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## Research Article

### TECHNOLOGICAL PROGRESS AND ECONOMIC GROWTH IN INDONESIA: A REGIONAL PERSPECTIVE

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#### ABSTRACT

This paper examined the relationship between technological progress, measured by TFP growth, and economic growth, measured by GDP growth, both at national and regional levels experienced by Indonesia. Spatially, Indonesias was disaggregated into 6 groups of Island: Sumatera, Java, Kalimantan, Sulawesi, Nusa Tenggara dan Maluku-Papua. Coefficients of correlation were calculated using simple regression model. Data resulted from a study at the Agency for the Assessment and Application of Technology of the Government of Indonesia, 1984-2010, were used for this study. The results showed that both at national level as well as at regional level the correlation between technological progress and economic growth was positive and very strong. It is then suggested that programs of technology development should continually be pushed in order to maintain sustainable economic growth.

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#### INTRODUCTION

Economic growth, by definition, 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 (real GDP), usually in per capita terms (IMF, 2012). Growth is usually calculated in *real* terms to eliminate the distorting effect of inflation on the price of goods produced. Since economic growth is measured as the annual percent change of gross domestic product (GDP), it has all the advantages and drawbacks of that measure. The rate of economic growth refers to the geometric annual rate of growth in GDP between the first and the last year over a period of time. Implicitly, this growth rate is the trend in the average level of GDP over the period, which implicitly ignores the fluctuations in the GDP around this trend. An increase in economic growth caused by more efficient use of inputs is referred to as intensive growth. GDP growth caused only by increases in the amount of inputs available for use is called extensive growth.

Theories and models of economic growth include: Classical Growth Theory of Ricardian which is originally Thomas Malthus theory about agriculture (Bjork, G.J., 1999), Solow-Swan Model developed by Solow, R., (1956) and Swan, T., (1956), Endogenous Growth Theory which focus on what

increases human capital or technological change (Helpman, E., 2004), Unified Growth Theory developed by Galor, O., (2005), The Big Push Theory which is popular in 1940s, Schumpeterian Growth Theory which is entrepreneurs introduce new products or processes in the hope that they will enjoy temporary monopoly-like profits as they capture markets (Aghion, P., 2002), Institutions and Growth Theory (Acemoglu, *at.al.*, 2001), Human Capital and Growth Theory (Barro & Lee, 2001), and Energy Consumption and Growth Theory (Committee on Electricity in Economic Growth Energy Engineering, 1986).

Historically, technology has played a central role in raising living standards across the region. The Green Revolution and various innovations of modern medicine and public health have been instrumental in improving nutrition, health, and livelihoods of millions of poor people. Agricultural and medical biotechnology hold tremendous promise but also bring with them new risks and concerns that need to be addressed before their full potential can be realized. New information technologies are only beginning to diffuse widely in developing Asia and the Pacific, but ultimately these too can have profound impacts on the lives of the poor, empowering them with access to information that once was the preserve of the privileged few (OECD, 2002).

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Advances in science and technology have continuously accounted for most of the growth and wealth accumulation in leading industrialized economies. In recent years, the contribution of technological progress to growth and welfare improvement has increased even further, especially with the globalization process which has been characterized by exponential growth in exports of manufactured goods. (Hippolyte, F., 2008) shows that the widening income and welfare gap between Sub-Saharan Africa and the rest of world is largely accounted for by the technology trap responsible for the poverty trap.

Technological progress, technological development, technological achievement, or technological change is the overall process of invention, innovation and diffusion of technology or processes. In essence technological progress is the invention of technologies and their commercialization via research and development, the continual improvement of technologies, and the diffusion of technologies throughout industry or society. In short, technological progress is based on both better and more technology. In economics, change in a production function that alters the relationship between inputs and outputs. Normally it is understood to be an improvement in technology, or technological progress. Technological change is a change in the set of feasible production possibilities (Hicks, J.R., 1963). Total factor productivity is used to measure technological progress (Crespo, R.J., 2005). Study on total factor productivity for Indonesia was intensively conducted by Sigit, Hananto (2004).

Technological progress and economic growth are truly related to each other. The level of technology is also an important determinant of economic growth. The rapid rate of growth can be achieved through high level of technology. The technological progress keeps the economy moving. Inventions and innovations have been largely responsible for rapid economic growth in developed countries. It has been observed that major part of increased productivity is due to technological progress. Technological progress is one of the most important determinants of the shape and evolution of the economy. Boskin & Lau (1992) indicated that in developed countries, technological progress contributed about 49 to 76 per cent on economic growth. According to Solow (1957) the contribution of technological progress on American economic growth was 87.5 per cent.

Technological progress has improved working conditions, permitted the reduction of working hours and provided the increased flow of products. The technology can be regarded as primary source in economic development and the various technological progress contribute significantly in the development of underdeveloped countries. The contribution of technical progress to economic development among others, that technical progress leads to the growth of output and productivity. As a result, per capita income is increased. On the one hand, consumption of the household rises, while, entrepreneurs start saving, generating more and more surplus. They are encouraged to make more and more investment in the economy. It helps to generate capital formation and the rate of growth automatically increases.

Objective of this paper is to examine empirically the correlation between technological progress on economic

growth for Indonesia both at national level as well as at regional level.

## METHODS

Simple regression analysis was employed to calculate correlation coefficients between technological progress and economic growth. Economic growth was measured by the growth of gross domestic products (GDP) and technological progress was measured by total factor productivity (TFP) growth.

The OECD defines GDP as "an aggregate measure of production equal to the sum of the gross values added of all resident and institutional units engaged in production, plus any taxes, and minus any subsidies, on products not included in the value of their outputs" (IMF, 2014). An IMF (2016) publication states that "GDP measures the monetary value of final goods and services - that is, those that are bought by the final user - produced in a country in a given period of time, for instance for a year". The modern concept of GDP was first developed by Simon Kuznets for a US Congress report in 1934 (Kuznets, S., 1934). In this report, Kuznets warned against its use as a measure of welfare. After the Bretton Woods conference in 1944, GDP became the main tool for measuring a country's economy (Dickinson, E., 2012). GDP can be determined in three ways, all of which should, in principle, give the same result. They are the production or output or value added approach, the income approach, or the expenditure approach. The most direct of the three is the production approach, which sums the outputs of every class of enterprise to arrive at the total. The expenditure approach works on the principle that all of the product must be bought by somebody, therefore the value of the total product must be equal to people's total expenditures in buying things. The income approach works on the principle that the incomes of the productive factors must be equal to the value of their product, and determines GDP by finding the sum of all producers' incomes (World Bank, 2009).

Growiec, J., (2009) proposed four alternative methods for computing technological progress, sorted according to increasing methodological sophistication, namely: 1. TFP growth rate from a Cobb-Douglas production function, computed using only physical capital and labour as inputs, 2. Potential TFP growth rate from a Cobb-Douglas production function, computed using either only physical capital and labour as input, 3. Rate of technological progress at the world technology frontier (WTF), computed from a production function constructed with the non-parametric DEA algorithm, and 4. The Malmquist productivity index, computed from a production function constructed with the non-parametric DEA algorithm.

Data of TFP growth and economic growth from the year 1984 to 2010 collected from the results of a research report published by the Agency for Assessment and Application of Technology (Socia Prihawantoro et. al., 2009; 2013).

Regression analysis was used to calculate the correlation coefficients, coefficients determination, regression coefficients and their significant level. Easy and user friendly software of MS-Excel was used to calculate those coefficients, where  $y$  = economic growth (GDP growth) and  $x$  = technological progress (TFP growth).

## RESULTS AND DISCUSSION

Figure 1(left panel) provides picture of Indonesian regional GDP growth. The islands of Maluku-Papua had the highest economic growth, followed by Sulawesi, Bali Nusa Tenggara, Kalimantan, Java and Sumatera. National economy during 1984-2010 grows at average 5.6 percent per year. The highest growth was 8.89 percent at the year 2000, two years after multi-dimension economic crisis in 1998 and 1999. In 1998-1999, Indonesian economic growth was negative, -6.95% and -1.86%.

At regional level, as a whole, the highest economic growth was in the Island of Maluku-Papua, followed by Sulawesi Island, Bali- Nusa Tenggara Islands, Kalimantan Island, Java Island and Sumatera Island. On Average, the highest economic growth was at Sulawesi Island (6.48%), followed by the Island of Bali-Nusa Tenggara (6.19%), Java Island (5.35%), Kalimantan Island (5.31%), Maluku-Papua Island (5.23%) and Sumatera Island (5.05%).

Island, followed by Maluku-Papua Island, Kalimantan Island, Bali-Nusa Tenggara Island, Java Island and Sumatra Island. In average, the growth of TFP in national economy was 0.05 percent, about 10 percent of national economic growth. The highest TFP growth was 6.68 percent in the year of 2000. The lowest TFP growth, -9.67 per cent, was in the year of 1998 when monetary crisis experienced by Indonesia. Many negative TFP growths were in the year of 1985 (-3.68%), 1986 (-0.43%), 1987 (-0.83%), 1988 (-0.10%), 1991 (-0.01%), 1993(-0.52%), 1997(-0.81%), 1998(-9.67%), 1999(-6.29%), and 2006 (-0.02%).

Figure 2 (right panel) presents scatter diagram between technological progress and economic growth at national level. The trend was linier, as technological progress increase, and then the economic will also increase. In Figure 2 (left panel) the TFP growth line was below the economic growth line, except in year of financial crisis, year 1998 and 1999.

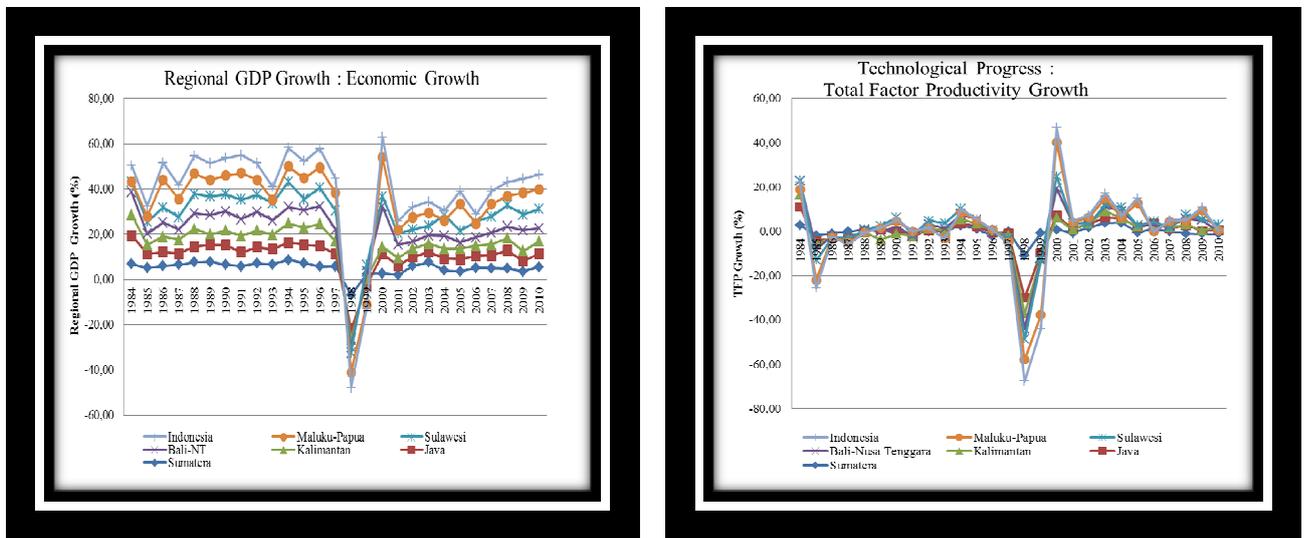


Figure 1 Regional Economic Growth (left) and Regional TFP Growth (right), Indonesia 1984-2010.

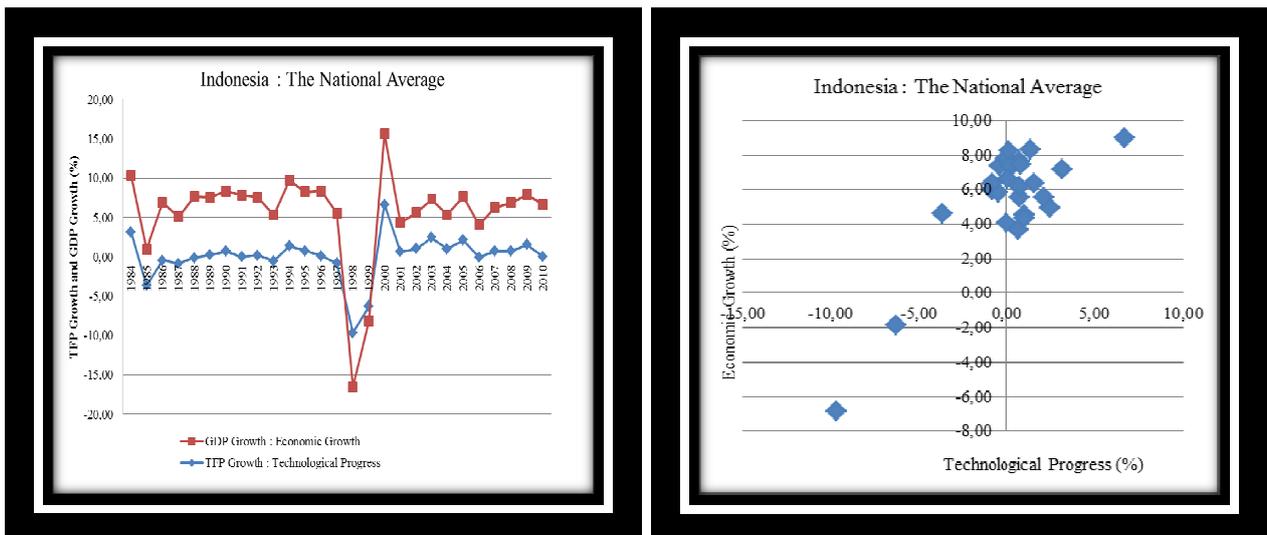
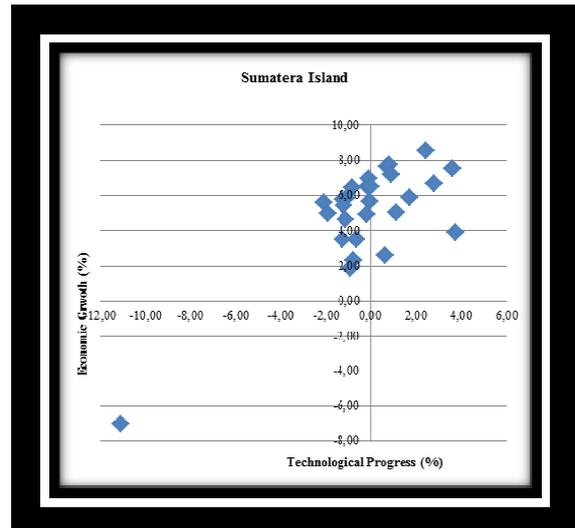
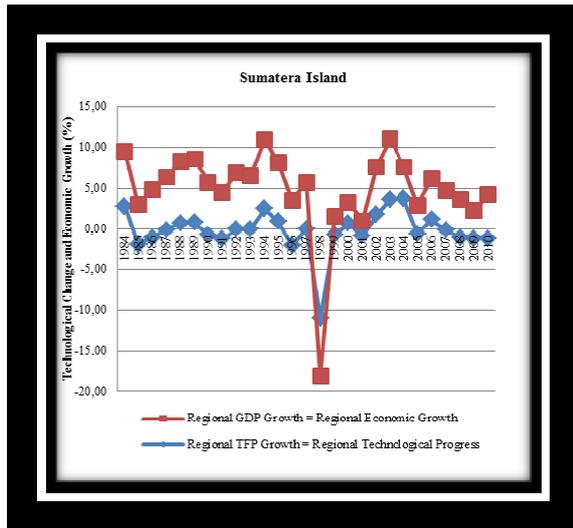


Figure 2 Technological Progress and Economic Growth: National Level, Indonesia

In Figure 1(right panel) the growth of total factor productivity, a measurement of technological progress, was presented. As a whole, the highest total factor productivity was at Sulawesi

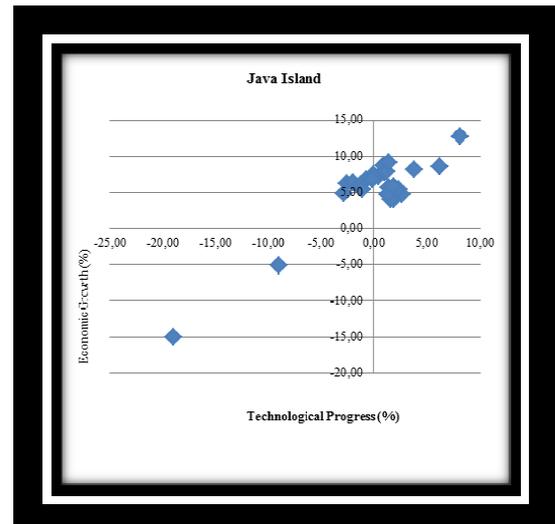
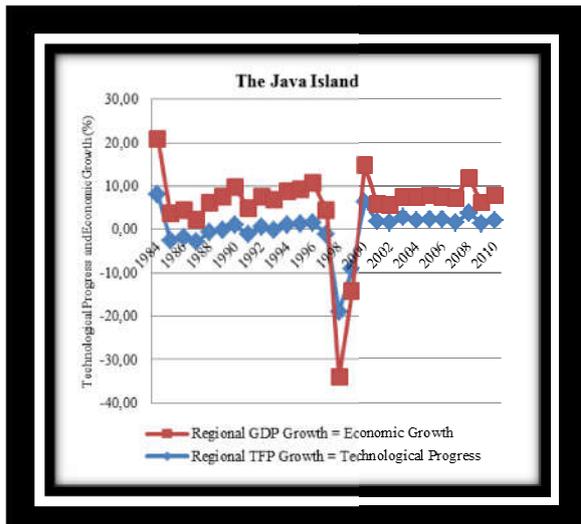
The same trend was also shown by Figure 3 (left panel) where TFP growth line for Sumatera Island was lower than Sumatera's economic growth line, except for the year of 1998. The trend was also linier as scatter diagram indicated (right panel).



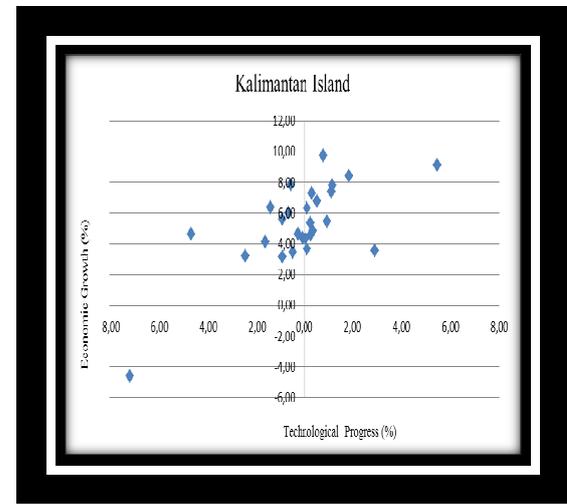
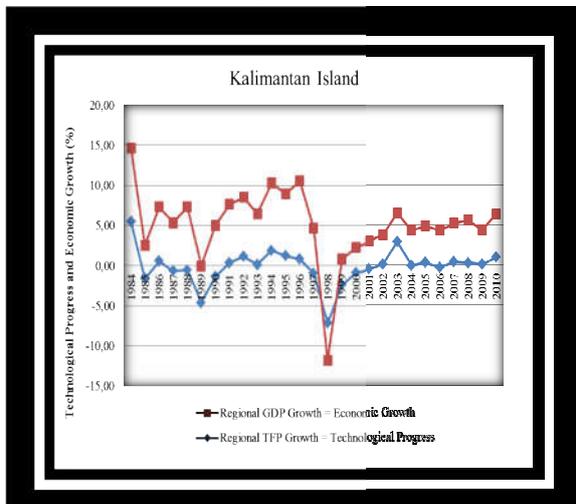
**Figure 3** Technological Progress and Economic Growth: Regional Level, Sumatera Island

Again, in the Island of Java, the trend between technological progress and economic growth was also linier as indicated by the scatter diagram at Figure 4 (right panel). The pattern of correlation between technological progress and economic growth in Java Island was similar with that at Sumatra Island (Figure 4, left panel).

In Kalimantan Island, TFP growth line was also located below the economic growth lines, except for the year 1998 (Figure 5, left panel). In Figure 5 (right panel), the trend between technological progress and economic growth at Kalimantan Island was still linier, even though the scatter diagram a bit more spread.



**Figure 4** Technological Progress and Economic Growth: Regional Level, Java Island



**Figure 5** Technological Progress and Economic Growth: Regional Level, Kalimantan Island

Figure 6 presents the trend of correlation between technological progress and economic growth at the Island of Bali-Nusa Tenggara. The line of economic growth was above that of TFP growth, except at the year when financial crisis was experienced. The trend between technological change and economic growth was also similar with those at Sumatera Island, Java Island and Kalimantan Island.

Figure 7 presents the trend between technological progress and economic growth at the Island of Sulawesi. Similar with the other island, the TFP growth line was located below the line of economic growth. The trend of correlation between technological progress and economic growth in Sulawesi Island was positive and linear as indicated in Figure 7 (right panel).

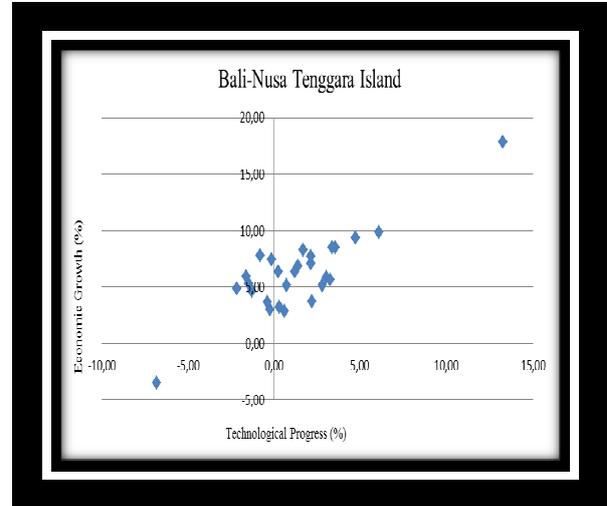
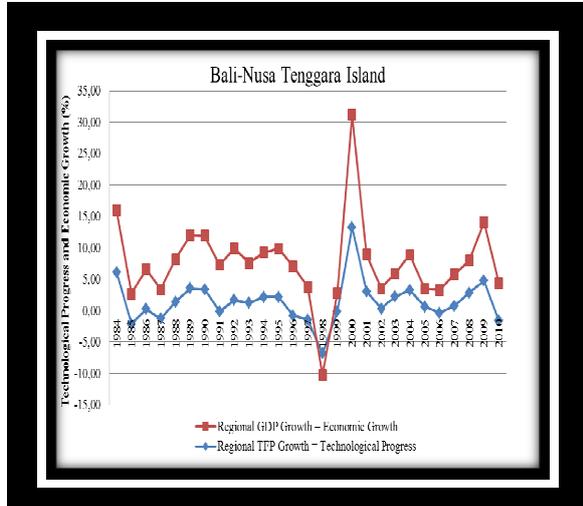


Figure 6 Technological Progress and Economic Growth: Regional Level, Bali-Nusa Tenggara Island

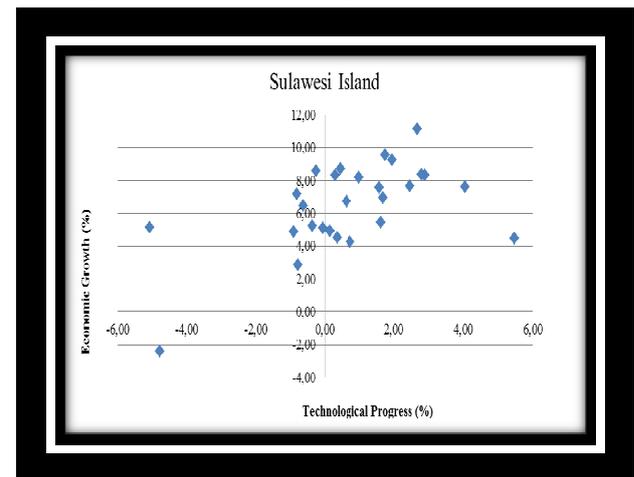
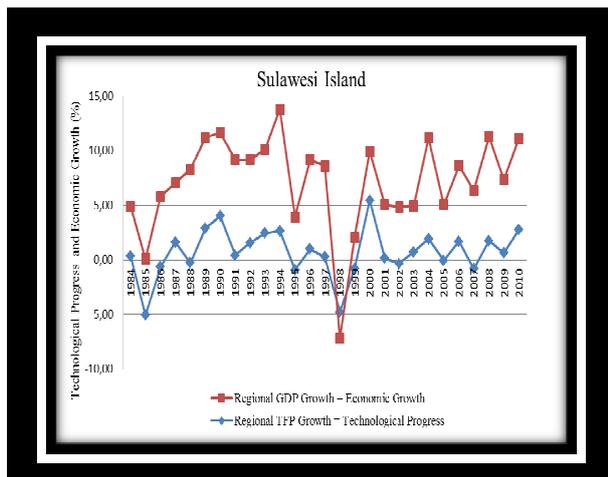


Figure 7 Technological Progress and Economic Growth: Regional Level, Sulawesi Island

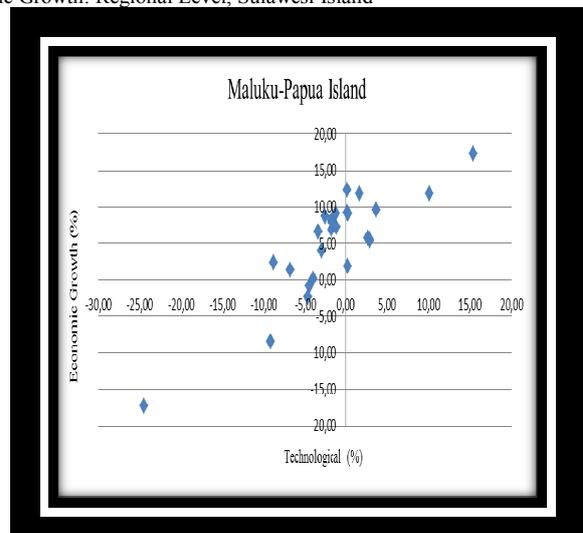
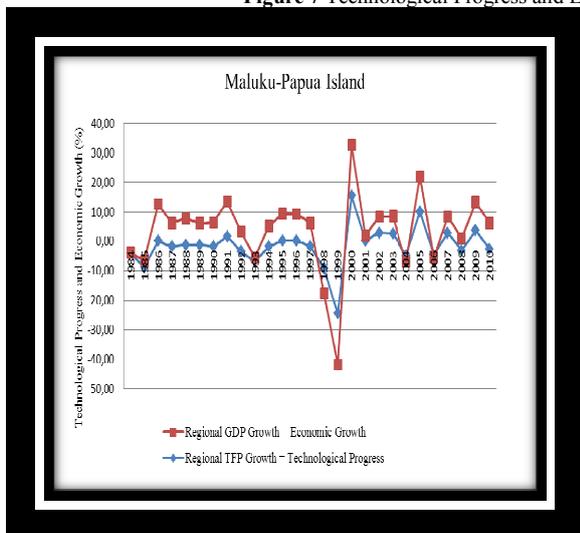


Figure 8 Technological Progress and Economic Growth: Regional Level, Maluku-Papua Island

Finally, Figure 8 (right panel) presents scatter diagram between technological progress and economic growth at national level. The trend was linier, as technological progress increase, and then the economic will also increase. In Figure 8 (left panel) the TFP growth line was below the economic growth line, except in year of financial crisis, year 1998 and 1999.

progress would increase economic growth of 0.88 per cent. In the Sulawesi Island, 1 per cent increase in technological progress would increase economic growth of 0.47 per cent. Regression analysis indicated that all the regression coefficients were statistically significant.

**Table 1** Results of Regression Analysis: Technological Progress on Economic Growth

	Indonesia	Sumatera	Java	Kalimantan	Bali-Nusa Tenggara	Sulawesi	Maluku Papua
R	0.81	0.78	0.90	0.71	0.86	0.55	0.86
R-Square	0.65	0.61	0.81	0.50	0.74	0.30	0.74
F	46.12	38.81	108.74	25.05	71.10	10.82	71.07
Significant	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Intercept	-3.99	-3.76	-4.60	-3.29	-3.83	-2.32	-5.98
t-Intercept	-5.82	-5.71	-7.50	-4.72	-5.40	-2.35	-6.89
X Var1	0.72	0.71	0.88	0.59	0.84	0.47	0.85
t-X Var1	6.79	6.23	10.43	5.01	8.43	3.29	8.43
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 1 provides the results of regression analysis between technological progress and economic growth in Indonesian economy, both at national and regional level. At the national level, coefficient of correlation between technological progress and economic growth was 0.81. It was a positive and very strong relation. The coefficient of determination, R-square, was 0.65. It means that at national level, 65 per cent of economic growth variations can be explained by technological progress. Other 35 per cent was the responsible of other factors. Regression analysis showed that the intercept between technological progress on economic growth was -3.99, means that if the growth of technological progress is zero per cent, then the economic growth would be negative, -3.99 per cent. Statistically this intercept coefficient was significant, indicated by the value of t-statistic. The slope of regression or the regression coefficient was 0.72, means that 1 per cent increase in the growth of technological progress would increase economic growth of 0.72 per cent. Regression analysis indicated that the regression coefficient was statistically significant.

At the regional level, coefficient of correlation between technological progress and economic growth varies where in the Java Island the coefficient was the highest (0.90) and in the Sulawesi Island the coefficient was the lowest (0.55). The coefficient of determination, R-square, was also follow the pattern, the highest was in the Island of Java (0.81) and the lowest was in the Sulawesi Island (0.30). It means that in the Java Island, 81 per cent of economic growth variations can be explained by technological progress. Another 19 per cent was the responsible of other factors. Meanwhile in the Sulawesi Island, only 30 percent of economic behavior can be explained by technological progress. Another 70 per cent was the responsible of other factors in economic growth. Regression analysis showed that the intercept between technological progresses on economic growth at regional levels varies, even though they all had negative value. These mean that when the growth of technical progress was zero, the value of economic growth would be negative. Statistically these intercept coefficients were significant, indicated by the value of t-statistic. The slopes of regression or the regression coefficients at regional level also vary among the Island where the Island of Java had the highest regression coefficient (0.88) and the Sulawesi Island has the smallest coefficient (0.47). In Java Island, 1 per cent increase in the growth of technological

**CONCLUSIONS**

It could be concluded that technological progress had significant contribution on Indonesian economic growth, both at national as well as at regional levels.

The correlation coefficients between technological progress and economic growth indicate the strength relation between the two. At national level, the relationship between technological progress and economic growth was positive and very strong (0.81). At regional level, the stronger correlation between technological progress and economic growth happened in the Java Island (0.90) and at the Sulawesi Island the strength correlation coefficient between technological progress and economic growth was categorised as moderate (0.55).

The coefficients of determination explain the variations of economic growth due to the growth of technological progress. At the national level, the highest coefficient existed in the Java Island (0.81) and the lowest existed in the Island of Sulawesi.

Finally, the regression coefficients or the slope of regression line between technological progress and economic growth both at national and regional levels were positive and statistically significant. At national level, the coefficient of regression was 0.72. At regional levels, the coefficients of regression vary. The highest regression coefficient was in the Island of Java (0.88) and the smallest coefficient of regression was in the Sulawesi Island (0.47).

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