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# Disparities in Regional Productivity, Capital Accumulation, and Efficiency across Indonesia: A Convergence Clubs Approach

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(Preliminary Draft)

**Abstract** This paper studies the evolution of regional disparities in labor productivity, capital accumulation, and efficiency across Indonesian provinces over the 1990-2010 period. Through the lens of a non-linear dynamic factor model, we test the hypothesis that all provinces would eventually converge to a common steady-state path. We find that the cross-provincial dynamics of labor productivity are characterized by two convergence clubs. The dynamics of the proximate determinants of labor productivity show some mixed results. On the one hand, physical and human capital accumulation are characterized by four and two convergence clubs, respectively. On the other hand, efficiency is characterized by a unique convergence club. The paper concludes suggesting that based on the provincial composition of each convergence club, considerable improvements in capital accumulation and efficiency are still needed to reduce regional disparities and accelerate productivity growth.

**Keywords** Regional productivity · Capital Accumulation · Efficiency · Convergence clubs · Indonesia

**JEL Classifications** R10 · R11 · R58

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## 1 Introduction

Regional inequality is a pervasive feature of the Indonesian economy (Es-mara 1975; Mishra 2009; Bendesa et al 2016). To a large extent, the insular geography and the unbalanced spatial distribution of natural resources suggest that regional inequality is an expected outcome. However, regional improvements in labor productivity may help reduce these regional imbalances and promote economic development. Moreover, since the early 2000s, major political reforms such as decentralization and democratization initiatives may have influenced the trajectories of labor productivity and its proximate determinants: physical capital, human capital, and efficiency.

Motivated by this context, this paper studies the evolution of regional disparities in labor productivity, capital accumulation, and efficiency across Indonesian provinces over the 1990-2010 period. Through the lens of the non-linear dynamic factor model developed by Phillips and Sul (2007, 2009), we test the hypothesis that all provinces would eventually converge to a common steady-state path in each of the previously mentioned production variables. One of the most appealing features of the convergence framework of Phillips and Sul (2007, 2009) is that it accommodates the role of technological heterogeneity both across economies and over time.

There is growing literature that studies regional convergence in Indonesia. For instance, Garcia and Soelistianingsih (1998) apply the classical convergence framework of Barro and Sala-i Martin (1991, 1992) to test the per-capita income convergence across provinces over the 1975-1993 period. They find that—on average—regional income disparities have decreased and provinces have tended to converge. Resosudarmo and Vidyattama (2006) re-evaluate the classical convergence framework in a panel data setting for the provinces of Indonesia over the 1993-2002 period. They find evidence of conditional regional income convergence. Vidyattama (2013) examine the role of neighbour effects on regional income convergence over the 1999-2008 period. His results indicate that geographical neighbours had a little effect on the speed of convergence.

Most of the previous studies on regional convergence in Indonesia have focused either on income or have applied variations of the classical convergence framework of Barro and Sala-i Martin (1991, 1992). This methodological approach, however, only describes the behaviour of an “average” economy, and thus, leaves aside important considerations such as non-linear dy-

namics and multiple equilibria, local convergence clubs (Galor 1996; Magrini 2009; Quah 1997). In the current paper, we aim to contribute a perspective that goes both beyond income and the “average” behaviour. In particular, we focus on the convergence dynamics of labor productivity and its proximate determinants (capital inputs and efficiency). We also emphasize the role of regional heterogeneity and evaluate the formation of multiple convergence clubs.<sup>1</sup>

Our results suggest that the cross-provincial dynamics of labor productivity are characterized by two convergence clubs. The dynamics of the proximate determinants of labor productivity show some mixed results. On the one hand, physical and human capital accumulation are characterized by four and two convergence clubs, respectively. On the other hand, efficiency is characterized by a unique convergence club.

The rest of this article is organized as follows. Section 2 describes the methodology and the data. Section 3 presents the results. Section 4 provides of brief discussion of the implication of the results. Finally, Section 5 offers some concluding remarks.

## 2 Methods and Data

### 2.1 Convergence Framework

Phillips and Sul (2007, 2009) proposed a convergence test based on the decomposition of a panel-data variable,  $y_{it}$ , as follows:

$$y_{it} = g_{it} + a_{it}, \quad (1)$$

where  $g_{it}$  is a systematic component and  $a_{it}$  is a transitory component. To further separate common from idiosyncratic components, Equation 1 is restated as follows:

$$y_{it} = \left( \frac{g_{it} + a_{it}}{\mu_t} \right) \mu_t = \delta_{it} \mu_t, \quad (2)$$

where  $\delta_{it}$  is an idiosyncratic component and  $\mu_t$  is a common component.

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<sup>1</sup> In the context of Indonesia, there are few studies that evaluate the formation of convergence clubs. Kurniawan et al (2019) and Mendez (2019) are some recent exceptions. The former studies the existence of convergence clubs in four socio-economic indicators: per-capita gross regional product, inequality, school enrollment, and fertility. The later studies the existence of clubs in three efficiency indicators: overall efficiency, pure technical efficiency, and scale efficiency.

More intuitively,  $\delta_{it}$  describes the transition path of each economy towards its own equilibrium growth path and  $\mu_t$  describes a hypothesized equilibrium growth path that is common to all economies. More formally, Equation 2 is a dynamic factor model where the idiosyncratic component,  $\delta_{it}$ , is a factor-loading coefficient that represents the individual distance between a common trending behavior,  $\mu_t$ , and the observed variable,  $y_{it}$ .

Next, the following semi-parametric specification is suggested by Phillips and Sul (2007) to characterize the dynamics of the idiosyncratic component,  $\delta_{it}$ :

$$\delta_{it} = \delta_i + \frac{\sigma_i \zeta_{it}}{\log(t) t^\alpha}, \quad (3)$$

where  $\delta_i$  is constant over time but varies across economies,  $\zeta_{it}$  is a weakly time dependent process with mean 0 and variance 1 across economies.

Given this setting, convergence is achieved when all economies move to the same transition path:

$$\lim_{t \rightarrow \infty} \delta_{it} = \delta \text{ and } \alpha \geq 0. \quad (4)$$

To empirically test this hypothesis, Phillips and Sul (2007) first define a relative transition parameter,  $h_{it}$ , as

$$h_{it} = \frac{y_{it}}{\frac{1}{N} \sum_{i=1}^N y_{it}} = \frac{\delta_{it}}{\frac{1}{N} \sum_{i=1}^N \delta_{it}}. \quad (5)$$

By dividing the observed variable,  $y_{it}$ , by the panel average, this parameter removes the common component,  $\mu_t$ , from Equation 2. Next, as  $t \rightarrow \infty$ , the convergence hypothesis defined in Equation 4 is equivalent to

$$H_t = \frac{1}{N} \sum_{i=1}^N (h_{it} - 1)^2 \rightarrow 0. \quad (6)$$

In other words, when the relative transition parameter converges to unity,  $h_{it} \rightarrow 1$ , the cross-sectional variance converges to zero,  $H_t \rightarrow 0$ . Finally, Phillips and Sul (2007) empirically test this null hypothesis by using the following log t regression model

$$\log \left( \frac{H_1}{H_t} \right) - 2 \log \{ \log(t) \} = a + b \log(t) + \epsilon_t \quad (7)$$

for  $t = [rT], [rT] + 1, \dots, T$  with  $r > 0$ ,

where  $[rT]$  is the initial observation in the regression, which implies that the first fraction of the data (that is,  $r$ ) is discarded. Based on Monte Carlo experiments, Phillips and Sul (2007) suggest to set  $r = 0.3$  when the sample is small or moderate ( $T \leq 50$ ).

A fairly conventional inferential procedure is also suggested for Equation 7. Specifically, a one-sided  $t$  test with heteroskedasticity-autocorrelation consistent (HAC) standard errors is used. In this setting, the null hypothesis of convergence is rejected when  $t_b < -1.65$ .

## 2.2 Convergence in growth vs levels

The most appealing feature, perhaps, of the model of Equation 7 is that the magnitude and sign of coefficient  $b$  indicates different convergence patterns. On the one hand, when  $b < 0$ , the model suggests divergence. On the other, when  $0 \leq b < 2$ , the model suggests convergence in growth rates (that is, relative convergence). When  $b \geq 2$ , the model suggests convergence in levels (that is, absolute convergence). Finally, a measure of the speed of convergence can be calculated as  $b/2$ .

## 2.3 Identifying convergence clubs

Even when the null hypothesis of convergence is rejected for the entire sample, it is still possible to identify multiple convergence patterns within subgroups of the data. To investigate this possibility, Phillips and Sul (2007) developed a data-driven algorithm. Specifically, this algorithm has four steps that are briefly summarized as follows.

1. Ordering: Economies are sorted in decreasing order according to their observations in the last period.
2. Core Group Formation: A core group of economies is identified based on the maximum  $t_k$ , which is obtained from a series of sequential estimations of Equation 7 for the  $k$  largest group ( $2 \leq kN$ ).
3. Club Membership: Economies not belonging to the core group are reevaluated one at a time. A new group is formed when the  $t$ -statistic is greater than zero.
4. Recursion and Stopping: The regression model of Equation 7 is applied for the remaining economies. If the null of convergence is rejected, Steps

1 to 3 are repeated. If no core group is found, then the remaining economies are labeled as divergent and the algorithm stops.

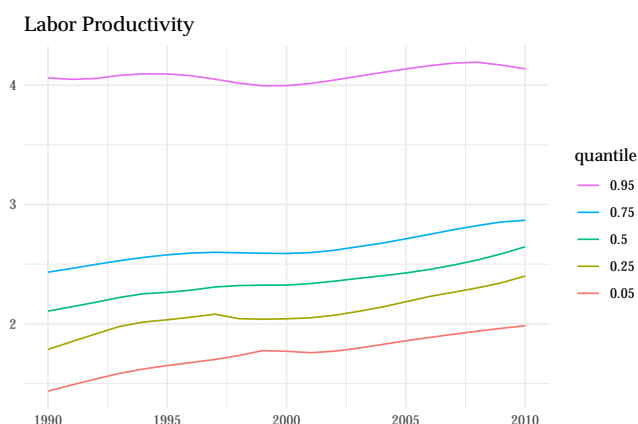
## 2.4 Data and Some Stylized Facts

The data used to measure productivity and its proximate sources are taken from different sources. First, we use gross regional domestic product (GRDP), factor inputs (labor and physical and human capital), and the population of 26 contiguous Indonesian provinces for 1990–2010. Political reforms after the economic crisis in 1998 increased the number of provinces from 27 to 34.<sup>2</sup>

Data on provincial GRDP at the 2000 constant price are sourced from Gross Regional Domestic Product of Provinces in Indonesia by Industry. The population data are sourced from Population Census and Intercensal Population Census Indonesia. The data for the provincial labor force by education attainment are sourced from Labour Force Situation in Indonesia. Average period of education of labor force is used as a proxy variable for human capital, weighted by the provincial labor force's share of education attainment. The Central Bureau of Statistics, Indonesia, officially publishes all the aforementioned datasets; however, data on physical capital stock have not been officially published in Indonesia. Therefore, we use provincial estimates from Kataoka (2013) and Kataoka (2018).

Based on the above provincial panel data, we computed the relative input-output overall efficiency score, by using the non-parametric approach of the data envelopment analysis. In computation, we treat a province as a decision making unit and use the output-oriented CCR model in order to take into account province-specific capital inputs and the presence of economies or diseconomies of scale in Indonesia's provinces. For simple comparison purposes, an alternative parametric indicator of absolute efficiency is also used. It is based on a Cobb-Douglas production setting with constant returns to scale and a physical capital elasticity of 0.3.

<sup>2</sup> The eight provinces were generated by splitting from the existing ones; and one province, East Timor, became a non-conforming region. However, no data adjustment has been made for these historical changes, which are modifiable areal unit problems that hamper the consistency of spatial analysis Fischer and Wang (2011). In an attempt to handle this issue, we aggregate data on new and existing provinces in each corresponding year. The eight newly established provinces are as follows: North Maluku (Maluku, 1999), West Papua (Papua, 1999), Banten (West Java, 2000), Bangka-Belitung (South Sumatra, 2000), Gorontalo (North Sulawesi, 2000), the Riau Islands (Riau, 2002), West Sulawesi (South Sulawesi, 2004), and North Kalimantan (East Kalimantan, 2012). Within parentheses are the original province and the year in which the new province was established Kataoka (2013).



**Fig. 1** Cross-provincial dynamics of labor productivity

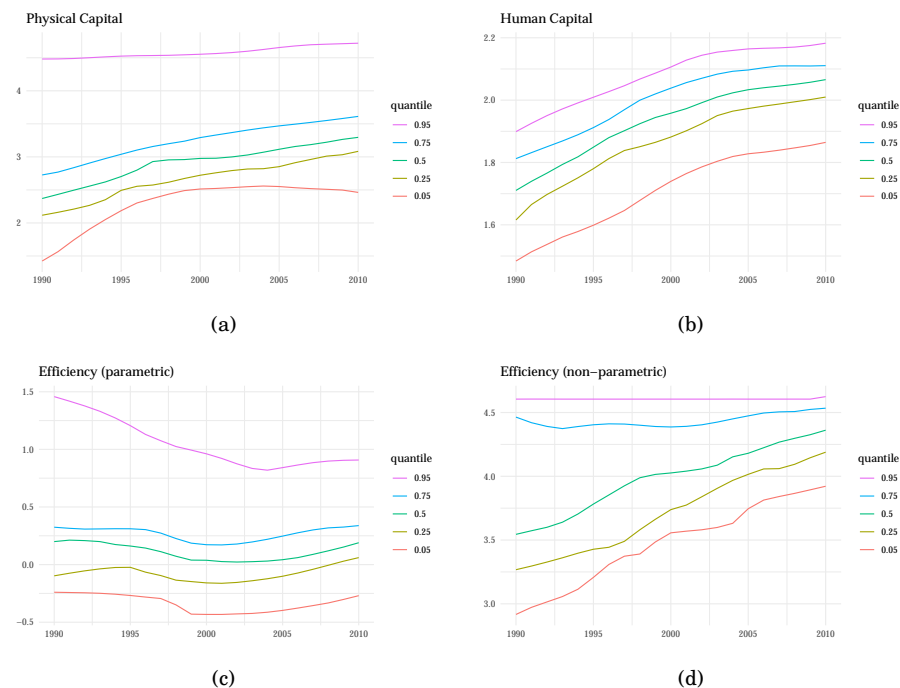
*Notes:* Labor productivity is computed as the long-run trend of (log) GDP per worker. The Hodrick-Prescott filter with a smoothing parameter of 6.25 is applied to obtain the long-run trend of the series.

To illustrate the data and document some initial facts, Figure 1 and Figure 2 present the cross-provincial dynamics of labor productivity and its determinants, respectively. In each case, the cross-provincial distribution is represented by five representative quantiles. This representation allows us to study the evolution of each variable beyond its simple average or median behaviour.

The cross-provincial dynamics of labor productivity clearly indicate that provincial inequality has been a prevalent over time. Although there is some progress arising from the bottom quantiles, their distance from the 95th quantile is still considerably large. The cross-provincial dynamics of the determinants of labor productivity show, to some extent, similar results. Physical capital and the parametric indicator of efficiency, in particular, indicate a large gap between the 95th quantile and the bottom quantiles. In contrast, such a large gap between the quantiles is not present in the dynamics of human capital or in the non-parametric indicator of efficiency.

Among the patterns of the determinants of labor productivity, the dynamics of the two efficiency indicators require further clarification. Although provincial disparities reduced in both indicators, the non-parametric measure of efficiency suggests a higher degree of regional convergence. Considering the construction of the indicators, this result could be expected because the non-parametric efficiency measure is a bounded indicator. It is constructed relative to the efficiency frontier of the DEA framework. In contrast, the para-

metric measure of efficiency is constructed in absolute terms and it is not bounded.



**Fig. 2** Cross-provincial dynamics of the proximate determinants of labor productivity

*Notes:* Labor productivity is computed as the long-run trend of (log) GDP per worker. The Hodrick-Prescott filter with a smoothing parameter of 6.25 is applied to obtain the long-run trend of the series.

Although provincial inequality has decreased in all the variables, the various patterns in which inequality has been reduced suggest that the performance of the individual provinces is far from homogeneous. Motivated by these two facts, the next section formally evaluates the statistical significance of the changes in regional inequality and then organizes the heterogeneous performance of the provinces according to their individual transition paths.

### 3 Results

The log  $t$  test of convergence suggested by Phillips and Sul (2007) rejects the convergence hypothesis for labor productivity. As shown in Table 1, the regression coefficient is negative and statistically significant. As such, provinces



in Indonesia do not appear to be converging to a unique steady-state path. The table also presents the results for the determinants of labor productivity for which the results are mixed. On the one hand, similar to labor productivity, overall converge is rejected for both capital inputs. On the other hand, cross-provincial convergence is not rejected for both efficiency indicators.

When the convergence hypothesis is rejected, Phillips and Sull (2009) suggest implementing a local clustering algorithm based on the transition paths of each cross-sectional unit. Tables 2 to 4 present the results of this clustering analysis for labor productivity and its non-converging determinants: physical capital and human capital.

**Table 1** Log t convergence test 1990-2010

Variable	Coefficient	Std. Error	t-statistic
Labor productivity per worker	-0.27	0.06	-4.24
Physical capital per worker	-0.54	0.02	-35.77
Human capital per worker	-0.25	0.06	-4.12
Efficiency (Parametric)	0.38	0.53	0.73
Efficiency (Non-Parametric)	0.76	0.07	11.02

*Note:* The null hypothesis of convergence is rejected when *t*-statistic is less than 1.65.

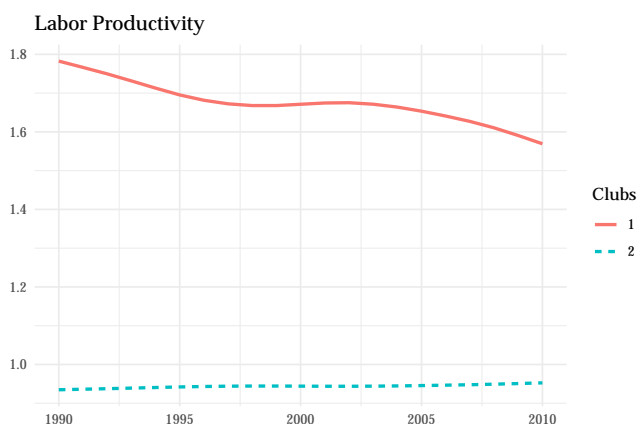
The convergence clubs of labor productivity are described in Table 2. Two convergence clubs characterize the cross-provincial dynamics of Indonesia. Figure 3 illustrates the transition paths of each club in labor productivity. Although the productivity differences between the clubs are smaller at the end of the sample period, the productivity gap between Club 1 and Club 2 remains large. In particular, Club 2 shows very little progress towards catching up with Club 1.

Figure 4 illustrates the provincial composition of each convergence club. The relatively high-productivity club is only formed by two provinces: the national capital, Jakarta, and the natural resource-rich province of East Kalimantan. The remaining 24 provinces form the relatively low-productivity club. The difference in the convergence patterns within each club is also evident. In particular, given the magnitude of the convergence coefficient of each

**Table 2** Convergence clubs classifications for labor productivity 1990-2010

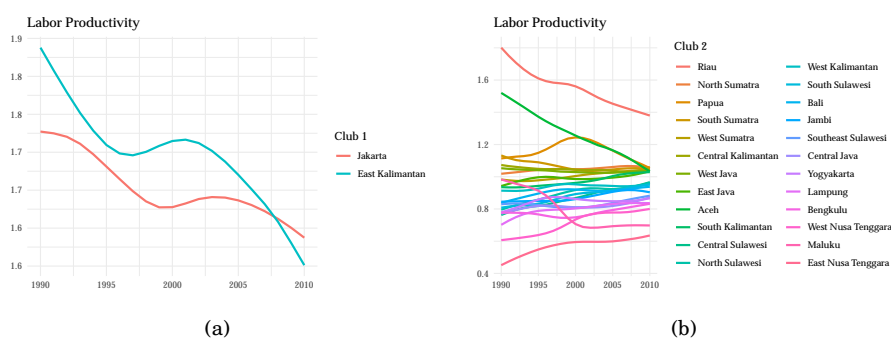
Club	No. of countries	Coefficient	Standard Error	t-statistic
1	2	3.089	1.7334	1.7821
2	24	0.0192	0.0831	0.2314

*Note:* The null hypothesis of convergence is rejected when the *t*-statistic is less than 1.65.



**Fig. 3** Convergence clubs in labor productivity

*Notes:* Each observation is normalized by the cross-sectional mean of each year.



**Fig. 4** Members of the convergence clubs in labor productivity

*Notes:* Each observation is normalized by the cross-sectional mean of each year.

group (See Table 2), the provinces in Club 1 appear to be converging in levels while the provinces in club 2 are just converging in growth rates (See Phillips and Sul (2007) for technical details).

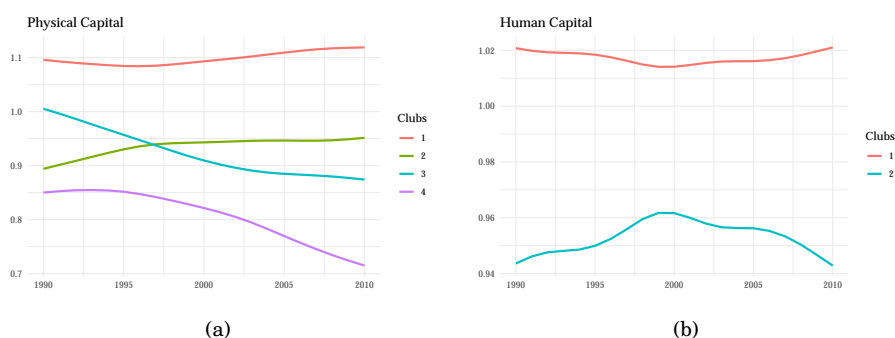
Table 3 indicates that the cross-provincial dynamics of physical capital appear to be characterized by four convergence clubs. Panel (a) of Figure 5 indicates that the three bottom clubs are systematically below average, while only Club 1 is systematically above it.<sup>3</sup> Over time, there is an increasing divergence between Club 1 and Club 4, which appears to have started in the mid-1990s. Figure 6 shows the composition of each convergence club. Most provinces belong to Club 1, where the physical capital gaps at the end of

<sup>3</sup> Recall that in Figures 3 to 6, the national average of each period is equal to one.

**Table 3** Convergence clubs classifications for physical capital per worker 1990-2010

Club	No. of countries	Coefficient	Standard Error	t-statistic
1	13	-0.055	0.04	-1.3752
2	7	0.4093	0.0161	25.4488
3	2	1.3432	1.4211	0.9452
4	3	3.3393	0.5707	5.8511

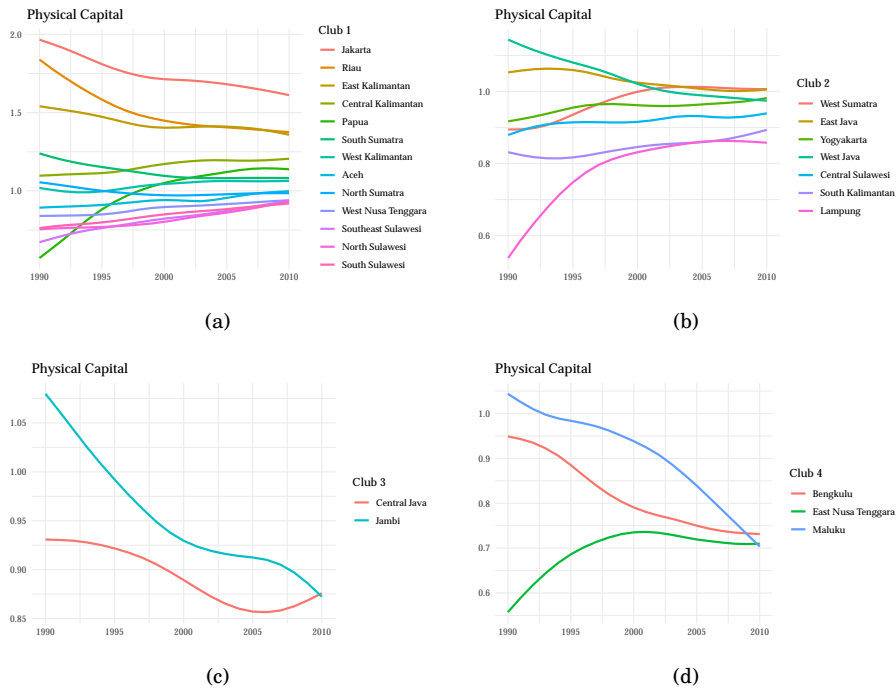
*Note:* Non-converging countries: Bali. The null hypothesis of convergence is rejected when the *t*-statistic is less than 1.65.

**Fig. 5** Convergence clubs in physical and human capital

*Notes:* Each observation is normalized by the cross-sectional mean of each year.

the period remain relatively large. Note that the regression coefficient for this club is negative but it is not statistically significant. Phillips and Sul (2009) indicate that this pattern can be suggestive of weak convergence. In contrast, provinces of Club 4 appear to have closed their relative gaps, thus, the coefficient reported Table 3 suggest convergence in levels, as opposed to growth rates.

Table 4 indicates that two convergence clubs characterize the dynamics of human capital. Panel (b) of Figure 5 indicates that the lower club is systematically below the average, while the upper club is systematically above it. The long-run tendencies of the clubs suggest that they started to diverge from each other in the late 1990s. Figure 7 shows the composition of each convergence club. Most provinces belong to the upper club, which is characterized by convergence in growth rates. Only seven provinces belong to the lower club and the appear to be characterized by a weak pattern of convergence.



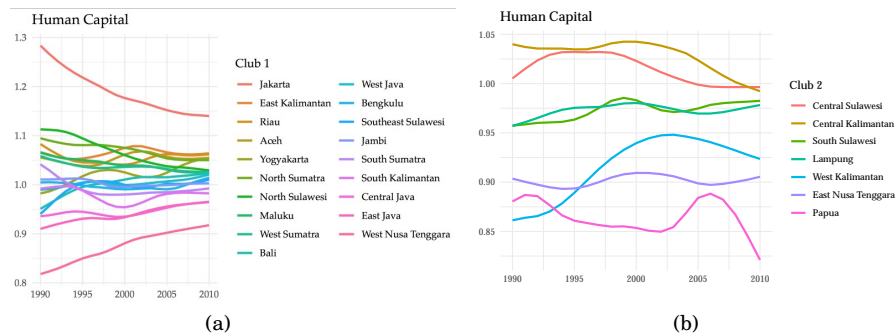
**Fig. 6** Members of the convergence clubs in physical capital

*Notes:* Observations are normalized by the cross-sectional mean of each year.

**Table 4** Convergence clubs classifications for human capital per worker 1990-2010

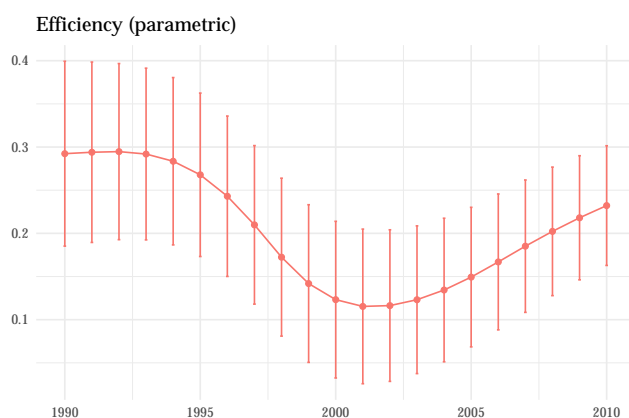
Club	No. of countries	Coefficient	Standard Error	t-statistic
1	19	0.1426	0.0701	2.0342
2	7	-0.2178	0.1485	-1.467

*Note:* The null hypothesis of convergence is rejected when the  $t$ -statistic is less than 1.65.



**Fig. 7** Members of the convergence clubs in human capital

*Notes:* Observations are normalized by the cross-sectional mean of each year.



**Fig. 8** Efficiency dynamics in absolute levels

*Notes:* The mean and the 95 confidence interval is computed for each year

## 4 Discussion

### 4.1 Efficiency still matters

When comparing the dynamics of the determinants of labor productivity, it may appear that efficiency is the only variable in which provincial inequality is less of a problem. However, improving average efficiency could further help reduce the labor productivity gaps across Indonesian provinces.

Figure 8 indicates that from the mid-1990s to the early 2000s, there has been a negative trend in the evolution of efficiency. By the year 2010, the average level of efficiency is still below the level achieved in 1990. Moreover, there is a growing literature that suggests that inter-regional resource allocation is a still major policy concern for low efficiency in Indonesia (Kataoka 2018). The cross-provincial dynamics of efficiency presented in the previous sections suggest that the provinces of Indonesia have been converging to a common long-run equilibrium.

On the other hand, the labor productivity and capital inputs have been converging to multiple equilibria. Overall, there appears to be two broad groups of provinces. A higher-performance group, which is relatively homogeneous within island blocks, and a lower-performance group, which is mostly composed of single island provinces where network effects are less effective. In other words, the persistent spatial imbalance of capital inputs keeps the two convergence equilibria away from each other. In this context,

further coordination of national and regional policies is still needed to ensure that the common convergence path rapidly recovers from the losses the 1990s and remains stable along a positive trend.

## 5 Concluding Remarks

This paper studies the evolution of provincial disparities in labor productivity, physical and human capital accumulation, and efficiency in Indonesia over the 1990-2010 period. In particular, the convergence test proposed by Phillips and Sul (2007) is applied to evaluate whether all provinces are converging to a common steady-state path. The results are three fold. First, there is a lack of overall convergence in labor productivity and two convergence clubs characterize its cross-provincial dynamics. Second, the hypothesis of overall convergence is also rejected for both capital inputs. Physical and human capital are characterized by four and two convergence clubs, respectively. Third, efficiency is the only production variable for which the convergence hypothesis is not rejected.

Classical summary measures of regional convergence such as those proposed by Barro and Sala-i-Martin (1991, 1992) only describe the behaviour of an "average" economy. However, regional heterogeneity—behaviour beyond the average—is a pervasive feature of many developing countries. In the case of Indonesia, in particular, its insular geography and the unbalanced spatial distribution of production endowments suggest that a simple evaluation of provincial averages would be incomplete at best and misleading at worst. Focusing on the role of heterogeneity both across economies and over time is the most appealing feature of the convergence framework proposed by Phillips and Sul (2007). The results of the current paper suggest that such heterogeneity is largely present in the recent history of Indonesia. They also remind us that evaluations of regional convergence should go beyond a simple dichotomous classification of convergence versus divergence. The experience of Indonesia suggest that convergence is a heterogeneous process in itself, and thus, there exist multiple patterns of convergence that vary over time and across groups of regions.

Finally, the findings of regional efficiency convergence do not imply that regional policy makers should only focus on closing regional gaps in capital inputs. It is clear from the discussion of the previous section that low efficiency is still a problem across many provinces in Indonesia. Convergence

to a low equilibrium should be avoided. Thus, policy coordination at the national and regional level should aim to reduce regional disparities in capital accumulation and accelerate the common growth rate of efficiency.

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