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Technology and Convergence in Indonesia

Yusuf Wibisono

Abstract

Almost three decades after the pioneering work of Esmara (1975), technology has not yet received enough attention as a determinant of regional disparities in Indonesia. This paper views technological transfer as the main driver of convergence in regional income. As suggested by the old and new growth theory, we found that technology plays a significant role in explaining cross-province differences in growth rates. We also found that government policies have a significant influence in promoting technological diffusion among the regions, and hence on rapid and sustainable regional economic growth.

Keywords: *Technological Transfer-Total Factor Productivity-Income Convergence-Regional Economic Growth-Indonesia*
JEL Classification: O33, O47, E13, R11

1. INTRODUCTION

The empirical convergence literatures, mostly classical convergence, are based on the Solow model of economic growth (see Sala-i-Martin, 1996). The central hypothesis is that the principle of dimishing returns to capital causes richer economies to grow slower than poorer economies, implying convergence in income per capita across varying economies.

This idea ignores the long-held belief among economic historians and growth theorists that puts emphasis on technology and the potential for technological transfer.

Economic historians have long emphasized the importance of technological progress as the driving force behind economic growth as well as one of the key advantages associated with 'relative backwardness' (Abramovits, 1986). As an example, 'innovation-sharing' is one of the primary variables claimed to be responsible for the convergence among advanced economies (Baumol, 1986).

Solow (1956) argued that the only possible source of growth in the long run is technological change. Investment can not be a source of growth in the long-run; hence this is also true for saving. Nonetheless, while most economists apply Solow's growth model to many economies, few accept his view that technological change is the main factor for long-run growth. Capital fundamentalists continue to believe that investment is the dominant determinant of growth, both in the short-run and long-run.

Commenting on the forgotten, and yet still important, issue, Bernard and Jones (1996) have called for further research on the possibility of technological transfer as an explanation for convergence. Recent research suggests that technology is a crucial factor for the differences in economic growth and income across countries (Easterly and Levine, 2001). Therefore, understanding technology is important in order to raise economic performance.

Almost three decades after the pioneering work of Esmara (1975), technology has still not received enough attention as a determinant factor of regional disparities in Indonesia. This paper considers technological transfer as the main driver of convergence in regional income. Regional income inequality is considered first, while the hypothesis will then be explored in the next section.

2. HISTORICAL BACKGROUND

Regional disparity in Indonesia has long been studied as an interesting topic of research. After the pioneering work of Esmara (1975), similar studies were conducted by Uppal and Boediono (1986), Islam and Khan (1986), Akita and Lukman (1995, 1999), Garcia and Soelistianingsih (1998), Shankar and Shah (2001), and Wibisono (2003).

Those studies were mainly concerned with the large income disparities between backward and advanced regions which have persisted in spite of the government policies aimed at the reduction, if not, removal of regional income disparities.

The variation in per capita income among the regions of Indonesia is considerable. In 1975, per capita Gross Regional Domestic Product (GRDP) of the richest province (Riau) was some 25 times higher than that of the poorest (East Nusa Tenggara). If we exclude the oil and gas sector, the differential dropped to only (6) six times higher between the richest (East Kalimantan) province and the poorest (East Nusa Tenggara).

After 25 years, the disparities are still considerable. In 2000, per capita GRDP of the richest province (East Kalimantan) was 12 times higher than the poorest (East Nusa Tenggara). If we exclude the oil and gas sector, the richest region (Jakarta) was (9) nine times higher than that of the poorest (East Nusa Tenggara).

Determining if provincial income inequality increased or decreased over time, we used the so-called σ-convergence analysis and the Theil index. According to Sala-i-Martin (1996), σ-convergence can be defined as follows: a group of economies are converging in the sense of σ if the dispersion of their real per capita income levels tends to decrease over time. That is if

$$\sigma_{t+T} < \sigma_t \quad \text{..... [1]}$$

Where σ_t is the time t standard deviation of log ($y_{i,t}$) across i.

As a comparison of σ-convergence, we choose the Theil coefficient - a popular index for analyzing spatial distribution because it satisfies several desirable properties as a measure of inequality in welfare, i.e., mean independence, the principle of population replication, and the Pigou-Dalton principle of transfers. Following Terrasi (1999), we calculate the index according to the formula:

$$IC = \sum_i y_i \log \left(\frac{y_i}{x_i} \right) \quad \text{..... [2]}$$

where IC is the total inequality, y_i and x_i are the regional shares of national income and population respectively. (**Figure 1**).

Figure 1
Regional Income Disparity in Indonesia, 1975-2000: σ-Convergence

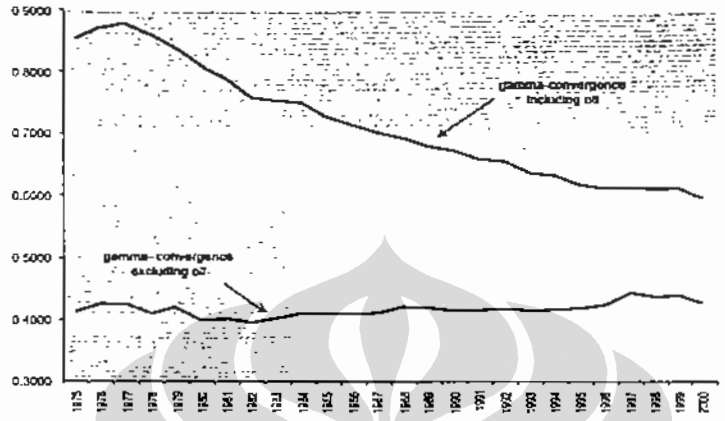
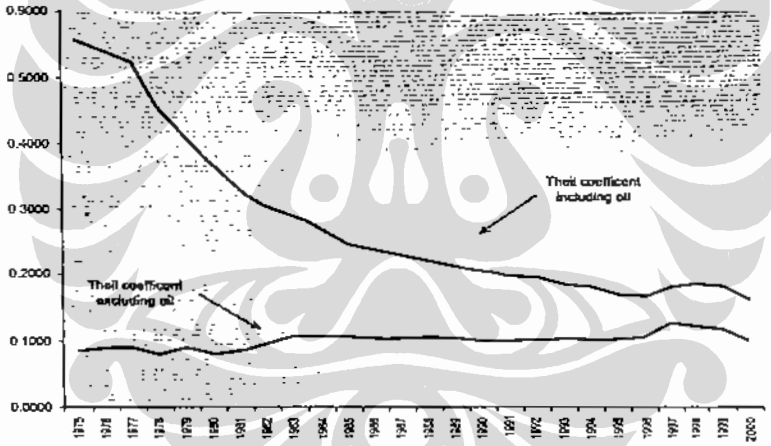


Figure 2.
Regional Income Disparity in Indonesia, 1975-2000: Theil Index



The result of σ-convergence and Theil index calculation is presented in **Figures 1 and 2**. Using per capita GRDP data, including the oil and gas sector, Indonesia experienced a continuous reduction in interregional inequality from 1975 to 2000. The surge in regional development policies

since the beginning of sustained and rapid economic development contributed to these outcomes. Prudent macroeconomic management enabled the country and its provinces to grow.

Most studies agree with this finding that there was no significant increase in inequality during the two decades since the mid-1970s. Nevertheless, even though there was a significant improvement, disparities in per capita GRDP across regions persisted.

The regions at the top and bottom end of the distribution in 1983 remained at the top and bottom end of the distribution in 1993 (Garcia and Soelistianingsih, 1998). Our data during the period of 1975-2000 show the same result, namely the regions at the top and bottom end remained the same, even when including or excluding the oil and gas sector from GRDP.

In relative terms, the degree of regional incomes disparities is still high. In comparison with other large developing countries like Pakistan, India, Brazil, and China, Indonesia has the largest disparities (Shankar and Shah, 2001).

Some studies estimating regional inequality exclude the mining sector. Such an estimate may be more plausible since it excludes high-income enclave revenues which accrue mainly to the central government.

Excluding the oil and gas sector from GRDP causes the tendency of reduction in interregional inequality to disappear. There has been no significant improvement in regional inequality from 1975 to 2000. The long-run trend in fact shows a little increase in inequality.

Furthermore, the study also shows that regional convergence in Indonesia does not appear to be a simple monotonic process, but seems to vary over time, and hence, requires further explanation. This can be seen more precisely by analyzing the Theil index. Indonesia has seen a constant reduction in interregional inequality since 1975. However, the drop was more pronounced prior to the 1990s, after which the decline slowed.

The persistence of extraordinary diversity generates serious socio-political implications. The complaints of regional inequality fueled political unrest and rebellions in many regions. The issue is further complicated by ethnic and historical factors. For this reason, there is always much concern about achieving balanced regional development in Indonesia.

3. TECHNOLOGICAL PROGRESS AND REGIONAL PERFORMANCE

Technological progress has long been recognized as an important source of improvement in income and welfare. Growth can be sustained in the long-run only if there is technological progress that avoids diminishing return of capital. Measuring total factor productivity (TFP) is therefore important in assessing a country's economic performance.

The sources of growth debate has drawn much attention after Young (1994), and then Krugman (1994), claimed that the "Asian miracle" was a myth because the engine of such spectacular growth in the region was mainly driven by factor accumulation instead of TFP growth.

Various estimates placed Indonesia in the mid-range of TFP growth since the late 1960s (Sigit, 2001). Moreover, examination of the trends showed TFP grew slowly before 1985 and strongly after 1985. Sigit (2001) showed that TFP grew by an average -2.36 % per annum during 1982-1985, and by an average annual rate of 0.27 and 0.73 % during 1986-1989 and 1990-1996 respectively.

In this section, a growth accounting exercise is conducted for Indonesia's 26 provinces during 1984-2000 to examine the sources of regional growth. The starting point for estimating TFP is a production function that represents how inputs are combined to produce output. As in Senhadji (1999), we use the following production function:

$$Y_t = A_t K_t^{\alpha} (L_t H_t)^{1-\alpha} \quad \text{[3]}$$

Where Y_t is GRDP, A_t is TFP, K_t is capital stock, L_t is total employment, and H_t is an index of human capital. Thus $L_t H_t$ is a skilled-adjusted measure of labor input. Taking logs and differentiating totally both sides of equation [3] yields:

$$\hat{y}_t = a_t + \alpha \hat{k}_t + (1-\alpha)(\hat{l}_t + \hat{h}_t) \quad \text{[4]}$$

Where the lowercase variables with a "hat" correspond to the growth rate of the uppercase variables described in equation [3]. Equation [4] decomposes the growth rate of output into the growth of TFP and a weighted average of the growth rates of physical capital and skill-augmented labor.

The estimation of TFP growth requires data on GRDP, capital stock, labor, education, and labor income share. Since TFP growth is computed at the provincial level for the national economy, the main source of data is the regional account statistics. For most variables, the data are available

only after 1983, and for that reason we choose the range of observations from 1984 to 2000.

While GDRP growth rates are easy to obtain, measuring the growth of K and H is much more difficult. The data on capital stock are based on the perpetual inventory method estimation with a common depreciation rate of 0.05. We estimate the initial capital stock of each province as an average share to national capital stock. The index of human capital is measured by the average years of schooling attained by the labor force.

The crucial point in estimating TFP growth is the information on parameters of the production functions. It is common to assume the values of capital share in aggregate output (α) to a benchmark value of 1/3 as suggested by the national income accounts of some industrial countries. This numerical specification is then applied to all countries. However, it is hard to believe that production technology is identical across countries.

In this paper, the value of α is econometrically estimated and the usual assumption of identical technologies production function across regions is relaxed. The Cobb-Douglas production function has been estimated both with and without human capital (H) to show the effect of human capital on the estimate of α. Table 1 shows the estimate of α.

The estimated α for Indonesia is higher than the benchmark value of 1/3. This result is consistent with the neoclassical view that the marginal product of capital in poor countries should be higher than in developed countries. This result also holds for Indonesia's provinces where the estimates of α is found higher in poorer regions.

Generally, we found that the size of α is lower when we include the human capital in the production function, except for the case of Sulawesi. This indicates that human capital is an omitted variable. The value of α chosen can matter a lot for the estimation of TFP growth. By decreasing (increasing) α, we are decreasing (increasing) the weight on the fastest-growing factor of production function –that is physical capital- resulting in higher (lower) estimated TFP growth.

Table 1.
Regional Estimate of Capital Share (α)

	Oil Data		Non Oil Data	
	Without H	With H	Without H	With H
Sumatera	0.6410	0.5810	0.4953	0.4880
Jawa-Bali	0.6688	0.2477	0.6602	0.2147
Kalimantan	0.5931	0.2792	0.4304	0.2183
Sulawesi	0.7917	0.9998	0.7917	0.9998
Others	0.6235	0.3980	0.6074	0.4627
Indonesia	0.6592	0.5126	0.6088	0.4310

Note: Regression using panel data of 26 provinces during 1984-2000. Fixed-effect methods are employed to control for unobserved heterogeneity in the initial level of production technology.

Data on regional TFP growth in Indonesia from 1984-2000 is presented in Table 2. The result is interesting in several respects. ***First,*** while most provinces have achieved a high growth of output, it is surprising that the contribution of TFP to the total growth of output is very small, even negative. In Table 2, only five provinces recorded a positive TFP growth. If we exclude oil and gas from the calculation, TFP growth increases rapidly in oil-rich regions. However, we still only found ten provinces –or less than half of the total number of provinces- that showed a positive TFP growth. A similar result obtains if we use regional α estimates rather than the national ones.

Second, the high regional growth has been driven mostly by capital accumulation, while gains in labor and human capital growth have been modest. The higher the capital growh the lower the TFP growth in provinces. The highest contributors of capital were found in provinces such as Jakarta, Riau, and East Kalimantan, indicating that the economic growth of these regions have been influenced by capital-intensive activities in the enclave sector.

In this context, the lowest TFP growth is found in the oil-rich regions such as Aceh and East Kalimantan. Once we exclude oil and gas sector from the calculation, the contribution of TFP increases. Maluku is found to be among the provinces with the lowest TFP growth, most likely because of the severe social conflicts in this province.

Similarly, the lower capital growth associated with the higher TFP growth, such as the ones experienced by North Sulawesi, North Sumatera, and West Kalimantan, indicates that these regions experienced

less capital-intensive activities, allowing for greater improvements in the quality of labor, and hence, making possible higher technological diffusion by the regions.

Third, surprisingly, the highest TFP growth is not found in the developed regions. There is no correlation between TFP growth and the level of development. Jakarta –the most economically advanced region in Indonesia- recorded a negative TFP growth that is -1.33% or -30% from the total output growth. On the other hand, East Nusa Tenggara –the economically most laggard region- accounted for a positive TFP growth that is 0.21% or 4% of total output growth. There are no indications that the eastern islands have smaller TFP growth than western islands.

These observations lead to the conclusion that the gains in regional TFP growth have been small. Rich regions can have small TFP and poor regions can have high TFP growth, showing the opportunity for poor regions to catch up with advanced ones.

Table 2.
Decomposition of Real GRDP Growth, 1984–2000: National Alpha Estimates

	Including Oil and Gas					Excluding Oil and Gas				
	dy	dk	dl	dh	dtfp	dy	dk	dl	dh	dtfp
DI Aceh	1.82%	3.95%	1.22%	1.17%	-4.53%	5.04%	3.32%	1.43%	1.37%	-1.08%
Sumut	5.86%	3.33%	0.89%	1.10%	0.54%	6.12%	2.80%	1.04%	1.28%	1.00%
Sumbar	4.87%	3.63%	1.35%	0.91%	-1.03%	4.87%	3.05%	1.57%	1.06%	-0.83%
Riau	4.42%	2.87%	2.00%	1.01%	-1.45%	7.69%	2.41%	2.33%	1.18%	1.77%
Jambi	6.01%	3.26%	1.72%	1.02%	0.02%	5.51%	2.74%	2.00%	1.19%	-0.42%
Sumsel	4.39%	3.13%	1.83%	0.68%	-1.45%	5.79%	2.63%	2.14%	1.03%	-0.01%
Bengkulu	5.89%	3.29%	2.20%	1.33%	-0.94%	5.89%	2.77%	2.57%	1.56%	-1.01%
Lampung	5.50%	4.19%	1.03%	1.46%	-1.18%	5.50%	3.52%	1.20%	1.71%	-0.93%
DKI	4.55%	3.67%	1.95%	0.45%	-1.51%	4.55%	3.08%	2.27%	0.52%	-1.33%
Jabar	6.10%	3.50%	1.38%	1.23%	-0.01%	6.81%	2.94%	1.61%	1.44%	0.83%
Jateng	4.73%	3.19%	0.55%	1.25%	-0.27%	4.52%	2.68%	0.64%	1.47%	-0.27%
DIY	4.15%	3.74%	0.32%	1.63%	-1.55%	4.15%	3.15%	0.37%	1.90%	-1.28%
Jatim	4.43%	3.67%	0.32%	1.27%	-0.83%	4.41%	3.09%	0.37%	1.48%	-0.53%
Bali	6.20%	3.64%	0.78%	1.80%	0.00%	6.20%	3.06%	0.91%	2.10%	0.14%
NTB	6.99%	3.84%	1.09%	1.81%	0.25%	6.99%	3.23%	1.27%	2.12%	0.38%
NTT	5.52%	3.83%	0.45%	1.34%	-0.10%	5.52%	3.22%	0.53%	1.56%	0.21%
Kalbar	7.02%	3.97%	1.23%	1.54%	0.27%	7.02%	3.34%	1.44%	1.80%	0.44%
Kalteng	5.88%	4.43%	2.22%	1.37%	-2.15%	5.88%	3.73%	2.60%	1.60%	-2.05%
Kalsel	5.88%	3.86%	1.34%	1.21%	-0.53%	6.14%	3.24%	1.56%	1.42%	-0.08%
Kaltim	3.32%	3.75%	2.35%	1.00%	-3.78%	7.07%	3.15%	2.75%	1.16%	0.00%
Sulut	5.60%	3.19%	1.13%	0.71%	0.56%	5.60%	2.69%	1.32%	0.83%	0.76%
Sulteng	6.00%	3.74%	1.96%	1.16%	-0.86%	6.00%	3.15%	2.29%	1.35%	-0.78%
Sulsel	5.91%	3.84%	1.10%	1.60%	-0.64%	5.91%	3.23%	1.29%	1.87%	-0.48%
Sultra	6.07%	4.03%	1.78%	1.95%	-1.70%	6.07%	3.39%	2.08%	2.28%	-1.68%
Maluku	3.66%	3.92%	1.70%	0.95%	-2.91%	3.52%	3.29%	1.99%	1.10%	-2.87%
Irja	7.48%	5.29%	1.62%	0.92%	-0.34%	10.05%	4.45%	1.89%	1.07%	2.64%

However, these results may be distorted by the financial and economic crisis that started in 1997 and peaked in 1998 in the form of economic and political crisis. It is therefore useful to distinguish three episodes in Indonesia's economic development: (i) the recovery period of 1984-1990, following a series of deregulation measures to raise economic growth; (ii) the private investment boom period of 1991-1996, and; (iii) the economic crisis period of 1997-2000. The results are presented in **Table 3.**

Table 3.
Trend in TFP Growth, 1984-2000: National Alpha Estimate

	dtfp including oil				dtfp excluding oil			
	84-90	91-96	97-00	84-00	84-90	91-96	97-00	84-00
DI Aceh	0.65%	-4.53%	-15.53%	-4.53%	1.24%	0.89%	-9.99%	-1.08%
Sumut	2.11%	1.87%	-5.59%	0.54%	2.58%	2.31%	-5.43%	1.00%
Sumbar	1.62%	-0.54%	-9.37%	-1.03%	1.58%	-0.05%	-9.31%	-0.83%
Riau	-1.30%	-0.62%	1.60%	-1.45%	0.77%	3.69%	3.65%	1.77%
Jambi	2.32%	-0.16%	-7.39%	0.02%	2.35%	-0.22%	-9.63%	-0.42%
Sumsel	-2.46%	0.92%	-3.94%	-1.45%	-0.49%	2.25%	-2.98%	-0.01%
Bengkulu	-0.25%	0.20%	-6.69%	-0.94%	-0.23%	0.35%	-7.16%	-1.01%
Lampung	0.82%	-0.05%	-10.55%	-1.18%	0.74%	0.42%	-10.90%	-0.93%
DKI	-0.90%	1.08%	-11.27%	-1.51%	-0.89%	1.45%	-11.05%	-1.33%
Jabar	1.49%	0.04%	-1.91%	-0.01%	2.71%	0.66%	-1.36%	0.83%
Jateng	0.73%	0.93%	-4.65%	-0.27%	0.69%	1.41%	-5.49%	-0.27%
DIY	0.04%	0.50%	-7.64%	-1.55%	0.22%	1.03%	-7.72%	-1.28%
Jatim	0.92%	1.02%	-7.61%	-0.83%	1.16%	1.45%	-7.41%	-0.53%
Bali	2.26%	0.43%	-4.73%	0.00%	2.27%	0.74%	-4.72%	0.14%
NTB	-0.46%	-0.40%	2.00%	0.26%	-0.61%	-0.23%	2.39%	0.38%
NTT	-0.01%	0.98%	-1.98%	-0.10%	0.08%	1.60%	-1.93%	0.21%
Kalbar	4.75%	0.36%	-8.65%	0.27%	4.79%	0.70%	-8.36%	0.44%
Kalteng	1.87%	-1.92%	-10.59%	-2.15%	1.42%	-1.29%	-10.41%	-2.05%
Kalsel	1.58%	0.56%	-6.07%	-0.53%	2.32%	1.20%	-6.17%	-0.08%
Kaltim	-5.58%	-1.98%	-6.05%	-3.78%	2.41%	0.80%	-7.56%	0.00%
Sulut	0.33%	3.59%	-4.23%	0.56%	0.54%	3.90%	-4.26%	0.76%
Sulteng	1.32%	-1.45%	-5.22%	-0.86%	1.30%	-1.15%	-5.42%	-0.78%
Sulsel	1.60%	0.08%	-8.05%	-0.64%	1.56%	0.31%	-7.95%	-0.48%
Sultra	1.55%	-3.93%	-6.59%	-1.70%	1.41%	-3.82%	-6.68%	-1.68%
Maluku	3.31%	-3.51%	-17.45%	-2.91%	3.50%	-3.18%	-18.40%	-2.87%
Irja	4.94%	-2.41%	-8.00%	-0.34%	9.77%	-0.28%	-6.75%	2.64%

Table 3 shows different patterns of TFP growth between these three periods. As before, the TFP growth is much better when we exclude the oil and gas sector. Using different α estimates does not change the TFP growth significantly (result not reported).

The highest TFP growth occurred in the recovery period of 1984-1990 when the end of the oil boom era prompted the government to launch a series of significant reforms, including a series of deregulation measures to improve the investment climate for private entrepreneurs. Most regions recorded positive and high TFP growth in this period. Reforms appeared to be beneficial for regional productivity.

However, the 1991-1996 private investment boom periods showed a declining TFP growth from the previous period. In this period, capital growth accelerated, causing GRDP to increase rapidly. During this period, the regional growth of total output was mainly caused by the growth of capital, resulting in a lower contribution from TFP.

The lowest TFP growth is found during the economic crisis in 1997-2000. Most regions experienced negative GRDP growth. But capital accumulation still took place, mostly due to previous commitments. With a steep reduction in GRDP growth and still high capital growth, the TFP growth dropped deeply.

These observations give us new insights about regional TFP growth. As in the case of regional inequality, regional TFP growth seems to vary over time. During the period when TFP growth plunged, regional inequality seemed to increase, and vice versa. This tendency is very clear and strong when we distinguish TFP growth by periods. We suggest that there is a close relationship between regional productivity and regional inequality. We will explore this hypothesis further in the next section.

4. TECHNOLOGICAL TRANSFER AND CONVERGENCE

In analyses based on the traditional neoclassical theory of economic growth, whatever the source of differences in income per capita may be, it is not technology, because this is assumed to be a public good a famous example, see Mankiw, Romer, and Weil, 1992). On the other hand, the technological gap approach views technological differences as the primary cause of the differences in income per capita across economies.

The catch-up hypothesis suggests that being backward in the level of productivity carries a potential for rapid advance. The larger the technological, and therefore the productivity, gap between leader and follower, the stronger the follower's potential for growth in productivity; and hence, the faster the follower's growth rate is.

Convergence occurs because the catch-up process would be self-limiting. As the follower catches up, the possibility of making large leaps

by replacing old technology with new ones becomes smaller and smaller. A follower's potential for growth weakens as its productivity level converges towards that of the leader.

However, researchers inspired by either the technology-gap approach or the Solow model have used similar empirical models, although for different reasons (Fagerberg, 1994). For example, in the technology-gap literature, income per capita is assumed to reflect the degree of technological sophistication of the country, while in the neoclassical story it is a proxy for the capital-labor ratio.

In order to quantify the estimate of the convergence rate across 26 provinces, we use regression analysis (so called β-convergence). Based on Dowrick and Nguyen (1989), we estimate the following equation:

$$\log (y_{iT} / y_{i0}) / T = a - b \log (y_{i0}) \quad \text{[5]}$$

Where $\log (y_{iT} / y_{i0}) / T$ are the annual growth rate of real GRDP of region i between the initial and final years and $\log (y_{i0})$ stand for the initial per capita GRDP relative to the leading regions.

Table 4 shows the estimated convergence rate during 1984-2000. While the result from the oil data estimation looks good, non-oil data estimation is far from the expectation. But the picture is still clear; convergence occurs only in an oil economy and is absent in a non-oil economy. The negative sign of the initial income per capita indicates that GRDP has been growing slower in richer regions, implying a tendency for income levels to converge.

Using β-convergence analysis, we found that the income convergence rate in Indonesia slowed to 0.94 % a year over 1984-2000. This result is consistent with the previous findings where the reduction in regional inequality slowed after 1985.

The underlying assumption of specification [5] is a common production technology level across economies, that is the term of a is assumed to be the same for all regions. Furthermore, the term reflects not just technology but also resource endowments, climate, institutions, and so on. Therefore, it may differ across economies, which means that the initial level of technology should be included in the regression.

In the absence of a suitable proxy for the level of technology, the only way to obtain a consistent estimate is to use panel data methods (Islam, 1995). Since the initial level of efficiency is an omitted variable that is constant over time, it can be treated as a fixed effect.

If we allow for technological differences, the negative coefficient on initial income requires careful interpretation. It may indicate not only those regions are converging to their steady states through capital accumulation but also that technological transfer is taking place (Temple, 1999).

Once we take into account technological and institutional differences across regions, the income convergence rate jumps to 3.17 %. It means that if there had been no technological differences –that is technological transfer occurred during the period- and regions differed only in income per capita, the convergence would have proceeded at a faster rate.

These findings clearly support the view that technological transfer is a significant factor in reducing differences in income per capita across regions.

Table 4.
Estimated Speed of Income Convergence in Indonesia, 1984–2000

Independent Variable	Dependent Variable: Annual growth rate of real GRDP, 1984-2000			
	Oil Data		Non-oil Data	
	OLS	Panel	OLS	Panel
Constant	0.0359	-	0.0621	-
	(5.8110)		(6.4209)	
Log (relative per capita GRDP in 1984)	-0.0101	-0.0404	0.0026	0.2894
	(-3.3347)	(-3.0149)	(0.4028)	(6.5024)
Adjusted R-squared	0.2487	0.1127	-0.0341	0.5574
S.E. of Regression	0.0108	0.0359	0.0132	0.0346
DW-statistic	1.9858	2.4357	2.1114	2.3963
F-statistic	9.2794	-	0.1746	-
(Prob. F-statistic)	(0.0055)		(0.6797)	
Implied λ	0.0094	0.0317	-0.0027	-0.0839

Note: Estimation is by OLS and panel data approach with *fixed effect*. Figure in brackets are *t-statistics*. The implied value of λ is calculated by using formula $b = 1-(1-\lambda)^T/T$, where T is the length of interval.

Following Dowrick and Nguyen (1989) once more, we then estimate a model that suggests how much catching up in technology has contributed to differences in growth rates. We estimate the following equation:

$$\log (y_{iT} / y_{i0}) / T = a - b \log (y_{i0}) + c \log (k_{iT} / k_{i0}) / T + d \log (l_{iT} / l_{i0}) / T \quad [6]$$

Where $\log (k_{iT} / k_{i0}) / T$ and $\log (l_{iT} / l_{i0}) / T$ are the annual growth rate of capital stock and employment of region i between the initial and final years, respectively, and others are the same as in equation [5].

Thus, having controlled for capital and labor input growth, we can interpret the coefficient on initial income as a measure of the rate of TFP catch-up. The result is presented in table 5. Again, we see that the estimation based on non-oil data is not satisfactory. For this reason, we will focus only on the estimation based on oil data. After this, we only run estimations based on oil data.

Convergence of income per capita may result from differences in the growth rates of capital stock and/or employment. If this is true, the estimated coefficient on the initial income moves toward zero when we include capital stock and employment growth as explanatory variables. However, the result shows that the magnitude of the coefficient actually increased.

These findings suggest that Indonesia's regional convergence has been neither due to the higher rates of investment nor to the more rapid rise in labor participation rates in poorer regions.

Furthermore, we see that the rate of income convergence is slightly slower than the rate of TFP catch-up. Previously, we had hoped that we can measure TFP catch-up as a residual between the coefficient of initial income as in [5] minus the same ones as in [6]. In other words, we had hoped that income convergence is higher than the underlying TFP catch-up. This might occur because capital and/or labor intensities have been growing more slowly in the poorer regions.

Table 5
Estimated Speed of TFP Catch-Up in Indonesia, 1984-2000

Variabel Independen	Dependent Variable: Annual growth rate of real GRDP, 1984-2000			
	Oil Data		Non-Oil Data	
	OLS	Panel with F.E.	OLS	Panel with F.E.
Constant	0.0054	-	0.0109	-
Log (relative per capita GRDP in 1984)	(0.2699)		(0.3369)	
	-0.0119	-0.0847	-0.0029	0.2585
Growth rate of capital stock	(-2.8159)	(-7.3037)	(-0.3546)	(5.5732)
	0.2718	0.5505	0.4844	0.2601
Growth rate of employment	(0.9732)	(6.2871)	(1.0873)	(1.4473)
	0.2688	0.3358	0.3540	0.1981
	(1.5371)	(2.1027)	(1.8854)	(2.3688)
Adjusted R-squared	0.3002	0.4866	0.1187	0.5564
S.E. of regression	0.0104	0.0324	0.0122	0.0342
DW-statistic	2.3106	2.2264	2.0381	2.0664
P-value for joint hypotheses	0.1567	0.0000	0.1078	0.0020
F-statistic				
(Prob. F-statistic)	4.5741	62.8167	2.1227	78.6016
	0.0123	(0.0000)	0.1263	(0.0000)
Implied λ	0.0110	0.0550	0.0021	-0.0740

Note: Estimation uses OLS and panel data approach with *fixed effect*. Figure in brackets are *t-statistics*. P-value for joint hypothese refer to the hypotheses that the coefficient of all explanatory variables except initial income are all equal to zero. The implied value of λ is calculated by using formula $b = 1-(1-\lambda)^T/T$, where T is the length of interval.

We also found that TFP catch-up is much faster when we control for heterogeneity in initial efficiency. Once we take into account differences in the initial level of technology, TFP catch-up jumped from 1.1 % to 5.5 % annually. This result is consistent with previous findings.

This evidence suggests that differences in technological level are a significant factor that encourages TFP catch-up In fact, the much higher TFP catch-up rate after controlling for technology, indicates that differences in technological level across regions is large, and therefore, has impeded significantly the TFP catch-up by poorer regions.

5. THE ROLE OF GOVERNMENT

Catch-up is not an automatic process, but requires a significant amount of effort and institutional building. The so-called "social capability" is designated as that factor constituting a country's ability to import or engage in technological and organizational progress. Abramovits (1986)

suggests that technical competence and political, commercial, industrial, and financial institutions are important elements of social capability.

According to this perspective, the role of government becomes the most controversial aspect of the growth story. The debate is no longer about whether policy mattered, but over its relative importance.

We follow the strategy of Collins and Bosworth (1996) that uses regression analysis in which the output growth and its components appear as dependent variables. Our choice of indicators for macroeconomic policy is entirely influenced by the existing literature. The result of the regression analysis is presented in Table 6.

Contrary to the expectation, human quality -measured by life expectancy and average years of schooling- is statistically insignificant and has a wrong sign. This may reflect the lag between the human capital investment decision and its pay off in terms of increase in output growth.

Next is the role of macroeconomic policy. Regions with lower inflation rates and government consumption ratios tend to grow more rapidly. The improvement in the terms of trade has a significant positive effect on the expansion of domestic output.

However, the three elements of policy work through very different channels. The lower inflation rate and government consumption ratio are strongly associated with higher productivity growth, while it works inversely with factor accumulation. The improvement in the terms of trade seems to have a similar impact.

It is quite interesting to note that the worsening of the regional macroeconomic environment does not seem to affect the growth of input factors. On the other hand, improvement in the macroeconomic environment makes a significant contribution to raising TFP growth.

The evidence suggests that these policies appear to be significantly correlated with TFP growth, but not with factor accumulation. In the previous sections, we demonstrated that TPF catch-up is a significant factor that reduces interregional inequality.

These observations lead us to the conclusion that the government plays an important role in promoting technological diffusion in poorer regions, and hence, drives rapid growth and reduces regional inequality. At the same time, this evidence also suggests that regions characterized by a large technological gap and a low "social capability" run the risk of being caught in a low-growth trap.

Table 6.
Determinants of Regional Economic Growth in Indonesia, 1984-2000

Variabel Independen	Dependent Variable		
	Growth of Output	Growth of Factors	Growth of TFP
Constant	-	-	-
Log (GRDP per capita)	-0.0104	0.0117	-0.0133
	(-5.2549)	(8.6122)	(-6.5865)
Log (Life Expectancy)	-0.0059	-0.0226	-0.0028
	(-0.5073)	(-17.5364)	(-0.2957)
Log (Years of Schooling)	-0.0278	-0.0219	-0.0052
	(-3.1381)	(-7.0613)	(-0.6354)
Regional Inflation Rate	-0.0934	0.0889	-0.1953
	(2.7598)	(2.7530)	(-4.5121)
Government Consumption Ratio	-0.0549	0.1008	-0.1029
Changes in Terms of Trade	(-3.2535)	(9.8732)	(-6.3719)
	0.0616	-0.0164	0.0693
	(5.4663)	(-2.8303)	(6.2081)
Adjusted R-squared	0.8967	0.9792	0.7389
S.E. of regression	0.0303	0.0180	0.0282
DW-statistic	2.7747	3.0666	3.0659
P-value for joint hypotheses	0.0000	0.0000	0.0000
F-statistic	139.97	731.38	49.78
(Prob. F-statistic)	(0.0000)	(0.0000)	(0.0000)

Note: Estimation is by panel data approach with *fixed effect*. We also ran cross-section regression, but the result is very poor (not reported). Figure in brackets are *t-statistics*. P-value for joint hypothese refer to the hypotheses that the coefficient of all explanatory variables except initial income are all equal to zero.

6. POLICY IMPLICATION

Technology transfers can close the income gap between the rich and the poor. It is difficult to see how there can ever be convergence unless poor regions take advantage of the many ideas that others have already generated. Convergence in income per capita can occur only if technology also converges. Therefore, we need to find ways for poor economies to raise their levels of technology at a faster rate. This requires more contacts with foreigners, more trade, more investment, greater communication, and greater incentives to develop and apply new ideas.

Economic growth occurs when people have the incentive to adopt new technologies or, in other words, are willing to sacrifice current consumption for future payoff by investing in new technology. Unfortunately, technological progress also creates both winners and losers. As growth proceeds, old industries die and new ones emerge. The groups working with the old technologies are identified as the most obvious vested interests that have an incentive to oppose the creative destruction process. Addressing this issue may require direct interventions to ensure that group interest does not sacrifice public interest.

When we look at differences in technological level, we may ask, "Why technological differentials across provinces are so wide?" Regions are probably 'too backward', so they lack the complementary inputs for the new technologies. In this case, there is no tendency for poor regions to catch up with the rich. Instead, they are falling further behind.

We then may proceed to the next question, "why technology does not spread across regions?" The reason is because technologies maybe are complementary goods rather than substitution goods. New technology does not always destroy old technology, but new technologies sometimes are complementary to one another. One innovation raises the rate of return to a different invention.

If complimentarily is more dominant than substitution, then innovation will tend to be highly concentrated in space and time. Innovation will only happen where technology is already highly advanced. This will offset the advantages of backwardness for imitation and leaping to the frontier.

Is there still hope for poor regions to catch-up with the rich regions? The answer is yes. Besides complementarity, we also see ways in which new technology substitutes for existing technology. If this is the case, poor regions that lack much of the existing technologies could see it as a blessing in disguise. They can jump to the frontier technology.

For example, the electronics revolution made possible a significant reduction in the price of communications and transportation which created new opportunities for poor regions to borrow knowledge and technology from the rich regions. The changing nature of technology and aggressive government incentives for technological adoption could drive the poor regions to the frontier at a faster rate.

Moreover, technology is a very broad concept, which is why Romer (1993) prefers to use the term 'ideas' rather than the traditional

'technology' in order for it to apply to all sectors of the economy:

> *The word technology invokes images of manufacturing, but most economic activities take place outside of factories. Ideas include the innumerable insights about packaging, marketing, distribution, inventory control, payments systems, information systems, transactions processing, quality control, and worker motivation that are all used in the creation of economic value in a modern economy. If one looks carefully at the details of the operations of a corporation like Frito-Lay, one sees that there are as many subtle ideas involved in supplying potato chips to a consumer as there are in making computer chips. In addition, the ideas involved in supplying potato chips are probably more important for successful development in the poorest countries. (p. 543).*

In short, poor regions may not need advanced technology to drive its productivity. Appropriate technology through imitation that matches with the comparative advantages of the regions may be more useful than imported technology or pure innovation activities that are usually expensive and risky.

7. CONCLUSION

Convergence is a dynamic process in Indonesia. This study documents income disparity across provinces that have gone up and down in the last 25 years. Disparity increases during the unstable periods and decreases during the good times.

We have shown that the contribution of TFP to regional output growth is small. Rapid regional growth is mostly due to capital accumulation. This result has important implications as regional growth can not be sustained in the long-run.

We have also shown that regional inequality has a similar pattern with TFP growth. We suggest that there is a close relationship between them. Higher productivity growth in poorer regions will lead income to converge.

We explored this hypothesis and found that productivity growth is a significant factor in regional convergence. Once we take into account technological differentials across provinces, the convergence rate increases significantly. This indicates that there is a large gap in technology levels across provinces.

Furthermore, we have found that several macroeconomic indicators have a significant effect on regional productivity growth. We conclude that the government has an important role to play in order to encourage technological diffusion in backward regions to promote its growth, and hence, reduce regional inequality.

We have shown that income disparities across regions are likely to remain substantial. Relying on market forces alone to remove sub national inequality is not enough. For this reason, direct interventions may be needed to ensure that poorer regions grow more rapidly than advanced ones. But there is no easy way out. The surge of regional development policy since the beginning of economic development has failed to reduce regional inequality. Our findings suggest that technological diffusion offers considerable promise.

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