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

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A Convergence Clubs Approach

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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 first test the hypothesis that all provinces would eventually converge to a common steady-state path. We reject this hypothesis and find that the provincial dynamics of labor productivity are characterized by two convergence clubs. We next evaluate the dynamics of the proximate determinants of labor productivity and find 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 club and the common low level of efficiency across Indonesia, considerable improvements in both 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 (Esmara 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 nonlinear 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 a 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 for per-capita income convergence across provinces over the 1975-1993 period. They find that—on average—income disparities have decreased and provinces have tended to converge. Resosudarmo and Vidyattama (2006) re-evaluate this analysis in a panel data setting for 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.

An emerging, yet smaller, literature evaluates the formation of convergence clubs in Indonesia. A first group of studies have applied the distribution dynamics framework of Quah (1993, 1996, 1997) to infer convergence clubs from the multi-modal shape of the provincial income distribution. For instance, Sakamoto (2007) finds a bi-modal income distribution after excluding the income contribution of oil and gas. Gunawan et al (2019) find increas-

ing income polarization after controlling for the role of spatial effects. Mendez (2019) finds two local convergence clusters within the overall and technical efficiency distributions. To the best of our knowledge, only one study has applied the convergence clubs framework of Phillips and Sul (2007, 2009) in the case of Indonesia. Kurniawan et al (2019) evaluate the provincial dynamics of four socio-economic indicators (per-capita gross regional product, inequality, school enrollment, and fertility) and conclude that there are two convergence clubs in each of those indicators.

Most of 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" or representative economy; and thus, leaves aside important considerations such as non-linear dynamics, multiple equilibria, and 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.

Among our main findings, we first reject the hypothesis that all provinces would eventually converge to a common steady-state path in labor productivity. Indeed, the provincial dynamics of labor productivity are characterized by two largely separated convergence clubs. We next evaluate the dynamics of the proximate determinants of labor productivity and find 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 results of this paper contribute to the literature of regional development in Indonesia in three fronts. First, there is a large literature that studies provincial income disparities in Indonesia (Akita 1988; Mishra 2009; Akita et al 2011). To this literature, this paper contributes an evaluation of provincial disparities in some of the main determinants of per-capita income: labor productivity, physical capital, human capital and efficiency.[1] Second, there

[1] By studying the determinants of income, this paper is also related to the literature that decomposes income differences into factors in Indonesia (Akita and Lukman 1995; Kataoka 2010, 2018).

is a growing literature that studies provincial convergence with a focus on the dynamics of the "average" province that converges to a unique equilibrium (Garcia and Soelistianingsih 1998; Resosudarmo and Vidyattama 2006; Vidyattama 2013). To this literature, this paper provides an alternative perspective the goes beyond the dynamics of the average province. Specifically, this paper incorporates the role of provincial heterogeneity and the formation of multiple convergence clubs (multiple equilibria). Third, there is an emerging literature that studies provincial convergence in Indonesia from a convergence club perspective (Sakamoto 2007; Gunawan et al 2019; Mendez 2019; Kurniawan et al 2019). To this literature, this paper contributes a more comprehensive and comparable evaluation of productivity-related indicators.[2]

The rest of this article is organized as follows. Section 2 describes the methodology and the data. Section 3 discusses 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 panel data. Consider a variable, y_{it}, that can be decomposed as follows:

$$y_{it} = g_{it} + a_{it}, \tag{1}$$

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:

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

where δ_{it} is an idiosyncratic component and μ_t is a common component.

More intuitively, δ_{it} describes the transition path of each economy towards its own equilibrium growth path and μ_t describes a hypothesized equilib-

[2] The papers of Sakamoto (2007) and Gunawan et al (2019), for instance, only focus on income, while the paper of Mendez (2019) only focuses on efficiency. Although Kurniawan et al (2019) evaluate a relatively more comprehensive set of socio-economic indicators, they do not include the dynamics of labor productivity, physical capital, and efficiency, which are the main indicators of the current paper.

rium growth path that is common to all economies. More formally, Equation 2 is a dynamic factor model where the idiosyncratic component, δ_{it}, is a factor-loading coefficient that represents the individual distance between a common trending behavior, μ_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, δ_{it}:

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

where δ_i is constant over time but varies across economies, ξ_{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. That is,

$$\lim_{t \to \infty} \delta_{it} = \delta \text{ and } \alpha \geq 0. \tag{4}$$

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

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

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

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

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

$$\begin{aligned} log\left(\frac{H_1}{H_t}\right) - 2log\left\{log\,(t)\right\} &= a + b\, log\,(t) + \epsilon_t \\ \text{for } t = [rT], [rT]+1, \ldots, T \text{ with } r > 0, & \end{aligned} \tag{7}$$

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 indicate 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 reaming 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 (physical and human capital), and the population of 26 Indonesian provinces for 1990–2010 period. [3] 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 the 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 and efficiency have not been officially published in Indonesia. Thus, we use provincial estimates from Kataoka (2013) and Kataoka (2018), respectively.

The computation of efficiency deserves some additional clarification. Based on the previously described data on regional domestic product and capital inputs, we computed a non-parametric efficiency score for each province using a data envelopment analysis (DEA). In the computation, we treat a province as a decision making unit and use an output-oriented model in order to take into account province-specific capital inputs and the presence of economies or diseconomies of scale. For simple comparison purposes, an alternative parametric indicator of absolute efficiency is also used. It is based on a Cobb-

[3] Political reforms after the economic crisis in 1998 increased the number of provinces from 27 to 34 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).

Douglas production setting with constant returns to scale and a physical capital elasticity of 0.3.

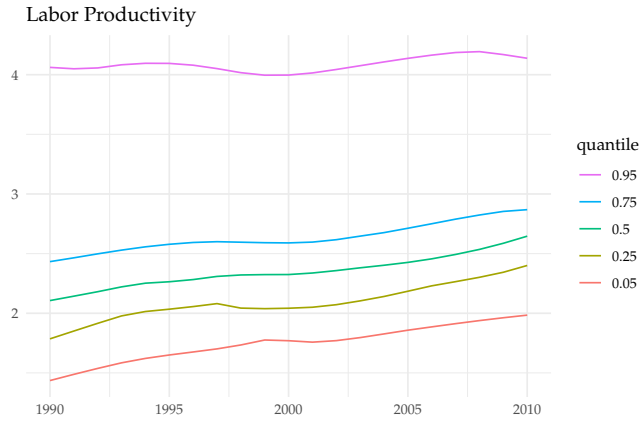

Fig. 1 Cross-provincial dynamics of labor productivity

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. In each case, the cross-provincial distribution is summarized 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 dynamics of the determinants of labor productivity show, to some extend, 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 determinants of labor productivity, the dynamics of the two efficiency indicators require further clarification. Although both indicators clearly indicate a decrease in regional disparities, the non-parametric measure of efficiency suggests a higher degree of regional convergence. This result could be expected, considering the construction of the indicators. Note

that the non-parametric efficiency measure is bounded by construction. In the DEA framework, first an efficiency frontier (upper bound) is derived from an input-out relationship; then, based on the distance to the frontier, a relative efficiency score is computed for each province. In contrast, the parametric measure of efficiency is constructed in absolute terms and it is not bounded.

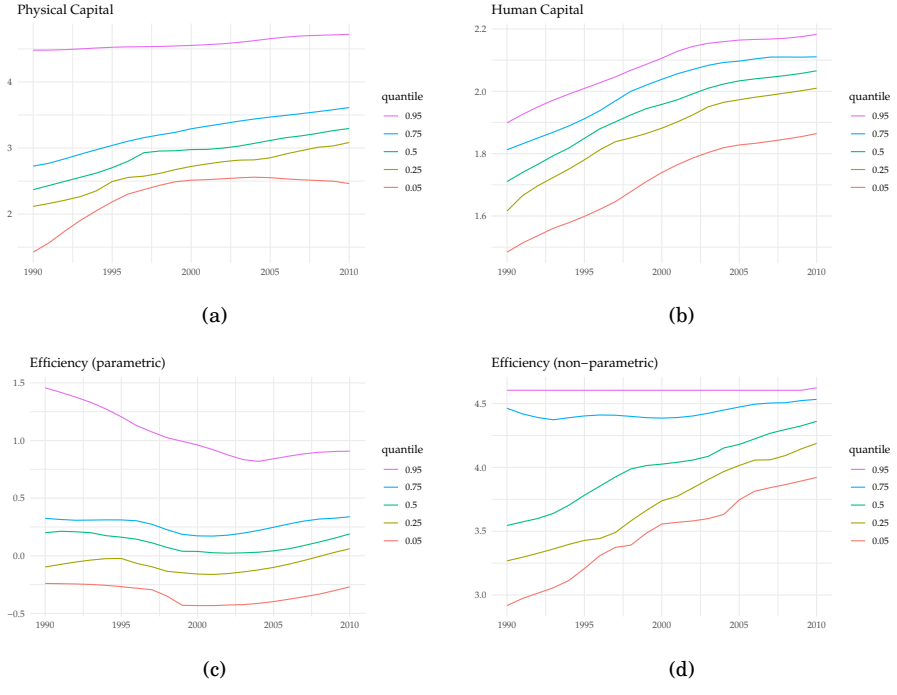

Fig. 2 Cross-provincial dynamics of the proximate determinants of labor productivity

Notes: Physical capital estimates are from Kataoka (2013). Human capital and efficiency (parametric) estimates are from Kataoka (2018). The parametric indicator of efficiency is based on the calibration of a Cobb-Douglas production function with a physical capital elasticity of 0.3. The Hodrick-Prescott filter with a smoothing parameter of 6.25 is applied to obtain the long-run trend of each 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 finds time-series clusters (convergence clubs) based on the individual performance of the provinces.

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 gap between Club 1 and Club 2 remains large. In particular, Club 2 shows very little progress towards catching up with Club 1.

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.

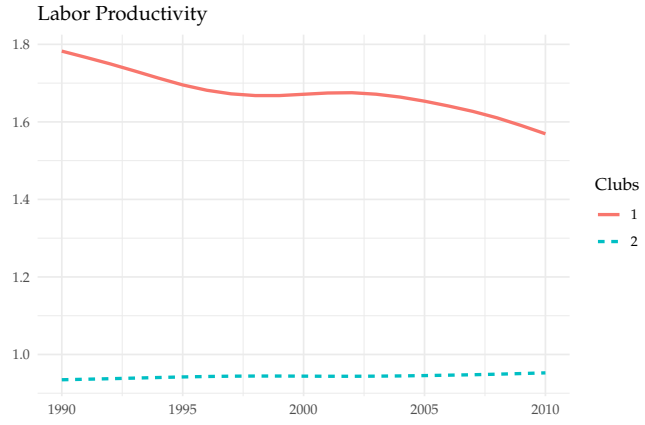

Fig. 3 Convergence clubs in labor productivity
Notes: Each observation is normalized by the cross-sectional mean of each year.

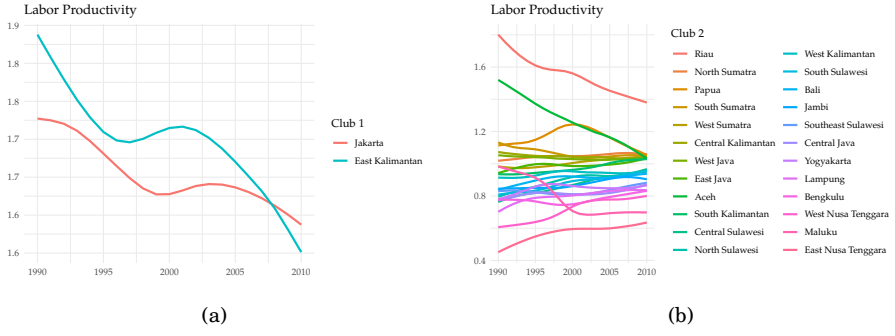

Fig. 4 Members of the convergence clubs in labor productivity
Notes: Each observation is normalized by the cross-sectional mean of each year.

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 speed of each group (See the coefficient column of 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.

Table 3 indicates that the cross-provincial dynamics of physical capital appear to be characterized by four convergence clubs. Panel (a) of Figure 5

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.

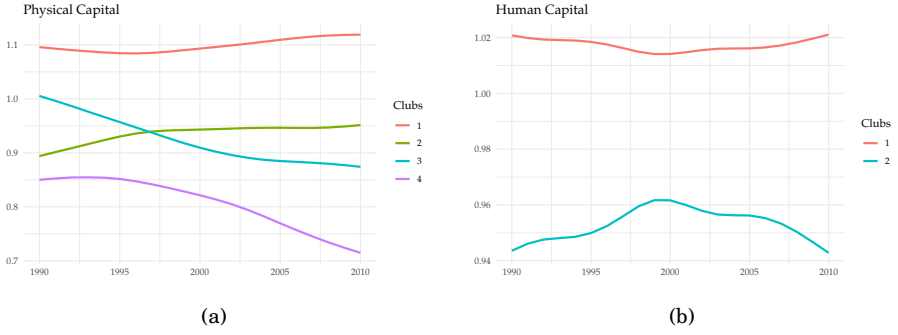

Fig. 5 Convergence clubs in physical and human capital
Notes: Each observation is normalized by the cross-sectional mean of each year.

indicates that the three bottom clubs are systematically below average, while only Club 1 is systematically above it.[4] 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 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

[4] Recall that in Figures 3 to 6, the provincial average of each period is equal to one.

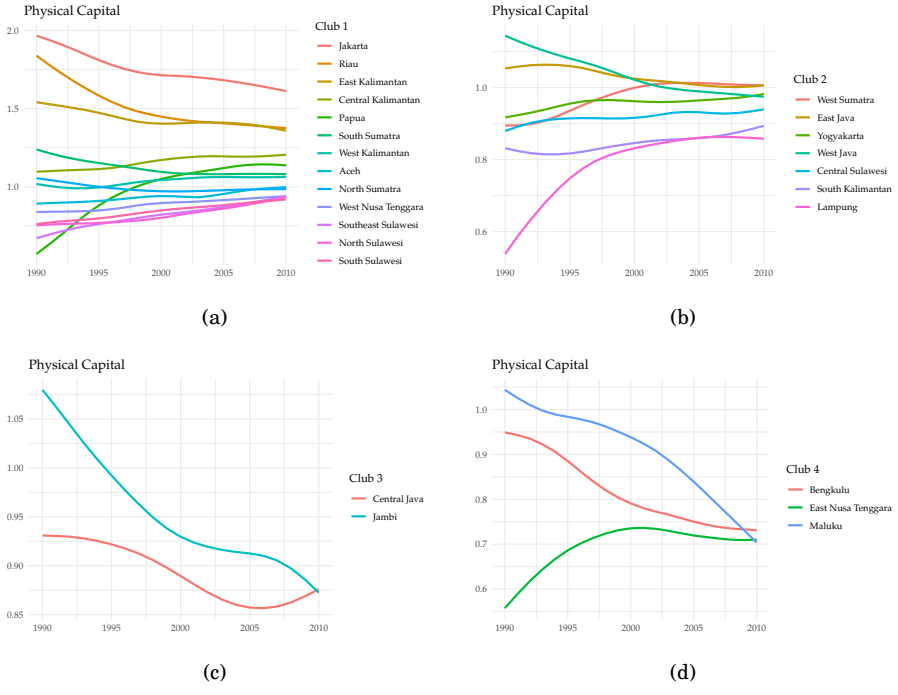

Fig. 6 Members of the convergence clubs in physical capital
Notes: Observations are normalized by the cross-sectional mean of each year.

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.

by convergence in growth rates. Only seven provinces belong to the lower club and they appear to be characterized by a weak pattern of convergence.

4 Discussion: 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 clear negative trend in the evolution of efficiency. By the year 2010,

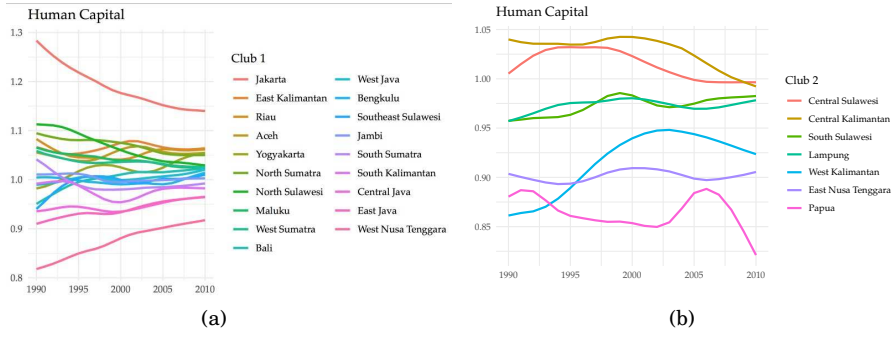

Fig. 7 Members of the convergence clubs in human capital
Notes: Observations are normalized by the cross-sectional mean of each year.

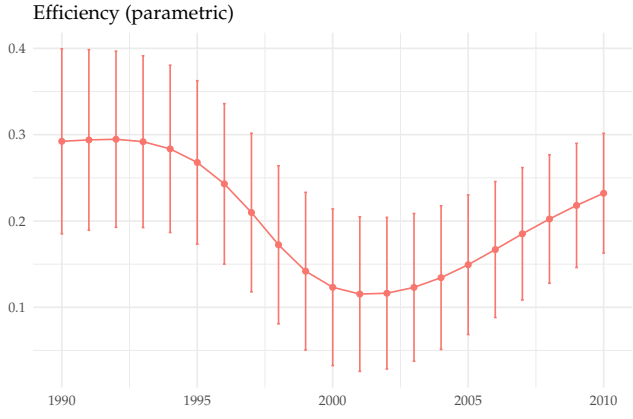

Fig. 8 Efficiency dynamics in absolute levels
Notes: The mean and the 95 confidence interval is computed for each year

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 (Bendesa et al 2016; Kataoka 2018; Mendez 2019). The results of Table 1 and the patterns of Figure 8 provide further evidence on this issue by indicating that the provinces of Indonesia have been converging to a commonly low equilibrium. In this context, national-level policies are still needed to ensure that this 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, 2009) 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 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" or representative 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. The most appealing feature of the convergence framework of Phillips and Sul (2007, 2009) is its focus on the role of heterogeneity, both across economies and over time. The results of the current paper suggest that such heterogeneity is largely present in the recent history of Indonesia. These results 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 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. As such, convergence to a low-efficiency equilibrium should be avoided. To accelerate productivity growth, national policies should focus on improving efficiency across all provinces and regional (coordination) policies should focus on reducing capital disparities within and between convergence clubs.

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