

THE ROLE OF TECHNOLOGY IN REGIONAL DEVELOPMENT: TFP AND ECONOMETRICS ANALYSIS

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ABSTRACT

The development in Indonesia regions has been unbalance over the years. In Indonesia, significant differences on local governance capacities and natural resources lead to variation of regional economic development. Following economic theory, technology and innovation are expected to solve regional unbalanced development through optimizing local endowments and human capital. This paper aims to explore the role of technology and knowledge in regional economic development. The total factor productivity (TFP) measurement and econometrics analysis are conducted to explore technology contributions on regional economic development in Indonesia regions. The paper finds that technology level contributes significantly to economic growth, complementary with manufacturing industry. In addition, regional expenditure on education and research and development (R&D) are insignificant to economic growth. These findings confirm the role of industries in regional economic development.

Keywords: regional development, TFP, econometrics, statistic

INTRODUCTION

Regional autonomy, which has been implemented since 2001 is the government's factual endeavor to realize an evenly and balanced regional economic development in every field. It is implemented based on two legal acts, i.e. Law article No. 22/1999 (amended by Law article No. 32/2004) on regional administration autonomy and Law article No. 25, 1999 (amended by Law article No. 34, 2004) on the central and local government financial balance.

Under this spirit of regional autonomy, regions are expected to develop their local economy based on local natural riches and other

resources available. However, the differences in their locations and natural riches necessitate an effective application of science and technology (Lenggogeni, 2003). Law article No. 22/1999 and No. 25/1999 stated that the implementation of regional autonomy has two strategic implications (Lenggogeni, 2003). The first, having larger authority and autonomy, regions can develop themselves through their own policies in company with, at the same time with the society. The second, at the same time, challenges and obstacles rise as they lack of regions' internal resources to optimize the authority given. Among other obstacles are the lack of human, local financial and bureaucrat's resource quality.

The implementation and the policy of technology application and analysis program currently have come in various forms of organization and implementation, for example

* The author would like to express his gratitude to Prihawantoro, S., Hutapea, R., and Suryawijaya, I., for the TFP data. The data is available online and can be accessed at <http://www.gin.web.id/index>

Regional Research and Development Board (Balitbangda) of Province and Regency and Regional Research Board (DRD). Other than that, the central government also has helped the improvement of the regional research and development by establishing National Research Board (DRN) (Tatang, 2007). This board is responsible for coordinating and directing the National Research Board and the Regional Research Board.

This research aims to analyze the impact of the level and program of regional science and technology development on the local economy development. Employing data taken from three major provinces (of DKI Jakarta, DI Yogyakarta, and West Java). This study is expected to reveal the role of science and technology in each region in different economic periods.

This paper is arranged as follows; section two discusses theories relevant to the impact of technology on the regional economic development, and section three explains the data and the research methodology. While section four elaborates the econometric analysis, employing the statistic data and the total factor productivity, section five elucidates the conclusion and implication of this research results towards the policies.

THEORETICAL FRAMEWORK

Theory of Endogenous Economy

Neo-classical theories suggest that inter-state and inter-region development will reach the balanced point at a certain point of time (Williamson, 1965). This theory assumes that on the long run, the difference of income per capita will reduce and so will the regional disparities (Pike, *et al.*, 2006). On the quantitative aspect, economy and econometrics methods employed in neo-classical theory are finding the determinant factors of the regional disparity and elucidating the level of balanced development rapidity.

Such factors are saving, population growth, and human resource, which are later called as external factors or *exogenous*. This exogenous assumption implicates two things, i.e. the first, along with the capital growth, the growth of inter-region development will reduce, and cease so that the inter-region balance will be achieved anchored in the capital moving flow from the developed regions to the under-developed ones. The second, as neo-classical theory is assumed on the diminishing return, that is, the value and the amount of resources will reduce along with the time passing by. Some economists of the 19th century, like Thomas Malthus and David Ricardo introduced this concept in economic growth. This concept clarifies that economic growth is measured based on the growth of income per capita Y , labor force L , and area N as described in the following formula:

$$Y = F(L, N)$$

If it is assumed that area N is limited and absent technology, the economic growth can only be pursued by enhancing the number of labor force. Somehow, the limited area implies the limited number of labor forces. Therefore, the more labor forces involved in the production process, the less the marginal growth of production output will be. This reduced marginal growth of output is called diminishing marginal returns.

The development of regional growth theory, as well as the central growth and input-output theory adopt the neo-classical economic theory with the account of productivity output per labor force, which is calculated as the ratio of the used resources to the number of the number of labor forces (Pike, *et al.*, 2006).

Regional Autonomy

The theory of decentralization postulated by Prud'homme (1995) asserts the importance of analyzing the concept of regional autonomy on the demand aspect, i.e. the superiority of

regional autonomy in terms of public services like the closer relationship between the decision makers with the common society, the decreasing level of bureaucracy, and the increasing role of regional government in public policies. However, the *supply* aspect such as the local bureaucracy quality, the low salary of civil servants, and the poor experience of bureaucracy is often forgotten in the decentralization literature. As in other countries, the condition of the world economy and politics after the World War II, resulted in the state-centralized development, while the regional government's experience and quality are very limited so as to make them inefficient and in bad need of training (*on-job-training*). It is very crucial, as institutional quality and capacity are influential in the differences of public policies and the regional development (Rodriguez-Pose & Gill, 2005).

Nowadays, compared with Keynesian theory that emphasizes on the *demand* aspect like tax policy and development expenditure, contemporary theory of growth has shifted its focus on to the *supply* aspect (Armstrong & Taylor, 2000: 356). Policy on this *supply* aspect requires substantial change on its social and institutional system policy. Currently, some researches have analyzed the role of both systems in the differences of regional economic growth. Furthermore, these various studies show that the difference of social capacity and the dynamic social system will elevate the quality of public policy and development implementation in accordance with the local necessities (Rodriguez-Pose & Ezcurra, 2010: 623; Rodriguez-Pose & Ezcurra, 2011: 622).

The following is the discussion of several argumentations on problems resulting from regional autonomy. First, regional autonomy will result in the inefficient and overlapping public administration chain (Rodriguez-Pose & Bwire, 2004). Besides, insufficient quality of human resource in the regional government and the limited bureaucracy experience result

in the failure of optimizing regional autonomy. This in turn, will cause less-qualified policy and regional development implementation (Rodriguez-Pose & Ezcurra, 2010: 622).

Second, regional autonomy will escalate the competitiveness of inter-regional development. Regions with rich natural resources and qualified dynamic human resource will have larger capacity and capability to optimize their development. For example, the regional government capacity will influence the level of tax income and the level of political access and lobbying, as well as the enhancement of investor's interest for capital investment. Thus, decentralization is assumed even to boost inter-regional competitiveness, but at the same time, it also spurs innovation and idea for public policy (Rodriguez-Pose & Gill, 2005).

Third, as a result of the competition of inter-regional development, Islam (2003) state publicly that regional autonomy would increase the regional disparity through ineffective infrastructure and facility development. This can be seen from the plan of Banten harbor construction to compete with Tanjung Priok Harbor of Jakarta. Regional autonomy may result in not only construction, but also the share in the adoption of infrastructures and facilities amongst the regions. Subsequently, regional autonomy will also affect the developed and rich regions to develop on and on, as they will bring in qualified labor force, capital and other economic activities.

Neo-classical economic theory declares that external factors are resources of development and economic activity agglomeration. It makes neo-classical theory believe that there will be development balance in the long run. Amidst its development, this theory is modified surrounded by endogenous growth theory, which aims at taking into account of the so-called, by neo-classical theory, external factors, which are not relevantly part of economic growth factors. In his research, Pike, *et al.* (2006: 102) stated that endogenous

theory is aimed at understanding the dynamism of regional development disparity and convergences. Principally, several endogenous theories as those developed by Cobb-Douglas and Solow-Swan follow neo-classical theory. Somehow, these new theories criticize and turn down neo-classical theory's assumption that human resource and technology are exogenous factors. This theory argues that human resource and technology are the outcome of economic agent's activities.

Therefore, endogenous theory realizes and admits the presence of regional development disparities in the long run. This model judges that region is the focus of spatial and geographical development, and introduces increasing returns mechanism to neo-classical theory in economic development concept. Increasing return mechanism can be clarified as a mechanism of economic growth, in which production factors increase along with the presence of science and technological development. This concept of increasing returns mechanism can be seen in two forms, which are, economic activities agglomeration and spillover from its axis of growth to the surrounding regions. That is why this model is able to explain the process and the result of the different level of regional development.

Endogenous Theory and Science and Technology Development

Endogenous model can be applied in order to comprehend regional development through local and regional policy focusing on the promotion of local endowments and potentials. For instance, classical donor-receipt model has been proved to fail in the distribution of development and has been altered with growth-oriented policy that focuses on economic development for each region (Pike, *et al.*, 2006: 106). Therefore, this model argues that the regional development can be achieved by reducing regional disparities and the improvement of under-developed regional development rapidity. Hence, this model gives empha-

sis on the importance of the government's role in creating conditions and policies, which focus on the development of science. The development of science can be carried out through the protection of intellectual property right such as patent and trademark that provides security for the process and the result of research and development. In his study, Lucas (1988) explained that creating social institution enables development and application of science like the reduction of costs for application, transfer-between-school-or-university, and trainings. Another thing that can be conducted is to subsidize the process of research and development so as to make it beneficial to the non-government party if the value of research and development is higher socially than individually, for example; by reducing the research and development tax.

On individual scale, endogenous theory argues that the accumulation of human resource quality is influenced by specialization and training through learning by doing (Lucas, 1988). There are two assumptions about human resources, namely the first, this model assumes that training is a process of learning new things so the diminishing returns will not occur and remains as economic growth resource (Lucas, 1988: 28). Secondly, this model argues that human resource is able to employ the previous knowledge to learn new things, so that, level of employees' early education and knowledge are influenced by their working environment. Therefore, employees' expertise and knowledge vary in every factories, this is influenced by the level of information and knowledge acquired by each factory.

Based on individual scale and technology development concept, endogenous theory attempts to explain economic development on industrial scale. Creating economy with increasing returns can result in economic activities agglomeration, the spillover of economic activity from the axis of growth region to the other regions. Agglomeration is a result of

accumulation of knowledge and geographical proximity to economic activity. More specifically, agglomeration elucidates the correlation between technology and innovation and the economic growth. With the availability of incentives for idea and knowledge invention in the form of economic advantage, technology development will become internalized part of the productive function. According to neo-classical theory, technology, which is developed exogenously implies and is affected by capital. While endogenous theory argues that technology contributes to economy separately from the capital, but depending upon the variety of innovation processes (the level of education, culture, institution and the level of research and development) in each region.

Secondly, endogenous theory clarifies that geographically economic activities spillover occurs as a result of the increase in productivity marginal, knowledge and capital (Romer, 1986). This shows that education and exchange of knowledge are related to region and restricted geographically with decreasing level. Using Neo-Schumpeterian, endogenous theory argues that economic activity spillover is non-rival and semi non-excludable, as technology and knowledge mobility decreases upon the increasing geographical distance (Romer, 1990). Consequently, geographical location of economic activity spillover is restricted to the process of information and knowledge exchange, forming clusters. On industrial scale, it results in agglomeration along with the low fare of transportation. The variety of technological development, the level of knowledge and the quality of labor force is influential toward the level of economic growth and inter-regional disparities.

DATA AND RESEARCH METHODS

This research employs secondary data in the form of statistic data and its management for the three provinces for analysis. The TFP (Total Factor Productivity) data for each province studied is statistic data that is man-

aged through formulas obtained from Prihawantoro, *et al.* (2012). Whereas the other statistic data like the data of regional gross domestic product (PDRB), the level of education, and the amount of population is obtained from BPS, of which either has been published or not yet been published. The data of regional budget, like gross regional income (PAD), education budget and research and development budget is obtained from the Directorate General of Finance Balance, Ministry of Finance.

In order to see the *trend* of the impact of science and technology towards economic growth, this research employed statistic data in the period of 1993-2005. This choice of period was based on the idea that in long-term period the mastery of science and technology will give much advantage towards the improvement of national competitiveness and will contribute to the betterment of national education (Jusmaliani, 1995). The above period was categorized into three, namely: (i) period of 1993-1996, which was a deregulation period and structural change of industry resulting from the abolition of several policies and tariffs, (ii) period of 1997-2000, which was a post-crisis economic and political transitional period, and (iii) period of 2001-2005, which was a period of regional autonomy and economic development. This argument is strengthened by the outcome of research conducted by BPPT confirming that the role of technology in development undergoes fluctuations along with the economic development (Prihawantoro, *et al.*, 2012).

Using the TFP managed data and other statistic data, this research employed econometric technique to analyze the role of science and technology in the economic growth of a region. The following is an econometric formula used in this research:

$$\frac{(y_{it} - y_{it-1})}{y_{it-1}} = \gamma_1 + \beta \ln y_{it-1} + X'_{it} \gamma_x + Z'_{it} \gamma_z + C'_{it} \gamma_d + \eta_i + u_{it}$$

From the above formula, it can be explained that on the right side is variable of regional economic growth level with Y_{it} as a region's gross domestic product (PDRB) in a certain year, while g_i is constant, b is coefficient of the impact of a region's gross domestic product in previous year (Y_{it-1}). This coefficient is expected to have negative value, which shows balanced inter-regional economic growth, which means an indicator of the decrease of inter-regional disparity.

Subsequently, X''_{it} is coefficient of the level TFP in one year (gx), Z'' is coefficient of the level of people's Senior High education (gz), and C'' is coefficient of manufacturing industry proportion. While h_i represents the level of budget expended by region on the development of science and research. These four variables presumably will have negative value, that is, the bigger coefficient of these variables, the lower the inter-regional economic growth will be. Last, U_i is error coefficient, namely the unconsidered factors of this study, which are influential to the regional economic growth.

The econometric analysis technique used in this research is a simple method (OLS), that combines data of region and each city's time integrally, and panel technique that isolates data based on city and time. Both methods of analysis are commonly employed in various analyses of regional development (Arbia, *et al.*, 2005; Resosudarmo & Vidyattama, 2006; McCulloch & Syahrir, 2008). As OLS technique describes general condition of regional

economic growth, panel technique, on the other side, describes regional economic growth by avoiding the local factors like physical characteristic, local's history, and local institutional-politic.

ANALYSIS AND DISCUSSION

On this section, econometric analysis and its outcome discussion is conducted.

1. Analysis

Before carrying out econometric analysis, statistic analysis for variables used in this research (see table 1) should precede. It can be seen that log of region's gross domestic product (PDRB) per capita has deviation standard of 0.049 and mean of 2.792. While the range of TFP growth among the three provinces is as much as 9% showing a significant disparity of technological development.

The outcome of econometric analysis can be seen on table 2. On the first column, it can be seen that this research outcome is different from others' (Aritenang, 2011; Resosudarmo & Vidyattama, 2006; McCulloch & Syahrir, 2008), as it does not show the significant role of the region's gross domestic product per capita in the previous year for all period analyzed. For the period prior to regional autonomy, the provincial economic growth is influenced significantly by the technology level growth. While for the period post regional autonomy, the technology level growth and the proportion of Senior High graduates and students significantly affect the provincial eco-

Table 1. Statistic Variables

| | Mean | Deviation Standard | Minimum | Maximum |
|--|--------|--------------------|---------|---------|
| Regional gross domestic product per capita | 2.792 | 0.049 | 2.753 | 2.861 |
| TFP Growth | 0.198 | 9.037 | -3.774 | 2.950 |
| Proportion of Senior High students and graduates | 0.101 | 0.0956 | 0.008 | 0.316 |
| Proportion of manufacturing industry | 0.246 | 0.121 | 0.110 | 0.447 |
| Science and technology budget (log) | 15.302 | 7.016 | 5.840 | 2.481 |

Table 2. Analysis Outcome

| | 1993-2000 | 2001-2006 | 1993-2006 |
|--|-------------------|-------------------|--------------------|
| Regional gross domestic product per capita | 0.011 (0.18) | 0.177 (0.46) | 0.078 (0.11) |
| TFP Growth | 0.017* (0.01) | 0.022** (0.00) | 0.024** (0.00) |
| Proportion of Senior High students and graduates | 1.657 (1.03) | 3.450** (0.10) | 2.970** (0.29) |
| Proportion of manufacturing industry | 0.084 (1.18) | -1.397 (2.80) | -0.652 (0.71) |
| Science and technology budget | -0.042 (0.063) | -0.003 (0.358) | -0.023** (0.00) |
| Constant | 0.550 (2.81) | -2.798 (7.31) | -0.950 (1.64) |
| Amount of Observation | 8 | 11 | 17 |
| R2 | 0.929 | 0.977 | 0.919 |
| Adj. R2 | 0.811 | 0.957 | 0.885 |

conomic growth. The outcome of the analysis indicates the technology level growth of 1% will increase the economic growth of 0.022% and the increase of the proportion of Junior High graduates and students will increase the economic growth of 3.4%.

The third column indicates the economic growth during 1993-2006, which was influenced by the technology level growth and the increase of the proportion of Senior High graduates and students. While the negative amount for the research and technology budget variable indicates that the increase of such fund stipulated increased by the regional government even turns out to be profligacy that results in negative impact on the economic growth. Despite the fact that numerous studies explain that the increase of budget for research and technology contributes positively to the economic growth (Toh, 2012; Thant, 2012), this variable appears not to have significant effect in the period of regional autonomy. It indicates that the various expenditures for re-

search and development do not affect the disparity level of the economic growth.

The variables used in this research can explain the quite high economic growth, which is above 80%. These variables are even able to explain the economic growth in the three provinces, which reaches 95% and also 88% of the variety of economic growth for the whole period as well. However, it is necessary to notice that small number of observation available results in the potential bias in the interpretation of the analysis outcome. The researcher is also aware that the analysis on the three provinces for only around one decade cannot represent the role of technology in the regional development in Indonesia entirely.

2. Discussion

From the econometric analysis outcome above, on its sub-section the development of human resource and technology policies is discussed. The first, the enhancement of the quality of human resource and technology

development activity in region is required. As such in bureaucracy, the researcher's human resource in region is still very limited owing to the autonomy-based regional development that has just prevailed for one decade. Human resource development program like the one, which has been done by Ministry of National Education through scholarships for Master's degree (S2), and Doctoral degree (S3) for lecturers and university researchers give direct contribution to the enhancement of the future research and development quality. Regional policies are required as well to ensure the correlations between research and regional necessity, so that the outcome of research and development will be able to give real impact on the regional development.

Secondly, promoting the role of the national research institution (like BPPT, LIPI) to encourage the regional program of science and technology by serving as technical counseling instrument, *knowledge-transfer*, and the development of research network for regional research and development. Besides, it is necessary to continue the technological policies that have been developed by this national research, like regional innovation system (SID), industrial clusters, and technological incubation, which can foster the regional technological activity. For instance, BPPT has developed intensive cooperation with the regional government of Pekalongan for the development of SID and industrial clusters. While Ministry of Research and Technology has cooperated with BPPT in carrying out routine *techno-camp*, a training for young *entrepreneur* in the field of technology. The presence of Law article No.18, 2002, as reference for national technology development is expected to be able to spur the regional R&D activity, with the assistance of the national research institution in order to elevate the regional development and economic growth. Last, the role of the national research institutions like BPPT and the Technology Audit Center is required to evaluate and monitor the level of technological devel-

opment, such as the adoption of *Technology Readiness Level* (TRL), (BPPT, 2007). Thus, regional development of technology can be carried out effectively and with firm orientation in a certain time.

Third, the econometric outcome indicates that the local condition plays a significant role in economic development, such as the technological competence of the local manufacturing industry, the society's level of education, and the policy of budgeted fund for science and technology research. Therefore, the capacities of leaders and decision makers, as well as the institutional capacities determine the quality of the local regional government's policy in supporting the regional development.

CONCLUSION

Many researches on the regional growth and disparity have been conducted in Indonesia with the result showing high regional disparity (Resosudarno & Vidyattama, 2006), and (Akita & Alisyahbana, 2002), and so is the result of research done by the technology research center like BPPT (Prihawantoro, *et al.*, 2012) using the role of technology and TFP analysis. However, at present, researches on the role of TFP towards the economic growth by putting into consideration of local endowments, have not yet much conducted. This research attempts to conduct such research using econometric analysis of TFP and other statistic data.

Based on the above research, some findings were found, as follows: First, the research outcome shows the role of technology competence level (TFP) of a region contributes to the economic growth. The higher the role of technology competence, the more developed a region's economy will be. Secondly, the government's large expenditure for the labor's knowledge and expertise in a region is a very important capital to gear up economic activity.

Third, this research shows that the level of education and the research and development

budget of a region does not play significant role in enhancing regional economic growth. It can be explained by considering the limited quality of human resource of the researcher and the limited amount of research budget. Other than that, various direct experiences to the region indicate that the compatibility between the R&D activities and industrial necessity is found very low.

With the research outcome above, this research brings implications on the policy. First, as it concluded that the human resource development supports development and economic growth. The implementation of compulsory study becomes very vital in an effort of ensuring the quality of human resource by mastering the basic knowledge. Subsequently, it requires a national-scale policy on the higher education, with both theories and researches, like universities, or with practices as in higher education and polytechnic academies. Therefore, not only do science and technology develop, but also the expansion of manufacturing industry supported by semi-skilled labors.

Second, this research also indicates that the level of manufacturing technology affects significantly towards the economic growth. Therefore, semi-skilled labors are required to support the development of technology level and innovation of manufacturing industry. For instance, manufacturing industry with semi-skilled labors will have greater opportunity to adopt new technology and know-how capacities to increase productivity.

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