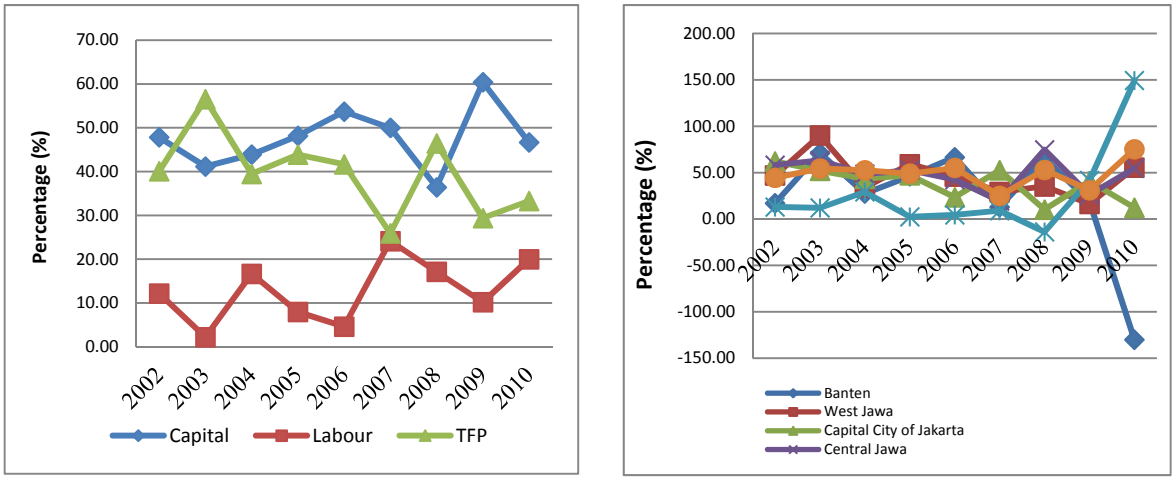

Figure 3.
Factors and Technology Contribution to Java Island Economy

Spatially among provinces in Java Island, all provinces gave positive technology contribution. The province that gave highest technology contribution to the province economy was the East Java Province (49.63%), followed by Central Java Province (48.61%) and West Java Province (44.90%). In Capital City of Jakarta, the contribution of technology to province economy was 37.19 per cent. In Banten Province, the contribution of technology was 31.30 per cent and in the Special Province of Yogyakarta, the contribution of technology to it province economy was 28.35 per cent. Figure 3 (right panel) presents the graph of technology contribution to the province economy in Java Island. In Kalimantan Island economy, the contribution of technology to economic growth was only 12.82

per cent; that was the lowest the contribution of factors of production; the contribution of capital was 69.47 per cent and the contribution of labour was 17.82 per cent. Figure 4 (left panel) depicts the contribution of factors in Kalimantan Island economy. In 2003 and 2008, the contribution of technology was the highest among factors, but in other years the contribution of technology was in between the contribution of capital and the contribution of labour in Kalimantan economy.

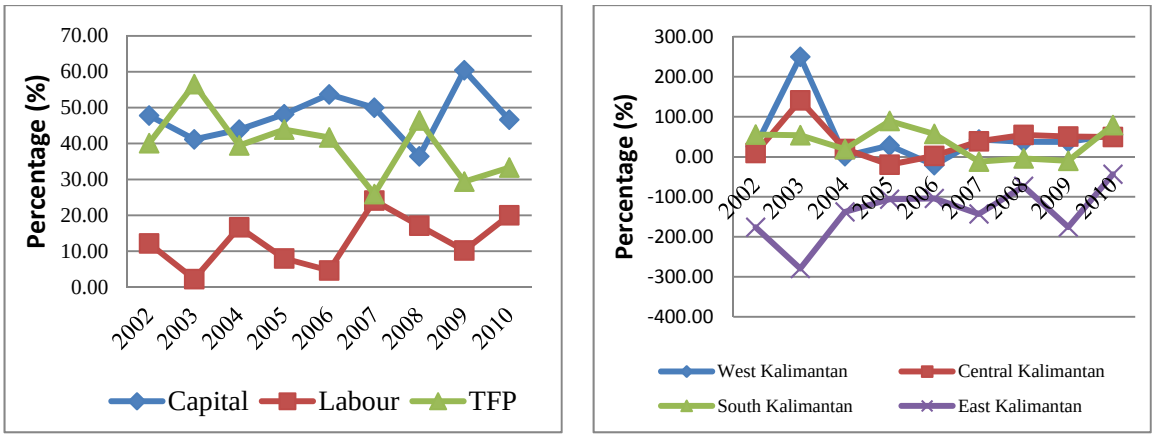

Figure 4.
Factors and Technology Contribution to Kalimantan Island Economy

Spatially among provinces in Kalimantan Island, one province, namely East-Kalimantan Province gave negative technology contribution; along the year during 2002-2010, the contributions of technology were negative. The province that gave highest technology contribution to the regional economy was the West Kalimantan Province (41.91%), followed by Central Kalimantan Province (36.88%) and South Kalimantan Province (24.25%). Figure 4 (right panel) presents the graph of technology contribution to the province economy in Kalimantan Island. In Bali-Nusa Tenggara Island economy, the contribution of technology to economic growth was 35.39 per cent; it was lower than the contribution capital (53.89) but higher than the contribution of labour (10.65%). Figure 5 (left panel) depicts the contribution of factors in Bali-Nusa Tenggara Island economy. In three years, 2002, 2005 and 2007, the contribution of technology was the lowest among factors, but in other years, the contribution of technology was in between the contribution of capital and the contribution of labour in Bali-Nusa Tenggara economy. Spatially among provinces in Bali-Nusa Tenggara Island, all provinces gave positive technology contribution. The province that gave highest technology contribution to the regional economy was the East Nusa Tenggara Province (51.71%), followed by West Nusa Tenggara Province (28.25%) and the Province of Bali (25.89%). Figure 5 (right panel) presents the graph of technology contribution to the province economy in Bali-Nusa Tenggara Island.

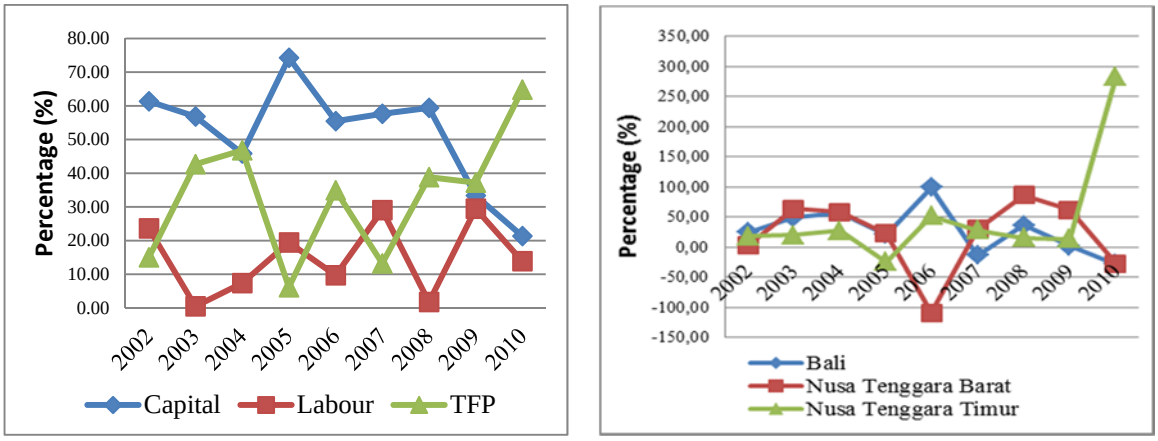

Figure 5.
Factors and Technology Contribution to Bali-Nusa Tenggara Island Economy

In Sulawesi Island economy, the contribution of technology to economic growth was 13.72 per cent; it was the lowest contribution among factors, where the contribution of capital was 67.47 per cent and the contribution of labour was 18.78 per cent. Figure 6 (left panel) depicts the contribution of factors in Sulawesi Island economy. In three years, 2003, 2006 and 2010, the contribution of technology was higher than the contribution of labour, but in other years, the contribution of technology was the lowest contribution to Sulawesi Island economy.

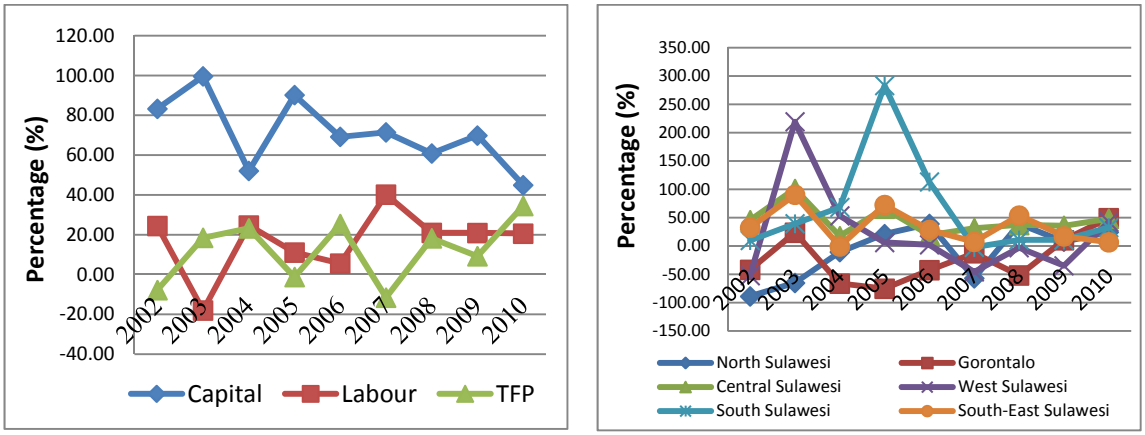

Figure 6.
Factors and Technology Contribution to Sulawesi Island Economy

Spatially among provinces in Sulawesi Island, all provinces gave positive technology contribution, except the Province of Gorontalo (-22.29%) and West Sulawesi Province (-9.87%) that gave negative technology contribution. The province that gave highest technology contribution to the regional economy was Central Sulawesi Province (43.23%), followed by South-East Sulawesi Province (35.17%) and North-Sulawesi Province (1.93%). Figure 6 (right panel) presents the graph of technology contribution to the province economy in Sulawesi Island.

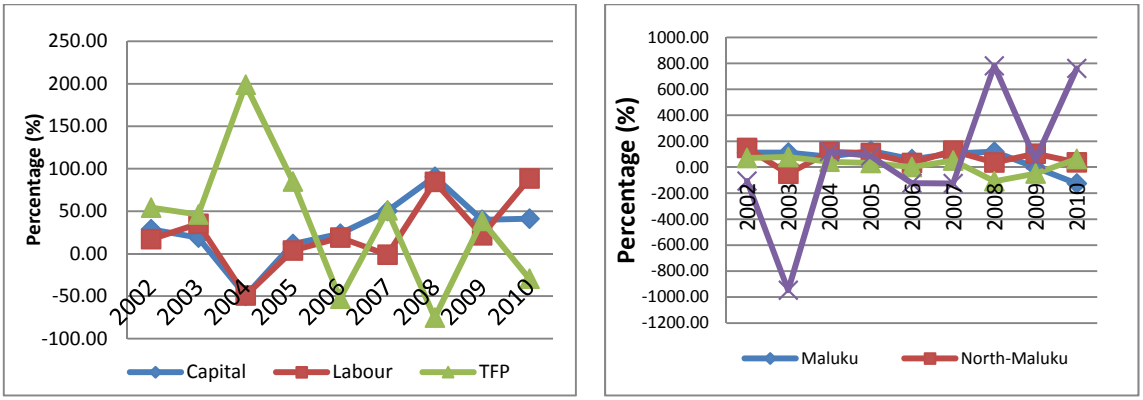

Figure 7.
Factors and Technology Contribution to Maluku-Papua Island Economy

In Maluku-Papua Island economy, the contribution of technology to economic growth was 15.50 per cent; it was the lowest contribution among factors, where the contribution of capital was 44.04 per cent and the contribution of labour was 40.46 per cent. Figure 7 (left panel) depicts the contribution of factors in Sulawesi Island economy. In three years, 2002, 2003, 2004 and 2005, the contribution of technology was higher than the contribution of labour and capital, but in year of 2006, 2008 and 2010, the contribution of technology was the lowest contribution to Maluku-Papua Island economy. Spatially among provinces in Maluku-Papua Island, the Province of Papua gave negative technology contribution (-522.83%). The province that gave highest technology contribution to the regional economy was North-Maluku Province (70.62%), followed by Maluku Province (55.56%) and West-Papua

Province 36.32%). Figure 6 (right panel) presents the graph of technology contribution to the province economy in Maluku-Papua Islands.

4. CONCLUSION

This paper aimed to analyze the contribution of technology to Indonesian regional economy. The contribution of technology to Indonesian economy, on average during 2002-2010 at national level, was 24.4 per cent. The contribution of technology to Indonesian regional economy varies among Island as well as among provinces within island. The highest contribution of technology was by Java Island (39.77%) followed by Bali-Nusa Tenggara Island (35.39%). The lowest technology contribution was in Kalimantan Island (12.82%). In Sumatra Island, the highest contribution of technology was in Province of West Sumatera (54.38%) and the lowest contribution of technology was in Nangroe Aceh Darussalam (-32.61%). In Java Island, the highest contribution of technology was in the East Java Province (49.63%) and the lowest contribution was in the Special Province of Yogyakarta (28.35%). In Kalimantan Island, the highest contribution of technology was in West Kalimantan Province (41.91%) and the lowest contribution was in South Kalimantan Province (24.25%). In Bali-Nusa Tenggara, the highest contribution of technology was in East Nusa Tenggara Province (51.71%), and the lowest contribution was in the Province of Bali (25.89%). In Sulawesi Island, the highest contribution of technology was in the Province of Central-Sulawesi (43.23%), and the lowest contribution was in Gorontalo Province (-22.29%). In Maluku-Papua Island, the highest contribution of technology was in the Province of North-Maluku (70.62%) and the lowest contribution was in Papua Province (-522.83%).

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