Essays on Aggregate Productivity, Structural Change, and Resource Misallocation

By

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Carlos A. Mendez Guerra

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Chapter 1

Introduction and Overview

1.1 Background

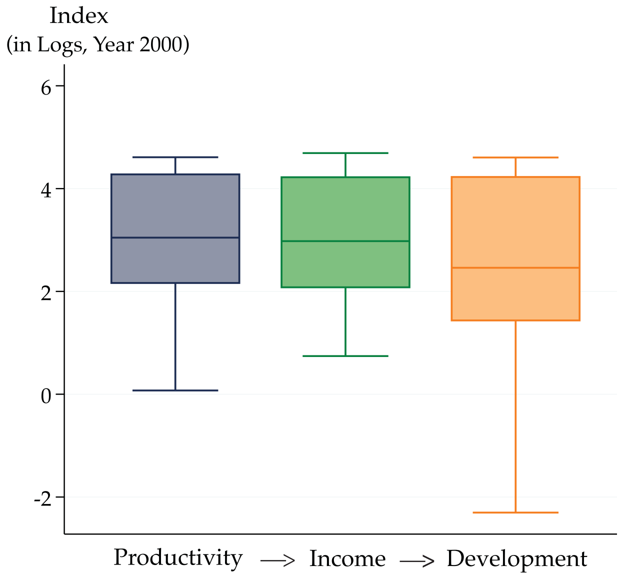
When Adam Smith wrote *The Wealth of Nations* in 1776, he was puzzled by the differences in per-capita income between the richest and poorest countries of the world. In those days, income differences were in the order of three, four or five, at most. By the year 2000, differences in per-capita income increased dramatically. For instance, per-capita Gross Domestic Product (GDP) between the United States and Niger were about 50 times[1]. What explains this astonishingly large differences in per-capita income around the globe? This dissertation argues that differences in aggregate productivity, structural change, and resource misallocation explains most of the observed income inequality in the world.

Development economists typically would argue in favor of analyzing a comprehensive set of measures of well-being. In other words, measures that go beyond GDP. Using box-and-whisker plots, Figure 1.1 illustrates the magnitude of the differences of a more comprehensive measure of development against those of per-capita income (GDP) and labor productivity. Adam Smith

[1] These income comparisons, and all comparisons in this dissertations, are carried out using Purchasing Power Parity (PPP) exchange rates. Cross-country differences in per-capita income and labor productivity are even larger when using market exchange rates.

surely would be surprised to know that today income differences are not only 10 times larger, but also such differences are smaller than those of labor productivity or a welfare-adjusted measure of income.

Figure 1.1: Cross-country Differences in Labor Productivity, Income per Capita, and Development



Note: The Development index is the welfare measure suggested by Jones and Klenow (2011). It adjusts income differences across countries by incorporating measures of life expectancy, consumption, leisure, and consumption inequality. Labor productivity is measured are potential output per worker. This measure is taken from Fernandez-Arias (2014). These box-and-whisker plots are constructed using a sample of 70 countries.
Source: Jones and Klenow (2011) and Fernandez-Arias (2014)

The arrows at the bottom of Figure 1.1 suggest a chain of causality that is closely followed in this dissertation. Although development indexes, such as the United Nations Human Development Index or others, are more comprehensive in terms of the coverage of the multidimensionality of a complex concept of such as *development*, their measurement is also less systematic over time. Moreover, Klenow and Jones (2011) show that income differences are highly correlated with different measures of welfare. In these lines of reasoning, this dissertation recognizes that development is a concept that goes much beyond income per capita. Yet, it is also true that income differences across countries explain a large fraction of the commonly used measures of development.

Next, there is a clear mapping between labor productivity and per-capita income. Let us consider the following decomposition:

$$\frac{GDP}{Population} = \frac{Employment}{Population}\frac{GDP}{Employment}. \tag{1.1}$$

Given the employment-to-population ratio[2], differences in labor productivity (measured as GDP per employed worker) translate into differences in per-capita income.

The main focus of this dissertation is on the cross-section dynamics of labor productivity and its proximate determinants. A graphical summary of those determinants is illustrated in Figure 1.2. At any point of time, differences in labor productivity could be due to differences in input accumulation, technology, and input allocation.

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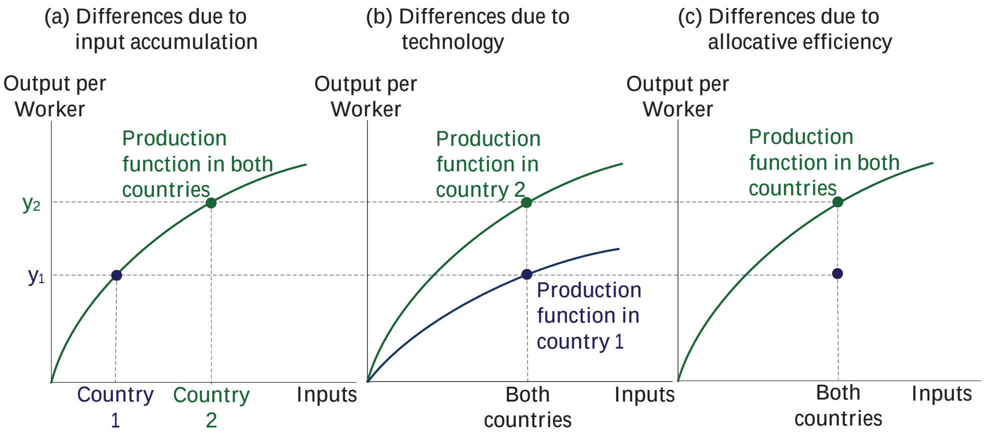
Figure 1.2: Proximate Determinants of Labor Productivity Differences



Source: Adapted from Weil (2013)

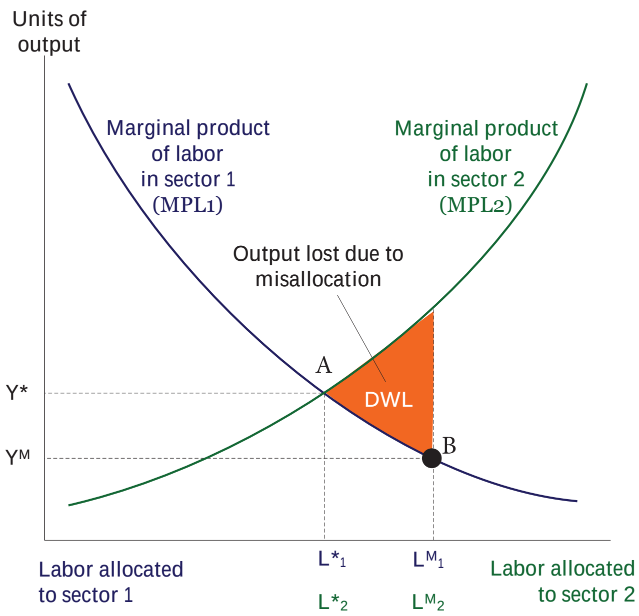
Since differences in input accumulation (e.g., physical and human capital) and technology are relatively more studied in the literature[3]. The other main goal of this dissertation is to study

[2] As documented by Caselli (2005) the employment-to-population ratio is not correlated either with GDP per capita or GDP per worker.

[3] See references summarized the survey articles by Caselli (2005) and Hsieh and Klenow (2010)

the effects of input/resource[4] misallocation across sectors on aggregate productivity. Figure 1.3 illustrates the main mechanism by which resource misallocation reduces output. Productivity gaps between sectors (e.g., $MPL_1 < MPL_2$) generate losses in aggregate output (DWL) when productive resources (e.g., labor) are over allocated ($L_1^* < L_1^M$) to relatively low-productivity sectors.

Figure 1.3: Resource Misallocation Effects



Source: Adapted from Weil (2013)

1.2 Research Objectives

General objectives of this dissertation are:

- Study the proximate determinants of labor productivity.
- Study the dynamics of the world productivity distribution.
- Study the effects of resource misallocation on labor productivity.

[4] In this dissertation, I use the terms productive factors, inputs, and resources as equivalent concepts.

Specific objectives for each analytical chapter are:

- Evaluate the cross-section dynamics of labor productivity, physical capital, human capital (Chapter 2).
- Estimate the world productivity distribution and study its evolution and determinants (Chapter 3).
- Study the evolution and determinants of the development gap between Latin America and East Asia (Chapter 4).

1.3 Research Questions

Research question for each analytical chapter are listed as follows:

Chapter 2: Aggregate Productivity and Resource Misallocation

- How large are the cross-country differences in physical capital, human capital, and aggregate efficiency?
- What is their relative contribution for understanding cross-country differences in labor productivity?
- How important is resource misallocation for understanding cross-country differences in aggregate efficiency, and ultimately labor productivity?

Chapter 3: On the World Productivity Distribution

- What are the most noticeable trends in labor productivity in the post-World War II period?
- What will the distribution of labor productivity look like in the (near/distant) future?

- How sensitive is the world productivity distribution to improvements in physical capital, human capital, and aggregate efficiency?

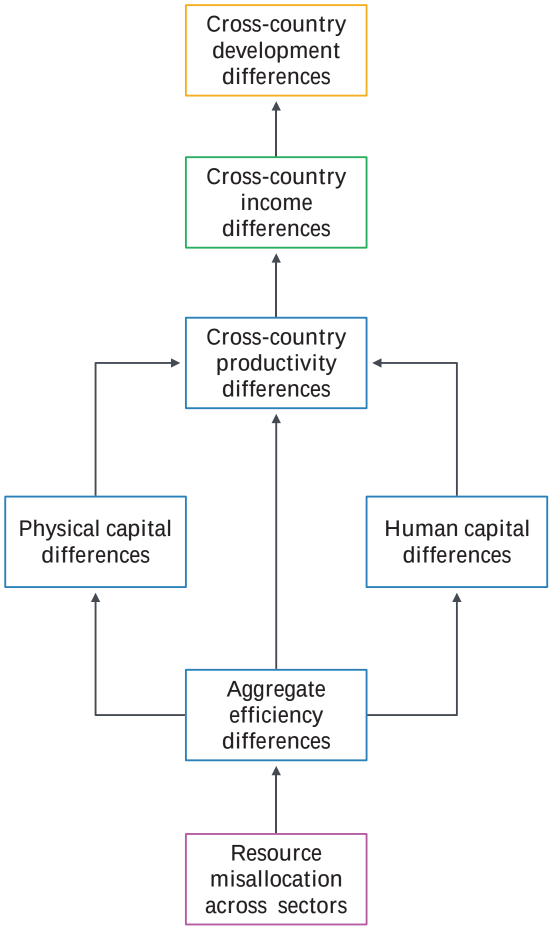
Chapter 4: On the Development Gap between Latin America and East Asia

- How large is the development gap between Latin America and East Asia?
- What are the main determinants of this development gap?
- What is the role of resource misallocation for understanding this development gap?

1.4 Overall Conceptual Framework

Following economic reasoning exposed in Figures 1.1-1.3, the overall conceptual framework is illustrated as follows:

Figure 1.4: Overall Conceptual Framework



1.5 Methodology and Data

This dissertation mostly uses calibration methods to evaluate the production structure of 92 countries over the 1950-2013 period.[5] Production functions for per-capita output, human capital, and physical capital are constructed using standard functional forms and parameters from the literature on economic growth. After documenting, updating, and extending a series of stylized facts on productivity, simulations exercises are implemented to evaluate the response of key variables. Newly available macro and sector-level level datasets are used to document productivity facts[6]: Barro and

[5] The number of countries and time coverage changes depending on the topic of each analytical chapter.
[6] Each chapter describes in detail its data sources.

Lee (2013), Fernandez-Arias (2014), Penn World Tables V 7.1, and McMillan and Rodrik (2011).

The methodological approach for each analytical chapter are listed as follows:

Chapter 2: Aggregate Productivity and Resource Misallocation

- Regression methods
- Calibration methods
- Variance decomposition methods

Chapter 3: On the World Productivity Distribution

- Dispersion and mobility statistics
- Kernel densities
- Transition matrices
- Calibration methods
- Markov Chains

Chapter 4: On the Development Gap between Latin America and East Asia

- Logarithmic decompositions
- Calibration methods.

1.6 Structure of the Thesis

Besides this introductory chapter and the last chapter that summarizes the overall findings, discusses policy implications, suggests avenues for further research, this dissertation is composed by three analytical chapters entitled as follows:

Chapter2: Aggregate Productivity and Resource Misallocation: Extending the Causality Chain

Chapter3: On the World Productivity Distribution: Convergence and Divergence Trends

Chapter4: On the Development Gap between Latin America and East Asia: Welfare, Efficiency and Misallocation.

Chapter 2 studies the cross-section dynamics of the proximate determinants of labor productivity: physical capital, human capital, and aggregate efficiency. Using a panel data set for 74 countries covering the 1950-2010 period, it first shows that regression methods consistently overestimate the fraction of the variation in labor productivity that is explained by physical capital. The source of this upward bias appears in the unaccounted covariance between capital accumulation and aggregate efficiency. Next, using calibration methods, it calculates the independent contribution of physical capital. Consistent with previous findings, most of the variation in labor productivity turns out to be explained by differences in aggregate efficiency rather than differences in physical capital. Finally, it argues that dual-economy models are useful for understanding the large and increasing differences in aggregate efficiency across countries.

Chapter 3 documents four facts about the world productivity distribution in the post-World War II period. First, there is a large and increasing disparity between the tails. Second, this disparity rapidly increased in the mid-1980s, slowed down in the next decade, and stabilized in the mid-2000s. Third, overtime there has been substantial forward and backward mobility of countries and regions. Fourth, the upper tail of the distribution is more sensitive to improvements in human capital, while the lower tail is more sensitive to improvements in aggregate efficiency.

Chapter 4 reports that long economic stagnation in Latin America and sustained growth in East Asia imply a rapidly raising development gap between the two regions. Using a series of numerical decompositions this chapter documents three facts about this gap. First, differences in welfare-adjusted development are larger than those predicted by per-capita GDP. Second, differences in labor productivity account for most of the differences in both production and welfare-adjusted development. Third, inefficient production is the main factor holding down labor productivity. Furthermore, detailed analysis of the sectoral dynamics suggests that labor misallocation across sectors had been reducing economy-wide efficiency in Latin America. In particular, premature deindustrialization (i.e., workers moving from manufacturing into services) and falling productivity in the service sector had potentially large negative effects on efficiency, productivity, and welfare-adjusted development.

1.7 Contribution to the Literature

Overall, this dissertation aims to contribute to the existent body of literature on growth and development by:

1. Reevaluating and updating the stylized facts on the cross-section dynamics of:
    - Labor productivity
    - Capital deepening and skill formation
    - Aggregate efficiency
2. Using sectoral level data to understand macro-level phenomena.
3. Highlighting the importance of dual-economy effects, and their dynamics, for understanding aggregate efficiency.

1.8 Scope and Limitations

From an overall perspective, two caveats deserve special mention at the outset of the dissertation:

- The analysis of cross-section dynamics covers only the post-World War II period, and the cross-section samples for every chapter typically cover less than 100 countries.
- Proximate sources of labor productivity across countries ultimately depend on country-specific rooted factors such as institutions, culture, history, and geography.
- Most of the modeling of production systems is based on steady-state relationships. As such, they abstract from transition dynamics.

All findings and policy implications reported in this dissertation should be considered keeping these caveats in mind.

Chapter 2

Aggregate Productivity and Resource Misallocation: Extending the Causality Chain

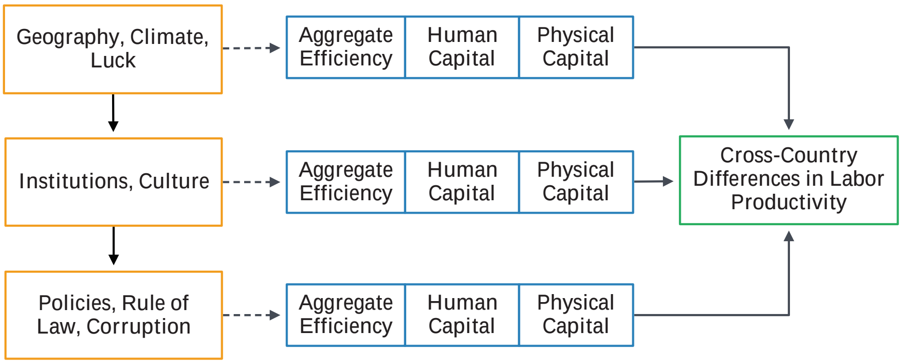
2.1 Introduction

Arguably, most research in the growth and development literature analyze cross-country differences in labor productivity according to the following chain of causation (Hsieh and Klenow, 2010):

Factors that affect labor productivity are typically classified into two groups. The first includes the most proximate factors such as physical capital, human capital, and aggregate efficiency. The second include more fundamental determinants of economic performance such as geography, culture, institutions, and polices.

This chapter first focuses on the proximate determinants of cross-country differences in labor productivity. It quantifies their dispersion and how it evolves overtime. Then it examines the ori-

Figure 2.1: Cross-Country Differences in Labor Productivity: A Chain of Causality



Source: Adapted from Hsieh and Klenow (2010)

gins of current debate on the relative importance of capital accumulation and aggregate efficiency. On one hand, using regression methods, seminal contributions such as that of Mankiw, Romer, and Weil (1992) argue that accumulation differences explain most of the variation of labor productivity across countries. On the other, using calibration methods, Klenow and Rodriguez-Clare (1997) point to the prevalence of efficiency over accumulation. In an attempt to shed light on this debate, this paper highlights that the source of disagreements relies on the strong conceptual and methodological assumptions of both lines of research. Accumulation proponents rely on the independence between capital and efficiency to implement Ordinary Least Squares regressions, whereas efficiency proponents rely on competitiveness of factor markets to calibrate key parameters.

Next this chapter focuses on the channels by which the fundamental determinants of labor productivity affect the proximate determinants. In particular, it highlights the prevalence of dual-economy structures in developing countries. Typically, standard growth models and productivity accounting procedures fail to incorporate insights from the classical development literature (Ros 2000, 2013). The work of Vollrath (2009), however, is an exception to this rule. Vollrath quantifies large dual-economy effects between agricultural and non-agricultural sectors using an accounting framework. After introducing some of the new insights from this emerging line of research, this chapter provides further evidence on the dynamics of the dual-economy. Using recent sector-level data from McMillan and Rodrik (2011), it suggests that misallocation across sectors increased over time, most notably in Latin America. A detailed example for Chile is presented in which workers move from relatively high-productivity sectors to low-productivity sectors.

Overall, this chapter argues for expanding the chain of causation that is illustrated in Figure 2.1. Integrating accounting methods (Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999; Caselli, 2005) with recent sector-level models and data (Echeverria, 2007; Vollrath, 2009; McMillan and Rodrik, 2011) seems to be a fruitful extension. In particular, resource misallocation across sectors could potentially clarify the consequences of institutional and policy failure and their effects on capital accumulation and efficiency. However, for this to happen, much progress is still needed. Section 2.4 concludes this chapter describing some open questions in which much progress towards answers is expected in the next decades.

2.2 Understanding Aggregate Productivity

Figure 2.2 shows two of the main features[1] that characterize the dynamics of labor productivity across countries. First, in contrast with the convergence predictions of the Neoclassical growth model, relative labor productivity of the medium[2] country was almost stagnant during the 1950-2010 period[3]. In 1950, output per worker relative to that in the United States was 22 percent; after

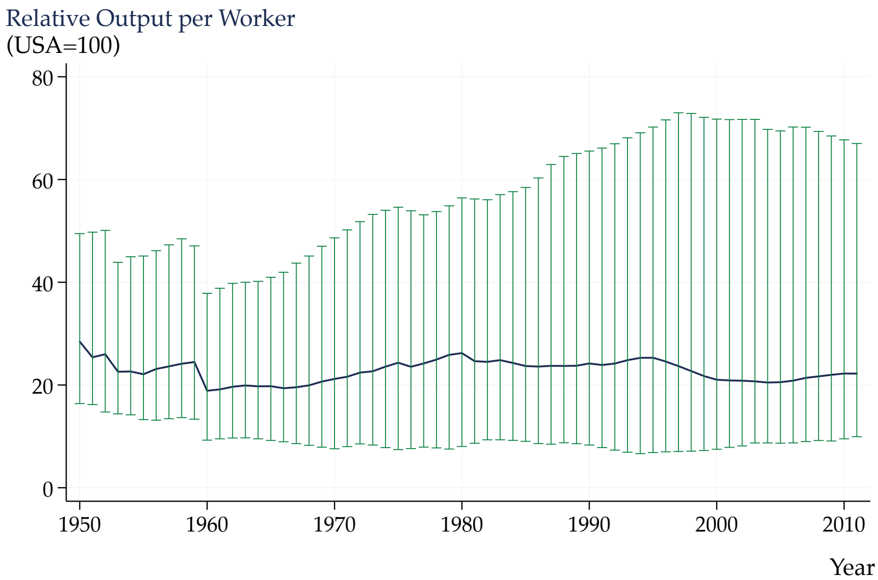
[1]Another feature not reported here would be the forward and backward mobility of specific countries or group of countries over time. This and another features are documented in the next chapter, which estimates the world productivity distribution.

[2]Here medium refers to the median (50th percentile), not the average.

[3]In support of the convergence predictions of the Neoclassical model, Barro (1992) finds conditional convergence across countries after controlling for other factors such as fertility, education, population growth, government expenditures, investment rates, among others. Durlauf, Johnson and Temple (2005), however, revise this and other well-know findings of the growth literature and highlight the limits of the previous evidence about conditional convergence. In particular, most studies supporting the conditional convergence hypothesis suffer from model uncertainty, parameter heterogeneity, endogeneity issues, and lack of robustness.

61 years it decreased to 20 percent[4]. Second, productivity differences across countries increased by a factor of 1.4. The standard deviation increased from 23 to 32 during this period. What are the main factors behind the lack of convergence and increasing disparities?

Figure 2.2: Cross-Country Differences in Labor Productivity Over Time



Source: Author's calculations using data from Fernandez-Arias (2014)

Standard growth theory provides the beginning of an answer by organizing our thoughts around an aggregate production function. For instance, Hall and Jones (1999) suggest the following functional form:

$$Y_i = A_i K_i^{\alpha} (h_i L_i)^{1-\alpha} \text{ for all } \alpha \in (0,1), \tag{2.1}$$

where Y_i is the total real GDP in country i , A_i represents aggregate efficiency[5], K_i is the total physical capital stock, h_i is the human capital per worker, L_i is the total labor force, and α is the elasticity of GDP with respect to physical capital. Dividing Equation 2.1 by the labor force L_i, and

[4]If in this computation the mean is used, average productivity increased from 33 percent to 35 percent. As a measure of centrality, the median is typically preferred to the mean when a sample contains extremely large or small values.

[5]The literature typically refers to A_i as total factor productivity (TFP). To reduce the use of jargon and avoid confusion with other productivity terms (e.g., labor productivity, capital productivity, or aggregate productivity) in this dissertation I use the term aggregate efficiency.

rearranging terms, we can obtain an expression for the average productivity of labor:

$$\frac{Y_i}{L_i} = A_i \left(\frac{K_i}{L_i}\right)^{\alpha} \left(\frac{H_i}{L_i}\right)^{1-\alpha}. \tag{2.2}$$

Equation 2.2 shows that the proximate forces driving the behavior of labor productivity can be organized into three factors: aggregate efficiency, physical capital per worker, and human capital per worker. Alternatively, they can also be categorized into two factors: aggregate efficiency and capital accumulation. In both classification the interpretation is equivalent: labor productivity in country i will be high if its workers accumulate productive resources (e.g., tools and skills) and if those resources are used efficiently. Ideally, one would like to use Equation 2.2 for answering comparative analysis questions such as how much labor productivity increase in response to variation in aggregate efficiency

One potential problem with Equation 2.2 is that capital accumulation increases endogenously in response to changes in aggregate efficiency (Klenow and Rodriguez-Clare, 1997). Conceptually, this endogeneity arises because physical capital is defined in units of final output. As a result, any increase in aggregate efficiency would affect output both directly and indirectly through capital accumulation. Hsieh and Klenow (2010) argue that keeping physical capital constant when there is an increase in efficiency requires a decrease in the investment rate. However, it is not obvious why the investment rate should decrease to improve efficiency.

To deal with the endogeneity of physical capital, Klenow and Rodriguez-Clare (1997) rearrange Equation2.2 and obtain the following production function:

$$\frac{Y_i}{L_i} = A_i^{\frac{1}{1-\alpha}} \left(\frac{K_i}{Y_i}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{H_i}{L_i}\right). \tag{2.3}$$

Equation 2.2 is consistent with the steady state equilibrium of the neoclassical growth model, where the capital-output ratio is exogenous to changes in aggregate efficiency. Intuitively, Equation 2.3 controls for the indirect effects of improvements in efficiency by raising its elasticity from one to $\frac{1}{1-\alpha}$.

Given cross-country data on total production, labor force, physical and human capital, previous studies use regression or calibration methods to empirically implement either Equation 2.2 or 2.3. In fact, Caselli (2005) and Hsieh and Klenow (2010) survey the literature that uses calibration methods. In these surveys, physical capital explains 20 percent, human capital explains 10 to 30 percent, and aggregate efficiency explains 50 to 70 percent of the cross-country differences in labor productivity[6]. Although most economists would tend to agree with these findings, there are important caveats and limitations. It is also important to analyze why, in spite of its limitations, the calibration approach would still be preferred to a regression-based approach (See section 2.2.2). Before going into such deep methodological concerns, I first discuss more general patterns about the evolution of capital accumulation and aggregate efficiency in the post-World War II period

2.2.1 Observing the Data: Capital Accumulation and Efficiency.

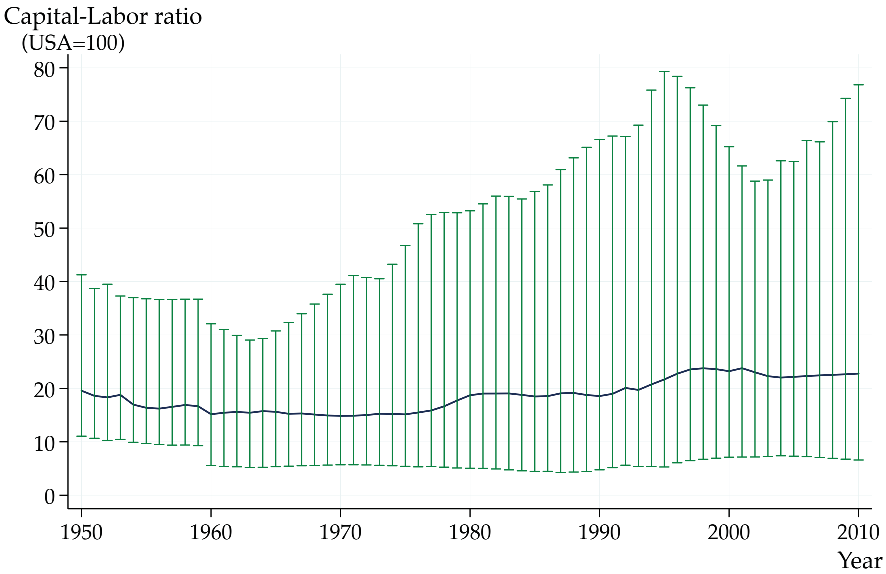
Differences in Physical Capital

Long data series on physical capital are not readily available from the national income accounts of most countries. The standard procedure in the literature is to build such series by adding investment inflows within an accumulation framework that includes depreciation outflows. For instance, the Penn World Tables V.8 database uses the perpetual inventory method to construct the physical capital series for 167 countries between 1950 and 2011. This inventory method only requires two parameters: the depreciation rate and the initial capital stock. Although the first is typically set to

[6] Originally Caselli (2005) and Hsieh and Klenow (2010) report cross-country differences in output per capita (a.i., income differences). However, it is well-know that differences in output per capita imply differences in output per worker when the employment-to-population ratio is not correlated with with output per capita.

six, the latter is not available. There exist a variety of methods for computing the initial capital stock. For instance, Jones (1997) use the capital stock in steady state which in turn depends on the long-run investment rate normalized by the sum of the population growth rate, depreciation rate, and the technical progress rate. In addition, independently of the chosen methodology, initial capital depreciates over time, so given a six percent depreciation rate, the usefulness of the initial capital would almost disappear after the first 30 years.

Figure 2.3: Cross-Country Differences in Physical Capital over Time



Source: Author's calculations using data from Fernandez-Arias (2014)

Figure 2.3 shows two features that characterize the dynamics of cross-country differences in physical capital per worker. First, similar to labor productivity, relative physical capital per worker of the medium country was almost stagnant during the 1950-2010 period. In 1950, physical capital per worker relative to that in the United States was 20 percent; after 61 years it only increased to 23 percent. Second, cross-country differences in physical capital are even larger than those in labor productivity. They increased by a factor of 1.6. over the sample period[7].

Figure 2.4 illustrates the strong correlation between labor productivity and physical capital.

[7] The standard deviation increased from 24 to 39.

Furthermore, this correlation appears to become stronger over time. To further clarify the sources of these results, consider a simplified logarithmic version of Equation 2.2:

$$log\left(\frac{Y_i}{L_i}\right) = \beta + \alpha\ log\left(\frac{K_i}{L_i}\right) + \varepsilon_i. \tag{2.4}$$

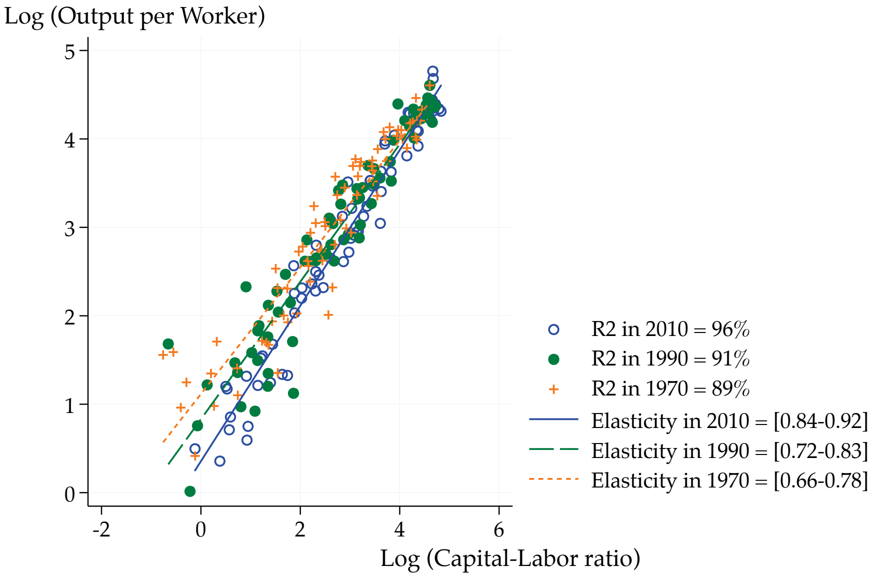
In this simplified model, cross-country differences in human capital and aggregate efficiency at a point in time would be included in the error term ε_i. Moreover, assuming that these two factors are orthogonal to physical capital, the elasticity of output per worker with respect to physical capital α can be estimated using an OLS regression.

Given the estimates for Equation 2.4 and the previously described assumptions, results from Figure 2.4 would suggest that most of the cross-country variation in labor productivity is explained by physical capital (the R-squared is close to one). For instance, in 2010 differences in aggregate efficiency and human capital would only explain four percent of the differences in labor productivity. Although the correlation between labor productivity and physical capital is indeed strong, the reported values for both capital elasticity and R-squared statistic are at odds with those suggested by national accounts (Gollin, 2002) and calibration methods (Klenow and Rodriguez-Clare, 1997). As will be discussed in Section 2.2.2, one can reduce the explanatory power of physical capital by adding measures of human capital, controlling for fixed effects, and changing the estimation framework. However, before that discussion, let us evaluate how large the differences in human capital are across countries.

Differences in Human Capital

The availability of comprehensive cross-country data on human capital seems be improving every decade. In the early 1990s, growth and level regressions typically proxied human capital using measures of school enrollment (Barro and Sala-i-Martin, 1992; Mankiw et al., 1992). In the late

Figure 2.4: Labor Productivity versus Physical Capital



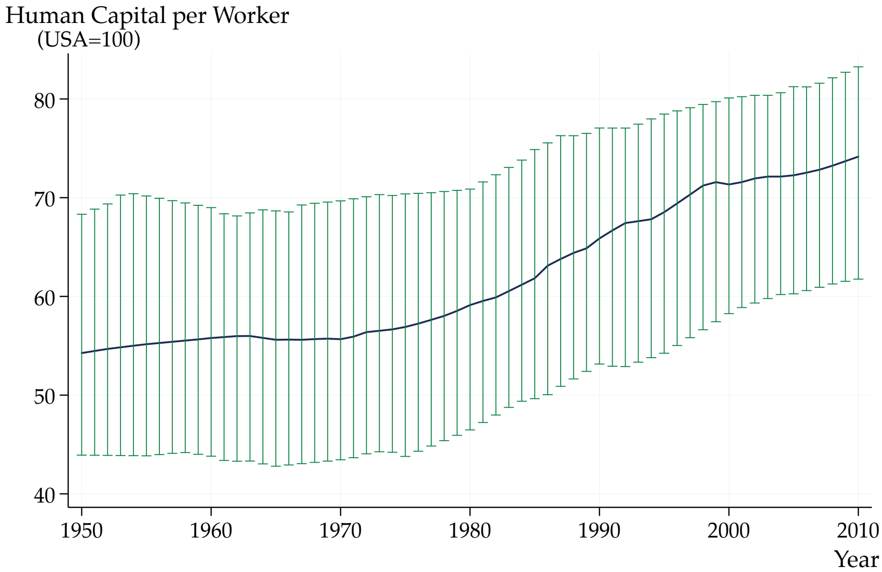
Source: Author's calculations using data from Fernandez-Arias (2014)

1990s and early 2000s, level decompositions typically used measures of years of schooling and the Mincerian returns to each year of schooling (Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999). More recently some level decompositions started using measures of the quality of schooling and returns to each year of work experience (Kaarsen, 2014; Lagakos et al., 2012).

Using the human capital production function suggested by Hall and Jones (1999), Figure 2.5 shows two features that characterize the dynamics of cross-country differences in human capital per worker. First, contrasting the dynamics of both labor productivity and physical capital, relative human capital per worker of the medium country increased during the 1950-2010 period. After two initial decades of stagnation, human capital accumulation started a rapid increase. In 1950, human capital per worker relative to that in the United States was 54 percent; by 2010 it reached 74 percent. Second, cross-country differences in human capital slightly decreased over this period. In 1950 the standard deviation was 18 percent; by 2010 it was 16 percent.

Figure 2.6 shows that human capital is also highly correlated with labor productivity, though

Figure 2.5: Cross-Country Differences in Human Capital Over Time



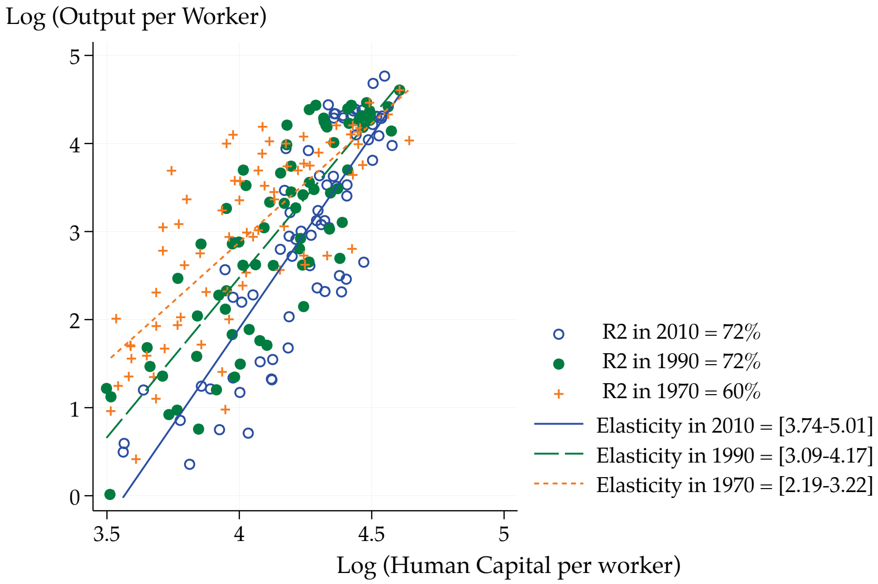
Source: Author's calculations using data from Fernandez-Arias (2014)

not as much as physical capital. As in Equation 2.4, an OLS regression would suggest that more than 60 percent of the cross-country differences in labor productivity are explained by differences in human capital alone. If anything, these regression results only highlight the strong correlation between human capital and physical capital. Thus, the orthogonality assumption that is needed to implement this kind of regressions is violated.

Differences in Aggregate Efficiency

Conceptually, aggregate efficiency is a measure that quantifies the efficiency with which an economy uses its productive resources. Efficiency gains arise due to improvements in either technical knowledge or reallocation of resources to better uses, or both. Empirically, aggregate efficiency is a residual measure. It captures everything else that affects output that is not already measured by the productivity inputs (e.g., physical and human capital). According to this empirical definition, most studies compute aggregate efficiency for any country at any point of time as the following

Figure 2.6: Labor Productivity versus Human Capital



Source: Author's calculations using data from Fernandez-Arias (2014)

ratio:

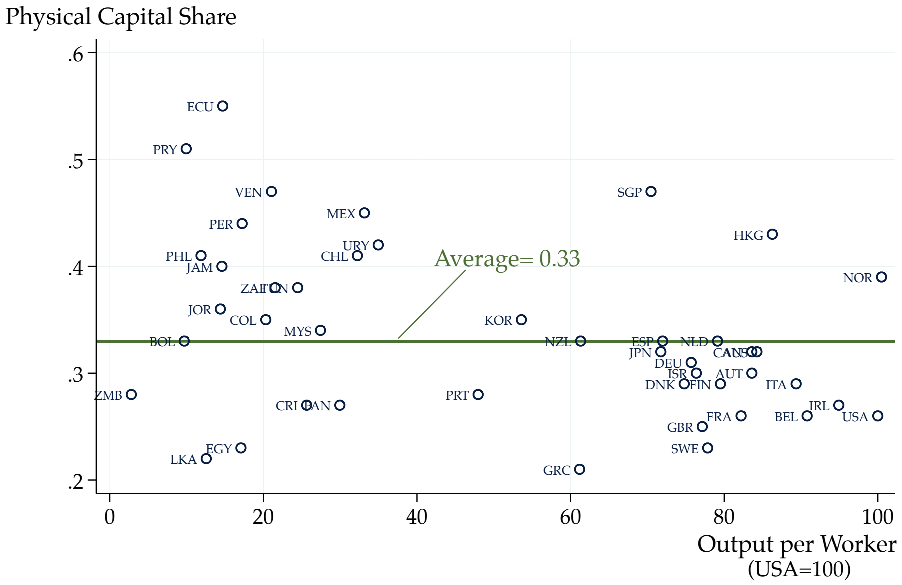
$$A_{it} \equiv \frac{output}{inputs} = \frac{\frac{Y_{it}}{L_{it}}}{\left(\frac{K_{it}}{L_{it}}\right)^{\alpha}\left(\frac{H_{it}}{L_{it}}\right)^{1-\alpha}}. \tag{2.5}$$

The only missing information to compute this ratio is the output elasticity with respect to capital α. Given the results of Figure 2.4, this parameter tends to be overestimated when using regression methods. An alternative would be to extract such information from other sources. For instance, it is well known that under perfect competition and constant returns to scale, the output elasticity with respect to capital is defined as the share of national income that accrues to physical capital:

$$\alpha = \frac{rK}{Y}, \tag{2.6}$$

where r is the price of physical capital. Gollin (2002) collects data from different sources across countries to construct measures of the capital income share. After adjusting for the income of self-employed workers, he finds no relationship between the capital share and the level of per-capita

Figure 2.7: Physical Capital Share versus Labor Productivity



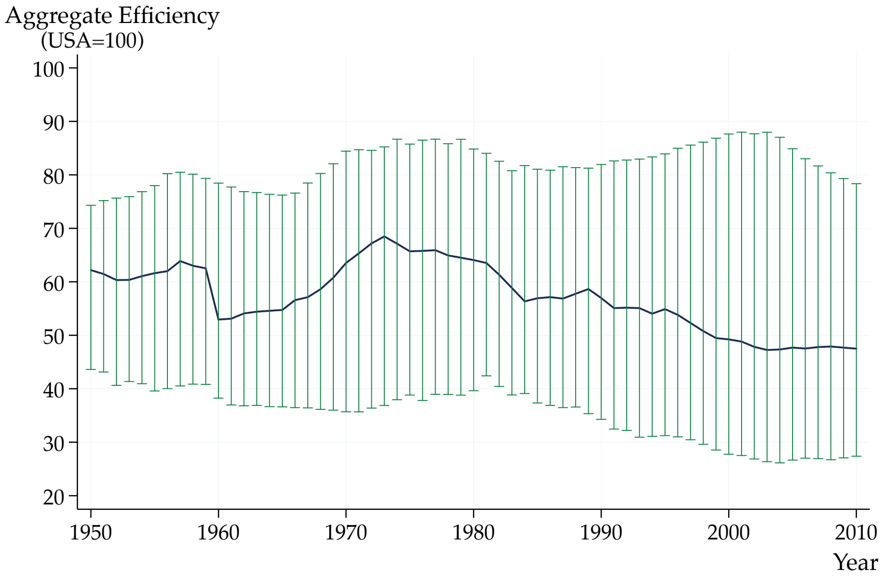
Source: Data on the capital share is from Bernanke and Gurkaynak (2002), table 10 and note 18. Data on output per worker are author's calculation using data from Fernandez-Arias (2014).

income (and labor productivity) across countries (See Figure 2.7). Moreover, the average capital share is about 1/3, which is consistent with long-term evidence of capital share series of the United States.

Using a physical capital share value of 1/3, Figure 2.8 shows the two key features that characterize the dynamics of aggregate efficiency across countries. First, relative aggregate efficiency of the medium country actually decreased during the 1950-2010 period. In 1950, aggregate efficiency relative to that in the United States was 62 percent; by 2010 it decreased to 48 percent. Second, aggregate efficiency differences across countries increased by a factor of 1.2. The standard deviation increased from 24 percent to 29 percent during this period.

Figure 2.9 shows that aggregate efficiency is strongly correlated with labor productivity. Moreover, the R-squared of a simple linear regression would suggest that in 2010 differences in aggregate efficiency explained 96 percent of the cross-country differences in labor productivity. Given

Figure 2.8: Cross-Country Differences in Aggregate Efficiency over Time



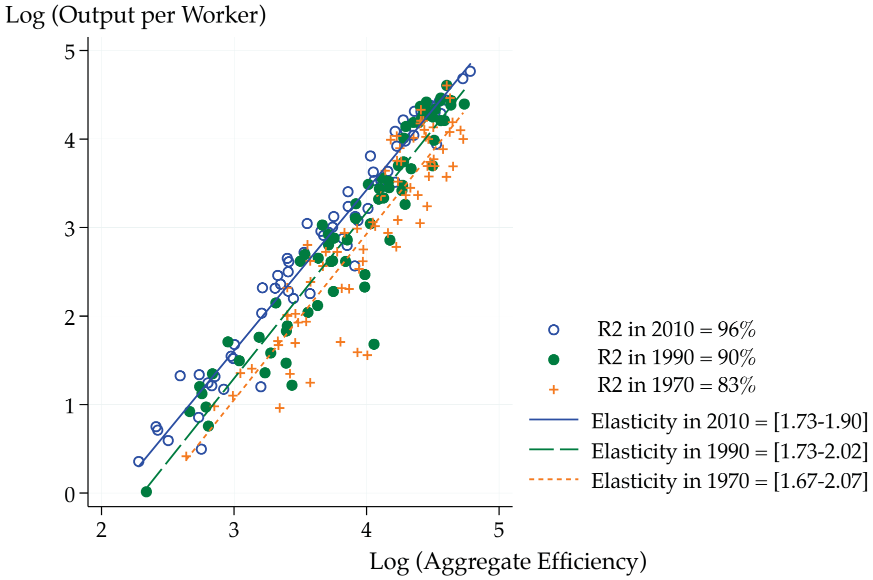
Source: Author's calculations using data from Fernandez-Arias (2014)

these findings, one would not only conclude that differences in aggregate efficiency are as important as capital, but also that these two measures are highly correlated. In fact, for the year 2010 the pairwise correlation between them was 0.93.

2.2.2 How Important is Capital Accumulation?

The main criticism to the regression approach is that both the elasticity of output (α) with respect to capital and the R-squared tend to be upwardly biased. The source of this overestimation is the uncontrolled correlation between capital accumulation and the residual term, which, in terms of the production model described in Equation 2.1, represents aggregate efficiency. Further regression analyses, summarized in Table 2.1, suggest that the implausible values for α and the R-squared still remain after controlling for human capital, country fixed effects, and constant returns to scale. Thus, if the correlation between capital and the residual so strong, how can we identify the variation of labor productivity that is due to capital differences alone?

Figure 2.9: Labor Productivity versus Aggregate Efficiency



Source: Author's calculations using data from Fernandez-Arias (2014)

Table 2.1: Different Estimations of Output Elasticities: 1950-2010 Period

Dependent Variable: Labor Productivity				
	Model (1)	Model (2)	Model (3)	Model (4)
Physical Capital	0.74	0.74	0.59	0.55
	(0.01)	(0.06)	(0.05)	(0.01)
Human Capital	0.26	0.26	-0.78	0.45
	(0.03)	(0.06)	(0.14)	(0.01)
Fixed Effects	NO	NO	YES	YES
Constraint ($\beta_1 + \beta_2 = 1$)	NO	YES	NO	YES
R2	0.90	na	0.84	na
Observations	4284	4284	4284	4284

Note: Numbers in parentheses indicate robust standard errors. All variables are significant at 1 percent. All regressions include a constant term that is not reported in the table.

Consistent with the calibration methodology suggested by Klenow and Rodriguez-Clare (1997), Vollrath (2014) describes a simple solution for controlling the previously described correlation.

Let us rewrite the simple econometric model described in Equation 2.4 as:

$$log\ y_i = \beta + \alpha\ log\ k_i + \varepsilon_i, \tag{2.7}$$

where labor productivity (y) and the capital-labor ratio (k) are expressed as lower-case letters just to simplify notation. Then, define the variation of the dependent variable that is explained by the model as:

$$R^2 = \frac{Var(\beta + \alpha \; log \; k_i)}{Var(log \; y_i)}. \tag{2.8}$$

Next, utilize the statistical properties of the variance and covariance operators and the definition of the OLS estimator to show that

$$\begin{aligned}
R^2 &= \frac{\alpha^2 Var(log \; k_i)}{Var(log \; y_i)} \\
&= \alpha \frac{Cov(log \; k_i, log \; y_i)}{Var(log \; k_i)} \frac{Var(log \; k_i)}{Var(log \; y_i)} \\
&= \frac{Cov(\alpha log \; k_i, log \; y_i)}{Var(log \; y_i)} \\
&= \frac{Cov(\alpha log \; k_i, \beta + \alpha \; log \; k_i + \varepsilon_i)}{Var(log \; y_i)} \\
&= \frac{Cov(\alpha log \; k_i, \beta)}{Var(log \; y_i)} + \frac{Cov(\alpha log \; k_i, \alpha \; log \; k_i)}{Var(log \; y_i)} + \frac{Cov(\alpha log \; k_i, \varepsilon)}{Var(log \; y_i)} \\
&= \frac{Var(\alpha log \; k_i)}{Var(log \; y_i)} + \frac{Cov(\alpha log \; k_i, \varepsilon)}{Var(log \; y_i)}
\end{aligned} \tag{2.9}$$

Equation 2.9 shows that we can compute the unbiased R-squared by letting $Cov(\alpha log \; k_i, \varepsilon) = 0$ and selecting a value for α. Using the results of Figure 2.7, most of the calibration literature sets $\alpha = 1/3$. Given this setting, in the year 2010 differences in physical capital accumulation explain only 14 percent of the differences in labor productivity across countries. One can also apply the same procedure for computing the contribution of aggregate efficiency[8]. For the same year, differences in aggregate efficiency explain 44 percent of the differences in labor productivity across countries.

[8]Note that in this case $Cov(log \; A_i, \varepsilon) = 0$

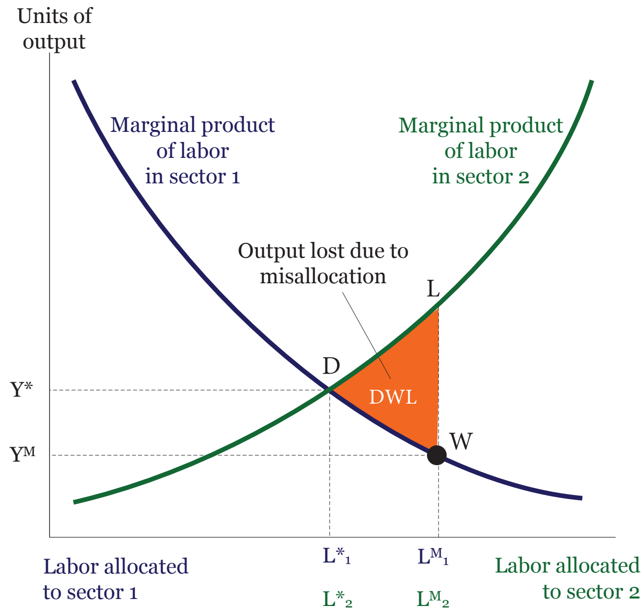
2.3 A Missing Factor: Resource Misallocation

Classical development economics models, such as Lewis (1954), focus on the coexistence of fundamentally different structures of production within an economy. In its simplest representation, Lewis' dual economy model conceptualizes the process of growth and development as the movement of workers from low productivity sectors (e.g., agriculture) to relative high productivity sectors (e.g., manufacturing). However, within such structural heterogeneity, it is possible that production factors face mobility barriers across production sectors, and so, from an aggregate perspective, the economy would suffer from efficiency losses. Another possibility is that workers (and firms) may have incentives to move to even lower productivity sectors. For instance, if labor and product markets are highly regulated so that operational costs are higher in the formal sector, many firms (and the workers they hire) would have additional incentives to move to the informal sector, where the regulation burden is minimized. The main lesson of this type of model is that structural heterogeneity within countries has aggregate efficiency implications. In other words, resource misallocation across sectors reduces aggregate efficiency, and ultimately aggregate labor productivity.

2.3.1 Dual-Economy Effects: Large Structural Differences

Figure 2.10 illustrates how structural heterogeneity and resource misallocation reduce output. In this example, an economy maximizes its efficiency when the marginal productivity of labor is equal across sectors ($MPL_1 = MPL_2$). At Point D, the economy allocates L_1^* workers to sector one and L_2^* workers to sector two. The efficiency maximizing level of output is represented by Y^*. If there exist market failures or government distortions (or both), this model captures such phenomena as wedges between the marginal products ($MPL_1 \neq MPL_2$). At point W, the economy allocates more workers to sector one L_1^M and less workers to sector two L_2^M. Given the wedges between marginal products ($MPL_1 < MPL_2$), the efficiency loss in the economy is represented by the DWL triangle and the new level of output is $Y^M < Y*$.

Figure 2.10: The Deadweight Loss of Resource Misallocation

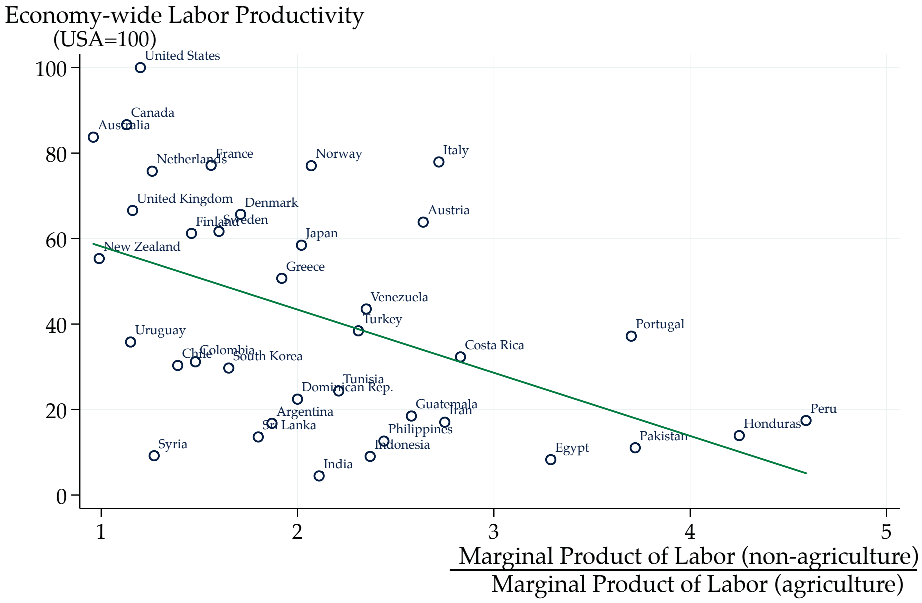


Source: Adapted from Weil (2013)

Given the theoretical insights of Figure 2.10, one would like to have a quantitative measure of the productivity wedges across sectors and their effect on aggregate output. Vollrath (2009) is a seminal contribution in this are of research. He first constructs agricultural and non-agriculture production functions for sample of countries in 1985. Then, he calibrates the parameters of each production structure to have measures of wedges in marginal productivities between agriculture and non-agriculture. As expected, marginal productivity differences tend be larger in developing countries. Figure 2.11 not only illustrates the original finding of Vollrath (2009), but it also shows that such inter-sectoral productivity gaps are highly correlated with differences in aggregate labor productivity.

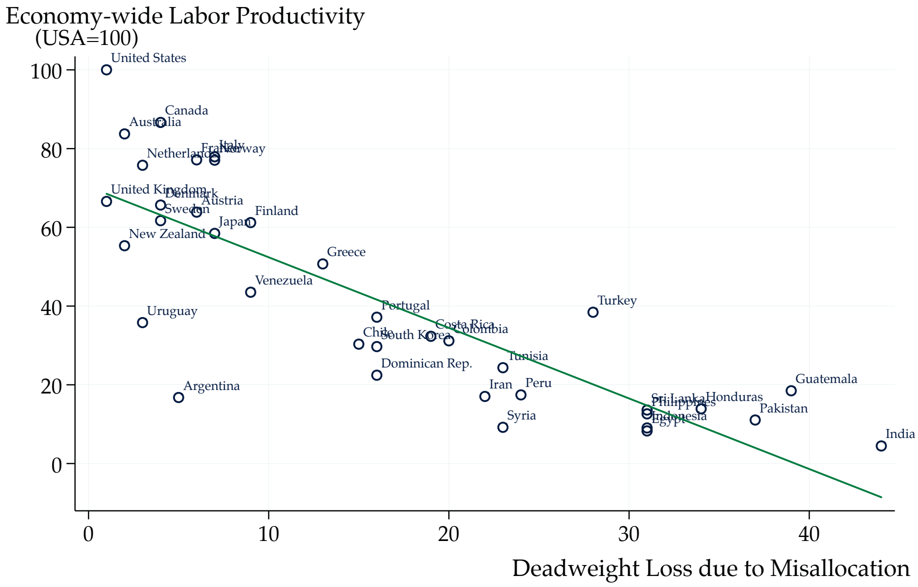
Following the logic of Figure 2.10, the next step is to compute the DWL triangle for sample of countries. Vollrath (2009) first hypothetically equalizes the marginal products between agriculture

Figure 2.11: Dual-Economy Evidence: Large Productivity Gaps across Sectors



Source: Author's calculations using data from Vollrath (2009)

Figure 2.12: How Large are the Dual Economy Effects?



Source: Author's calculations using data from Vollrath (2009)

and non-agriculture for each country. This equalization pins down the optimal allocation of resources across sectors. Then, using this efficiency maximizing allocation of labor (and capital), he recomputes aggregate production for each country. He finds that resource misallocation between agriculture and non-agriculture explains up to 80 percent of the variation in aggregate efficiency and between 30 percent 40 percent of the variation in labor productivity. Based on these findings, Figure 2.12 shows that countries with the lowest aggregate labor productivity are those with the largest efficiency losses due to misallocation.

2.3.2 Dynamic Dual-Economy Effects: Structural Change in Reverse

Figures2.11 and 2.12 document the static aggregate effects (i.e., at a fixed point in time) of the dual economy model. However, the original insight of Lewis focuses on the dynamics of reallocation, that is over time workers move from traditional low-productivity sectors to modern high-productivity sectors. Quantitative research on the dual economy, however, suffers from the lack time series data to calculate marginal productivity at the sector level.

McMillan and Rodrik (2011, 2013) aim to extend the research on the dynamics of the dual economy by constructing a panel dataset that covers a sample of developing and developed countries for the period 1950-2005. The only caveat of this dataset is that it measures average labor productivity rather than marginal productivity. Note that the conceptual framework illustrated in Figure 2.10 depends on the wedges between marginal products, which are not necessarily equal to average products. However, one can still try to infer differences in marginal products from differences in average products. Let us consider both the average and marginal products of labor in a standard Cobb-Douglass production function:

$$Y = AK^{1-\beta}L^{\beta} \tag{2.10}$$

$$\text{Average Product of Labor} \equiv \frac{Y}{L} \tag{2.11}$$

$$\text{Marginal Product of Labor} \equiv \frac{\partial Y}{\partial L} = \beta \frac{Y}{L}. \tag{2.12}$$

If the parameter β is relatively constant across sectors and over time, then differences in average products will translate into differences in marginal products. Whether this is a valid assumption or not is still a topic of research. For the purpose of exploration, and keeping in mind the limitations of the MacMillan-Rodrik dataset, Figure 2.13 describes the dynamics of the dual economy in Chile.

The striking feature of Chile, and Latin America in general, is that the structural change patterns described in Lewis (1954) appear to be working in reverse (McMillan and Rodrik, 2011). Over time, workers have kept gravitating from relatively low-productivity sectors (e.g., agriculture and manufacturing) to even lower-productivity sectors (e.g., wholesale and retail trade, and other services)[9]. More generally, McMillan and Rodrik (2013) document the structural change patterns for sample of developing countries from Latin America, Asia, and Africa. They conclude that after 2000, favorable labor reallocation increased productivity growth both in Asia and Africa, whereas labor misallocation decreased the growth potential of Latin America.

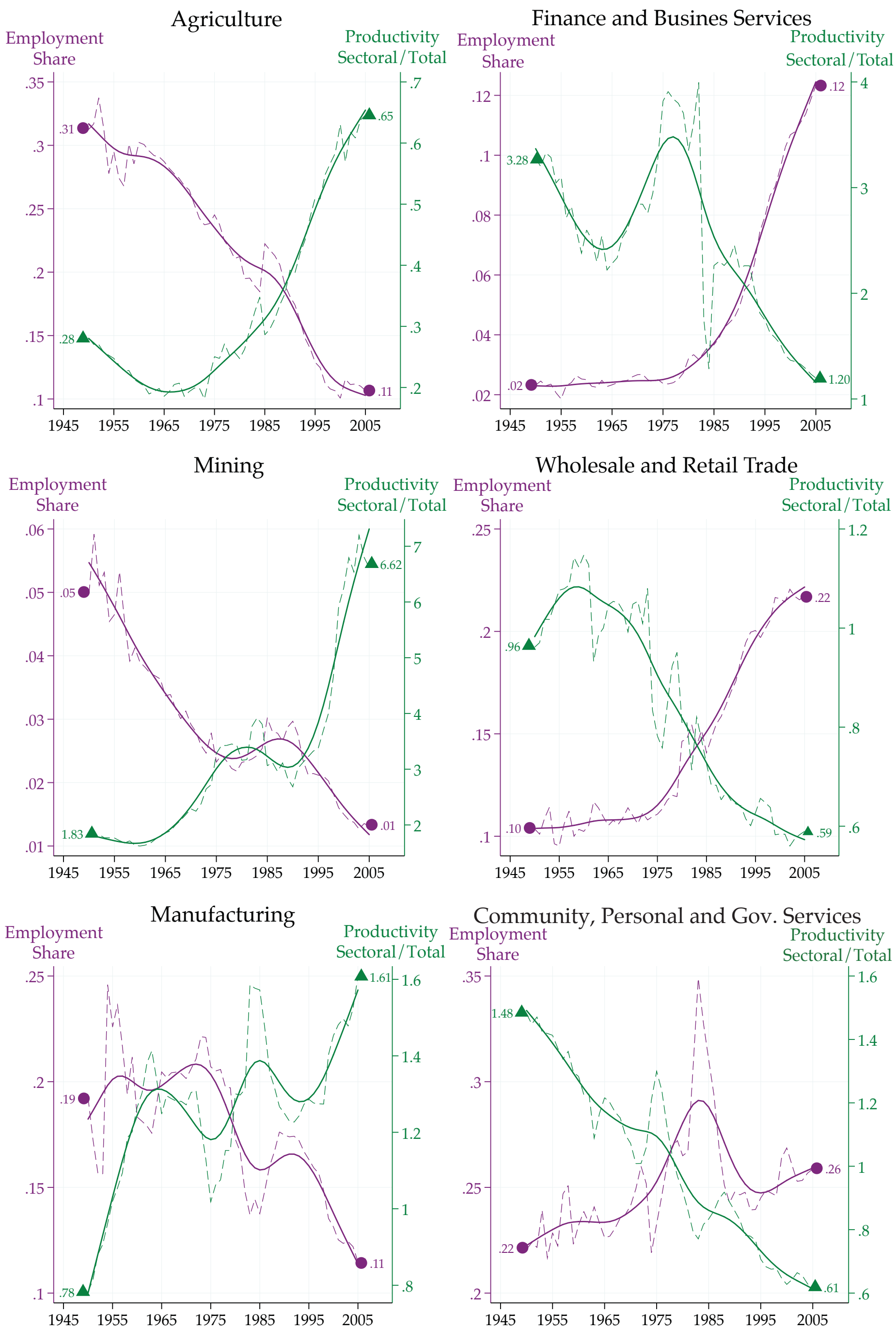
2.4 Concluding Remarks

Development macroeconomists focus their attention on cross-country differences in labor productivity. The literature on this topic is typically classified into two lines of research. One studies the most proximate and specific determinants of output: physical capital, human capital, and aggregate efficiency. The other focuses on deeper and more general determinants such as: geography, culture, institutions, and policies.

During the period 1950-2010, the relative labor productivity of the median country has been

[9] Note that average productivity has been increasing both in the mining sector and in the finance and business sector. The employment share in these sectors, however, is relatively small compared to other parts of the economy.

Figure 2.13: Dynamic Dual-Economy Effects: An Example from Chile



Source: Author's calculations using data from McMillan and Rodrik (2011)

stagnant, while cross-country differences have drastically increased. An evaluation of the cross-section dynamics of the proximate determinants of productivity reveals the following patterns[10]:

[10]Using the United States as a convergence benchmark, all variables are expressed in relative terms

- Physical capital accumulation in the median country also appears stagnant, with an increasing dispersion in the upper tail over time.

- Human capital accumulation in the median country increased over time. Contrasting the behavior of other determinants, this is the only variable in which the cross-country dispersion decreased over time.

- Aggregate efficiency in the median country decreased over time, with an increasing dispersion in both upper and lower tails.

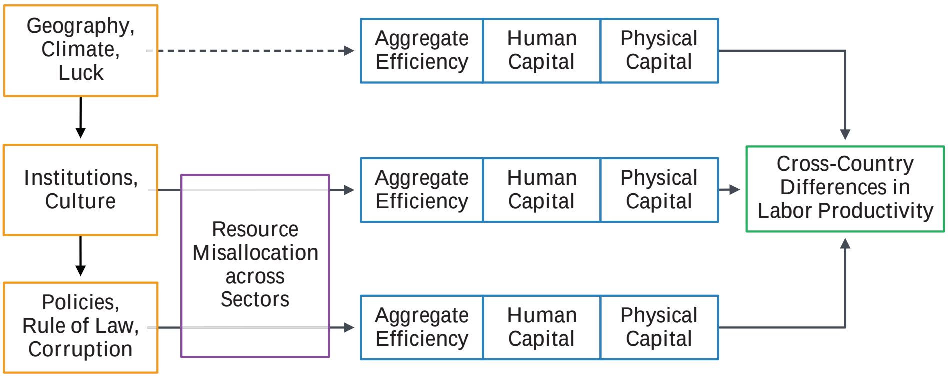
Regression methods typically overestimate the fraction of the variation in labor productivity that is explained by physical capital. Such overestimation arises from the uncontrolled covariance between capital accumulation and aggregate efficiency. Calibration methods attempt to control such covariance and highlight that most of the variation in labor productivity is actually explained by aggregate efficiency.

Figure 2.14 expands the chain of causality suggested by Hsieh and Klenow (2010)[11]. The recent quantitative and empirical literature on resource misallocation across sectors provides new insights into the intermediate channels between the fundamental and proximate sources of labor productivity. A large fraction of the observed deterioration in aggregate efficiency is likely to be driven by allocation failures. For instance, the economies of Latin America appear to be suffering from inefficient sectoral production, since most of their labor force is concentrated in the service sector, which is the part of the economy where average productivity is the lowest. Ultimately, misallocation is most likely to be driven by policy failures, institutional weaknesses, and cultural barriers.

Over the next decades, research in development macroeconomics is expected to generate new insights based on the potentially fruitful integration of quantitative dual-economy models and pro-

[11] See Figure 2.1.

Figure 2.14: Cross-Country Differences in Labor Productivity: An Extended Chain of Causality



Source: Adapted from Hsieh and Klenow (2010)

ductivity accounting methods. Some of the major questions for further research may include the following: what dimensions the production function of human capital differs in across sectors; what kind of allocative inefficiencies have the largest effects; whether misallocation effects across sectors larger than those across firms; the conditions under which a reduction in misallocation implies an unambiguous gain in welfare; and finally, why there is a secular deterioration in allocative efficiency in Latin America.

Chapter 3

On the World Productivity Distribution: Convergence and Divergence Trends

3.1 Introduction

Both convergence and divergence in output per worker characterize the post-World War II period. The world productivity distribution shows a noticeable divergence at the bottom, and convergence and overtaking at the top. For example, the average labor productivity in Taiwan relative to that of the United States rose from 13 percent in 1960 to 78 percent in 2010. Conversely, in the same period of time, labor productivity in Venezuela dropped from 60 percent to 25 percent.

In line with the work of Abramovitz (1986), Parente and Prescott (1993), and Duarte and Restuccia (2006), this study updates and expands the set of facts that theories of development should explain. Using data on potential GDP per worker, this research highlights three facts about disparity and mobility of the world productivity distribution between 1960 and 2010. In addition, two simple forecast exercises, following the work of Jones (1997a, b) and Quah (1993, 1996), suggest potential scenarios where convergence in labor productivity seems more plausible.

The first fact highlights large cross section disparities in labor productivity since 1960. For example, in 1960 an average worker in the ten most productive countries of the sample produced about 40 times more output than the average worker in the ten least productive countries. Also, the shape of the world productivity distribution in 1960 appeared unimodal and largely concentrated at the bottom: 50 percent of the sampled countries show a relative output per worker no greater than 17 percent relative to that in United States.

The second fact points to the speed at which the disparity in labor productivity has been evolving. After more than two decades of relative stability, productivity disparities across countries rapidly increased in the mid-1980s. In the next decade, however, the speed of this divergence slowed down; the data suggest a small tendency towards convergence, particularly since mid-2000s.

These two facts consistently update and extend the previous literature. Parente and Prescott (1993) report stable differences in labor productivity across countries for the coverage period ending in 1985. Duarte and Restuccia (2006) not only verify this stability, but also —after extending the coverage period until 1996— document a rapidly increasing dispersion. In this context, this study not only updates the disparity facts up to 2010, but also provides some initial evidence on the stabilization of productivity differences due to improvements in poor countries.

The third fact documents the substantial forward and backward mobility of countries and even regions within the world productivity distribution. For example, labor productivity in Asia relative to that in the United States rose from 15 percent in 1960 to 37 percent in 2010. In contrast, labor productivity in Latin America declined from 28 percent in 1960 to 23 percent in 2010. Overall, these forward and backward mobility patterns seem consistent with the polarization of the world productivity distribution and the "twin-peaks" hypothesis suggested by Quah (1993, 1996).

Given the previous facts, a natural question emerges: how might the world productivity distribution look in the future? Analysis based on an aggregate production function provides some insights to answer this question. Jones (1997a) emphasizes that potential differences in output per worker can be attributed to current differences in population growth rates, physical investment rates, human capital stocks, and the aggregate efficiency of the economy[1]. Building on this approach, countries above the 75th percentile are expected to increase their convergence rate and even overtake the technological leader. Less developed countries, however, might remain very close to, or even fall behind, their 2010 labor productivity levels. The results also emphasize the role of aggregate efficiency as the key driver of this convergence and divergence process.

An alternative yet complementary framework to forecast the world productivity distribution (over a more distant time horizon) uses Markov methods. This is an approach taken by Quah (1993, 1996) and Jones (1997b) among others. Based on historical mobility frequencies, the results suggest that labor productivity might still be characterized by a bimodal distribution, with a small yet significant number of countries at the bottom.

Overall, this chapter contributes to the earlier literature in three ways. First, it adds the period between 1996 and 2010 to the analysis. Second, it characterizes disparity, mobility, and the steady-state distribution of labor productivity using trended data to abstract from business-cycle fluctuations. Third, it presents a comprehensive view (past, current, and future) of the evolution of labor productivity for a large sample of countries.

The chapter proceeds as follows. Section 2 documents the main disparity and mobility facts. Section 3 describes how the world productivity distribution might look in the near future using a neoclassical production function approach. Assuming a more distant time horizon, Sections 4 describes the world productivity distribution using Markov methods. Section 7 offers some concluding remarks.

[1] Jones (1997a) uses the term "technology" instead of "aggregate efficiency". The latter, however, is a more general concept that not only encompasses the contribution of technology, but also other variables such as resource misallocation. Note that most of the literature on economic growth refer to this aggregate efficiency term as Total Factor Productivity (TFP). To avoid any source of confusion with other productivity related variables, in this dissertation I refer to TFP as aggregate efficiency.

3.2 Disparity and Mobility Facts

This section characterizes the cross-section dynamics of labor productivity around the world using a balanced sample of 92 countries for the period 1960-2010.[2] To build upon and extend previous findings, the organization and presentation of facts follows the work of Duarte and Restuccia (2006)

3.2.1 Large and Increasing Disparities

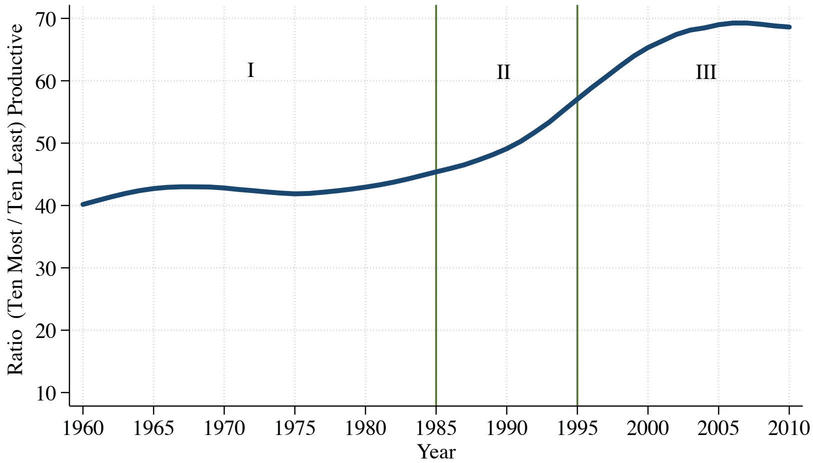
One of the main motivating facts in the field of economic growth and development is the large and increasing disparity in output per worker across countries. This subsection presents the behavior of disparity indicators between 1960 and 2010. Focusing first on the top and bottom of the world productivity distribution, Figure 1 illustrates the labor productivity gap between the ten most productive and ten least productive countries for each year from 1960 until 2010. Over this period, the productive gap between the tails of the distribution varied from 39 to 68 times. By 2010 the average worker in the ten most productive countries produced 67.6 times more output than the average worker in the least productive group of countries. Historically, the first decade of the new millennium records the largest disparity between the tails of distribution in the post-World War II period.

Consistent with earlier findings in the literature, Figure 1 suggests that the disparity between the tails of the distribution has been roughly constant during the first two decades of the sample period. From the mid-1980s until the mid-2000s, however, there has been a rapid increase in the productivity gap between the top and bottom of the distribution.[3]The first line drawn at 1985

[2]See Appendix A for a description about the construction of the sample.

[3]As noted by Sala-i-Martin (2006), increasing differences in average income per capita or average output per worker at the country level may not imply higher income inequality, or any other welfare measure, at the world level, since global inequality is also a function of within country inequality. In addition, worldwide improvements in life

Figure 3.1: Output per Worker—Ratio of the Ten Most Productive to the Ten Least Productive Countries



Note: Between 1960 and 2010, the following countries comprised the ten most productive group with the highest frequency (i.e., 51 years): Australia, Belgium, Netherlands, Norway, United States. The following countries comprised the ten least productive group with the highest frequency (i.e., 51 years): Burundi, Ethiopia, Malawi, Mozambique, Zimbabwe.

Source: Author's calculations using data from the Penn World Tables V7.1

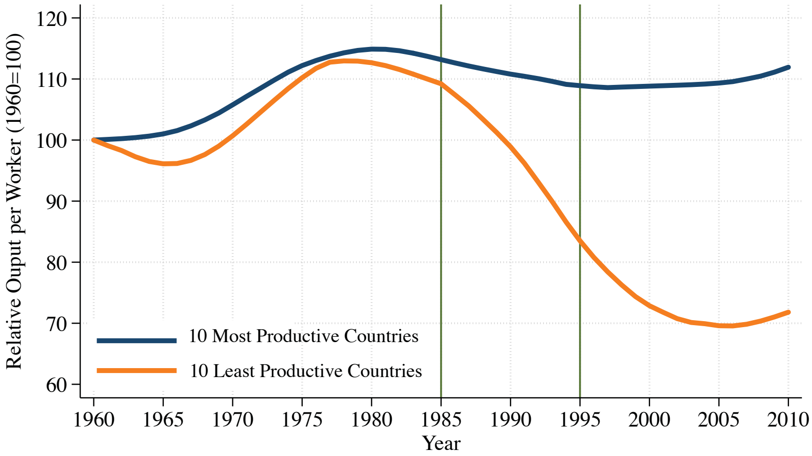
represents the end period of the first strand of the previous literature, which emphasizes constant disparities between the tails of the distribution. That literature includes the work of Parente and Prescott (1993), and Chari et al. (1997). The second line drawn at 1995 represents the second strand of the earlier literature, which emphasizes increasing disparities. That literature includes the work of Duarte and Restuccia (2006)

Extending the findings of the earlier literature, Figure 1 also documents that since the mid-1990s this increasing productivity disparity has slowed down. Moreover, since 2006 the gap has stabilized and shifted its tendency. Evaluating more extensively the nature of this trend, Figure 2 suggests that the recent stabilization of the productivity gap is driven by improvements at the bottom of the distribution.

Figure 2 illustrates the average labor productivity relative to that of the United States for the ten most productive and least productive groups, each normalized to 100 in 1960. Overall, this figure

expectancy and other health measures are not directly captured in standard productivity and income statistics, yet they help reducing income, welfare, and productivity differences in the world (Becker et al., 2005; Weil, 2007; Jones and Klenow, 2010).

Figure 3.2: Relative Output per Worker-Ten Most Productive and Ten Least Productive Countries (1960=100)



Note: Average output per worker relative to that in the U.S. for the ten most productive and least productive countries. Both series are normalized to 100 in 1960. As reference, in 1960 the average relative output per worker of the ten most productive countries is 85.88 percent, while for the ten least productive countries, it is 2.20 percent.

Source: Author's calculations using data from the Penn World Tables V7.1

shows that the increase in the disparity between the tails of the distribution is mostly driven by the decline in productivity in the least productive countries. For example, from 1977 to 2006, relative productivity decreased by 42 percent. Since 2006, however, the ten poorest countries have grown even faster than the ten richest countries. This positive growth episode ends a 30-year period of productivity divergence.

Moving beyond the analysis of the tails of world productivity distribution, Table 1 shows the relative labor productivity for a selected number of percentiles and years. The last two rows report the ratio of the ninetieth percentile to the tenth percentile and the ratio of the eightieth percentile to the twentieth percentile.

In 1960, the least productive countries of the tenth percentile showed an average productivity of 3.6 percent relative to that of the United States. In the same year, the most productive percentile percentile achieved 64.2 percent of the productivity in the United States. This difference yields a ratio of 18 between the highest and lowest percentile. Note that both percentile ratios increased

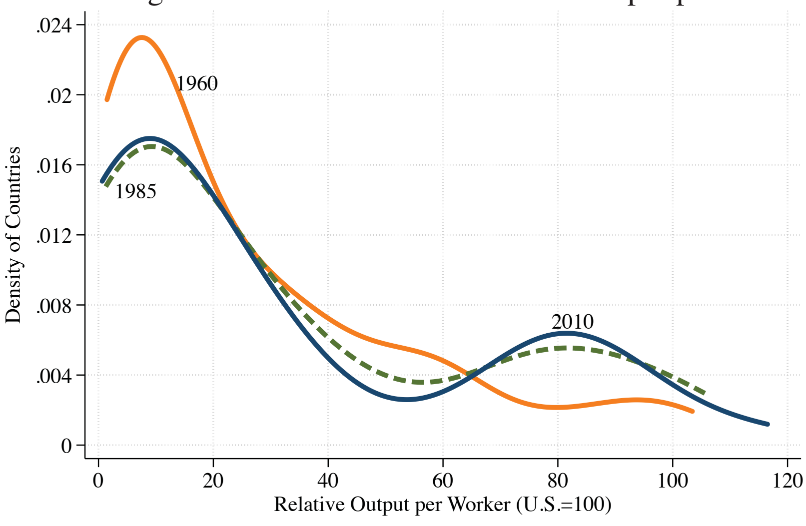
Table 3.1: Relative Output per Worker by Percentile

	1960	1970	1980	1990	2000	2010
Percentile:			(percent)			
P10	3.6	3.1	3.0	2.4	2.1	2.0
P20	4.7	4.5	4.4	3.5	2.9	3.8
P30	6.3	6.2	7.4	5.9	5.3	6.1
P40	8.2	10.1	10.7	10.2	8.3	9.6
P50	15.8	16.6	22.5	18.5	15.6	17.2
P60	23.1	25.5	27.9	25.2	23.1	25.9
P70	33.1	38.0	44.3	39.8	33.7	33.9
P80	47.5	63.4	72.6	74.2	74.4	78.0
P90	64.2	76.4	88.3	85.9	86.3	83.1
Ratio:						
P90/P10	18.0	24.9	29.2	35.9	41.8	41.0
P80/P20	10.0	14.2	16.4	21.1	25.3	20.5

Source: Author's calculations using data from the Penn World Tables V7.1

substantially until the year 2000, but then they started decreasing. Moreover, all other percentiles showed improvements in the last decade. This global convergence episode occurred after more than two decades of productivity divergence in all percentile groups.[4]

Figure 3.3: Distribution of Relative Output per Worker



Source: Author's calculations using data from the Penn World Tables V7.1

[4]From a geographical perspective, only Asian economies improved their relative productivity in the 1980s and 1990s, though at a slower pace compared to other decades.

When considering the entire distribution, our sample seems consistent with the "twin peaks" hypothesis (Quah (1993a,b), Quah (1996), Jones (1997)). Using gaussian kernel densities at different points in time, Figure 3 shows the movement in the mass of countries from the middle to both right and left of the distribution. This polarization of the distribution characterizes the third fact on the cross-sectional dynamics of labor productivity and is evaluated at the country and regional levels in the next subsection.

3.2.2 Substantial Mobility within the Distribution

Table 2 reports a mobility matrix based on the frequency of country movements over a period of 51 years. Based on their relative productivity in 1960 and 2010, the first column and the row classify countries into seven intervals. The variable $\tilde{y}$ indicates a country's labor productivity relative to that of the United States. The labels for each interval are somewhat arbitrary cut-offs for low (L), upper low (UL), lower-middle (LM), middle (M), upper-middle (UM), lower-high (LH), and high (H) productivity levels. For example, the first element of this matrix, 0.86, indicates that out of all the low-productivity countries (L) in 1960, only 14 percent of those countries upgraded their status to an upper-low productivity country (UL) by the year 2010.

Table 3.2: Mobility Matrix 1960-2010

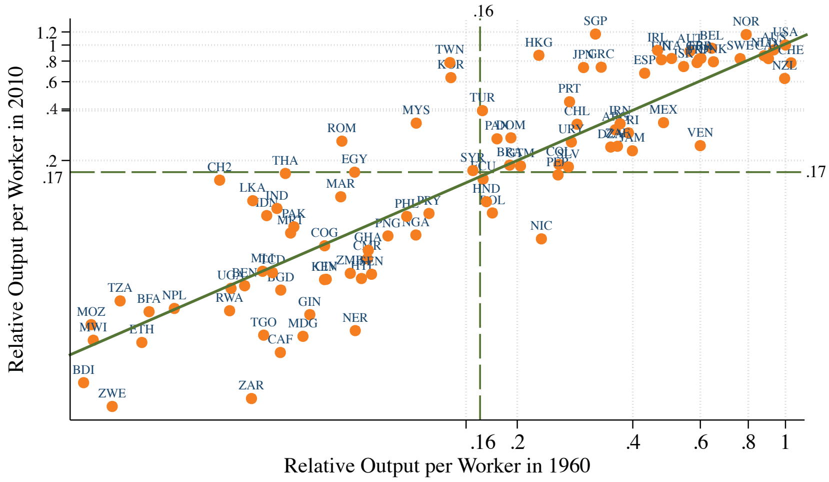
	L_{2010}	UL_{2010}	LM_{2010}	M_{2010}	UM_{2010}	LH_{2010}	H_{2010}
$(\tilde{y} < 2.5)\, L_{1960}$	***0.86***	0.14	0	0	0	0	0
$(2.5 \leq \tilde{y} < 5)\, UL_{1960}$	0.27	***0.40***	0.07	0.27	0	0	0
$(5 \leq \tilde{y} < 10)\, LM_{1960}$	0.18	0.29	***0.35***	0.12	0.06	0	0
$(10 \leq \tilde{y} < 20)\, M_{1960}$	0	0	0.29	***0.29***	0.21	0.21	0
$(20 \leq \tilde{y} < 40)\, UM_{1960}$	0	0	0.06	0.22	***0.44***	0.17	0.11
$(40 \leq \tilde{y} < 80)\, LH_{1960}$	0	0	0	0	0.13	***0.27***	0.6
$(\tilde{y} > 80)\, H_{1960}$	0	0	0	0	0	0.33	***0.67***

Source: Author's calculations using data from the Penn World Tables V7.1

Values in the off-diagonal elements of the matrix indicate the mobility frequencies of countries. The distribution shows a higher degree of mobility in the middle compared to the extremes. Among all the middle-productivity countries, most improvements occurred for the high-productivity countries in this subset. For example, out of all lower-middle (LM) productivity countries in 1960, 35 percent of those countries remained in the same productivity interval, while 47 percent moved backward and 18 percent moved forward after 51 years. In contrast, out of all upper-middle (UM) productivity countries in 1960, 44 percent of those countries remained in the same productivity interval, while and 28 percent moved backwards and 28 percent moved forward over 51 years. Overall, these results reiterate the story of Figure 3: the post-war period is characterized by both convergence and divergence patterns (that is, countries moving from the middle to both right and left of the labor productivity distribution).

Figure 4 also characterizes the mobility within the distribution by comparing the level of relative productivity for each country in 1960 and 2010. The solid 45-degree line represents countries in which productivity relative to that in the United States has not changed from 1960 to 2010. Countries above (below) the solid 45-degree line improved (deteriorated) their position relative to the technological frontier. The dashed lines indicate the median relative productivity for each year.

Figure 3.4: Relative Output per Worker- 1960 vs 2010

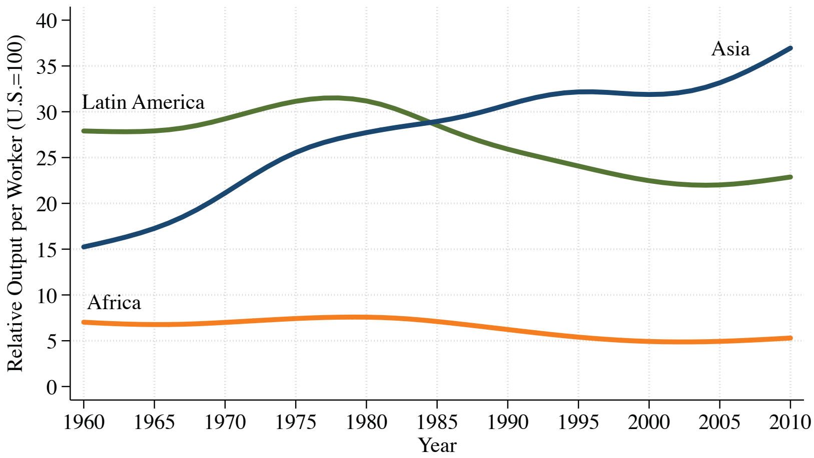


Source: Author's calculations using data from the Penn World Tables V7.1

Figure 4 is useful for identifying large convergence and divergence experiences. Countries with the largest productivity improvements include Taiwan, South Korea, China, Hong Kong, and Romania. In contrast, countries with the largest productivity deterioration include the Democratic Republic of Congo, Niger, Central African Republic, Nicaragua, and Madagascar.

Another approach to continuously characterize mobility reveals the level of relative productivity for every year since 1960 to 2010. Figure 4 summarizes this information from a regional perspective for Latin America, Asia and Africa.[5] Among these cases, the most noticeable pattern points to the contrasting performance of Latin America and Asia. Although regional averages tend to mask interesting exceptions,[6] Figure 5 is still informative in suggesting that the bulk of diverging countries are primarily located in Latin America and Africa.

Figure 3.5: Relative Output per Worker by Developing Regions



Source: Author's calculations using data from the Penn World Tables V7.1

So far this section has presented a set of facts about the increasing disparity and mobility within the world productivity distribution. These facts, naturally, lead to the question of what the distribution of labor productivity will look like in the future. The following two sections aim to answer this important question based on the characterization of a steady-state (long-run) equilibrium in both a determinist and a stochastic setting.

[5]This regional classification is based on the macro geographical classification of the United Nations. See http://unstats.un.org/unsd/methods/m49/m49regin.htm for details.

[6]These exceptions are identifiable from Figure 4.

3.3 Labor Productivity in the Long Run

This section uses economic theory to estimate the long-run (steady-state) distribution of labor productivity. Briefly, the following subsection describes the model suggested by Jones (1997a), which is a variation of the standard neoclassical growth model. Within this framework, long-run labor productivity depends on investments on physical and human capital, and the level of aggregate efficiency. After introducing the model, the following subsections describe the variables and parameters, which will be used in the computation of a steady-state distribution of output per worker for a sample of 85 countries.[7]

3.3.1 Model

Consider the following economy:

$$Y(t) = K(t)^{\alpha}\left(A(t)H(t)\right)^{1-\alpha}, \tag{3.1}$$

$$H(t) = e^{\phi S(t)}L(t), \tag{3.2}$$

$$\dot{k}(t) = s_K(t)y(t) - (n(t)+\delta)k(t), \tag{3.3}$$

where Y is total output, which is produced by physical capital K, human capital H, and labor-augmenting total factor productivity A. Human capital or skilled labor is produced by raw labor L, the time devoted to skill accumulation S , and the rate of return for a year of education ϕ. Letting lower case letters represent variables in per worker terms, the accumulation of physical capital per worker k depends on the investment rate s_K, the population growth n, and the depreciation rate δ.

To solve for a balanced growth path, all the variables should grow at constant rates. Then, in equilibrium, the growth rate of output per worker and the growth rate of capital per worker should

[7] Due to the lack of systematic educational data, this section is based on a smaller 85-country sample. This sample, however, is still larger (in terms of the number of countries and time periods) than that used in Jones (1997).

be equal to the growth rate of total factor productivity, which is denoted as g_A. By construction of the model, the exogenous variables are the growth rate of technology, g_A, the physical capital investment rate, s_K, the human capital investment rate,S, and the population growth rate, n.

Given the previous settings, the value of output per worker along a balanced growth path is specified as follows:

$$\frac{Y}{L} = \left(\frac{s_K}{n + g_A + \delta}\right)^{\frac{\alpha}{1-\alpha}} \frac{H}{L} A. \tag{3.4}$$

Note that in this equilibrium state, all economies growth at the same exogenous rate, g_A, but the levels of technology. A, are not necessarily the same across countries. Finally, redefining the variables in per-worker terms $\left(\frac{Y}{L} \equiv y;\ \frac{H}{L} \equiv h\right)$ and relative to those of the United States we have

$$\tilde{y}(t) = \tilde{\xi}_K^{\frac{\alpha}{1-\alpha}} \tilde{h} \tilde{A}(t), \tag{3.5}$$

where $\tilde{y} \equiv \frac{y(t)}{y_{US}(t)}$, $\tilde{\xi}_K \equiv \frac{\xi_K}{\xi_{KUS}}$, $\tilde{h} \equiv \frac{h}{h_{US}}$, $\tilde{A} \equiv \frac{A(t)}{A_{US}(t)}$, and $\xi_K \equiv \frac{s_K}{n+g_A+\delta}$. Equation 5 summarizes the most important prediction of the model: in a proximate sense,[8] the steady-state distribution of relative output per worker is a function of (1) the investment rate in physical capital, s_K, (2) the investment rate in human capital accumulation, S, (3) the population growth rate, n, and (4) the level of aggregate efficiency, A. Finally, as noted by Jones (1997a), other more fundamental factors such as political instability, macroeconomic policy, taxes and subsidies, social conflict, corruption and so on must work through one or more of these four proximate channels.

[8]See Acemoglu et al. (2005) and Acemoglu (2009) for a discussion of the relationship between proximate and fundamental causes in economic performance.

3.3.2 Determinants of the Steady State

Parameters

To calculate Equation 5 we need data on the parameters related to the shape of the production function: α, ϕ, and $g_A + \delta$. By construction, those parameters are assumed to be constant across countries and their calibration is based on standard estimates of the growth literature (See Table 3).

Table 3.3: Calibration of Parameters

Parameter	Calibration	Source
α	$\frac{1}{3}$	Mankiw, Romer, and Weil (1992)
ϕ	0.10	Psacharopoulos and Patrinos (1994)
$g_A + \delta$	0.075	Mankiw, Romer, and Weil (1992)

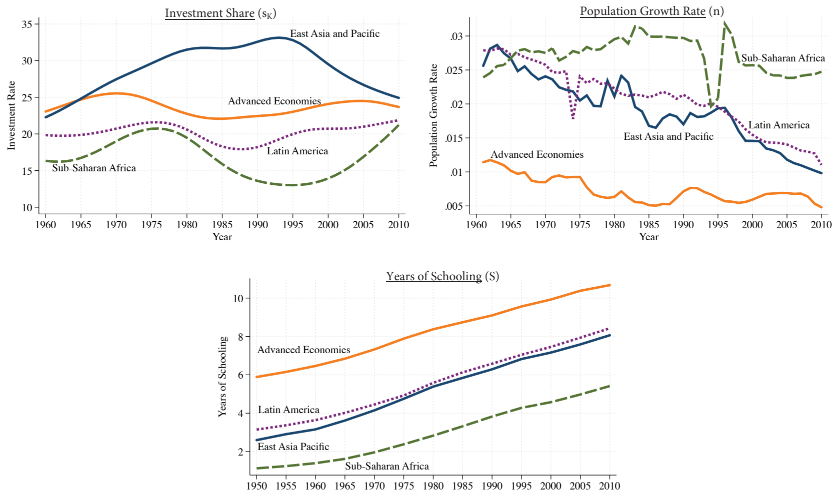
Variables

Equation 5 also requires variation across countries for s_K, n, S, and $\tilde{A}$. Last decade averages for the physical investment rate, s_K, and population growth rate, n, are computed from the Penn World Tables version 7.1. Data on average years of schooling, S, for the year 2010, are taken from Barro and Lee (2010). Finally, to estimate the relative level of technology $\tilde{A}$ in 2010, the paper follows development accounting decomposition suggested by Jones (1997a).

Figure 6 shows the behavior of three of four determinants of labor productivity (the construction of the relative level of aggregate efficiency is discussed in the next paragraph). Note that the rate of investment in physical capital s_K appears to be converging across regions. With the exception of countries in Sub-Saharan Africa, global convergence in population growth n is also observable. In terms of educational attainment, although there are noticeable improvements in all regions, there still exists a large gap between advanced and developing economies.

The relative level of aggregate efficiency is the last variable we need to forecast the distribution

Figure 3.6: Regional Averages for s_K, n, and S



Note: A smooth trend, based on the Hodrick-Prescott filter, is used to depict the behavior of physical investment rates. Equal weights for each country are used in the computation of regional averages. The regional definitions are from Barro and Lee (2013)

Source: Author's calculations using data from the Penn World Tables V7.1

of labor productivity. Table 4 summarizes the calculation of this variable for a selected sample of countries.[9] The overall finding of this exercise is that for the whole 85-country sample, the standard deviation of the natural logarithm of technology ($log\tilde{A}$) is about 80 percent of the standard deviation of the natural logarithm of output per worker ($log\tilde{y}$). This finding favors the predominant role of aggregate efficiency in the determination of output per worker. Among the particular cases, it is worth noting that although Japan shows the same capital-labor ratio as the United States, output per worker is about 31 percent less than because of lower efficiency. In contrast, Hong Kong and the United Kingdom report higher efficiency levels than the United States, but output per worker is lower mainly due to inferior educational attainment. Performance in developing countries lags far behind in all these variables, yet the major determinant of output per worker seems clearly to be aggregate efficiency.

[9] Appendix B documents the relative TFP levels for the complete 85-country sample

Table 3.4: Relative TFP levels ($\tilde{A}$) in 2010

		Contributions		
	$log\,\tilde{y}$	$\alpha\,log\,\tilde{k}$	$(1-\alpha)\,log\,\tilde{h}$	$(1-\alpha)\,log\tilde{A}$
United States	0.00	0.00	0.00	**0.00**
Hong Kong	-0.14	0.03	-0.18	**0.01**
United Kingdom	-0.20	-0.15	-0.24	**0.20**
Japan	-0.31	0.00	-0.10	**-0.21**
Venezuela	-1.40	-0.38	-0.40	**-0.62**
Brazil	-1.67	-0.53	-0.37	**-0.78**
China	-1.88	-0.65	-0.33	**-0.91**
India	-2.28	-0.81	-0.53	**-0.94**
Cameroon	-2.98	-1.03	-0.46	**-1.49**
Mean (85 countries)	-1.80	-0.61	-0.35	**-0.84**
Standard Deviation	1.37	0.51	0.18	**0.73**

Source: Author's calculations using data from the Penn World Tables V7.1

3.3.3 The Steady-State Distribution and Alternative Scenarios

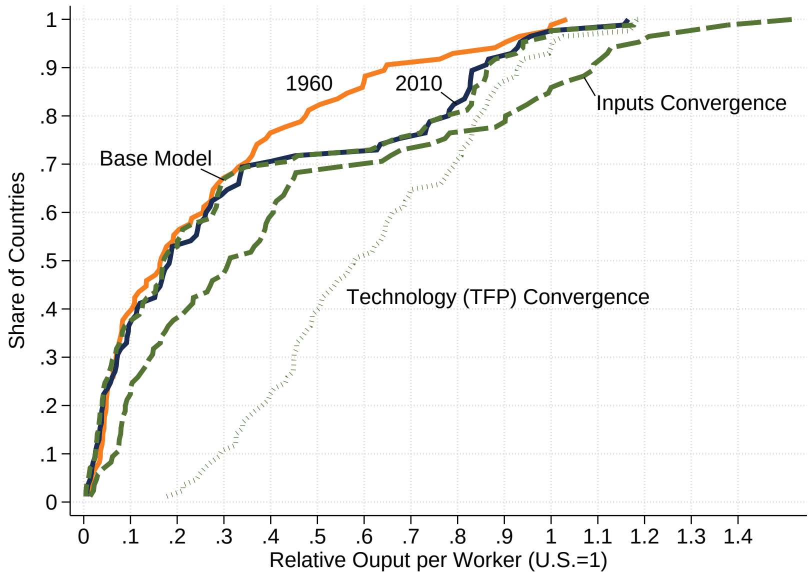
Figures 7, 8 and 9 illustrate the main empirical results of this section. They describe the steady-state distribution of labor productivity under different assumptions. Also, Appendix B presents further information for every country in the sample.

Base Model

To predict the steady-state output per worker, I use decade averages for the investment rate s_K and population n growth; also I assume the *relative* levels of aggregate efficiency and human capital from 2010 to be constant in the near future. Given this setting, two results are worth noting.

First, consistent with the previous findings of the literature (Jones1997a), the steady-state distribution of labor productivity appears very similar to the 2010 distribution, particularly for the poorer 70 percent of the sample. The R^2 statistic comparing labor productivity in 2010 and in steady state equals 0.99. Also, the standard deviation raises from 34 percent to 35 percent and the median decreases from 19 percent to 17 percent. Overall, these statistics suggest that if todays' policies regarding human capital accumulation and aggregate efficiency remain invariant (in

Figure 3.7: Cumulative World Productivity Distributions



Source: Author's calculations using data from the Penn World Tables V7.1 and Barro and Lee (2013)

relative terms across countries), divergence in labor productivity —and income— is expected to continue in the future.

Second, although the 2010 and steady-state distribution look broadly similar, they also exhibit some interesting differences in terms of additional convergence and divergence cases. For example, countries which are expected to have the largest improvement in labor productivity in the near future include China, India, South Korea, Romania, and Taiwan. In contrast, countries which are expected to have the largest deterioration include the Democratic Republic of Congo, Togo, Burundi, Cote d'Ivoire, and Central African Republic.

Convergence in Inputs: The Power of Human Capital is at the Top

In this scenario, I equalize the physical investment rate s_K, and years of schooling S of all countries to that in the United States. The results of this experiment are somewhat mixed.

Figure 8 (panel a) shows that almost all countries[10] improve their position (they lie above the 45-degree line) after allowing for full convergence in inputs. Further analysis reveals that human capital is the main driver when shifting the distribution. Also the largest effect of human capital convergence is concentrated at the top of the distribution. The median labor productivity raises from 19 percent in 2010 to 31 percent; and the upper middle and top[11] of the distribution show the largest improvements. The downside of this scenario, however, is an increase in the disparity of labor productivity. The standard deviation of relative output per worker raises from 34 percent in 2010 to 40 percent in steady state.

Evaluating the shape of the cumulative distribution in a steady state, Figure 7 points to a potential explanation for understanding the unsatisfactory results of input convergence. Productivity at the bottom of the distribution appears very sticky in spite of additional accumulation of productive factors (inputs). Other countries at the middle and top of the distribution get better returns with similar endowment levels. This results suggests that it is not only the low level of inputs that keeps productivity stagnant in the poorest countries, but also the way in which inputs are used. In the next scenario, I empirically test this well known argument from the economic growth literature.

Convergence in Efficiency: The Main Determinant of Development

In this scenario, I allow countries with an efficiency level less than the United States to converge to this benchmark, and the twelve countries with higher higher maintain their technological advantage.

Results in this setting are more encouraging, convergence in aggregate efficiency both condenses and shifts the steady-state distribution. Contrary to input convergence, the standard deviation of relative labor productivity falls from 34 percent in 2010 to 25 percent in steady state. Almost

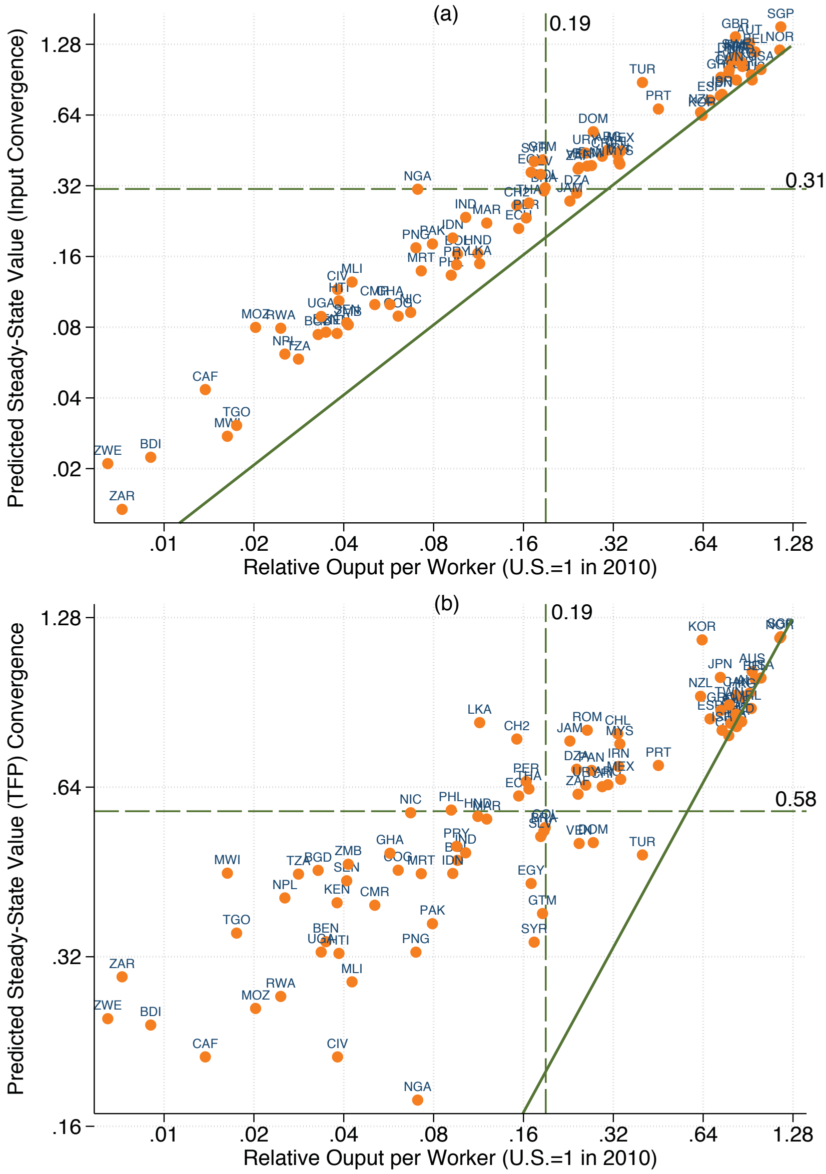
[10]Only Australia deteriorates its 2010 position.

[11]In this scenario nine countries overtake the United States and join Singapore and Norway as new technological leaders. The new overtakers include the United Kingdom, Austria, Belgium, Sweden, Finland, Italy, France, Denmark, Netherlands, and Hong Kong.

all countries lay above the 45-degree line[12] —all developing countries move forward within the steady state distribution— and the median raises from 34 percent to 62 percent. The overall magnitude of this improvement appears more clearly in Figure 7. Convergence in aggregate efficiency shifts the entire cumulative distribution with larger effects on countries at the bottom 70 percent of the distribution. This result is consistent with the growth and development accounting literature in the sense that efficiency differences are at least as important as capital accumulation differences. Particularly for this exercise, the effect of convergence in efficiency on the median country is about two times the effect of input convergence.

[12]The exceptions are Netherlands, Ireland, and Italy

Figure 3.8: Output per Worker- 2010 vs Predicted Steady State

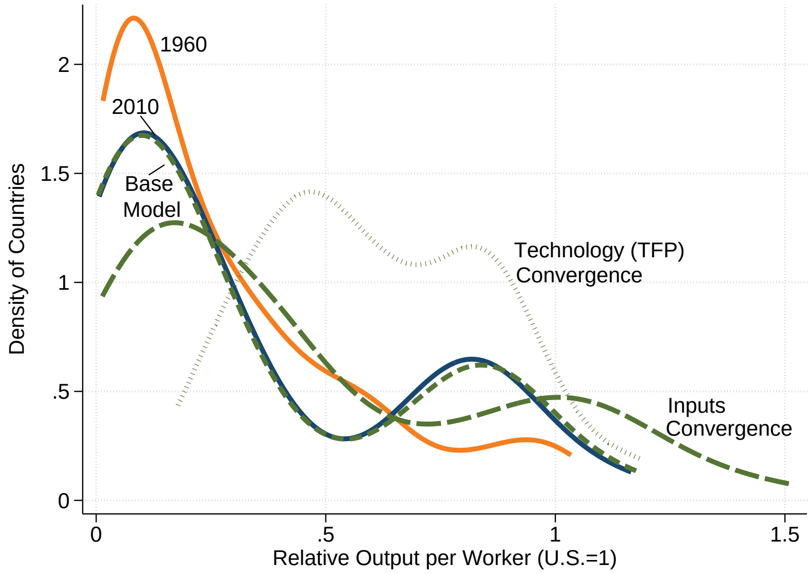


Source: Author's calculations using data from the Penn World Tables V7.1

There are also interesting changes at the top of the distribution. South Korea, Australia, and Japan are expected to overtake the United States. The intuition behind the Korean and Japanese case is that both countries currently have low efficiency levels among industrialized nations and high physical and human capital stocks.

Figure 9 summarizes the different shapes of the world productivity distribution for 1960, 2010, and the three forecasted scenarios. Note that overtime the bimodal distribution persists even under input convergence or efficiency convergence. The twin-peaks hypothesis and convergence clubs arguments appear in the literature as potential explanations for this phenomenon. In the next section, I use the basic tools of this literature to evaluate the probability of the persistence of these two peaks.

Figure 3.9: World Productivity Distributions



Source: Author's calculations using data from the Penn World Tables V7.1

3.4 Labor Productivity in the Very Long Run

Motivated by the mobility and polarization of countries within the world income distribution, Quah (1993a,b) and Jones (1997) use Markov methods to study the evolution of the world income distribution in a distant time horizon[13]. This section applies similar methods in the context of the 2010 productivity distribution.

Essentially Markov methods compute the evolution of a system based on initial states and

[13]In somewhat more technical jargon, to asymptotically evaluate the evolution of the world income distribution.

Table 3.5: World Productivity Distribution-Using Markov Chains

States	Interval	1960	1985	2010	Predicted 2035	2060	Steady State
L	[0, 0.025)	0.08	0.09	0.14	0.17	0.14	0.12
UL	[0.025, 0.05)	0.16	0.15	0.13	0.06	0.05	0.04
LM	[0.05, 0.10)	0.18	0.12	0.13	0.04	0.03	0.03
M	[0.10, 0.20)	0.15	0.12	0.15	0.05	0.05	0.05
UM	[0.20, 0.40)	0.20	0.21	0.15	0.07	0.08	0.08
LH	[0.40, 0.80)	0.16	0.17	0.13	0.21	0.23	0.23
H	[0.80, 1.2)	0.07	0.14	0.16	0.40	0.43	0.45

Source: Author's calculations using data from the Penn World Tables V7.1

transition probabilities. Mathematically, this process is described by

$$d_t \mathbf{M}^s = d_{t+s}, \tag{3.6}$$

where the vector d_t corresponds to the productivity distribution in the year t, the transition matrix **M** contains mobility frequencies from sample data and s represents the number of years into the future.

The first set of columns in Table 2 reports the world productivity distribution, for the years 1960, 1985, and 2010, based on the same seven productivity intervals (states) defined in Table 2. Using Equation 6 for $s = 25$, $s = 50$, and $s \to \infty$, we can compute estimates of the very long-run productivity distribution.

Before going over the results let us recall the differences and complementarities between the deterministic approach used in Section 3 and the stochastic approach of this section. First, in the previous section, I computed the near-future steady state towards which each country seems to be headed. This section, however, focuses both on a more distant time horizon and seven broad productivity intervals (states). Second, in the previous section, there were not policy changes (recall that aggregate efficiency and human capital are constant in the baseline model SS). This section, however, by the stochastic nature of the Markov process, explicitly recognizes policy changes, which in turn, might shift the position of a country's steady state.

Section 3 ended with an open question: are the twin peaks of the world productivity distribution persistent? Results from Table 5 suggest that the answer of this question has two folds.

First, even in a more distant future (i.e., the steady-state vector of a Markov chain), labor productivity might be characterized by a bimodal distribution. Second, although the world productivity distribution appears to be bimodal, the two peaks are far from being twins: convergence dominates the process in the long run. Consider the following example: in 1960 only 7 percent of countries reported a productivity level higher than 80 percent; in the long run, however, almost 50 percent of countries are expected to report a productivity level higher than 80 percent.

When contrasting these results with the early findings of Jones (1997b), the main differences arise at the bottom of the distribution. Jones' analysis defines the lowest interval between 0 and 5 percent and finds continuous convergence in relative income since 1988. The steady-state fraction of countries in this lowest interval is 8 percent— a reduction of 7 percentage points compared to the fraction of countries in the same interval in 1960. This study, however, defines a narrower interval, between 0 and 2.5 percent, and it initially finds continuous divergence from 1960 to 2035 (continuous convergence emerges thereafter). The steady-state fraction of countries in this lowest interval is 12 percent— an increase of 4 percentage points compared to the fraction of countries in the same interval in 1960 (8 percent).

Table 5 also shows that in the long run (steady-state) distribution there is a positive probability of any country spending some time in any interval. The interpretation of this result is that, as the time horizon increases asymptotically, any country might experience a large policy disaster or reform. To illustrate this point, Jones (1997) highlights Japan's reforms, in post-World War II period, as a notable example of a country moving to the very top of the productivity distribution. In contrast, there is the famous example of Argentina, one of the richest and most productive countries in the world in the early part of the twentieth century that drastically moved backwards within the productivity distribution. Other similar examples, include Hong Kong and Venezuela.

Finally, using the transition matrix of Table 2 we can conduct further experiments based on the conditional distribution of labor productivity. For instance, consider the situation of a low productivity country (i.e., $\tilde{y} > 80$ percent in 2010) and a high productivity country (i.e., $\tilde{y} < 10$ percent in 2010). Intuitively, the former has a greater change of remaining poor, while the latter has greater changes of remaining rich in the near future.[14] This intuition is consistent with the empirical results reported in the Appendix A. These results predict that, by 2035, a low productivity country has a 45-percent probability of remaining poor. In turn, a high productivity country has a 50-percent probability of remaining rich.[15] Both distributions, however, asymptotically converge to the world productivity distribution reported in Table 5.

3.5 Concluding Remarks

The world productivity distribution in the post-World War II period is characterized by four remarkable facts: (1) a large and increasing disparity between the tails of the distribution; (2) this disparity rapidly increased in the mid-1980s, slowed down in the next decade, and stabilized in the mid-2000s; (3) overtime, there has been substantial forward and backward mobility of countries and regions within the distribution; and (4) the upper tail of the distribution is more sensitive to improvements in human capital, while the lower tail is more sensitive to improvements in efficiency. Overall, the dynamic nature of these facts not only presents a challenge to the existing theories of development, but also provides opportunities for the development of new theories and policy initiatives.

Disparities in labor productivity across countries are large, but disparities in aggregate effi-

[14] This is one of the results of Section 3.

[15] To compute the predicted distribution in each case, the initial distribution is d(2010)=[1,0,0,0,0,0,0] for a low productivity country and d(2010)=[0,0,0,0,0,0,1] for a high productivity country.

ciency are even larger. Efficiency improvements in developing countries might drastically affect the distribution of labor productivity and accelerate the process of convergence. If current institutions and policies remain in place, however, the world productivity distribution might be characterized by additional divergence at the bottom, and further convergence and overtaking at the top.

Chapter 4

On the Development Gap between Latin America and East Asia: Welfare, Efficiency, and Misallocation

4.1 Introduction

The contrasting economic performance of Latin America[1] and some fast-growing countries in East Asia[2] constitutes one of the most interesting cases in modern development studies. Just after the World War II, GDP per capita in Latin America was just under 30 percent relative to that of the United States, while relative GDP per capita in East Asia was just under 20 percent. By 2010, Latin America had not only failed to catch-up, but its relative GDP per capita had fallen to 23 percent.[3] In contrast, relative GDP per capita in East Asia had increased to 83 percent. From a welfare perspective, the results are mixed. Latin America is lagging behind in life expectancy and

[1]Economies in this sample include: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.

[2]Economies in this sample include: Hong Kong, Japan, Singapore, and South Korea.

[3]In this article, all GDP measures are expressed in purchasing power parity (PPP) terms. Also, regional measures are un-weighted geometric averages, unless otherwise specified.

inequality, yet it enjoys a larger consumption share and higher leisure for adult. These contrasting experiences in both production and welfare motivate what I call the development gap between Latin America and East Asia. How large is this development gap? How can we add up measures of the production and welfare into a more comprehensive measure of development?[4] What explains the evolution of this development gap?

Using aggregate data on production and welfare, I document three facts about the development gap between Latin America and East Asia. First, based on the expected utility framework suggested by Jones and Klenow (2011), in 2000, differences in welfare-adjusted development are larger than those suggested by per-capita GDP. Second, although differences in life expectancy and consumption inequality hold down welfare and development in Latin America, labor productivity actually accounts for most of the development gap between the regions. Third, based on the production framework suggested by Caselli (2005), most of the labor productivity gap stems from a continuous fall in aggregate efficiency in Latin America.

The importance of aggregate efficiency[5] as the main determinant of production has been well documented in the growth and development literature, in particular for a large set of countries at one point in time (Caselli, 2005; Hall and Jones, 1999; Klenow and Rodriguez-Clare, 1997). This chapter, however, not only emphasizes its importance from a time series perspective, but also evaluates its contribution to a welfare-adjusted measure of development. As expected, the contribution of aggregate efficiency to development (27 percent) is less than that in production (49 percent[6]), yet this contribution is still larger than other determinants such as physical capital or human capital.

Given its relatively large contribution, and the availability of new industry-level and firm-level

[4]The development index used in this paper is based on the expected utility framework proposed by Jones and Klenow (2011). This approach differs from the United Nations' Human Development Index not only from a theoretical perspective (a.i., aggregation method), but also in the type of social indicators that are used to construct the index.

[5]Also known in the growth literature as total factor productivity (TFP) or Solow Residual.

[6]Welfare-adjusted decompositions are only available for the year 2000. Production decompositions, however, are implemented for the periods 1960-2013 and 1960-2010.

data sets, the growth and development literature has focused its attention on a well-known theoretical determinant of aggregate efficiency: resource misallocation (Banarjee and Duflo, 2005; Hsieh and Klenow, 2011; McMillan and Rodrik, 2011; Restuccia and Rogerson, 2008). Using industry-level data on employment and value added, I explore the efficiency consequences and features of intersectoral labor misallocation. First, from an empirical standpoint, I document a strong negative correlation between aggregate efficiency and the variation in intersectoral productivity. Second, from a theoretical standpoint, I adapt the simple two-sector model suggested by Jones (2011) and show that labor misallocation across sectors reduces aggregate efficiency. Finally, in line with the empirical findings of Pages (2010) and McMillan and Rodrik (2011), I argue that both premature de-industrialization (i.e., employment moving from manufacturing into services) and falling productivity in the service sector have deteriorated the overall efficiency of Latin America.

This chapter builds on a large body of literature that studies the proximate sources of economic divergence in Latin America from a comparative perspective. This literature (Cole et al., 2005; Daude 2013; Ferreira, Pessoa, and Veloso, 2013) typically focuses on the development gap between Latin America and the technological leader of the post-World War II period–the United States. This chapter, however, focuses on the development gap with respect to some economies of East Asia that were at similar or even lower stages of development in the early 1950s.

In terms of methodology and data this article is closest to Daude and Fernandez-Arias (2010) and Restuccia (2013). Using similar data sources, both studies evaluate the relative the contribution of capital accumulation and aggregate efficiency to the per-capita GDP gap[7]. Restuccia (2013) goes further and proposes a model in which resource misallocation across firms reduces aggregate efficiency. Despite these similarities, my research still differs in other aspects, both methodological and empirical. First, it measures the contribution of capital accumulation[8] and efficiency to a

[7]Both studies, however, focalize its analysis on the development gap between Latin America and the United States.

[8]When decomposing the contribution of physical capital, Restuccia (2013) uses the capital-output ratio instead of the more intuitive capital-labor ratio. This adjustment aims to control for the endogeneity of physical capital to

welfare-adjusted measure of development, not only to per-capita GDP. Second, it proposes a model in which labor misallocation across sectors reduces aggregate efficiency. And third, it highlights the time-series features[9] of the development gap between Latin America and East Asia.

Among the limitations of the methodological approach of this study (and this particular literature), one deserves attention at the outset. Proximate sources of growth and development such as physical capital, human capital, and aggregate efficiency ultimately depend on deep rooted factors such as institutions, culture, history, and geography (Acemoglu et al., 2005; Nunn, 2009). Also, trade protectionism, Dutch disease, competitive barriers, and macroeconomic volatility are typically cited as deeper causes of the Latin American underdevelopment. (De Gregorio, 2004; Edwards, 2009; Elson, 2013). The analysis of proximate sources, however, still might prove useful. It not only gives a first pass and a quantitative description of the mechanics of development, but also imposes discipline in our thinking and discussion. Ultimately, any more fundamental source should affect growth and development through one or more the proximate channels emphasized in this chapter.

Another limitation has to do with the selection of countries and generalization of findings. The criterion for the selection of countries, in particular for the East Asian sample, was driven by the availability of long-run time series. Although, the four economies in the East Asian sample grew faster and achieved higher levels of development, this is not the case for other countries in East Asia that still remain underdeveloped. Historically, however, the average performance of these four countries may still provide useful alternative to the typical benchmark used in the literature–the United States.[10] Regarding the Latin American sample, the selected seven countries may not fully depict the large heterogeneity of the region. However, they still represent more than 80

improvements in aggregate efficiency. This paper follows the production decomposition suggested by Caselli (2005), and thus it uses the capital-labor ratio.

[9]Daude and Fenandez-Arias (2010) also emphasize the trend of aggregate efficiency of Latin America relative to that of East Asia. However, they leave aside the evolution of physical capital and human capital.

[10]Recall that these four countries had similar or even lower levels of per-capita GDP than Latin America at the beginning of the period of analysis (1950s).

percent of the regional GDP and almost 80 percent of the total population.

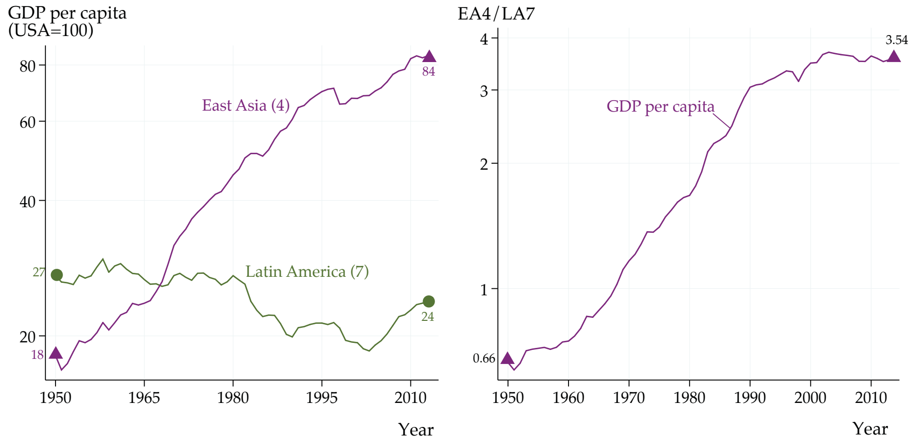
The rest of the chapter is organized as follows. Section 2 first characterizes the development gap between Latin America and East Asia in terms of welfare and production differences, then it evaluates their the relative contribution. Section 3 further decomposes differences in production into differences in labor productivity, employment-to-population ratio, and annual worked hours. Section 4 uses a neoclassical production function to evaluate the relative contribution of capital accumulation and aggregate efficiency as proximate determinants of labor productivity. Section 5 discusses one of the main sources of aggregate efficiency: labor misallocation across sectors. Finally, Section 6 offers some concluding remarks.

4.2 The Development Gap: Production and Welfare

Lucas (1988) famously points out that differences in production across countries imply staggering consequences for human welfare. After World War II, GDP per capita in East Asia rapidly converged to the levels of advanced economies, while Latin America first remained stagnant and then diverged (Figure 4.1). Following Lucas's observation, these convergence and divergence experiences suggest not only an increasing production gap, but also a welfare gap between the two regions. Both the large gap in production per capita and its welfare consequences constitute what I call the development gap between Latin America and East Asia.

When evaluating a set of standard welfare indicators, the overall welfare gap between the two regions is not immediately clear, at least quantitatively. Table 1 shows that, on one hand, welfare in East Asia tends to be higher due to its higher life expectance and lower inequality. On the other, welfare in Latin America could be higher due to its higher consumption share and leisure time. Adding these differences, and having and overall picture is not a straightforward task, since all

Figure 4.1: The Production Gap, 1960-2013



Note: East Asia (EA4) is composed by: Hong Kong, Japan, South Korea, and Singapore. Latin America (LA7) is composed by: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela. Both figures are in log scale

Source: Author's calculations using data from the Conference Board (2013)

these indicators are qualitatively different.[11]

In an attempt to add up and compare different measures of welfare, Jones and Klenow (2011) use an expected utility framework. They constructed an aggregate welfare statistic which includes differences in life expectancy, consumption share in GDP, leisure per adult, and consumption inequality. An attractive feature of their methodology is that each welfare component is measured in consumption-equivalent units, and therefore, quantitative comparability and additivity seems reasonable. Also, one can use this overall welfare measure to evaluate differences in welfare-adjusted development and then compare such differences with those predicted by GDP per capita.[12]

The framework and results from Jones and Klenow (2011) are particularly useful to quantitatively evaluate development gap between Latin America and East Asia. First, let us define the development gap, $\tilde{\psi}$, between country i and a benchmark country (the United States) as the sum

[11]For instance, it is not clear whether differences in life expectancy and leisure time should have the same weight on welfare. Yet aggregate development indicators such as the United Nations' human development mechanically add up differences in health and education and give them equal weights.

[12]Jones and Klenow (2011) find that differences in per-capita GDP are highly correlated with differences in their overall measure of welfare. The correlation coefficient is 0.95 for a sample of 134 countries in the year 2000.

Table 4.1: Production and Welfare Indicators, 2000

Countries	GDP per capita	Life Exp.	C/GDP	Leisure per adult	Inequality
Brazil	21.80	70.40	0.86	0.79	52.10
Chile	37.40	76.90	0.65	0.79	49.60
Colombia	17.00	71.10	0.86	0.76	50.50
Mexico	25.90	74.00	0.75	0.78	50.90
Peru	12.90	69.30	0.79	0.77	44.00
Venezuela	27.40	73.30	0.54	0.79	47.70
Hong Kong	82.10	80.90	0.71	0.76	41.70
Japan	72.40	81.10	0.66	0.81	28.50
Singapore	82.90	78.10	0.43	0.74	37.90
South Korea	47.10	75.90	0.58	0.75	31.50
Latin America	22.42	72.46	0.73	0.78	49.06
East Asia	69.41	78.97	0.58	0.76	34.51
EA/LA	3.10	1.09	0.80	0.98	0.70

Note: GDP per capita is measured relative to that in the United States (USA=100). C/GDP includes both private and government consumption. Leisure is measured as $1-$ (annual hours worked per worker/(16×365)) $\cdot$(employment/adult population). Inequality is measured in terms of the *consumption* Gini coefficient. Regional averages are unweighted geometric averages

Source: Jones and Klenow (2011)

of their production gap, $\tilde{y}$, and welfare gap λ. In log terms this means:

$$\underbrace{\log\, \tilde{\psi}_i\,(e,c,\ell,\sigma,\tilde{y})}_{\text{Development Gap}} = \underbrace{\log\, \tilde{y}_i}_{\text{Production Gap}} + \underbrace{\log\, \lambda_i\,(e,c,\ell,\sigma)}_{\text{Welfare Gap}}, \tag{4.1}$$

where e is average life expectancy, c is average consumption per capita, ℓ is average leisure per adult, and σ is the standard deviation of consumption within a country. To add up different welfare measures into one welfare index, Jones and Klenow (2011) suggest the following adjustment:

$$
\begin{aligned}
\log \frac{\lambda_i}{\tilde{y}_i} = \; & \tfrac{e_i - e_{us}}{e_{us}} \left(\bar{u} + \log c_i + v\left(\ell_i\right) - \tfrac{1}{2}\sigma_i^2 \right) && \text{Life Expectancy} \\
& + \log c_i / y_i - \log c_{us} / y_{us} && \text{Consumption Share} \\
& + v\left(\ell_i\right) - v\left(\ell_{us}\right) && \text{Leisure} \\
& + \tfrac{1}{2}\left(\sigma_i^2 - \sigma_{us}^2\right). && \text{Inequality}
\end{aligned} \tag{4.2}
$$

Table 2 presents the results of the decomposition of the development gap into its production and welfare components. The most important finding is that this gap is actually larger than that predicted by GDP per-capita. The log of the development gap is 1.57 whereas the log of the production gap is 1.36. The main driving forces behind these differences are also tractable. Higher inequality and lower life expectancy have large negative effects in Latin America, while lower consumption and leisure in East Asia are partially compensated by a longer life expectancy.

Though the qualitative aspects of the Jones and Klenow (2011) decomposition are already observable in the standard welfare indicators of Table 4.1, their quantitative approach may help us evaluate the contribution of labor productivity, capital accumulation and aggregate efficiency beyond their production scope. For instance, Section 4.4 quantifies what fraction of the welfare-adjusted development gap is explained by the efficiency with which the economies use their resources.

Table 4.2: The Development Gap: Production and Welfare in 2000

Countries	Log DEV.	Life Exp.	C/GDP	Leisure per adult	Inequality	Log GDPpc
Brazil	2.49	-0.38	0.12	-0.03	-0.30	3.08
Chile	3.19	-0.01	-0.16	-0.02	-0.24	3.62
Colombia	2.24	-0.33	0.12	-0.12	-0.26	2.83
Mexico	2.75	-0.17	-0.02	-0.05	-0.27	3.25
Peru	1.96	-0.42	0.04	-0.08	-0.13	2.56
Venezuela	2.54	-0.21	-0.35	-0.01	-0.20	3.31
Hong Kong	4.36	0.23	-0.06	-0.12	-0.10	4.41
Japan	4.48	0.25	-0.15	0.03	0.07	4.28
Singapore	3.67	0.06	-0.58	-0.19	-0.04	4.42
South Korea	3.37	-0.07	-0.27	-0.18	0.04	3.85
Latin America	2.53	-0.25	-0.04	-0.05	-0.23	3.11
East Asia	3.97	0.12	-0.27	-0.12	-0.01	4.24
EA/LA	1.57					1.36

Note: Regional averages are unweighted arithmetic averages. Inequality refers to consumption inequality.

Source: Jones and Klenow (2011)

Though the qualitative aspects of the Jones and Klenow (2011) decomposition are already observable in the standard welfare indicators of Table 4.1, their quantitative approach may help us evaluate the contribution of labor productivity, capital accumulation and aggregate efficiency beyond their production scope. For instance, Section 4.4 quantifies what fraction of the welfare-adjusted development gap is explained by the efficiency with which the economies use their resources.

To summarize the results of this section, let us take the antilog of Equation 4.1, and use the results from Table 4.2 as follows:

$$\underbrace{\frac{\psi_{EA}}{\psi_{LA}}}_{4.22} = \underbrace{\frac{\lambda_{EA}}{\lambda_{LA}}}_{1.36} \times \underbrace{\frac{(Y/Pop)_{EA}}{(Y/Pop)_{LA}}}_{3.10}. \tag{4.3}$$

In 2000, differences in welfare-adjusted development between East Asia and Latin America (4.22[13]) were larger than those implied by per-capita GDP (3.10). However, the GDP gap is still the main determinant of the welfare-adjusted development gap, since it explains 78 percent (log 3.10/log 4.22) of its variation. Given this large contribution, what factors account for differences in production between the regions?

4.3 Decomposing Production

To further understand the evolution of GDP per capita we can decompose it into three components: labor productivity, employment to population ratio, and worked hours. Following Restuccia (2013), production per capita for an economy at any time can be written as:

$$\frac{Y}{Pop} = \frac{Y}{nL} \times \frac{L}{Pop} \times n, \tag{4.4}$$

where Y/Pop is GDP per capita, n is the average worker hours, L/Pop is the employment to population ratio, and Y/nL is labor productivity (GDP per worked hour[14]). Then taking two economies

[13]To obtain the gap in adjusted-welfare development, first compute the antilog of the regional averages of Table 4.2, and then take the ratio ((exp(3.97)/exp(2.53))=4.22). Use the similar procedure to compute the production gap.

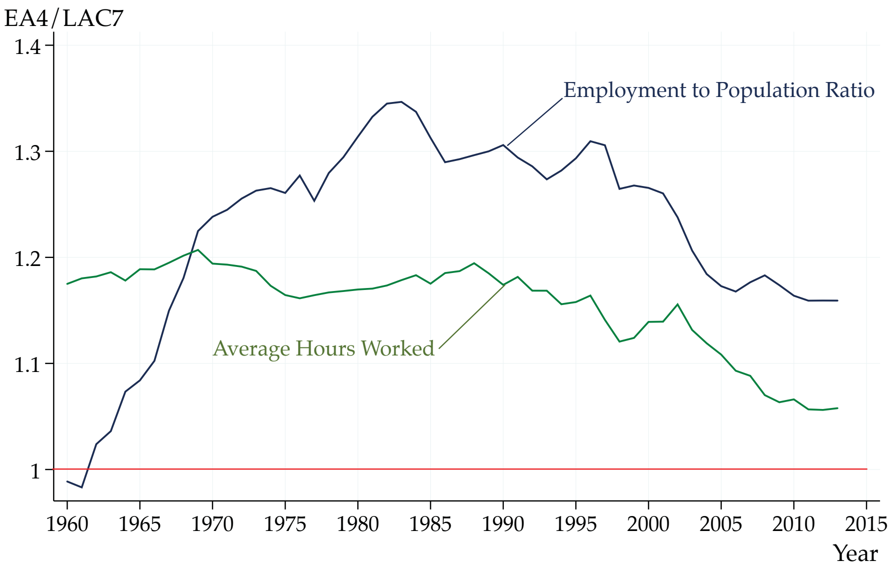
[14]Note that in previous chapters labor productivity is measured in GDP per worker. Measuring the labor productivity in terms of GDP per worked hours is a more precise measure of productivity. However, systematic data availability on

i and j, and dividing their per-capita GDP, we can rewrite the previous decomposition in ratio form:

$$\frac{(Y/Pop)_i}{(Y/Pop)_j} = \frac{(Y/nL)_i}{(Y/nL)_j} \times \frac{(L/Pop)_i}{(L/Pop)_j} \times \frac{n_i}{n_j}. \tag{4.5}$$

The interpretation of Equation (6) is intuitive. The per-capita GDP gap between economy i and j is the product of their productivity, employment to population, and worked hours gaps. Results from Figure 4.1 indicate that the per-capita GDP gap between East Asia (economy i) and Latin America (economy j) increased from 0.75 in 1960 to 3.62 in 2010.[15] Which factors from the above decomposition would primarily account for this increase? To answer this question I compute and discuss the evolution of each factor in turn.

Figure 4.2: Worked Hours Gap and Employment to Population Gap, 1960-2013



Note: East Asia (EA4) is composed by: Hong Kong, Japan, South Korea, and Singapore. Latin America (LA7) is composed by: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.
Source: Author's calculations using data from the Conference Board (2013)

this variable is still a challenge.

[15]For this and the following two sections, the main time period of analysis is from 1960 to 2010.

Hours Gap The main finding regarding the gap in hours of work is that due to its decline over time, differences in hours cannot explain the gap in per-capita GDP. Figure 2 illustrates that since the late 1980s there has been convergence in worked hours.[16] In 1988, the average worker in East Asia worked 18 percent more hours than the average worker in Latin America. By 2010, however, the average worker in East Asia only worked 6 percent more.

Over time, with the exception of Argentina, economies in both regions declined their number of hours worked, however Latin America experienced a much slower decline.[17] Note that during the whole 1960-2010 period, East Asian workers have worked more hours than their Latin American counterparts. Yet, by 2010 worked hours only accounted for 5 percent of gap in per-capita GDP between the regions. Given these results, most of the per-capita GDP differences must be explained by employment and labor productivity differences.

Employment to Population Gap The main finding regarding the employment to population ratio is that despite its initial divergence, the following convergence episode significantly reduced its contribution to the gap in per-capita GDP. Figure 2 documents the inverted-U pattern in employment.[18] In 1960, both regions had almost the same employment to population ratio. Since 1962, however, employment grew faster in East Asia, and by 1983 it was 30 percent higher relative to that of Latin America. After its lost decade (the 1980s), employment in Latin America started recovering, and by 2010 employment in East Asia was 15 percent larger.

As with worked hours, the implication of the previous convergence episode is that it reduces the explanatory power of employment. For instance, in 1983, differences in employment explained 39

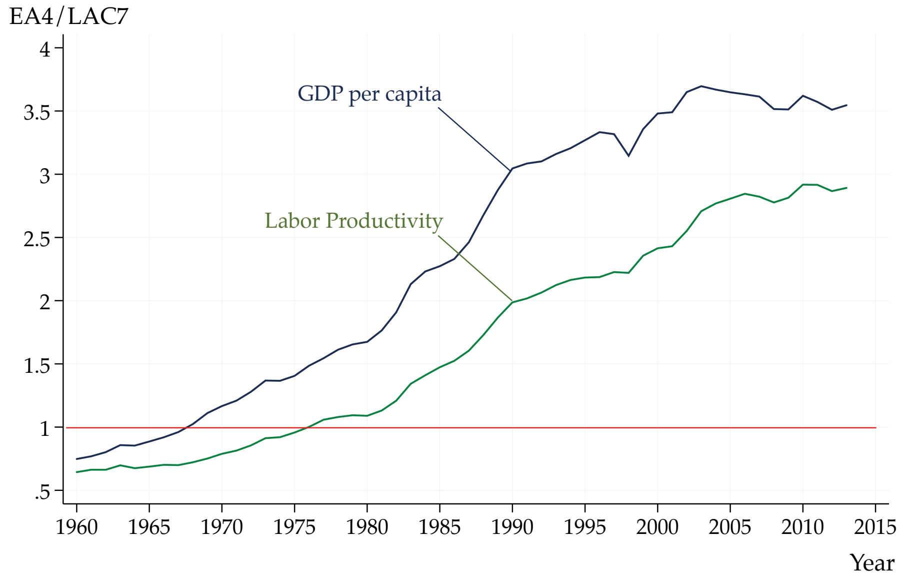
[16]Note that this convergence pattern of hours contrasts sharply the divergence pattern of GDP per capita (Figure 4.1). As a result, we can expect that differences in hours explain relatively little of the GDP gap.

[17]Both regions, however, still work more hours relative to the United States. For example, in 2010 the average worker in Latin America worked 18 percent more hours than the average worker in the United States. Similarly, the average worker in East Asia worked 24 percent more hours. As noted in Section 4.2 working more hours affects negatively the suggested welfare measure. Ideally, an economy could both increase its welfare and production by reducing working hours and increasing labor productivity.

[18]This gap is after controlling for the effect of population.

percent of their per-capita GDP gap. By 2010, however, it explained only 12 percent. As a result, given these findings, differences in labor productivity must explain most of the current differences in per-capita GDP.

Figure 4.3: Labor Productivity Gap, 1960-2013



Note: East Asia (EA4) is composed by: Hong Kong, Japan, South Korea, and Singapore. Latin America (LA7) is composed by: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.
Source: Author's calculations using data from the Conference Board (2013)

Labor Productivity Gap The main findings regarding labor productivity point to both the continuous divergence in Latin America and its large contribution to per-capita GDP. Figure 4.3 shows that East Asia first caught up with the productivity of Latin America in 1976, and then left it far behind. By 2010, labor productivity in East Asia was almost three times larger (See Table 4.3) than its Latin American counterpart. In this process, note that it was not only the fast convergence of East Asia, but also the fast divergence of Latin America that drove the evolution of the gap in productivity. For instance, in 1960 labor productivity relative to that in the United States was 8 percent in South Korea and 71 percent in Venezuela. By 2010, productivity in the former increased to 44 percent and in the latter decreased to 22 percent. Table 4.3 illustrates that these type of convergence-and-divergence patterns still hold for the regional averages during the 1960-2010 period, though they are less severe.

Overall, the gap in labor productivity mirrors the behavior of the gap in per-capita GDP (See Figure 4.3). It also explains most of the differences in per-capita GDP between the regions. By 2010, labor productivity differences explained 83 percent of the per-capita GDP differences between East Asia and Latin America.

Table 4.3: Relative GDP per hour,1960-2013

Countries	1960	1970	1980	1990	2000	2010
Argentina	37.30	40.11	41.17	28.94	30.49	21.69
Brazil	16.86	17.54	24.01	17.99	17.41	16.22
Chile	25.05	26.13	24.98	20.64	25.27	26.75
Colombia	19.62	19.06	20.91	19.85	16.37	15.19
Mexico	37.84	42.50	41.56	30.78	26.65	23.88
Peru	27.41	30.53	28.74	15.94	13.32	15.48
Venezuela	71.17	68.30	48.21	34.19	27.24	21.93
Hong Kong	31.94	25.63	38.15	52.24	51.52	60.27
Japan	23.50	43.40	56.74	67.37	66.88	65.32
Singapore	22.39	31.96	42.51	51.88	61.16	62.62
South Korea	8.48	10.77	14.78	24.55	34.44	44.43
Latin America	30.18	31.54	31.34	23.16	21.50	19.72
East Asia	19.43	24.87	34.15	46.01	51.90	57.53
EA/LA	0.64	0.79	1.09	1.99	2.41	2.92

Note: Regional values are unweighted geometric averages. Country values are expressed relative to those in the United States (USA=100).

Source: Author's calculations using data from the Conference Board (2013)

To summarize the results of this section, the per-capita GDP gap between East Asia and Latin America in 1960 can be accounted for as follows:

$$\underbrace{\frac{(Y/Pop)_{EA}}{(Y/Pop)_{LA}}}_{0.75} = \underbrace{\frac{(Y/nL)_{EA}}{(Y/nL)_{LA}}}_{0.64} \times \underbrace{\frac{(L/Pop)_{EA}}{(L/Pop)_{LA}}}_{0.99} \times \underbrace{\frac{n_{EA}}{n_{LA}}}_{1.18},$$

and in 2010:

$$\underbrace{\frac{(Y/Pop)_{EA}}{(Y/Pop)_{LA}}}_{3.62} = \underbrace{\frac{(Y/nL)_{EA}}{(Y/nL)_{LA}}}_{2.92} \times \underbrace{\frac{(L/Pop)_{EA}}{(L/Pop)_{LA}}}_{1.16} \times \underbrace{\frac{n_{EA}}{n_{LA}}}_{1.07}$$

Finally, the decomposition for the year 2000 is also particularly useful for extending the results of the decomposition implemented in Section 4.2. Since differences in per-capita GDP accounts for 78 percent of the development gap, and labor productivity accounts for 71 percent of the per-capita GDP, then by composition, labor productivity could potentially account for 55 percent of the development gap. Given this large contribution, what factors account for these differences in labor productivity?

4.4 Decomposing Labor Productivity

Labor productivity is typically determined by the inputs that workers have at their disposal (i.e., physical and human capital) and the way in which they use those inputs (i.e., efficiency). Following Caselli (2005), labor productivity for an economy at any point in time can be written as:

$$\frac{Y}{nL} = A\left(\frac{K}{nL}\right)^{\alpha}\left(\frac{H}{nL}\right)^{1-\alpha} \tag{4.6}$$

where Y/nL is labor productivity (measured as output per worked hour), K is the aggregate stock of physical capital, nL is the employed labor force (measured in hours), H is a measure of aggregate human capital, A is the level of aggregate efficiency[19]and α is a technological parameter (typically[20] set to 1/3)

While data on physical capital can be constructed from the investment series of GDP[21], data

[19]In the literature, aggregate efficiency is typically know as total factor productivity (TFP). For the purposes of this article, and to emphasize the distinction and minimize any source of confusion between labor productivity (Y/L) and total factor productivity (A).

[20]See Caselli (2005), Bernanke and Gurkaynak (2001), and Gollin (2002) for a discussion on the robustness of this value.

[21]See Caselli (2005) or Hall and Jones (1999) for a detailed description of this procedure

on human capital requires further elaboration. Motivated by the extensive micro literature on the returns of schooling, Hall and Jones (1999) suggest the following production function for human capital:

$$\frac{H}{nL} = e^{\phi(s)}, \tag{4.7}$$

$$\phi(s) = \begin{cases} 0.134s & \text{if} s \leq 4 \\ 0.134(4) + 0.101(s-4) & \text{if} 5 \leq s \leq 8 \\ 0.134(4) + 0.101(4) + 0.068(s-8) & \text{if} s > 8 \end{cases} \tag{4.8}$$

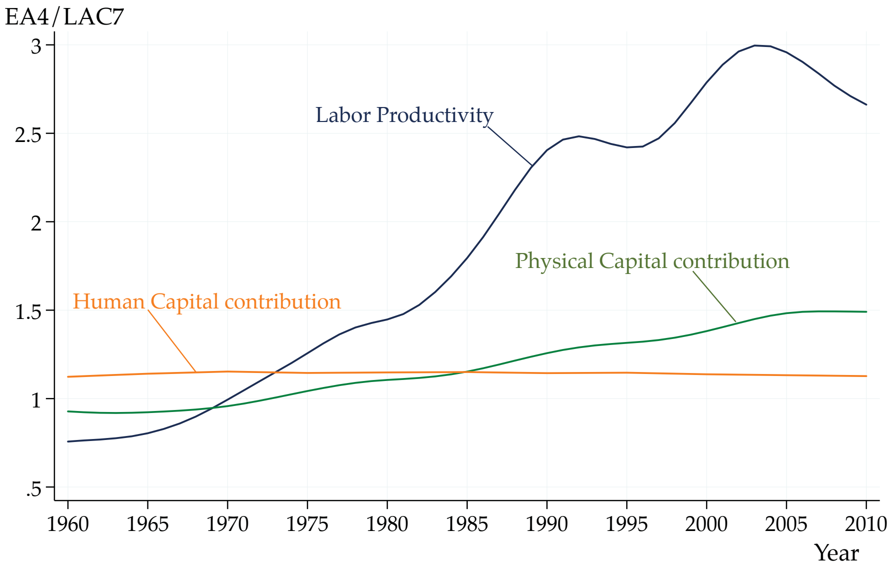
where s is the average years of schooling of the workforce and $\phi(s)$ is a piecewise linear function in which the coefficients represent world averages of the returns to schooling for different levels of education.[22] Given the previous economic framework, let us consider two economies i and j. We can divide its GDP per worker and rewrite Equation 4.6 in ratio form:

$$\frac{(Y/nL)_i}{(Y/nL)_j} = \frac{A_i}{A_j} \times \left(\frac{(K/nL)_i}{(K/nL)_j}\right)^{1/3} \times \left(\frac{(H/nL)_i}{(H/nL)_j}\right)^{2/3}. \tag{4.9}$$

The interpretation of Equation 4.9 is intuitive. The gap in labor productivity between economy i and j is the product of their gaps in aggregate efficiency, physical capital, and human capital. Results from Table 3 indicate that the gap in labor productivity between East Asia (economy i) and Latin America (economy j) increased from 0.64 in 1960 to 2.92 in 2010. Which factors from the above decomposition would primarily account for this increase? To answer this question I compute the contribution of each factor and discuss its evolution in turn.

[22] Note the diminishing returns property of the accumulation of human capital.

Figure 4.4: Physical and Human Capital Gap, 1960-2010



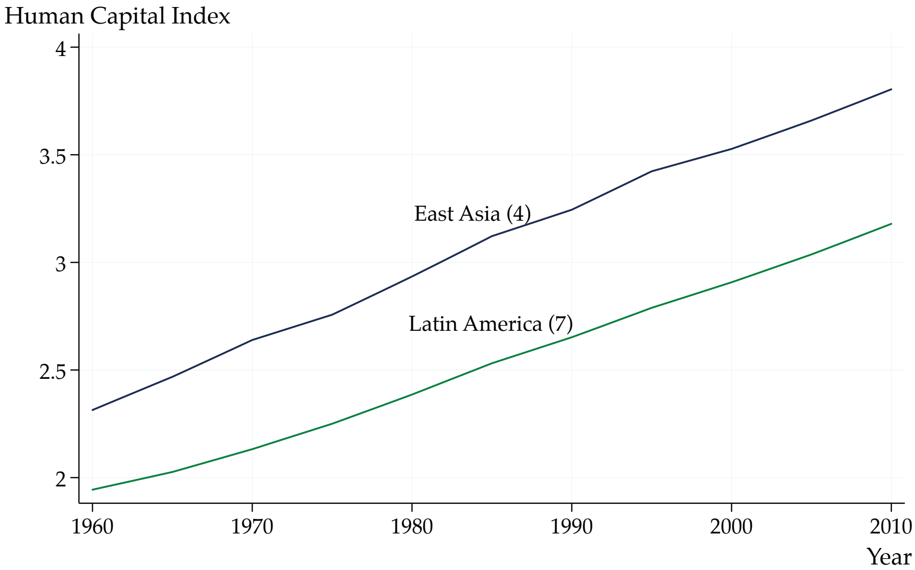
Note: East Asia (EA4) is composed by: Hong Kong, Japan, South Korea, and Singapore. Latin America (LA7) is composed by: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.
Source: Author's calculations using data from Fernandez-Arias (2014)

Physical Capital Gap Over time the gap in physical capital gap increases monotonically (See Figure 4.4). In 2010, this gap had a quantitatively large effect (37 percent) on the labor productivity gap. This effect, however, becomes relatively small once the endogeneity of physical capital to aggregate efficiency is taken into account (See Restuccia, 2013 for details). Note that in 1973 both regions had similar capital stocks per worker. Thereafter, capital accumulation grew much faster in East Asia, and as a result, by 2010 the average worker in East Asia had 40 percent more physical capital at his disposal than his Latin American counterpart.

Human Capital Gap Over time there has been considerable progress in human capital accumulation, both in East Asia and Latin America (See Figure 4.5). Since both regions have been accumulating human capital at a fairly similar speed, the initial gap remains stable. For instance, in 1960 human capital was 12 percent higher in East Asia. Since then this gap fluctuated between 12 and 15 percent, and in 2010 human capital was still 12 percent higher in East Asia. As a result,

Figure 4.4 shows this gap as a horizontal line. In terms of its contribution to productivity, human capital explains only 11 percent of the labor productivity gap.[23]

Figure 4.5: Human Capital, 1960-2010



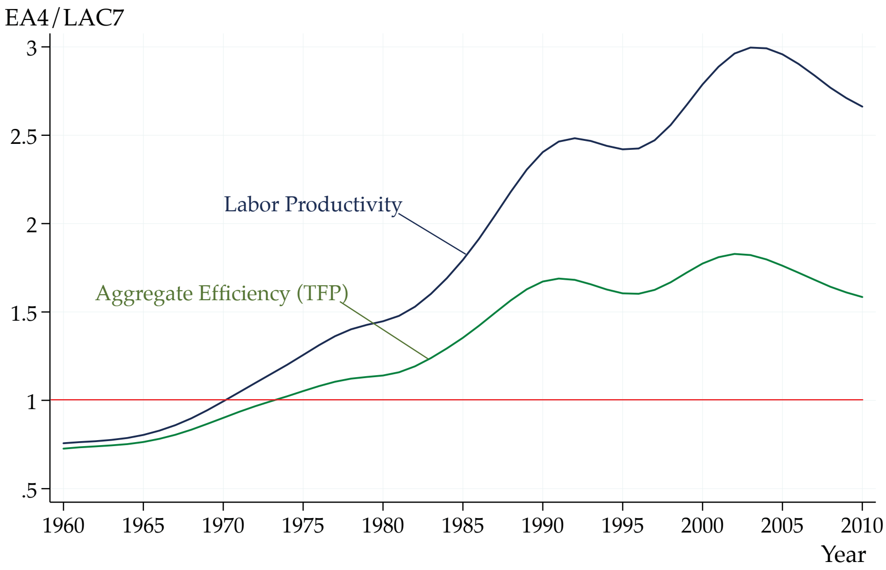
Note: East Asia (EA4) is composed by: Hong Kong, Japan, South Korea, and Singapore. Latin America (LA7) is composed by: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.
Source: Author's calculations using data from Fernandez-Arias (2014)

Aggregate Efficiency Gap Figure 4.6 documents that the efficiency divergence between the regions started in the early 1970s. Similar to the labor productivity gap, the post-1980 evolution of aggregate efficiency not only reflects an acceleration of efficiency growth in East Asia, but also lower efficiency in Latin America. As a result, in 2010, aggregate efficiency in East Asia was 55 percent larger relative to that of Latin America. In terms of its effect on the labor productivity gap, in 2010 differences in aggregate efficiency explained 52 percent of the differences in labor productivity.

To summarize the results of this section, the labor productivity gap between East Asia and

[23]It is important to note that this measure abstracts from differences in the quality of human capital, which are likely to play a large role given the large regional differences in the results of the PISA tests.

Figure 4.6: Aggregate Efficiency Gap, 1960-2010



Note: East Asia (EA4) is composed by: Hong Kong, Japan, South Korea, and Singapore. Latin America (LA7) is composed by: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.
Source: Author's calculations using data from Fernandez-Arias (2014)

Latin America in 1960 can be accounted for as follows:

$$\underbrace{\frac{(Y/nL)_{EA}}{(Y/nL)_{LA}}}_{0.64} = \underbrace{\frac{A_{EA}}{A_{LA}}}_{0.62} \times \underbrace{\left(\frac{(K/nL)_{EA}}{(K/nL)_{LA}}\right)^{1/3}}_{0.93} \times \underbrace{\left(\frac{(H/nL)_{EA}}{(H/nL)_{LA}}\right)^{2/3}}_{1.12}$$

and in 2010:

$$\underbrace{\frac{(Y/nL)_{EA}}{(Y/nL)_{LA}}}_{2.92} = \underbrace{\frac{A_{EA}}{A_{LA}}}_{1.74} \times \underbrace{\left(\frac{(K/nL)_{EA}}{(K/nL)_{LA}}\right)^{1/3}}_{1.49} \times \underbrace{\left(\frac{(H/nL)_{EA}}{(H/nL)_{LA}}\right)^{2/3}}_{1.13}$$

Finally, the last paragraph of the previous section points out that labor productivity in the year 2000 could potentially account for 55 percent of the welfare-adjusted development gap between East Asia and Latin America. Adding the results of the current section, aggregate efficiency could potentially account for 27 percent of the welfare-adjusted development gap. Given this relatively large contribution (compared to physical and human capital), what factors can explain the differences in aggregate efficiency?

4.5 Exploring Aggregate Efficiency

The literature on economic growth and development typically emphasizes two main determinants of aggregate efficiency: technological progress and resource misallocation. On one hand, an economy-wide efficiency increases when there are new production methods (e.g., new blueprints, new production processes, new organizational structures, new management techniques). On the other hand, efficiency gains occur when there are improvements in the allocation of resources (e.g., capital, labor, and technologies) across production units (e.g., when resources move from less productive units to more productive ones). The distinction between technological progress and resource misallocation matters because the policy implications of each factor could be completely different.

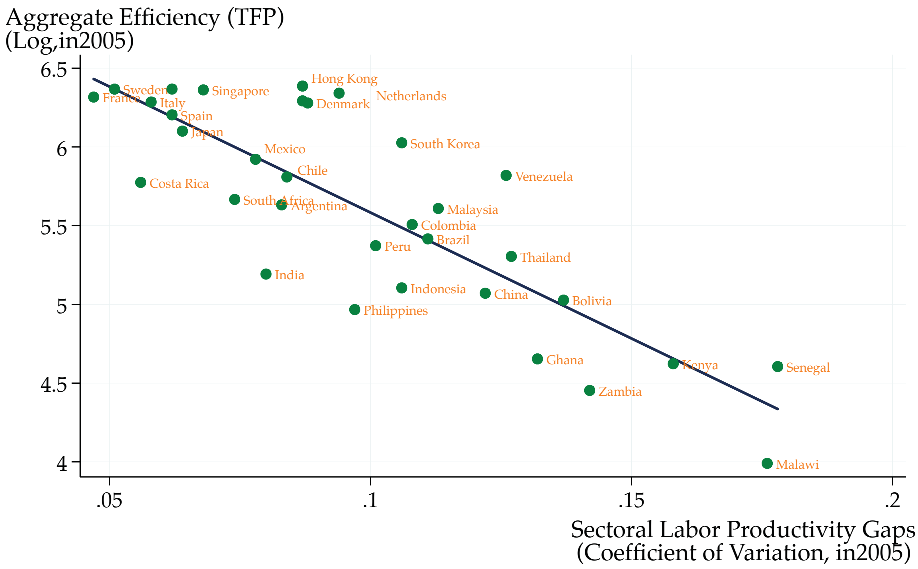
This section explores the role of resource misallocation on aggregate efficiency. The motivation comes from the fact that developing countries are characterized by a large variety of allocation problems, which arise from both government and market failures. Latin America, in particular, shows a history of protectionist policies and recurrent crises that may have drastically altered the allocation of resources.

To introduce the negative effect of resource misallocation on aggregate efficiency, Figure 4.7 displays the strong negative relation between these variables. Here, large variation in average labor productivity across sectors could potentially reflect differences in marginal productivities,[24] which ultimately provide prima face evidence for labor misallocation.[25] Though this correlation could

[24]Recall, for instance, that in a Cobb-Douglas production function the marginal product of labor is proportional to its average product. If the proportionality factor, the elasticity of output with respect to labor, is relative stable across sectors, then differences in average average products reflect differences in marginal products.

[25]The recent literature on economic growth and development interprets the differences in marginal products across productive units as prima face evidence for resource misallocation. See, for instance, Banerjee and Duflo (2005) and Restuccia and Rogerson (2008).

Figure 4.7: Aggregate Efficiency and Sectoral Productivity Gaps, 2005



Source: Author's calculations using data from McMillan and Rodrik (2011)

prove useful as a starting point, we need a model (and further evidence) to clarify the mechanisms by which sectoral productivity gaps affect aggregate efficiency.

Based on the simple misallocation model suggested by Jones (2011), consider an economy composed by two sectors (e.g., manufacturing and services):

$$\text{Production in Sector 1:} \quad X_{man} = 2L_{man}, \tag{4.10}$$

$$\text{Production in Sector 2:} \quad X_{serv} = L_{serv}, \tag{4.11}$$

$$\text{Resource Constraint:} \quad \bar{L} = L_{man} + L_{serv}, \tag{4.12}$$

$$\text{GDP (Aggregation):} \quad Y = X_{man}^{0.8} X_{serv}^{0.2}. \tag{4.13}$$

The only difference between the sectors is their labor productivity. In particular, assume that labor productivity in manufacturing is two times the productivity of services. Then, define the employment share allocated to manufacturing as $\theta \equiv L_{man}/\bar{L}$, where $\bar{L}$ is the total labor force and L_{man} is the number of employed workers in manufacturing. Note that θ could be either an outcome of competitive free markets or government planning. Given the resource constraint (Equation 4.12) and the aggregation of output across sectors (Equation 4.13), total GDP in this economy is

$$Y = A(\theta)\bar{L}, \tag{4.14}$$

and the equilibrium efficiency level, $A(\theta)$, is only determined by allocation of workers across sectors:

$$A(\theta) = (2\theta)^{0.8}(1-\theta)^{0.2}. \tag{4.15}$$

Figure 4.8: Sectoral Misallocation Reduces Aggregate Efficiency

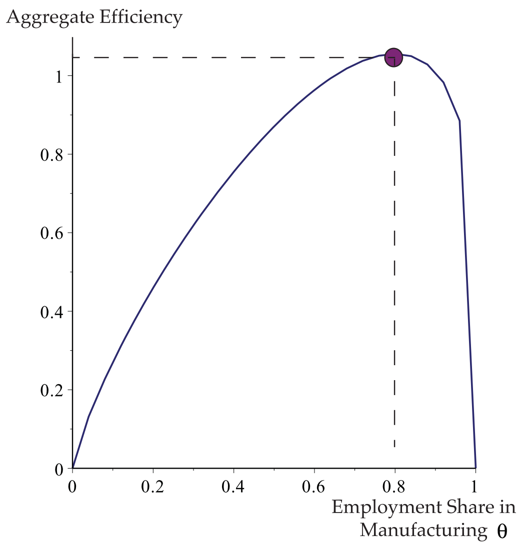
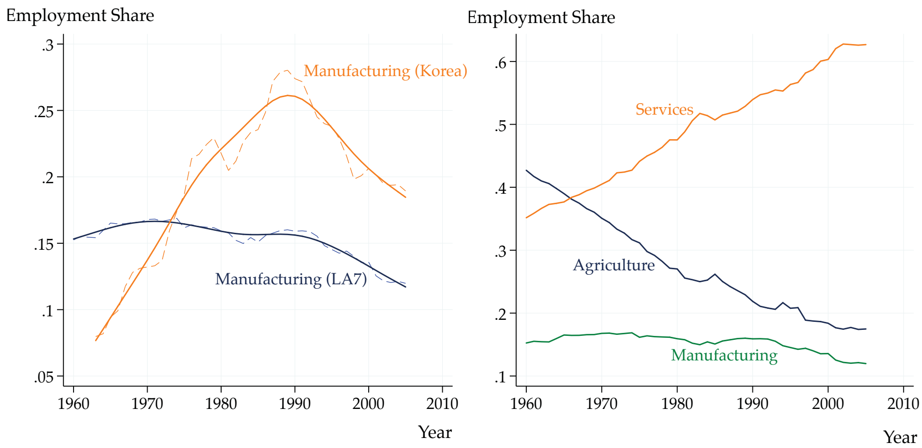


Figure 4.8 shows the nonlinear behavior of Equation 4.15. Aggregate efficiency attains its maximum value, 1.06, when 80 percent of the labor force works in manufacturing and 20 in services. But if 80 percent were employed in services, aggregate efficiency would fall to 0.46. From Figure

4.8 it is clear that, given the relatively low productivity of services, increasing this sector's employment share reduces aggregate efficiency. In other words, reallocating workers from relatively high productivity sectors into relatively low productivity sectors reduces overall efficiency.

Figure 4.9: Premature Deindustrialization and the Raise of Services , 1960-2005



Note: Latin America (LA7) is composed by: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.

Source: Author's calculations using data from McMillan and Rodrik (2011)

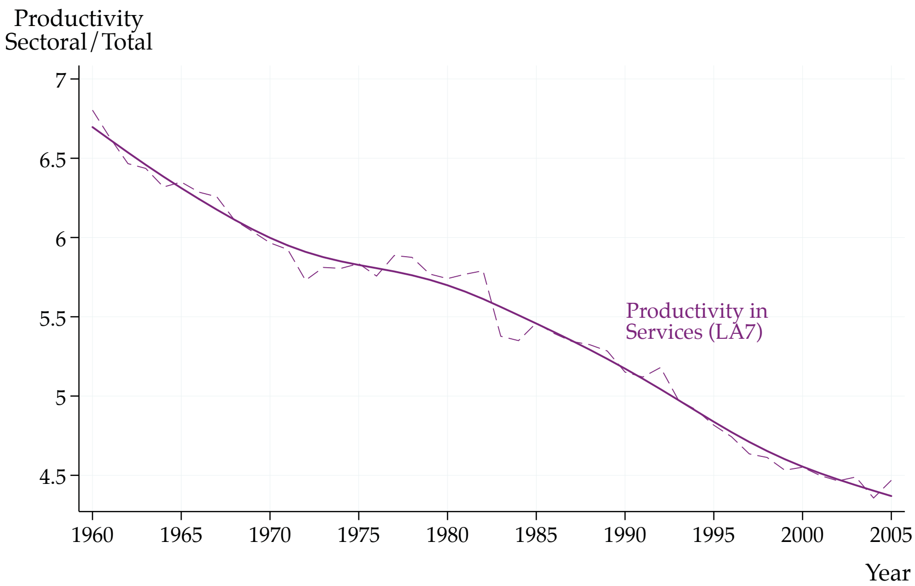
The main prediction of the above model describes fairly well the industrial dynamics of Latin America in the post-World War II period. Figure 4.9 shows the continuous raise of the employment share in the service sector. Relative to the economy-wide level, however, productivity in the service sector had been falling rapidly (See Figure 4.11). As a result, this large reallocation of labor should reduce the overall efficiency of the region.

Figure 4.10: Raising Productivity in Agriculture and Manufacturing, 1960-2005

Note: Latin America (LA7) is composed by: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.

Source: Author's calculations using data from McMillan and Rodrik (2011)

Figure 4.11: Falling Productivity in Services, 1960-2005



Note: Latin America (LA7) is composed by: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.
Source: Author's calculations using data from McMillan and Rodrik (2011)

Figures 4.9, 4.10 and 4.11 illustrate the structural transformation of Latin America and how this process damaged aggregate efficiency in the region. Three patterns require particular attention. First, compared to the typical structural transformation process exhibited by South Korea (and other fast-growing and developed economies), the region transitioned into a service economy without a consolidated industrial base.[26] Second, although labor productivity had been raising in both agriculture and manufacturing (Figure 4.10), by 2010 these sectors employed less than one third of the labor force. Third, between 1960 and 2005, the employment share in the service sector increased 80 percent,[27] yet productivity in this sector decreased 35 percent.

Following McMillan and Rodrik (2011), Figure 4.12 provides a more detailed sectoral view that summarizes two contrasting patterns of structural transformation.[28] Similar to Latin America, most of the labor force of Hong Kong and Singapore transitioned to the service sector, in particular wholesale and retail. However, Latin American productivity in these sectors is considerably lower; arguably due to the abundance of very small and low productivity firms, which are typically associated with the informal sector (Pages, 2010). Although productivity in business and financial services is relative high in Brazil, employment absorption is much smaller compared with Hong Kong and especially with Singapore. Over time, poorly educated and rural workers from Latin America kept gravitating to sectors in which the scale of production is minuscule (e.g., informal retail trade), mostly non-tradable (e.g., community and personal services), and difficult to standardize.

Although a comprehensive discussion of the factors and policies driving the patterns of Figures 4.9-4.12 goes beyond the scope of this study, the regression results of McMillan and Rodrik (2011) are a good starting point. Using a sample of developing countries from Latin America, Asia,

[26]In addition, since the early 1990s, there has been an acceleration deindustrialization process of the region.

[27]From 35 to 63 percentage points

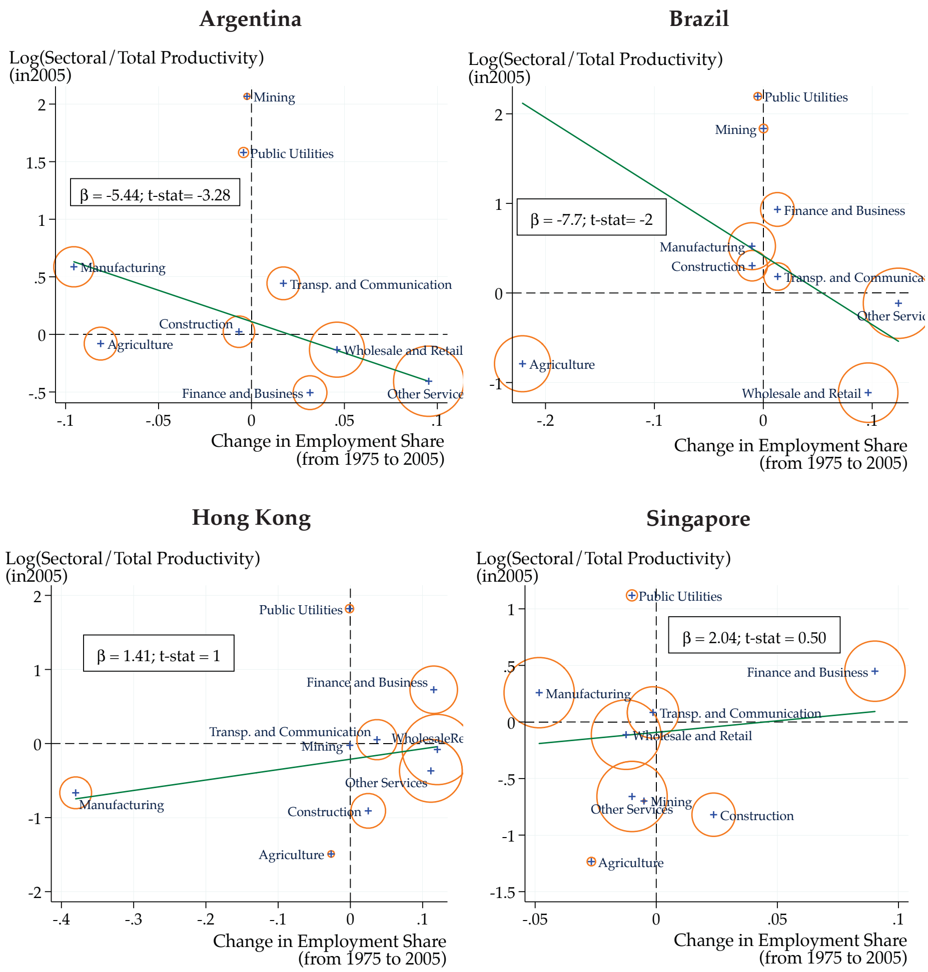
[28]The contrasting patterns of structural change between Latin America and East Asia were originally documented in the pioneering work of McMillan and Rodrik (2011). Although similar in nature, Figure 12 describes these patterns using a longer sample period (1975-2005), different countries (Hong Kong and Singapore), and a different regression to fit the line (employment weights are those of the end of the period). Altogether, these results point to the robustness of the structural change patterns. In Latin America workers moved from relatively high-productivity sectors to low productivity sectors, whereas in the East Asian sample the opposite holds true.

and Africa, the authors show that there is a strong (consistently significant) negative association between growth-enhancing structural change and the reliance on the export of primary products. They also show that both currency overvaluation (a symptom of Dutch disease[29]) and employment market rigidities are associated with the movement of labor[30] towards relatively less productive activities.

[29] I thank an anonymous referee for pointing out this symptom.

[30] Note that labor movement towards and within the informal sector are still possible (and even more likely) when there are rigidities in the formal labor market. In a highly regulated labor market, new and existing firms have more incentives to initiate operations in the informal sector. As a result, entrants to the labor market (e.g., high school and college graduates) have more changes to end up in low productivity firms.

Figure 4.12: Patterns of Structural Change, 1975-2005



Note: Size of the circle represent employment share in 2005. Since movements from agriculture initiate the process of structural change, the fitted line excludes agriculture from the regression.

Source: Author's calculations using data from McMillan and Rodrik (2011)

In the context of Latin America, the increasing concentration exports in primary products for export, the historical prevalence of overvalued currencies[31], and rigid labor markets are well documented features (See Bertola and Ocampo, 2012; Edwards, 2010; Franko, 2007; and the references

[31] Overvaluation of currencies in Latin America reflected one of the negative outcomes of the import substitution industrialization (ISI) policies that were implemented in the region during the 1950-1970 period. More recently, however, noticeable progress has been made due to a better monetary policy framework and more flexible exchange regimes.

therein). Detailed quantitative evaluations of policy efforts in these and other related areas, however, are less studied. In this context of scarcity, the works of Lora (1997, 2001, 2012) are notable contributions. In these studies, the author evaluates the progress of structural reforms that were implemented in Latin America during the 1985-2010 period. It notable that among the five areas of structural reform (trade policy, financial policy, privatizations, tax policy, and labor regulation), policy initiatives dealing with the flexibility of labor markets have shown the least progress. This result is consistent across most countries in the region and over the last three decades.

4.6 Concluding Remarks

Rapid growth and convergence in East Asia and stagnation and divergence in Latin America imply a rapidly raising development gap between the two regions. In fact, this gap is larger than that predicted by differences in per-capita GDP. Higher inequality and lower life expectancy have large negative effects in Latin America.

Despite noticeable large differences both in welfare and production, the latter still accounts for most of the variation of the welfare-adjusted development index suggested by Jones and Klenow (2011). Further analysis suggests that labor productivity is the main force driving the production gap between the regions. Although physical and human capital per worker is relatively low in Latin America, the lack of investment is not the main productivity problem. Inefficient production is the main factor holding down labor productivity.

A more detailed view of the sectoral dynamics suggests that labor misallocation across sectors have been reducing economy-wide efficiency in Latin America. In particular, premature deindustrialization (i.e., workers moving from manufacturing into services) and falling productivity in the service sector have potentially large negative effects on efficiency, labor productivity, and welfare-adjusted development. Over time, workers have kept gravitating to sectors and firms in which the scale of production is minuscule, mostly non-tradable, and difficult to standardize.

Looking ahead, Latin America still faces three policy challenges. First, the region should gradually diversify its export base away from primary commodities. Progress in this domain not only creates new and more productive jobs, but also reduces both pressures toward the overvaluation of local currencies and the prevalence of Dutch disease concerns. Second, the region should make its labor markets flexible. Progress in this domain generates incentives for the creation of larger and more productive firms. Third, when implemented, industrial policy should be pragmatic and experimental. It should be guided by careful diagnostics and continuous identification and monitoring of public and private constraints.

Chapter 5

Main Findings, Policy Implications, and Further Research

5.1 Introduction

This dissertation first studied the cross-country dynamics of labor productivity and its proximate determinants: physical capital, human capital, and aggregate efficiency. Then, it evaluated the role of intersectoral resource misallocation and its potential effects on aggregate efficiency. Labor productivity across countries not only help us understand differences in per-capita income across countries, but also differences in welfare and development. In addition, the analysis of intersectoral productivity gaps helps us understand that developing countries suffer from highly heterogeneous production structures. Some countries, most of the in East Asia, have managed such heterogeneity in the right way: by reallocating workers from the low-productivity sectors to the most productive parts of their economies. Others, mostly in Latin America, reduced their productivity growth prospects by misallocating their resources, meaning workers moved from relatively high-productivity sectors to low productivity sectors.

This final chapter summarizes the main findings of the dissertation. Section 5.2 briefly introduces the overall findings by grouping them into three analytical pillars: patterns describing the world productivity distribution, the measurement of aggregate productivity and efficiency, and patterns of structural change and misallocation. Section 5.3 discusses five general policy implications that arise from the previously described structural differences between Latin America and East Asia. Finally, Section 5.4 outlines some avenues for further research.

5.2 Main Findings

5.2.1 The World Productivity Distribution

During the 1950-2010 period, the relative labor productivity of the median country has been stagnant, while cross-country dispersion has drastically increased. An evaluation of the cross-section dynamics of the proximate determinants of productivity reveals the following patterns[1]:

- Physical capital accumulation of the median country appears stagnant, with an increasing dispersion only in the upper tail of the distribution.
- Human capital accumulation of the median country increased over time. Contrasting the behavior of other determinants, this is the only variable in which the cross-country dispersion decreased over time.
- Aggregate efficiency of the median country decreased over time, with an increasing dispersion in both upper and lower tails.

In the proximate future, if current institutions and policies remain in place, the world productivity distribution might be characterized by additional divergence at the bottom, and further convergence

[1] Using the United States as a convergence benchmark, all variables are expressed in relative terms

and overtaking at the top. The upper tail of this distribution is more sensitive to improvements in human capital, whereas the lower tail is more sensitive to improvements in aggregate efficiency.

5.2.2 Aggregate Productivity and Efficiency

Regression methods overestimate the fraction of the variation in labor productivity that is explained by physical capital. This upward bias is due to the unaccounted covariance between physical capital and aggregate efficiency. Calibration methods attempt to control for this covariance. Results from this approach highlight that most of the variation in labor productivity is actually explained by aggregate efficiency rather than physical capital.

Most of the welfare-adjusted development gap between Latin America and East Asia (55 percent) is explained by their gap in labor productivity. In turn, inefficient production is the main factor holding down labor productivity in Latin America. In addition, differences in aggregate efficiency account for 27 percent of the development gap between the regions.

5.2.3 Structural Change and Resource Misallocation

Resource misallocation is an important channel for understanding the relationship between the fundamental determinants (i.e., geography, culture, institutions and policies) and the proximate determinants (i.e., physical capital, human capital, and aggregate efficiency) of labor productivity. Resource misallocation a cross sectors generate significant losses in aggregate efficiency. Misallocation is also a symptom of dysfunctional factor and output markets. That means that in a static equilibrium, markets fail to equalize the marginal productivities across sectors. In the last 60 years, different structural change and allocation patterns have largely contributed to the increasing socioeconomic gap between Latin America and East Asia. In the former, workers moved from relatively high-productivity sectors to low-productivity sectors, whereas in the latter the opposite holds true.

Economies in Latin America appear to be suffering from large inefficiencies at the sectoral level. Most of their labor force (61 percent) is concentrated in the service sector, which is the part of the economy that reports the lowest productivity levels. Over time workers keep gravitating to low productivity and low wage sectors, where the scale of production is minuscule, mostly non-tradable, and difficult to standardize.

5.3 Policy Implications

The following policy implications are based on the productivity, structural change, and misallocation patterns of Latin America and East Asia. Since this dissertation is motivated by broad cross-country and regional differences, the implied interventions should only be considered as a first filter for more detailed policy analysis. Specific policy interventions ultimately depend on each country's latent comparative advantage, social realities, and institutional constraints.

5.3.1 Making Productivity a Central Issue

Aggregate productivity growth should be a central theme of the public debate (Pages 2010). Similar to the importance of inflation or unemployment, policy makers, citizens, and opinion leaders should be aware of the welfare implications of low productivity growth. Higher public awareness of the importance of aggregate and sectoral productivity may increase the demand for productivity-oriented policies. In fact, discussions of any type of economic and social policy should take into consideration the potential direct and indirect effects on long-term productivity. For instance, well-intentioned social policies such as subsidies to small producers and high taxes on large companies, usually encourage the proliferation of very small firms. Such firms tend to have lower productivity and remain small to avoid larger taxes. Recent research shows that these well-intended social policies distort the size of firms and have large effects on aggregate productivity (Rogerson and Restuccia 2008; Guner et al. 2008). In Latin America, a history of macroeconomic instability and lack of social inclusion seems to have pushed aside the importance of aggregate productivity in the policy agenda.

Making productivity a central issue of the policy and public debate requires independent, opportune, and credible productivity statistics. In the last three decades, most Latin American countries have made large progress on the independence of their central banks. Monetary policy is motivated by professional technical analysis, and inflation statistics are credible.[2] In a similar fashion, productivity statistics should be elaborated and diffused by independent and credible institutions. Although this function could typically be fulfilled by the national bureau of statistics, it does not necessarily have to be the case. For instance, in 2010, the New Zealand government passed an act and created the New Zealand Productivity Commission, which functions as an independent entity. Since its creation, the commission has been promoting the understanding of productivity issues and nourishing the policy and public debate with credible and opportune statistics.

5.3.2 Overcoming Labor Market Rigidities

In Latin America, workers have more incentives to move from relatively high-productivity sectors such as agriculture and manufacturing to low-productivity sectors such as wholesale and retail. This type of misallocation is symptomatic of a poorly functioning labor market. In particular, current labor market regulations increase the labor costs that formal firms face. More than 60 percent of the labor force works in the service sector, where millions of small retail firms and street vendors operate in the informal sector. Business owners in this part of the economy typically do not face labor costs related to social security and have more freedom to hire and fire workers. In practice, stringent job security laws do not apply in an informal economy.

[2]Currently, Venezuela and Argentina are well-know exceptions.

To reallocate workers from low-productivity sectors to high-productivity parts of the economy, policy makers should first make job security laws flexible. Heckman and Pages (2000) argue that such flexibility could increase the demand of workers by relatively large and formal firms. These authors also argue that stringent job security laws not only reduce aggregate efficiency but also increase inequality, since they mostly affect the employment prospects of young, female, and unskilled workers. It is typically the case that some social policies have productivity trade-offs, and yet are implemented because of their positive net effect on welfare. In the case of Latin America, however, job security laws have not only failed to promote social inclusion but appear to have contributed to the degree of labor misallocation in the region.

5.3.3 Overcoming Dutch Disease Concerns

When an economy lacks large and internationally competitive industries, workers typically do not have any choice but to find survival jobs in low productivity parts of the economy. Latin America is endowed with a large variety of natural resources. Its export bundle contains little value added and the sectors where it is produced are typically intensive in capital rather than labor. For instance, although productivity in the oil and mining sectors is high, they cannot absorb a large fraction of the labor force. In a context of high commodity prices, other export industries such as textiles, which absorb a larger fraction of workers, face survival problems when there are overvaluation pressures in the exchange rate. McMillan and Rodrik (2011, 2013) show that, among other variables[3], the share of natural resources in the export bundle and the overvaluation of the exchange rate are highly correlated with their measure of intersectoral resource misallocation. The robustness of these two variables in their regression results suggests that resource misallocation is, in part, a consequence of a Dutch Disease problem and a failure of local macroeconomic policy to manage the booms and busts of the world economy.

[3] Labor market rigidities and the share of agriculture in output.

Historically, Latin America has experienced a variety of currency crises. The policy management of commodity booms and busts has also been constrained by the limited independence of central banks. Although macroeconomic stability is not a sufficient condition for high productivity growth, it is a necessary condition for the basic functioning of markets. Moreover, overvalued exchange rates can easily dismantle the international competitiveness of emerging export industries that have the potential to absorb a relatively larger fraction of the labor force. In the future, as in the recent financial crisis, sound macroeconomic and exchange rate frameworks should help mitigate misallocation effects originated in external shocks.

5.3.4 Exploring Productive Development Policies

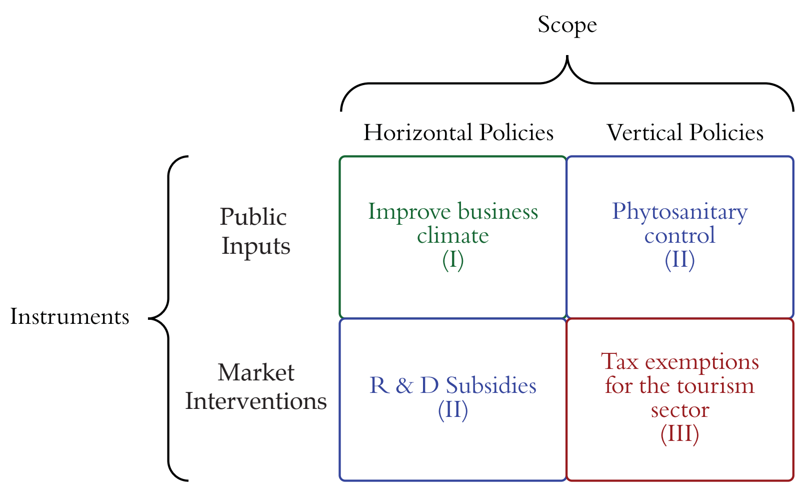
Crespi et al. (2014) and Pages (2010) argue that Latin America could increase aggregate productivity and simultaneously reduce resource misallocation by exploring a new generation of industrial policies. Contrasting with the previous failed attempts of the 1960s and 1970s, this new generation of policies should neither be inward oriented nor focus exclusively on the industrial sectors. Therefore, these authors suggest the term 'Productive Development Policies' instead of the ideologically charged term 'Industrial Policies'. Since the Washington Consensus type of reforms, the prevailing view in Latin America has been that the best industrial policy is one that does not exist. However, the East Asian experience suggests that the active participation of the state can help solve coordination problems, promote knowledge spillovers, and enhance private sector capabilities. In defense of the latter approach, Rodrik (2014) highlights that today's policy making does not focus so much on *whether* countries should implement industrial policies, but rather on *how* to do it. For Latin America, dismissing the potential of industrial policies and not learning from past mistakes is a luxury the region cannot afford.

The exploration of productive development policies has to be systematic and pragmatic. To achieve these purposes, Crespi et al. (2014) propose that any productive development policy should pass the three fundamental tests: market failure, policy design, and institutional capabilities. As a simple guidance, policy makers should aim to answer the following questions:

- What is the specific market failure that requires a policy intervention?
- Does the policy design match the characteristics of the market failure?
- Are the institutional capabilities sufficiently strong to implement the policy design?

Crespi et al. (2014) go further and suggest that productive development policies should be categorized based on their scope of application and the availability of instruments. Figure 5.1 illustrates this categorization with an example for each category.

Figure 5.1: A Typology of Productive Development Policy Interventions



Source: Adapted from Crespi et al. (2014), Figure 2.1

In terms of scope, policies can be applicable to all sectors (i.e., horizontal policies) or, alternatively, applicable only to selected sectors (i.e., vertical policies). In terms of availability of instruments, they can take the form of public inputs or market interventions. The latter affects directly the profits and behavior of firms.

In this classification Latin American countries should gradually implement policies in three stages. First, the region should improve its business climate by improving labor and entry regulations. Second, vertical policies, such as phytosanitary control of agricultural products, and market interventions, such as subsidies for research and development, could facilitate access to new international markets, and technology adoption and diffusion. Third, subsides and tax exemptions to specific sectors and firms should be *temporary* and strictly *conditional* on economic performance. However, policy interventions in this last stage are the most vulnerable to rent seeking behavior and political capture. As a result, most countries in the region should accumulate institutional capabilities before implementing these more ambitious policies.

5.3.5 Building Institutional Capabilities

If productive development policies do not consider the institutional and political economy constraints of each country, these policies could instead reduce aggregate productivity and increase resource misallocation. In his comparative analysis of the policy making process of Latin America and East Asia, Elson (2013) argues that the former is characterized by a weak state and strong oligarchies, while the latter is characterized by a strong state and weak oligarchies. These institutional differences are likely to explain most their contrasting structural change and misallocation patterns observed in the data.

Increasing aggregate productivity is a complex task. It requires the implementation of robust long-run policies to different political cycles and regimes. Political institutions need to favor experimentation, creative destruction, and learning. This type of support, however, is rarely found in most of the economic history of Latin America (Acemoglu and Robinson 2012; Edwards 2012; Fukuyama 2008). At least in the short term, an important number of countries in the region may not yet be ready to withstand rent seeking pressures and capture by political or private interests.

Given their highly constrained institutional and political environment, in the short term, most Latin American countries can only implement a somewhat limited set of productive development policies (quadrants I and II in Figure 5.1). Over time, Latin American countries should focus on building institutional and state capabilities to enable more ambitious policies .

5.4 Further Research

5.4.1 On the World Productivity Distribution

Conceptually, the shape and dynamics of the economy-wide distribution are driven by sector-level productivity distributions. In other words, the world productivity distribution is driven by cross-country productivity differences in agriculture, industry, and services. Analyzing the world productivity distribution by sector is a promising avenue for further research. For instance, Duarte and Restuccia (2010) highlight that sectoral productivity differences are crucial for understanding economy-wide differences in productivity. Using a sample of 29 countries, these authors document that productivity differences are large in agriculture and services and smaller in manufacturing. They also argue that lack of catch-up in services explains low growth and stagnation in economy-wide productivity. Newly available datasets on sector-level output (e.g., De Vries et al. 2014) can help us not only evaluate the robustness of these recent findings, but also extend the coverage of developing countries.

5.4.2 On Aggregate Productivity and Efficiency

Differences in physical capital across countries could be larger than those reported in this dissertation. For instance, developing countries usually keep using physical capital goods even after their full depreciation. If in the data developing countries systematically use old vintages, then the fraction of labor productivity differences that is explained by physical capital could increase. In addition, Pritchett (2000) highlights the fact that differences in the efficiency of public investment could increase the variance of physical capital across countries. If in the data developing countries systematically show delays in the execution of public investment projects, then the contribution of the gap in physical capital to the gap in labor productivity could increase. As a result, further studies that quantify differences in the quality of physical capital across countries would provide a more precise calculation of the residual contribution of aggregate efficiency.

Similarly, differences in human capital across countries could be larger when adjusting for quality differences across countries. Adjusting for differences in the quality of schooling, however, is not the only promising extension. The process of human capital accumulation extends beyond schooling and includes life cycle patterns. For instance, if developing countries systematically underinvest in early childhood development or on-the-job training, then the contribution of the gap in human capital should be larger. The challenge of these extensions, however, relies on finding the functional form and parameters of the production of human capital.

5.4.3 On Structural Change and Resource Misallocation

The analytical core of the literature on structural change and resource misallocation relies on the measurement of marginal productivity gaps across sectors, which in turn depends on the functional form and parameters of sector-level production functions. The literature, however, does not agree on the shape and parameters of such functions, at least from a cross-country perspective. Further studies first would benefit by the availability of data on factor inputs at the sectoral level for a large sample of countries. Evaluating different functional forms and parameters would then give us a more comprehensive and robust measure of the marginal productivity gaps, and ultimately the degree of misallocation across sectors.

After quantifying the scope of misallocation across sectors for a larger sample of countries, further studies would have more ability to identify and quantify the effects of specific sources of misallocation. At this stage, potential areas of debate, where research would be most needed, include identifying certain institutional and political economy variables that have the largest marginal effects on misallocation, as well as the conditions under which a reduction in misallocation implies an unambiguous gain or loss in welfare.

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Appendix A

Labor Productivity in the Very Long Run: Three Alternative Cases

Table A.1: The Case of a Low Productivity Country:

State	Interval	2035	2060	SteadyState
L	[0, 0.025)	0.30	0.17	0.12
UL	[0.025, 0.05)	0.10	0.06	0.04
LM	[0.05, 0.10)	0.05	0.04	0.03
M	[0.10, 0.20)	0.07	0.05	0.05
UM	[0.20, 0.40)	0.07	0.07	0.08
LH	[0.40, 0.80)	0.15	0.21	0.23
H	[0.80, 1.2)	0.27	0.39	0.45

Table A.2: The Case of a Middle Productivity Country:

State	Interval	2035	2060	SteadyState
L	[0, 0.025)	0.16	0.13	0.12
UL	[0.025, 0.05)	0.06	0.05	0.04
LM	[0.05, 0.10)	0.03	0.03	0.03
M	[0.10, 0.20)	0.05	0.05	0.05
UM	[0.20, 0.40)	0.07	0.08	0.08
LH	[0.40, 0.80)	0.22	0.23	0.23
H	[0.80, 1.2)	0.41	0.44	0.45

Table A.3: The Case of a High Productivity Country

State	Interval	2035	2060	SteadyState
L	[0, 0.025)	0.07	0.11	0.12
UL	[0.025, 0.05)	0.03	0.04	0.04
LM	[0.05, 0.10)	0.03	0.03	0.03
M	[0.10, 0.20)	0.04	0.04	0.05
UM	[0.20, 0.40)	0.08	0.08	0.08
LH	[0.40, 0.80)	0.26	0.24	0.23
H	[0.80, 1.2)	0.50	0.46	0.45

Appendix B

Data:

This article uses data from Penn World Tables V7.1 (see Heston, Summers, and Aten 1991) to construct annual time series of PPP-adjusted GDP per worker in chained 2005 prices (variable RGDPWOK). Following the criteria of Duarte and Restuccia (2006), the selection of countries was based on the following criteria:

1. Countries that have data for every year from 1960 to 2010

2. Countries that have at least one million in population in 2010.

These restrictions rendered a set of 92 countries. Adding data on educational attainment, which comes from Barro and Lee (2010), the final data set contains complete information for 85 countries.

For every output observation, business-cycle fluctuations are removed using the Hodrick-Prescott filter with a smoothing parameter equal to 100. For the most part of the article, data series on output per worker are reported relative to that of the United States. It is the conventional view in the literature that the United States is a stable technological benchmark against which to measure potential gains in labor productivity in all countries. As a reference, in the post-war period, potential labor productivity in the United States grew at roughly 2 percent per year. .

The capital stock is calculated by summing investments from 1960 to 2010 using a depreciation rate of 6 percent and an initial capital stock determined by the steady-state capital-output ratio of 1960. Given the 51 years of the capital series and the selected depreciation rate, the calculated values of the capital stock are quite insensitive to the initial value.

	Determinants				Relative Output per Worker						
Countries	s_K	n	S2010	A2010	1960	2010	(1)	(2)	(3)	(4)	(5)
							Steady-State Prediction				
Algeria(DZA)	0.33	0.01	7.63	0.30	0.35	0.24	0.21	0.30	0.21	0.36	0.69
Argentina(ARG)	0.20	0.01	9.42	0.46	0.36	0.31	0.29	0.45	0.31	0.43	0.65
Australia(AUS)	0.30	0.01	12.12	0.92	0.93	0.93	0.94	0.90	0.94	1.04	1.03
Austria(AUT)	0.24	0.00	9.52	1.23	0.56	0.92	0.94	1.30	0.94	1.34	0.94
Bangladesh(BGD)	0.21	0.02	5.91	0.08	0.05	0.03	0.04	0.07	0.04	0.07	0.46
Belgium(BEL)	0.26	0.00	10.62	1.13	0.64	0.96	0.99	1.19	0.99	1.27	0.99
Benin(BEN)	0.19	0.03	4.35	0.09	0.04	0.03	0.03	0.08	0.03	0.07	0.34
Bolivia(BOL)	0.11	0.02	9.87	0.17	0.17	0.10	0.08	0.16	0.12	0.11	0.47
Brazil(BRA)	0.21	0.01	7.55	0.31	0.19	0.19	0.17	0.30	0.17	0.29	0.54

	Determinants				Relative Output per Worker						
Countries	s_K	n	S2010	A2010	1960	2010	(1)	(2)	(3)	(4)	(5)
Burundi(BDI)	0.12	0.04	3.35	0.03	0.01	0.01	0.01	0.02	0.01	0.02	0.24
Cameroon(CMR)	0.16	0.02	6.21	0.11	0.08	0.05	0.04	0.10	0.05	0.08	0.39
Canada(CAN)	0.24	0.01	12.08	0.89	0.90	0.83	0.83	0.90	0.83	0.92	0.93
Cent. African Rep(CAF)	0.08	0.02	3.68	0.05	0.05	0.01	0.01	0.04	0.02	0.03	0.21
Chile(CHL)	0.26	0.01	10.17	0.44	0.29	0.33	0.35	0.43	0.35	0.46	0.80
China(CH2)	0.35	0.01	8.11	0.26	0.03	0.15	0.20	0.26	0.20	0.33	0.78
Colombia(COL)	0.20	0.01	7.75	0.32	0.26	0.19	0.17	0.31	0.18	0.30	0.54
Congo Dem. Rep.(ZAR)	0.17	0.03	3.26	0.01	0.04	0.01	0.00	0.01	0.01	0.01	0.29
Congo Republic (COG)	0.23	0.03	6.30	0.10	0.06	0.06	0.05	0.09	0.05	0.09	0.46
Costa Rica(CRI)	0.24	0.02	8.74	0.44	0.39	0.29	0.28	0.43	0.28	0.44	0.64
Cote d'Ivoire(CIV)	0.06	0.02	4.60	0.12	0.06	0.04	0.03	0.12	0.05	0.06	0.21
Denmark(DNK)	0.25	0.00	9.97	1.05	0.65	0.79	0.83	1.09	0.83	1.13	0.83
Dominican Rep(DOM)	0.20	0.02	7.33	0.56	0.19	0.27	0.29	0.54	0.31	0.51	0.51
Ecuador(ECU)	0.25	0.02	8.18	0.22	0.16	0.15	0.14	0.21	0.14	0.22	0.62
Egypt(EGY)	0.16	0.02	6.97	0.39	0.08	0.17	0.17	0.36	0.20	0.31	0.43
El Salvador(SLV)	0.16	0.00	7.88	0.35	0.27	0.18	0.18	0.36	0.21	0.30	0.52
Finland(FIN)	0.25	0.00	9.96	1.07	0.47	0.81	0.87	1.12	0.87	1.18	0.87
France(FRA)	0.22	0.01	10.53	1.06	0.60	0.83	0.83	1.09	0.84	1.07	0.83
Ghana(GHA)	0.20	0.02	7.26	0.11	0.08	0.06	0.05	0.10	0.06	0.09	0.49
Greece(GRC)	0.26	0.00	10.68	0.88	0.33	0.73	0.77	0.93	0.77	0.98	0.88
Guatemala(GTM)	0.19	0.02	4.90	0.44	0.20	0.19	0.17	0.41	0.18	0.38	0.38
Haiti(HTI)	0.12	0.01	5.13	0.11	0.08	0.04	0.03	0.10	0.05	0.08	0.32
Honduras(HND)	0.27	0.02	7.30	0.18	0.17	0.11	0.10	0.17	0.10	0.18	0.57
Hong Kong (HKG)	0.31	0.01	10.40	1.01	0.23	0.87	0.93	1.03	0.93	1.21	0.93
India(IND)	0.28	0.02	5.20	0.24	0.05	0.10	0.12	0.23	0.12	0.26	0.49
Indonesia(IDN)	0.20	0.01	5.95	0.20	0.04	0.09	0.09	0.19	0.09	0.18	0.45
Iran(IRN)	0.27	0.01	8.64	0.41	0.37	0.33	0.29	0.41	0.29	0.45	0.70
Ireland(IRL)	0.26	0.02	11.62	1.00	0.46	0.93	0.88	0.95	0.88	1.02	0.88
Israel(ISR)	0.23	0.02	11.36	0.83	0.54	0.74	0.67	0.78	0.67	0.79	0.81
Italy(ITA)	0.26	0.00	9.46	1.07	0.51	0.83	0.82	1.11	0.82	1.18	0.82
Jamaica(JAM)	0.26	0.01	9.75	0.27	0.40	0.23	0.21	0.28	0.21	0.30	0.77
Japan(JPN)	0.27	0.00	11.59	0.73	0.30	0.73	0.73	0.77	0.73	0.85	1.00
Kenya(KEN)	0.16	0.03	6.65	0.08	0.06	0.04	0.03	0.08	0.04	0.06	0.40
Korea Rep.(KOR)	0.36	0.00	11.94	0.62	0.13	0.63	0.72	0.64	0.72	0.81	1.17
Malawi(MWI)	0.30	0.03	4.69	0.03	0.02	0.02	0.01	0.03	0.01	0.03	0.45
Malaysia(MYS)	0.27	0.02	10.16	0.42	0.11	0.34	0.32	0.40	0.32	0.43	0.76
Mali(MLI)	0.19	0.03	2.38	0.14	0.04	0.04	0.04	0.12	0.04	0.11	0.29
Mauritania(MRT)	0.30	0.03	4.51	0.15	0.05	0.07	0.07	0.14	0.07	0.16	0.45
Mexico(MEX)	0.23	0.01	9.06	0.46	0.48	0.34	0.30	0.45	0.30	0.45	0.66
Morocco(MAR)	0.37	0.01	5.01	0.22	0.07	0.12	0.13	0.22	0.13	0.28	0.56
Mozambique(MOZ)	0.17	0.02	1.81	0.09	0.02	0.02	0.02	0.08	0.03	0.07	0.26
Nepal(NPL)	0.25	0.02	4.02	0.06	0.03	0.03	0.03	0.06	0.03	0.06	0.41
Netherlands(NLD)	0.21	0.01	11.02	1.04	0.88	0.86	0.84	1.07	0.87	1.03	0.84
New Zealand(NZL)	0.21	0.01	12.68	0.66	1.00	0.63	0.61	0.66	0.63	0.64	0.93

Countries	Determinants				Relative Output per Worker						
	s_K	n	S2010	A2010	1960	2010	(1)	(2)	(3)	(4)	(5)
Nicaragua(NIC)	0.29	0.01	6.66	0.10	0.23	0.07	0.05	0.09	0.05	0.10	0.58
Niger(NGA)	0.08	0.02	1.84	0.33	0.11	0.07	0.06	0.31	0.10	0.18	0.18
Norway(NOR)	0.25	0.00	12.26	1.17	0.79	1.16	1.18	1.21	1.18	1.28	1.18
Pakistan(PAK)	0.15	0.02	5.53	0.19	0.05	0.08	0.07	0.18	0.08	0.15	0.37
Panama(PAN)	0.23	0.02	9.60	0.41	0.18	0.27	0.28	0.39	0.28	0.39	0.69
Papua(PNG)	0.17	0.02	4.08	0.19	0.09	0.07	0.06	0.17	0.07	0.15	0.33
Paraguay(PRY)	0.15	0.02	8.51	0.15	0.12	0.10	0.08	0.15	0.09	0.12	0.50
Peru(PER)	0.23	0.01	8.93	0.24	0.26	0.16	0.15	0.23	0.15	0.23	0.65
Philippines(PHL)	0.20	0.02	8.95	0.14	0.10	0.09	0.08	0.13	0.09	0.13	0.58
Portugal(PRT)	0.28	0.00	8.03	0.66	0.27	0.45	0.46	0.68	0.46	0.76	0.70
Romania(ROM)	0.22	0.00	10.34	0.36	0.07	0.26	0.29	0.39	0.29	0.38	0.81
Rwanda(RWA)	0.13	0.03	3.96	0.09	0.04	0.02	0.02	0.08	0.03	0.06	0.27
Senegal(SEN)	0.25	0.03	5.20	0.09	0.08	0.04	0.04	0.08	0.04	0.09	0.44
Singapore(SGP)	0.30	0.02	9.13	1.57	0.32	1.17	1.18	1.52	1.18	1.76	1.18
South Africa(ZAF)	0.22	0.01	8.48	0.38	0.36	0.24	0.23	0.38	0.24	0.37	0.62
Spain(ESP)	0.29	0.01	10.40	0.76	0.43	0.67	0.64	0.74	0.64	0.84	0.85
Sri Lanka(LKA)	0.24	0.01	11.10	0.15	0.04	0.11	0.12	0.15	0.12	0.15	0.83
Sweden(SWE)	0.18	0.00	11.48	1.07	0.76	0.83	0.86	1.13	0.96	1.01	0.86
Switzerland(CHE)	0.25	0.00	9.92	0.94	1.03	0.78	0.74	0.97	0.74	1.02	0.79
Syrian (SYR)	0.16	0.03	5.21	0.45	0.15	0.17	0.15	0.41	0.18	0.34	0.34
Taiwan(TWN)	0.24	0.00	11.34	0.96	0.13	0.78	0.86	0.99	0.86	1.03	0.90
Tanzania(TZA)	0.23	0.02	5.78	0.06	0.02	0.03	0.03	0.06	0.03	0.06	0.45
Thailand(THA)	0.28	0.01	7.41	0.27	0.05	0.17	0.17	0.27	0.17	0.30	0.64
Togo(TGO)	0.15	0.03	5.77	0.03	0.04	0.02	0.01	0.03	0.01	0.02	0.35
Turkey(TUR)	0.18	0.01	7.18	0.91	0.16	0.40	0.44	0.88	0.49	0.79	0.49
Uganda(UGA)	0.14	0.03	5.46	0.10	0.04	0.03	0.03	0.09	0.04	0.07	0.33
United Kingdom(GBR)	0.18	0.01	9.44	1.34	0.60	0.82	0.86	1.38	0.96	1.23	0.86
United States(USA)	0.23	0.01	13.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uruguay(URY)	0.21	0.00	8.56	0.42	0.28	0.26	0.27	0.44	0.28	0.43	0.65
Venezuela.(VEN)	0.21	0.01	7.13	0.39	0.60	0.25	0.20	0.38	0.21	0.36	0.51
Zambia(ZMB)	0.21	0.03	6.68	0.09	0.07	0.04	0.04	0.08	0.04	0.08	0.47
Zimbabwe(ZWE)	0.04	0.00	7.70	0.02	0.02	0.01	0.00	0.02	0.01	0.01	0.25

Notes: The determinants of steady-state output are: s_K investment share, last decade average, trended data; n population growth, decade average; $S2010$ average years of schooling in 2010; and $A2010$ relative level of technology (TFP) in 2010. Simulations: (1) Base Model, (2) $s_{K_i} = s_{K_{USA}}$ and $h_i = h_{USA}$, (3) $s_{K_i} \geq s_{K_{USA}}$, (4) $h_i = h_{USA}$, (5) $A_i \geq A_{USA}$. Data on output per worker is also available for the following countries: Burkina Faso(BFA), Ethiopia(ETH), Guinea(GIN), Madagascar(MDG), Niger(NER), Puerto Rico(PRI), Chad(TCD). This countries, however, are not including in Section 2 of this paper due to lack of data on educational attainment