

UNIVERSITA' CATTOLICA DEL SACRO CUORE
MILANO

Dottorato di ricerca in Istituzioni e Politiche
ciclo XXII

S.S.D: SECS-P/01

**Productivity Differences and Factors' Allocation:
Empirical Evidence from Macro and Micro Data**

Tesi di Dottorato di: Jacopo Ponticelli

Matricola: 3580114

ANNO ACCADEMICO 2009/10



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Introduction

Productivity is the dark side of macroeconomics. It is hard to define, and, at the same time, it plays a crucial role in explaining important issues such as why a country's GDP grows, why income is so unequally distributed across countries, as well as why some firms exit and others stay in the market.

In all macroeconomic models output is a function of at least two elements: factors of production like labor or capital, and something called the productivity of those factors. We tend to have a clear idea of what factors of production are in real life (workers, machines), but when it comes to productivity, there is no unique definition: technological progress, better organization, managerial skills are just the first examples that comes to mind. Harberger [1998] tells that during a visit to a clothing plant in Central America, the owner told him how he obtained a 20 % reduction in real costs with the installation of background music that played as the seamstresses worked. This is a productivity increase indeed. But how would you categorize it?¹

I think that a rewarding way to approach the productivity issue is to divide it in two different components: technology and factor allocation. Productivity can be read as technology - the efficiency with which factors are used in production - but it can also be interpreted as the efficiency with which factors are allocated across the agents that participate in the production process. The first component of productivity, technology, has to do with new and more effective ways of processing the available factors of production. The second component of productivity, factor allocation, suggests that it is possible to obtain an increase in output keeping technology fixed by simply reallocating to their most

¹This would not be a big problem if productivity was not accounting for such a large share of output. Solow [1956] was the first to realize how increments in traditional inputs like capital and labor fell short in explaining why output was growing. About one half of economic growth was explained by "the residual", or, in Solow's words, "the measure of our ignorance". The Solow residual is often associated with productivity.

productive uses the available factors of production. This second approach clearly makes sense as long as economic agents (countries, firms) are heterogeneous.

In this Thesis I will focus on factor allocation as a determinant of productivity. The two chapters that make up the Thesis deals with the issue of factor allocation at different levels: across countries in chapter 1, across firms in chapter 2. Both the chapters are mainly empirical works.

In the first chapter I investigate the efficiency with which physical capital is allocated across countries. This is a question that Lucas [1990] raised almost 20 years ago. He found hard to reconcile the large differences in capital-labor ratios existing between rich and poor countries with the scarce flows of physical capital observed in data. The puzzle here is given by a textbook application of the neoclassical model where returns to capital are inversely proportional to capital-labor ratios. So, if in a poor country there is a low amount of physical capital available per each worker (as it is usually the case), the returns of the next unit of capital invested there should be very high. As Lucas pointed out, arbitrage opportunities should make people in richer countries invest in poor countries until returns are equalized. Since we don't observe such flows, two explanations are possible: the first is that there are distortions out there - e.g. international financial market frictions - that don't allow capital to move freely across countries. This explanation implies that there is plenty of investment opportunities out there whose benefits are not reaped because international capital markets don't work efficiently. If this was the case, the world allocation of physical capital would not be optimal, and everyone would be better off by reallocating capital from rich to poor countries. A second concurrent explanation is that if capitals are not flowing from rich to poor countries is probably because their returns in poor countries are not as high as a naive comparison of capital-to-labor ratios would suggest.

In the first chapter I will present evidence suggesting that this second explanation works better. I will do it by essentially test with new data how far the returns to physical capital across countries actually are. The main finding of chapter 1 is that, when returns to physical capital are properly measured, they are actually very similar across countries, so we should not be surprised to observe small international capital flows. I basically enrich the classical measure of returns to capital, the marginal product of physical capital,

in order to take into account of other factors - such as the availability of human capital, the quality of schooling, the health of the labor force, the substitutability between skilled and unskilled workers and the share of physical capital in total output - that, I believe, enters crucially in the investment decision.

In the second chapter I investigate the relationship between factor allocation at firm level and aggregate total factor productivity (hereafter TFP). In order to do that I use manufacturing firm level data of Chile and Mexico during 1980s. The main question I raise here is how much the aggregate productivity of a country could increase by simply reallocating capital and labor across its firms. This allows me to take into consideration all the heterogeneity that exists at micro level and that is not taken into account by macro models that relies on the "one country, one representative firm" assumption. The approach I follow here is the one proposed by Hsieh and Klenow [2009] who compare the performance of China, India and United States in terms of the efficiency with which they allocate resources across their manufacturing firms. Their idea is to switch the focus from how efficiently a representative firm can transform inputs into output (*within-firm* approach) to how efficiently inputs are allocated across different firms (*between-firms* approach). A crucial advantage of this approach is that it is testable at micro-level using plant data. I decided to apply this approach to the case of Chile and Mexico during the 1980s with the aim of shedding new light on why, in the aftermath of the severe crisis that hit Latin America in 1982-83, Chile recovered quickly why Mexico stagnated until the mid-1990s. The main finding of chapter 2 is that Chile showed a more efficient allocation of resources across its manufacturing firms with respect to Mexico during that period. I estimate potential gains in aggregate manufacturing TFP from moving Mexico to the level of efficiency observed in Chile in the mid-1980s to be up to 11%.

The aim of this introduction is to depict the framework in which the two chapters have been conceived. In the next two sections I will present a literature review divided by chapters.

0.1 Literature Review of Chapter 1

In this section I review the explanations proposed by the literature on why capital is so immobile internationally.

The literature on missing international capital flows starts with Lucas [1990] paper: *Why capital doesn't flow from rich to poor countries?*. Lucas perform a simple calibration of the textbook neoclassical model and obtain as a result that returns to capital in India should be 58 times higher than the returns in the US. Differences in returns of such a magnitude are clearly at odds with the small flows of capital actually observed between rich and poor countries.

Two main types of explanations of the "Lucas' paradox" have been proposed: differences in countries' fundamentals and international capital market imperfections. The former basically claims that capital doesn't flow from rich to poor countries because countries are different in fundamentals such as their level of technological progress, their availability of certain crucial factors of production like human capital or the quality of their institutions. On the other hand, the international capital market imperfections' argument suggests that capital would actually flow towards poor countries, but it doesn't because there are distortions, like sovereign risk, that lower incentives to do so.

The approach proposed in the first chapter points to differences in fundamentals as a key explanation of the lack of capital flows. I will focus on differences in human capital (including education, health and the substitutability across types of workers) and on differences in the share of capital used in production.

There are, however, other potentially important differences in fundamentals proposed by the literature. One stream of the literature has focused on institutions (see for example Alfaro et al. [2008] or Papaioannou [2009]). Institutions are intended as the set of formal and informal rules that govern a society. Institutions of different quality can, for instance, guarantee different levels of property rights' protection, an element that enters crucially in the investment decision taken by foreign entrepreneurs. A poor country with plenty of potentially interesting investment opportunities could not become a recipient of foreign capital simply because the investment risk is significant. Even if expected returns are high, an entrepreneur could decide not to invest in a country with weak institutions because the

risk of expropriation by local government is also high.

Another stream of the literature has focused on different degrees of technology adoption as a crucial determinant of capital flows (in the spirit of Parente and Prescott [2002] and Parente and Prescott [1994]). If barriers to the adoption of new technologies are higher in poor countries (or, simply, poor countries are less efficient in using existing technologies) then poor countries will have a lower return to capital investment.

The second type of explanation, the one that relies on international financial market imperfections, focuses on asymmetric information and sovereign risk. Large asymmetric information on the domestic market between borrowers (local investors) and lenders (foreign investors) can generate under-investment from abroad (see on this the model proposed by Gordon and Bovenberg [1996]). Sovereign risk (see for example Reinhart and Rogoff [2004]) is another possible source of low investment in poor countries. It can take the form of government default on loan contracts with foreigners or of expropriation of foreign assets by local government.

It is important to notice here that all these possible explanations are likely to be highly correlated with each other. A country with weak institutions has probably a labor force with scarce average education, low skilled workers are more likely to use old technologies, high political risk is associated with higher probabilities of default, low guarantees for foreign investors make investment outcomes more uncertain. These factors are all associated with low incentives for foreign entrepreneurs to invest. Regressions have been used in several of the papers presented in this review, but they are likely to be strongly biased in this framework. Since all these competing explanations are highly correlated with each other, it is hard to find a clean identification strategy or to interpret the obtained coefficients as the sole effect of the included dependent variables.

I choose to tackle this issue in chapter 1 by using a calibration approach. I will basically assume a production function form, compute a standard measure of returns to capital as the marginal product of physical capital, and then bring this simple measure to data and check its predictions in terms of capital flows across countries.

The closer reference to my work is Caselli and Feyrer [2007] that, using a different calibration, reach a very similar result: once properly measured, marginal products of capital between rich and poor countries are not that far apart from each other. Caselli

and Feyrer [2007] documents an even stronger stylized fact: the marginal product of capital is actually higher in rich countries. Lucas might have asked exactly the wrong question, the right being: why capital doesn't flow from poor to rich countries?

0.2 Literature Review of Chapter 2

In this section I review the literature establishing a link between factor allocation across firms and how this can affect aggregate productivity.

Here the micro and macro level are quite connected: a different degree of allocative efficiency across firms between two countries can translate in important differences in aggregate TFP between them. Macroeconomists in the last years are more and more interested in this kind of micro evidence, quoting Syverson they are

[..] dissecting aggregate productivity growth, the source of almost all per capita income differences across countries, into various micro components, with the intent of better understanding the sources of such growth.

The crucial question that have been asked by the literature is: what kind of distortions can prevent the optimal use of resources to be reached in equilibrium? Each work reviewed in this section has in mind a different mechanism: labor market regulations, firm size restrictions, lack of meritocracy in appointing companies' managers, trade barriers or any kind of vested interests that block firm dynamics (growth, exit, entry).

This literature starts with empirical works documenting large heterogeneity in terms of size and productivity at firm level (e.g. Bartelsman et al. [2009], Foster et al. [2008]), even within very narrowly defined sectors². Heterogeneity can obviously be due to many reasons, but it raises questions about how close real markets within countries are to the neoclassical vision where all firms are threaten as one. In economic theory an efficient allocation is not associated with large heterogeneity across agents operating in the economy. An efficient allocation is one in which resources are allocated such that there is no way to increase aggregate productivity by redistributing resources across firms. In more technical

²The more narrowly are sectors defined, the less of an issue is the assumption that all firms in the same sector produce the same kind of good, or, in other terms, that they all have the same production function inside each sector. The existence in the real world of different varieties of the same good, each one of a different quality, makes this exercise an heroic one.

terms, an efficient allocation is one in which marginal products of factors are equalized across all firms producing the same good. If two firms produce the same good and enjoy the same technology but do not have the same marginal products, it means that there is some kind of misallocation in place.³

Restuccia and Rogerson [2008] claim that one important factor behind the observed firm heterogeneity is government intervention. They stress how any kind of policy can change factors' prices (wages and returns to capital) faced by different producers and, as a consequence, how these differences in prices can potentially have substantial negative effects in terms of aggregate productivity. They propose a model with idiosyncratic distortions at firm level. In their model, upon entering in the market, each firm draw from a joint distribution a productivity and an specific output tax τ that can take the form of a tax (positive τ) or of a subsidy (negative τ). What they find is that no matter if idiosyncratic distortions (read taxes) are correlated or uncorrelated with firm-level productivity, they have negative effects on aggregate output and TFP. This means that even if subsidies entail reallocation towards more productive units they will distort the optimal establishment size. Their take is that government intervention is always negative, since any intervention, even in favor of less productive firms, allow some firms that wouldn't operate in a market free of distortions to actually stay in the market. Whether this is so bad is an open question. Are there plausible reasons why you may want less productive firms operating in the market? This could be the case if a government aims at containing unemployment, or if a government think that some sectors are strategic for future development and must be protected even if, at the moment, they are not competitive⁴.

The theoretical approach proposed by Restuccia and Rogerson [2008] has been applied to manufacturing firm level data by Hsieh and Klenow [2009]. They build a simple model where the dispersion in marginal products of capital and labor within individual four digit manufacturing sectors can be read as a measure of distortions operating in that sector. The main message of the empirical exercise they propose is that there are large margins

³As an example suppose that firm A and firm B use only labor to produce the same good, and firm A has an higher marginal product of labor. This implies that firm A has an unexploited potential (i.e. firm A could use the next unit of input more efficiently than firm B) and therefore that the society would be better off by moving resources from firm B to firm A until their marginal products equalize.

⁴Maybe those firms that seem that unproductive are simply investing in R&D and the benefits of this investment will be seen only in the future

for aggregate TFP improvements by reallocating resources across heterogeneous firms. Taking the US as a benchmark of efficiency, they estimate potential manufacturing TFP gains of 30-50% in China and 40-60% in India deriving by the reallocation of resources across firms to the level of efficiency observed in the US. These numbers show how gains from reallocation in terms of income can be potentially significant. Hsieh and Klenow [2009] also try to match their measure of misallocation with explicit government policies in China and India. In China they claim most of the misallocation within industries could come from the presence of state owned plants that survive because subsidized, although not efficient. They observe how the process of privatization that took place in China, and the consequent decrease in state owned plants, has brought to free resources that have then been reallocated to more productive firms. In India misallocation within industries is mostly attributed to licensing and size restrictions⁵, all policies that may prevent efficient plants to reach the optimal scale.

The fact that factors of production are not efficiently allocated, especially in developing countries, has been confirmed also by another stream of the literature that focus on natural experiments. In their paper "The Misallocation of Capital", Banerjee et al. [2003] try to answer the following question: are Indian (small) firms credit constrained? To do that they use as an exogenous source of variation the change in the threshold for being considered a small firm decided by the Indian government in 1998. If a firm is defined as "small" it become automatically eligible for subsidized credit by banks. This change in policy allowed them to compare the investment behavior of firms that were not considered "small" before 1998 and that became "small" after 1998. They find a gap between the marginal product of capital of Indian credit constrained firms and market interest rate of at least 70%. When these credit constrained firms become eligible for subsidized credit lines they increase in size, and probably decrease in their MPK. In the terms of Hsieh and Klenow [2009] approach, a better allocation means a lower dispersion in MPK across firms.

In another case study Banerjee et al. [2003] show how factors like belonging to a specific community could matter a lot in the allocation of capital and the availability of credit in a country like India. They show how in the city of Tirupur (Southern India) the local

⁵See on size restriction also Guner et al. [2008].

cast of the Gounders dominates the local knitted garment industry thanks to the easier access to capital they have due to social ties, while firms run by outsiders, although more productive, can't prevail due to their weak access to capital. This can be read as a case of misallocation, where capital would be better used by outsiders, but a distortion like social ties in the local cast group do not allow the more efficient allocation.

Going back at more aggregate level, Bartelsman et al. [2009] investigate the effect of firm specific distortions on aggregate outcomes. They propose as a measure of distortion the covariance within industries between size and productivity, where higher covariance would imply that more productive firms do not face any prevention to become larger. Their key empirical finding is that there is substantial variation across countries in the within industries covariance between size and productivity.

If Restuccia and Rogerson [2008] identifies distortions with any type of government intervention, other papers have a more specific shot on what could be a potential driver of inefficient allocation of resources in a market. Caselli and Gennaioli [2003] (and, similarly Buera and Shin [2010]) points to the ability to select the right people for decision making. They claim that this could be an important source of differences in the returns a firm can make from the available resources. In particular they focus on the intergenerational transmission of managerial responsibilities in family firms (what they call "dynastic management").

Midrigan and Xu [2010] focus on financial frictions and try to investigate how they can distort resource allocation among firms. Using Colombian and South Korean manufacturing firm level data they find that financing frictions are important: roughly half of the plants in our sample are financially constrained. However, their model fails in generating important TFP losses since the most productive establishments have the ability to quickly accumulate internal funds and overcome the borrowing constraint.

All these papers face similar issues, in particular when it comes to measure productivity. What kind of productivity at firm level are we looking at is a crucial question. In a very influential paper Foster et al. [2008] underline the differences between revenue and physical productivity. Physical productivity is inversely correlated to price (more efficient you are, lower price you will be able to charge) while revenue productivity is positively correlated with prices (being the revenue productivity the product of physical productivity and price

at firm level). Mixing the two, and using revenue productivity as a proxy for technical efficiency can lead, for example, to understate the physical productivity of a young firm simply because it is charging lower prices in order to gain a share of the market. The main point of their paper is that selection occurs on profitability and not on productivity, though the two are likely correlated. However what is most interesting is their observation that if one can not observe firm level prices the differences in output and input prices across firms within an industry are embodied in their productivity measures. Therefore, all measures of productivity that do not take this into account are dirty and must be read with cautious.

Chapter 1

Capital Productivity and Capital Allocation Across Countries

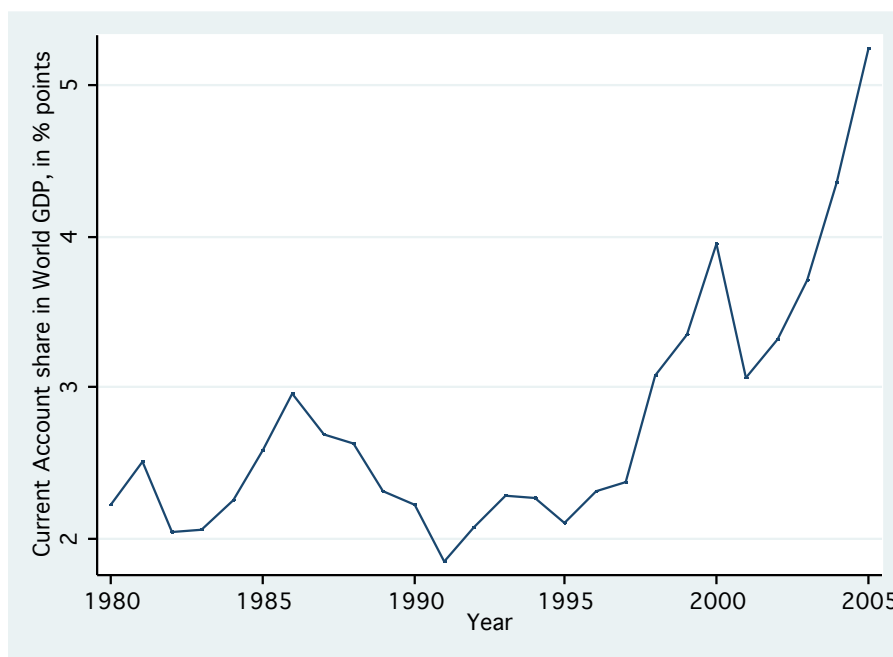
1.1 Introduction and motivating evidence

In this chapter I propose a calibration that could shed new light on why capital is so immobile internationally. The large differences in the capital-per-worker ratios that we observe across countries would suggest that there is room for significant improvement on the current allocation. According to the neoclassical theory, in fact, capital should flow from relatively capital rich to relatively capital poor countries. However, as Lucas [1990] points out, we do not observe large flows of capital from the capital rich US to the capital poor India in the real world. On top of that, the flows of capital across countries in general appears small with respect to world GDP.

Until the mid-1990s the sum of current accounts of all countries was stagnating around 2% of world GDP. This number counts both inflows and outflows, so we could say that until mid-1990s every year just 1% of world GDP moved across countries. This number seems quite small if one thinks that there are countries, like Sweden or Denmark, that devote every year 1% of their GDP to foreign aid. As Figure 1.1 shows, starting from mid-1990s the share of world GDP that moved across countries more than doubled. In 2005 the share of current account on GDP was around 5%. This is still a rather small number relative to the huge dispersion we observe in the availability of physical capital per worker across countries. If we were to observe the distribution of physical capital per

worker in 2005, a country at the 90th percentile of the distribution had 70 times more capital per worker with respect to a country at the 10th percentile, a country at the 99th percentile had almost 300 times more capital per worker with respect to a country in the 1st percentile.

Figure 1.1 Share of Current Accounts on World GDP, in % points



Besides the small magnitude, also the net direction of physical capital flows across countries is unclear. One would expect that at least the fraction of physical capital that moves internationally flows from rich to poor countries. This is not exactly what seems to happen, at least at first sight.

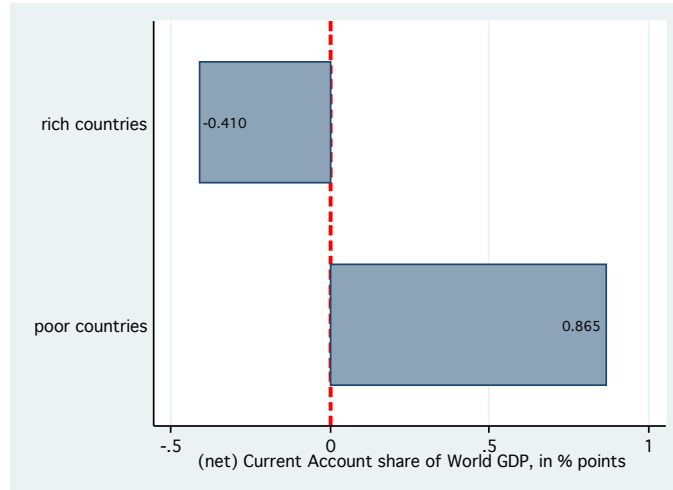
As Figure 1.2 shows the net current account of rich countries¹ in 2005, the last year of my sample, is negative. A negative number means that, in rich countries, capital inflows have been larger than capital outflows in 2005. The opposite is true for poor countries where capital outflows are higher than capital inflows². In 2005, 0.4% of World GDP

¹Rich countries are those countries with output per worker higher than 32,000 PPP adjusted 2005 international dollars. To make it clear, these are countries richer than Portugal.

²Each country's current account is measured in PPP international dollars and weighted by the share of GDP of that country in World GDP. The word "net" means that for each group (rich and poor countries) I summed up these weighted current accounts so that the result is the net flow of capital: it is an inflow if the number is positive, an outflow if the number is negative. The two numbers do not sum up to 0 (we should expect world net current account to be 0), this could be due to multiple reasons: first, here I am considering a big sample, 129 countries, but not the entire population of countries (the term World here refers to the total of countries considered, excluding those for which I don't have the relevant data);

flowed into rich countries while 0.9% of World GDP flowed out from poor countries

Figure 1.2 Net Current Account of Rich and Poor countries, 2005



Note: data from PWT6.3, WDI(2009), author's calculation. 129 countries, year 2005. See Appendix A for more details.

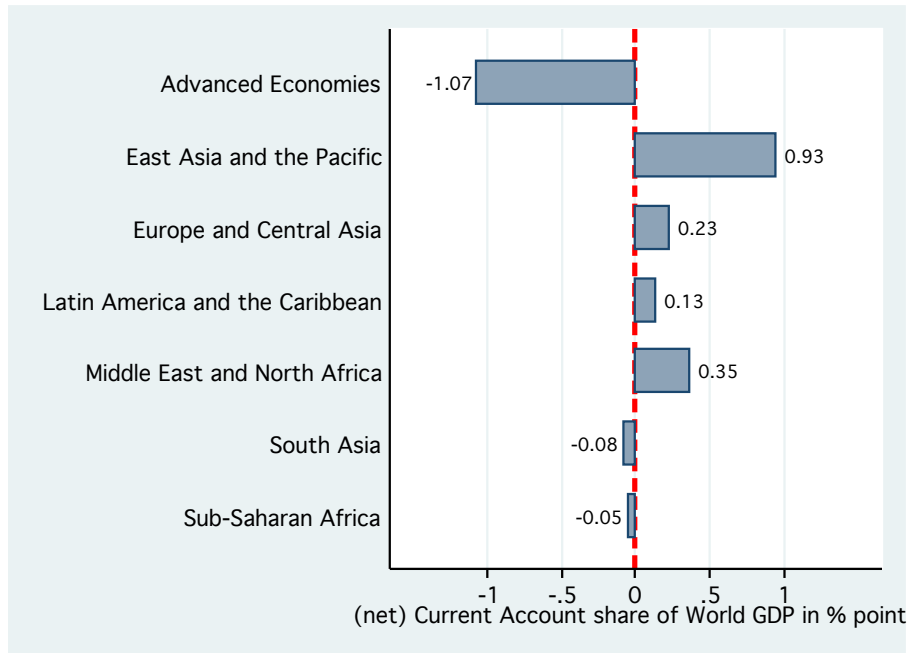
Figure 1.3 reports net current accounts split by region of the world. Advanced Economies (that are basically OECD countries) have been net capital importer with a net negative current account of around 1% of World GDP in 2005, while almost all other regions of the world are net capital exporter, the only exceptions being Sub-Saharan Africa whose negative number is probably almost totally accounted by foreign aid, and South Asia.

As Figure 1.4 shows, poor countries seem to have become net capital exporter only in the last decade while before they were mostly net recipient of foreign capital. On the other hand, rich country have been net recipient of world capital ever since the 1980s.

Given that current account data takes into account not only movement of private capital but also operations carried out by governments, I also look at foreign direct investment statistics as an alternative measure of movements of physical capital across countries. Figure 1.5 shows the net share on world GDP of FDI in rich and poor countries. Here the patterns seem more stable over time and consistent with neoclassical predictions. Poor countries are on average recipients of FDI while rich countries are on average exporter of FDI. Again, even using FDI data, the magnitudes are small, FDI net flows rarely go above half a percentage point in absolute value.

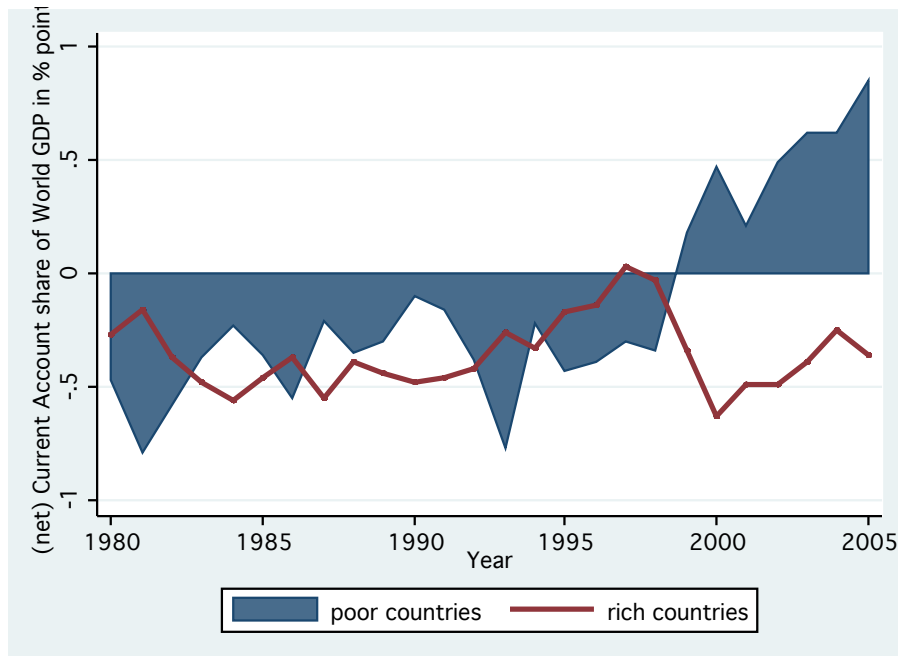
second, here I am working with PPP dollars, so the deflators change from country to country depending on the price level of the basket of consumption goods considered; third, there is always the possibility of measurement errors in national accounts

Figure 1.3 Net Current Account by Region, 2005



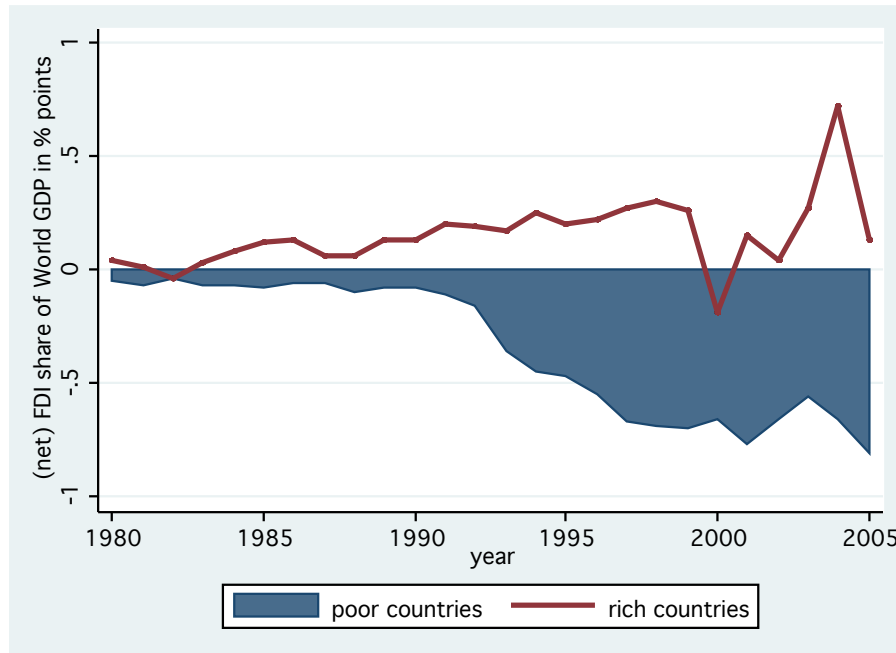
Note: data from PWT6.3, WDI(2009), author's calculation.129 countries, year 2005. See Appendix A for more details.

Figure 1.4 Net Current Account of Rich and Poor countries, 1980-2005



Note: data from PWT6.3, WDI(2010), author's calculation.129 countries, year 2005. See Appendix A for more details.

Figure 1.5 Net FDI of Rich and Poor countries, 1980-2005



Note: data from PWT6.3, WDI(2010), author's calculation. 129 countries, year 2005. See Appendix A for more details.

1.2 Aim and main results of the chapter

All the empirical evidence presented in this introduction suggests two things:

1. Capital flows seem to be quite a small fraction of World GDP
2. There is no clear pattern in the direction of capital flows between poor and rich countries.

These two facts together suggest that physical capital does not move much, and if it does, it doesn't seem to respond to differences in capital per worker. The aim of this chapter is therefore to test with new data how far the returns to physical capital across countries actually are. In the following sections I analyze the predictions of the neoclassical model starting from its simplest formulation. In each section I introduce new ingredients to the simplest formulation and check the contribution of each ingredient to our understanding of capital flows. In each section I also perform a new calibration and compare the ratio of returns to capital in poor versus rich countries. The main result of the chapter is to provide evidence that, when properly accounted, the returns to physical capital essentially equalize between rich and poor countries.

1.3 Lucas's result

In this section I briefly sum up Lucas [1990] original results. To make his point Lucas uses data from US and India, taken as representative of rich (US) and poor (India) countries, and assumes that, in both of them, production obeys a Cobb-Douglas production function with constant returns to scale and a common intercept³:

$$Y = AK^\alpha L^{1-\alpha}$$

where Y is output, A is technology, K is physical capital and L is labor. Under this framework the marginal product of capital is:

$$MPK = \alpha A \left(\frac{K}{L} \right)^{\alpha-1}$$

Assuming equal technologies (A) across countries and setting $\alpha = 0.4$, Lucas obtains an India-US ratio of MPK equal to 58, meaning that the return to 1 unit of capital invested in India should be 58 times higher than 1 unit of capital invested in the US. Correcting its calibration for human capital using estimates from Krueger [1968], Lucas arrives to a final estimate of the India-US ratio of MPK equal to 5. A natural implication of its exercise is that, in front of return differentials of this magnitude, we should observe net investments rapidly flow from the US to India and other developing countries.

1.4 Lucas's result 20 years later

My starting point is the replication of Lucas [1990] computation using data available today⁴. The framework proposed by Lucas has the following characteristics:

1. Production function is Cobb-Douglas, and common to poor and rich countries.
2. Capital is physical reproducible capital, calculated with the standard perpetual inventory method⁵.
3. TFP is not allowed to change across countries.

³This implies no differences in TFP across the two countries.

⁴For a detailed description of all the variables used in this section see Appendix A.

⁵See Appendix A for details on how I computed physical capital stock starting from investment flows.

4. The capital share (α) is assumed constant across countries⁶.
5. Labour is only raw labour, meaning: number of workers.

Hence:

$$y_c = Ak_c^\alpha$$

where y_c is output per worker, A is TFP and k_c is physical capital stock per worker. The subscript c identify country-specific variables. Setting $A = 1$ I obtain the first estimate of *MPK*:

$$MPK_c = \alpha k_c^{\alpha-1} \tag{1.1}$$

Table 1.1 reports the results of the calibration exercise under this first framework. The first row shows the ratio of marginal products of poor versus rich countries, where *MPK* is computed as in equation 1.1.

The number I obtain is 6.6, to be interpreted as capital being 6.6 times more productive in poor with respect to rich country. The second row shows the ratio of marginal products of India versus US, the differential in capital returns is 6.8.

Table 1.1 Framework 1: Basic calibration

| | | | |
|----------------------------------|------------------------|-----|-----|
| Ratio of MPK poor/rich countries | | | N |
| F1 | Basic calibration | 6.6 | 142 |
| F1 | Ratio of MPK India/ US | 6.8 | |

Remember that in this very basic formulation I still do not take into account differences in human capital, as Lucas does in the more sophisticated calibration presented in his paper. Therefore, the numbers presented in Table 1.1 have to be compared with those that Lucas obtains in the simplest calibration, according to which capital in India was

⁶I will use the US value of 0.33, this is different from the 0.4 used in Lucas [1990], but it is the most widely measure used today. Even though a constant α across countries is clearly rejected by data, the correlation between α and income per capita is not significantly different from 0, meaning that I am not systematically assigning an higher (or lower) alpha to rich (or poor) countries.

58 more productive than in the US! This is indeed a sign that, even in the most brute calibration, the returns between poor and rich countries are not that far away as they appeared 20 years ago. However, a ratio of 5-6 is still more than enough to justify flows in the opposite direction with respect to what we observe in data.

As Figure 1.14 shows, the estimate of MPK under this first framework is highly correlated with GDP per worker. Rich countries have low MPK primarily because they have higher k with respect to poor countries.

Figure 1.6 Relationship between MPK and GDP per worker under Lucas calibration

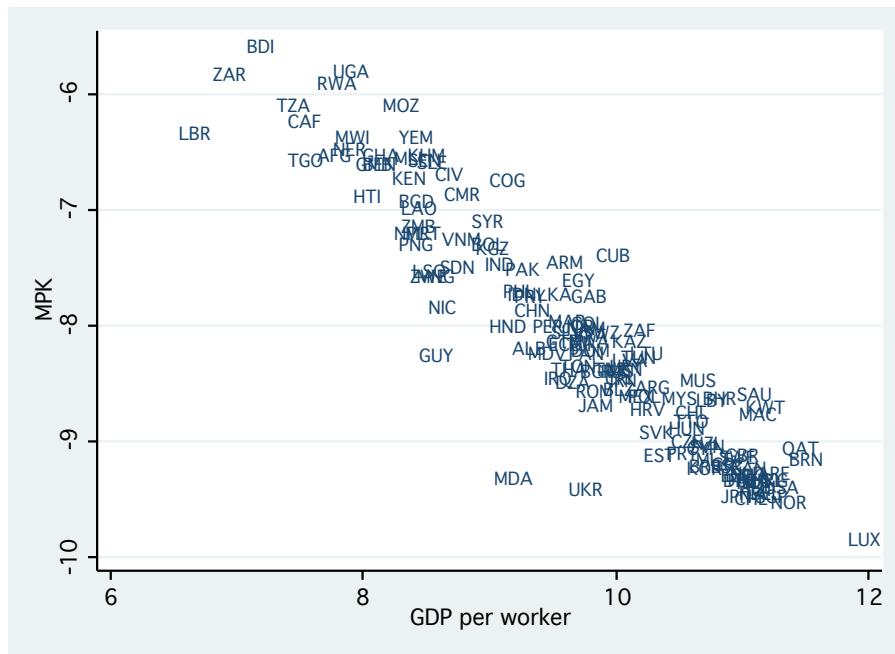
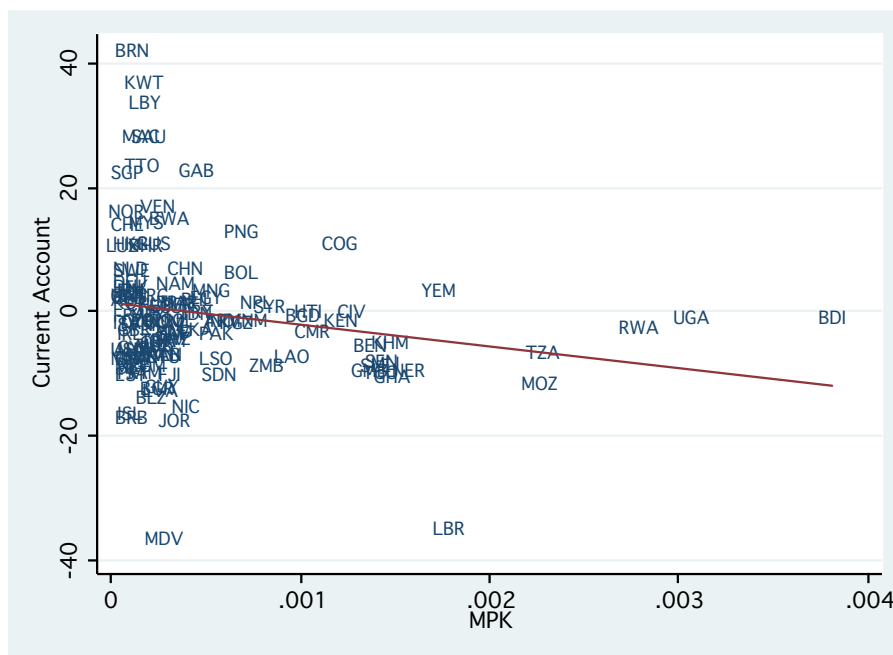


Figure 1.7 shows the relationship between MPK and current accounts. We expect this relationship to be negative since countries with higher MPK should be capital importer (negative current account) and vice versa for countries with lower MPK . Looking at Figure 1.7 the relationship is actually negative but not strongly significant (t-stat: -2.24, p-value: 0.027).

1.5 Controlling for human capital

In this section I explore how much differences in human capital across countries matters in accounting for differences in the productivity of physical capital. In other words, I take

Figure 1.7 Relationship between Current Account and MPK with Lucas calibration



into the picture differences in the *quality* of workers across countries. This is something that Lucas already tried in his paper using estimates of human capital from Krueger [1968]. Here I am using data that were not available at the time Lucas wrote his paper. In particular I take into account different aspects of human capital: quantity (measured in years) of schooling, health and quality of schooling/parenting.

1.5.1 Schooling Capital

To control for the level of schooling I use the specification proposed by Hall and Jones [1999]. I assume that there is a mapping from years of schooling to human capital. To formalize this mapping I use results taken from labor economics. This second framework shares the first 4 basic assumptions with the first framework (common Cobb-Douglas production function, capital is physical reproducible capital, TFP and capital shares are not allowed to change across countries). What changes is that now output is produced using not only capital and raw labor but also human capital (per worker), h_c , that is defined as follows:

$$h_c = \sum_{j=1}^J e^{\beta_s S_j} L_{j,c} \quad (1.2)$$

where $L_{j,c}$ is the proportion of labour force in educational attainment group j (in country c), S_j is years of schooling of educational attainment group j and β_s is the Mincerian return to schooling for those with s years of schooling. The Mincerian return is set constant and equal to 0.1⁷.

The schooling group are those proposed by Barro et al. [2010]. They report, for each country, the proportion of labour force with:

1. No education
2. Some primary
3. Primary completed
4. Some secondary
5. Secondary completed
6. Some college
7. College completed and more

Having data on the proportion of labor force in each educational attainment group, the duration of each schooling level and the mincerian return, I have all I need to construct a more sophisticated measure of MPK . The new production function is:

$$Y_c = k_c^\alpha h_c^{1-\alpha} = k_c^\alpha \left(\sum_{j=1}^J e^{\beta_s S_j} L_{j,c} \right)^{1-\alpha}$$

and the marginal product of physical capital is now defined as:

$$MPK_c = \alpha \left(\frac{k_c}{h_c} \right)^{\alpha-1} = \alpha \left(\frac{k_c}{\left(\sum_{j=1}^J e^{\beta_s S_j} L_{j,c} \right)} \right)^{\alpha-1} \quad (1.3)$$

⁷This calibration is based on results of log-wage regressions (in the most simple specification: $\log W_{j,c} = \alpha_c + \beta_s S_j$) suggesting that one extra year of schooling increases earnings (and hence human capital) by about 10% on average. This is a rough average computed considering both poor and rich countries together. It can be interpreted as follows: if workers in country A have on average one year of schooling more than in country B, country A has 10% more human capital than country B.

With respect to Hall and Jones [1999], where β varies with average schooling years, here I use a common mincerian return 0.1. It is worth notice that this has no impact whatsoever on the computation results.

Table 1.2 reports the results of the ratios of MPK of poor/rich countries (and India/US) under the framework with schooling capital. As Table 1.2 shows, once one takes into account difference in human capital, the ratio of MPK between poor and rich countries shrink to 2.8 (2.2 between India and US). This number, however, is still big enough to justify capital movements from rich to poor countries.

Table 1.2 Framework 2: adding Schooling Capital

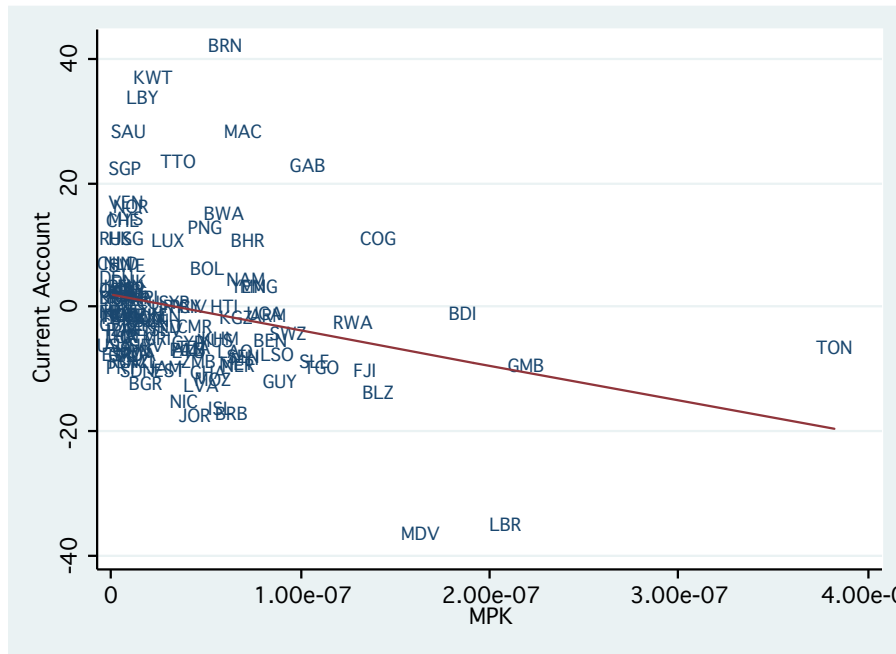
| | | | |
|----------------------------------|---------------------|-----|-----|
| Ratio of MPK poor/rich countries | | | |
| F1 | Basic calibration | 6.6 | 142 |
| F2 | + Schooling capital | 2.8 | 141 |
| Ratio of MPK India/ US | | | |
| F1 | Basic calibration | 6.8 | |
| F2 | + Schooling capital | 2.2 | |

Figure 1.8 and Figure 1.9 shows the relationship between the MPK and GDP per worker and the relationship between the MPK and Current Account respectively. Once we correct for schooling capital the relationship between MPK and GDP per worker is not as strong as in the basic calibration, while current account seem to respond more to variation in MPK with respect to the basic calibration (t-stat: -3.03, p-value: 0.003).

Figure 1.8 Relationship between MPK and GDP per worker with Schooling capital



Figure 1.9 Relationship between Current Account and MPK with Schooling capital



1.5.2 Health Capital

Health is certainly another factor to be taken into account when controlling for the quality of workers. Borrowing from Weil [2007] I add health capital to the definition of

human capital:

$$h_c = \sum_{j=1}^J e^{\beta_H H_j + \beta_s S_j} L_{j,c} \quad (1.4)$$

Where groups are now schooling-health groups, H_j is the health indicator for group j , and β_H maps health status in human capital. As an indicator of health status I use the adult survival rate, that is the probability of reaching 60 years conditional on reaching 15 years.

Since survival rate data at schooling group level were not available, in practice I could not use equation 1.4. I use instead the following formulation where the health indicator is common to all schooling group (and varies only across countries):

$$h_c = e^{\beta_H \bar{H}_c} \sum_{j=1}^J e^{\beta_s S_j} L_{j,c} \quad (1.5)$$

To calibrate β_H I build upon existing empirical studies mapping survival rate into height, and then height into wages⁸. This literature proposes a $\beta_H \approx 0.653$ ⁹, and this is the number I use to calibrate the new estimate of MPK :

$$MPK_c = \alpha \left(\frac{k_c}{h_c} \right)^{\alpha-1} = \alpha \left(\frac{k_c}{e^{\beta_H \bar{H}_c} \sum_{j=1}^J e^{\beta_s S_j} L_{j,c}} \right)^{\alpha-1} \quad (1.6)$$

Table 1.3 reports the results of the calibration adding health capital. The results doesn't change much, but still bring to a lower difference in returns to physical capital between poor and rich countries.

Figure 1.10 and Figure 1.11 mimic closely those with only schooling capital.

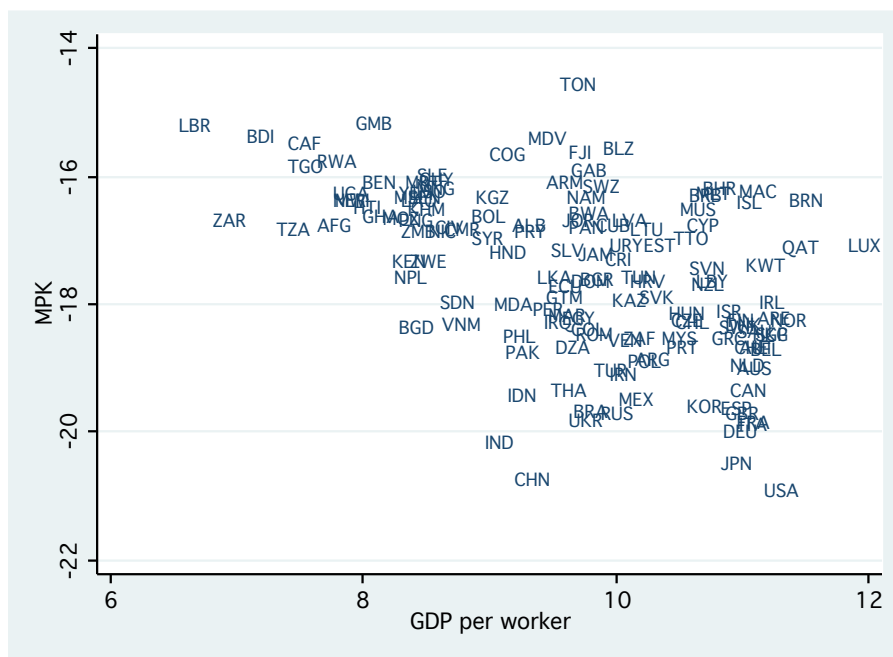
⁸See Weil [2007] and Schultz [2002] on how to get unbiased estimates of the return to health

⁹Note that I use the adult survival rate (ASR) in distance from the country with the lower ASR (Zimbabwe).

Table 1.3 Framework 3: adding Health Capital

| Ratio of MPK poor/rich countries | | N | |
|----------------------------------|---------------------|-----|-----|
| F1 | Basic calibration | 6.6 | 142 |
| F2 | + Schooling capital | 2.8 | 141 |
| F3 | + Health capital | 2.6 | 141 |
| | | | |
| Ratio of MPK India/ US | | N | |
| F1 | Basic calibration | 6.8 | |
| F2 | + Schooling capital | 2.2 | |
| F3 | + Health capital | 2.1 | |

Figure 1.10 Relationship between MPK and GDP per worker with Health capital



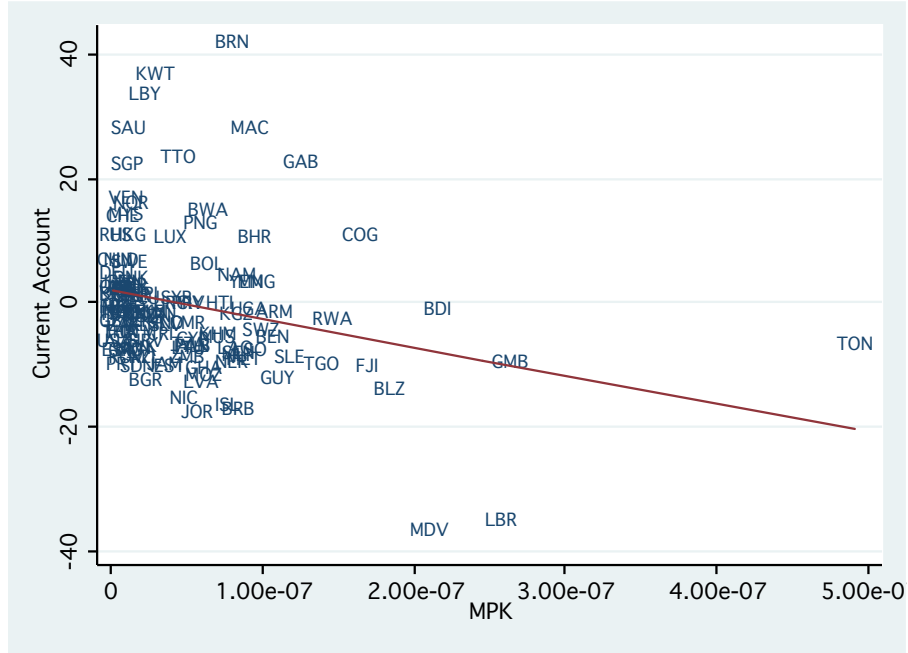
1.5.3 Quality of Schooling/Parenting

In this section I try to take into account differences in the quality of schooling across countries¹⁰. In order to do so, I borrow from Caselli [2005] and use standardized test scores. Standardized test scores can be interpreted as a sign of schooling quality¹¹, or as

¹⁰Human capital is not only a matter of the number of years of schooling, but also of the quality of the schooling itself.

¹¹Though micro evidence on that is weak, more on that in Hanushek and Woessmann [2008] that underlines big cross-country differences in standardized test scores, at given age

Figure 1.11 Relationship between Current Account and MPK with Health capital



a sign of differences in parental inputs¹².

I add test scores to the calibration and interpret them as a summary indicator of school quality/parental background. The new definition of human capital per worker is:

$$h_c = e^{\beta_T \bar{T}_c} e^{\beta_H \bar{H}_c} \sum_{j=1}^J e^{\beta_s S_j} L_{j,c} \quad (1.7)$$

where β_T is coefficient on test score in log-wage regression and T is test-score average at country level. Data on test scores are from World Development Indicators (2009) and cover standardized test imparted by international agencies to pupils in their 8th grade. In particular I use the TIMSS math and science test and the PIRLS reading test imparted by the International Association for the Evaluation of Educational Achievement¹³, and the PISA (Program for International Student Assessment) math, science and reading tests, coordinated by the OECD¹⁴.

Data on test scores refers to different dates and different sets of countries between 1995 and 2007. However there is a high correlation across different tests for the same country.

¹²On this point the micro evidence is more convincing, see Leibowitz [1977].

¹³See more details in the Appendix A and in <http://timss.bc.edu/>.

¹⁴Although they cover also non-OECD countries. More on sample selection in what follows.

I construct the indicator of test score (T_c) as the average score over all available tests in each country¹⁵. To calibrate β_T I use Lazear [2003], that run the following regression on data from the National Education Longitudinal Survey:

$$\log(W_i) = \alpha + \beta_T T_i + \varepsilon_i,$$

where W_i is the wage of individual i observed in late 20s of his/her life, and T_i is the result of a school test that is very similar to the international ones used in the cross-country exercise. Lazear [2003] finds a $\beta_T = 0.01$.

The new estimate of MPK is therefore as in equation 1.8:

$$MPK_c = \alpha \left(\frac{k_c}{h_c} \right)^{\alpha-1} = \alpha \left(\frac{k_c}{e^{\beta_T \bar{T}_c} e^{\beta_H \bar{H}_c} \sum_{j=1}^J e^{\beta_s S_j} L_{j,c}} \right)^{\alpha-1} \quad (1.8)$$

Table 1.4 reports calibration results adding Test Scores. The ratio of MPK between poor and rich countries is now 1.2, very close to the equalization of capital returns. Since there is no test score data for India I have no results for the ratio of MPK between India and US.

Table 1.4 Framework 4: adding Test Scores

| | | | |
|----------------------------------|---------------------|-----|-----|
| Ratio of MPK poor/rich countries | | | N |
| F1 | Basic calibration | 6.6 | 142 |
| F2 | + Schooling capital | 2.8 | 141 |
| F3 | + Health capital | 2.6 | 141 |
| F4 | + Test scores | 1.2 | |
| Ratio of MPK India/ US | | | |
| F1 | Basic calibration | 6.8 | |
| F2 | + Schooling capital | 2.2 | |
| F3 | + Health capital | 2.1 | |
| F4 | + Test scores | . | |

A possible concern in using test scores is the sample bias over rich countries. This is because most of the countries participating in international programs of student evaluation

¹⁵See Appendix A for a detailed description of how I constructed this indicator.

are middle or high income countries. Figure 1.12 suggests that this concern is potentially important¹⁶.

Figure 1.12 Relationship between MPK and GDP per worker with Test scores



To correct for sample selection I compute again the ratio of MPK between poor and rich countries in framework 3 (the one with health capital) using only the sample of countries for which test score data are available. I obtain a ratio of 1.27 in framework 3 (1.22 in framework 4) meaning that adding test scores only make the ratio decrease by 0.05, and not by 1.4 as Table 1.4 suggests. This implies that most of the decrease showed in Table 1.4 is due to sample selection. I will therefore do not report the calibration results for test scores in the following Tables.

1.5.4 Imperfect Substitution in Schooling

Labor force in each country is not an homogenous collection of equally skilled workers, it is instead a collection workers with different degree of skills. In this section I use a formulation of human capital that takes these differences into account distinguishing, in the simplest specification possible, between skilled and unskilled workers¹⁷. I back out skilled and unskilled labor force from the education attainment of workers in each country.

¹⁶Most country-observation are on the right of the x-scale (GDP per worker)

¹⁷I assume that unskilled and skilled workers are imperfect substitutes.

Workers attaining a certain level of schooling are defined as skilled, those who do not attain a certain level are defined as unskilled¹⁸

Following Caselli [2010] I model imperfect substitution replacing

$$h_c = \sum_{j=1}^J e^{\beta_s S_j} L_{j,c}$$

With

$$h_c = \left[\left(\sum_{j=1}^{z-1} e^{\beta_j} L_{j,c} \right)^\rho + B \left(\sum_{j=z}^J e^{\beta_j} L_{j,c} \right)^\rho \right]^{1/\rho} \quad (1.9)$$

Where:

- z is lowest schooling group in high-education labour force. This is the minimum level of education that a worker have to reach to be defined as skilled.
- $\beta_1 = \beta_z = 1$ ¹⁹ while the other β_j s are relative productivities
- $1/(1 - \rho)$ is the elasticity of substitution

To construct a new estimate of *MPK* based on imperfect substitution I need to calibrate the parameter ρ that governs elasticity of substitution (EOS), the β_j , the returns to education that is likely to be different for each education group, and B , a parameter governing relative productivities of education groups.

As for ρ , many estimates of EOS are clustered around 1.4, 1.5. In particular, I choose the number proposed by Ciccone and Peri [2005] that, using US census data and an IV econometric approach²⁰, find an estimate of EOS = 1.5.

As for β_j I use the numbers proposed by Caselli [2010]. To calibrate the returns to education at different education levels he uses data on white males taken from the Current Population Survey in the US (1991). The methodology is the following. He firstly creates 7 dummy variables, corresponding to seven schooling groups proposed by Barro et al.

¹⁸Educational attainment is likely to determine, at least in part, the skills of each worker. This aspect is not considered in the Hall-Jones schooling capital measure.

¹⁹I set to 1 the β s of the base education sub-group in lower (no schooling) and higher (secondary school completed) education labor force.

²⁰They set z as high-school completed, as I do here

[2010]²¹, and then basically runs two separate log-wage regressions to estimate the 7 β_j s:

$$\log(W_j, j < z) = \underline{\alpha} + \beta_j$$

$$\log(W_j, j \geq z) = \bar{\alpha} + \beta_j$$

In the first regression he only puts dummies for the bottom four groups, in the second regression only the dummies for the top three groups²². The results are showed in Table 1.5

Table 1.5 Calibrated β_j s

| Low Education | | High Education | |
|-------------------|------|--------------------|------|
| No Schooling | 0 | Secondary Complete | 0 |
| Some Primary | 0.32 | Some College | 0.14 |
| Completed Primary | 0.38 | College and More | 0.46 |
| Some Secondary | 0.56 | | |

As for the parameter governing imperfect substitution (B), it is calibrated as follows:

- From

$$\left[\left(\sum_{j=1}^{z-1} e^{\beta_j} L_{j,c} \right)^\rho + B \left(\sum_{j=z}^J e^{\beta_j} L_{j,c} \right)^\rho \right]^{1/\rho}$$

- one can rewrite the wage premium as in equation 1.10 using perfect labor markets (equalization of marginal products between skilled and unskilled workers):

$$\frac{W_{z,c}}{W_{1,c}} = B \frac{\left(\sum_{j=z}^J e^{\beta_j} L_{j,c} \right)^{\rho-1} e^{\beta_z}}{\left(\sum_{j=1}^{z-1} e^{\beta_j} L_{j,c} \right)^{\rho-1} e^{\beta_1}} = B \frac{\left(\sum_{j=z}^J e^{\beta_j} L_{j,c} \right)^{\rho-1}}{\left(\sum_{j=1}^{z-1} e^{\beta_j} L_{j,c} \right)^{\rho-1}} \quad (1.10)$$

- From equation 1.10 one can retrieve B if for at least one country both relative wage and relative supply are observable. This is the case for the US where the relative

²¹The 7 schooling groups in Barro et al. [2010] are: no schooling, primary incomplete, primary complete, secondary incomplete, secondary complete, higher incomplete, higher complete. See more on this in Appendix A.

²²In both regressions are included controls for full set of age dummies.

supply of skilled versus unskilled workers is equal to 3 and where relative wage (from a CPS log-wage regression) is equal to 2.29. Then B for the US is therefore equal to 4.76, and this number is then applied to all other countries.

The new estimate of MPK is therefore as in equation 1.11:

$$MPK_c = \alpha \left(\frac{k_c}{h_c} \right)^{\alpha-1} = \alpha \left(\frac{k_c}{e^{\beta_H \bar{H}_c} \left[\left(\sum_{j=1}^{z-1} e^{\beta_j} L_{j,c} \right)^\rho + 4.76 \left(\sum_{j=z}^J e^{\beta_j} L_{j,c} \right)^\rho \right]^{1/\rho}} \right)^{\alpha-1} \quad (1.11)$$

Notice that in equation 1.11: (i) the imperfect substitutability framework substitutes the framework of schooling capital as in the Hall and Jones [1999] formulation, (ii) the health capital is taken into account while (iii) the quality of schooling/parenting is not.

Table 1.6 Framework 5: adding Imperfect Substitution

| | | | |
|----------------------------------|--------------------------|-----|-----|
| <hr/> <hr/> | | | |
| Ratio of MPK poor/rich countries | | | N |
| F1 | Basic calibration | 6.6 | 142 |
| F2 | + Schooling capital | 2.8 | 141 |
| F3 | + Health capital | 2.6 | 141 |
| F5 | + Imperfect substitution | 2.2 | 141 |
| | | | |
| Ratio of MPK India/ US | | | |
| F1 | Basic calibration | 6.8 | |
| F2 | + Schooling capital | 2.2 | |
| F3 | + Health capital | 2.1 | |
| F5 | + Imperfect substitution | 1.1 | |
| <hr/> | | | |

The results obtained using the measure of marginal product of physical capital in equation 1.11 are reported in table 1.6. The sample of countries is (almost) exactly the same as in the basic calibration, therefore it is not sample selection to drive the result. The ratio of returns between poor and rich countries lowers to 2.2, while returns to capital in India and US under this framework are almost equalized: their ratio is 1.1. This last number suggests that differences in the returns to physical capital between India and US, once we correct for differences in human capital, start to disappear. The Lucas's paradox, according to which the neoclassical framework predicts a fivefold return

differential between India and US (that we do not see in real data), seems to be vanishing as we go correcting his measures. However, when we consider the whole sample of countries, the ratio is still bigger than 2, meaning there is still room for improvement.

Figure 1.13 Relationship between MPK and GDP per worker under imperfect substitutability framework

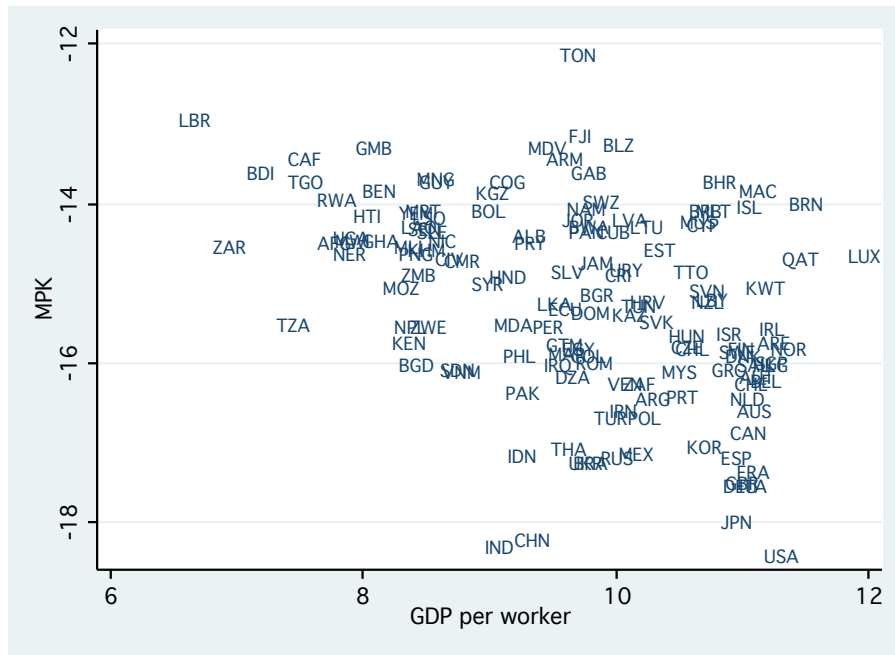
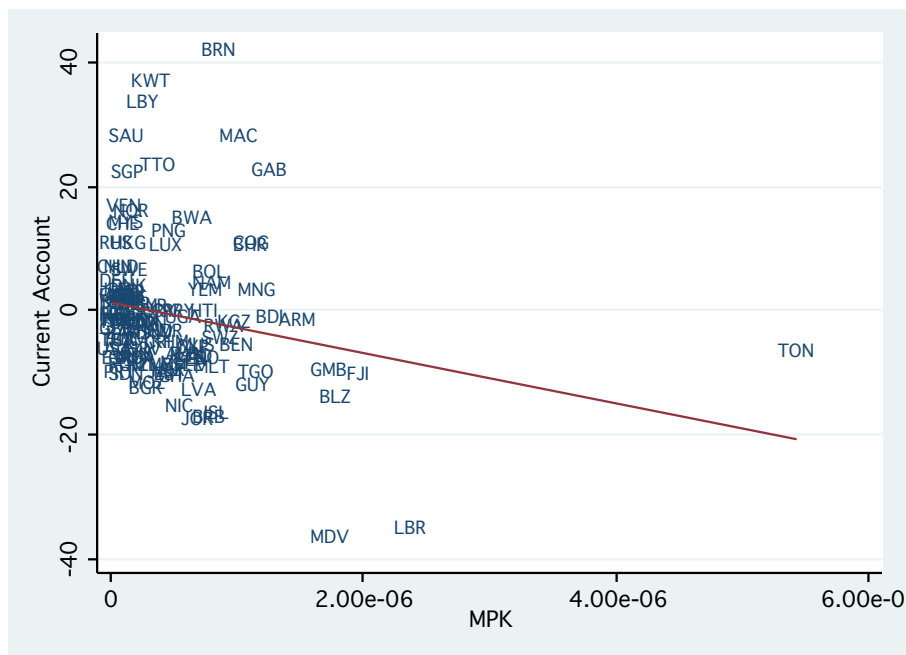


Figure 1.14 Relationship between Current Account and MPK under imperfect substitutability framework



1.6 Controlling for country-varying capital shares

What emerges from the last section is that when one controls accurately for human capital, the ratio of returns to physical capital between poor and rich countries almost equalize. In this section I take the measure of human capital that gives better results²³ and start changing another important parameter that I kept fixed so far: the measure of capital share in income. This parameter, that I called α , governs the share of output used to reward factor K , physical capital. So far the parameter α have been kept constant across countries and set equal to the number that (economists believe) best describes the capital share of output in the US, that is: 0.33. In this section I allow this parameter to change at country level and check how the ratios of returns to physical capital between poor and rich country change when I add this additional source of variation.

1.6.1 Bernanke and Gollin "naive" measure of capital shares

The first measures of capital share I use are from Bernanke and Gurkaynak [2001] and Gollin [2002]. Since a direct estimate of the capital share does not exists, country-specific α s are computed subtracting from the value of output the amount payed to the other factor of production (i.e. labor)²⁴. In this framework I compute MPK as:

$$MPK_c = \alpha_{wc} \left(\frac{k_c}{h_c} \right)^{\alpha_{wc}-1} \quad (1.12)$$

where h_c is human capital adjusted for health and imperfect substitutability of workers with different skills and α_{wc} is country varying capital share according to Bernanke and Gurkaynak [2001]

The results obtained under this framework are showed in table 1.7: the ratio of marginal products jumps to 21.8, ten times higher the last estimate obtained in the previous section. Does this number mean the complete failure of the empirical approach followed so far? I think it doesn't, for a bunch of reasons I am about to present. First, the sample used to perform the last calculation is one third of the sample used in the

²³I.e. the one that takes into account health capital and imperfect substitutability of workers with different skills.

²⁴The amount of the value of output that goes to labor is computed multiplying wages by the number of workers (country's total payroll).

previous frameworks, and it is unbalanced towards rich countries²⁵. Second, the numbers proposed by Bernanke and Gurkaynak [2001] are computed as 1980-1995 averages, while data on physical and human capital used to calibrate equation 1.12 refers to 2005. Third, and more importantly, these estimates of capital shares, as an influential paper by Caselli and Feyrer [2007] underlines, essentially take into account payments that go to all types of capital²⁶, while when estimating *MPK* we are interested in payments that go only to physical reproducible capital. As I show in the next section, the results change a lot when using the "right" capital shares.

Table 1.7 Framework 6: Bernanke capital shares

| Ratio of MPK poor/rich countries | | N | |
|----------------------------------|---------------------------|------|-----|
| F1 | Basic calibration | 6.6 | 142 |
| F2 | + Schooling capital | 2.8 | 141 |
| F3 | + Health capital | 2.6 | 141 |
| F5 | + Imperfect substitution | 2.2 | 141 |
| F6 | + Bernanke capital shares | 21.8 | 53 |

²⁵That are usually countries for which it is easier to find data on payroll, and, therefore, on capital shares.

²⁶The other types of capital being essentially land and natural resources.

1.6.2 Caselli "land adjusted" measure

In this section I compute MPK using the estimates of reproducible capital shares proposed by Caselli and Feyrer [2007]. MPK is defined as:

$$MPK_c = \alpha_{kc} \left(\frac{k_c}{h_c} \right)^{\alpha_{kc}-1} \quad (1.13)$$

where, as before, h_c is human capital adjusted for health and imperfect substitutability of workers with different skills and α_{kc} is computed as follows:

$$\alpha_{kc} = \alpha_{wc} * \frac{K_c}{W_c} \quad (1.14)$$

where $\frac{K_c}{W_c}$ is the ratio of physical reproducible capital over total wealth, that includes the value of all types of capital²⁷ according to Hamilton and Ruta [2006]. Multiplying the (all types of) capital share in income α_{wc} by the share of reproducible capital in all types of capital we obtain an estimate of the reproducible capital share in income α_{kc} . Using the specification in equation 1.13 I obtain the results reported in table 1.8. As the last row shows, adding the estimate of capital share from Caselli and Feyrer [2007] I obtain a number suggesting perfect equalization in the returns to physical reproducible capital between poor and rich countries²⁸.

Table 1.8 Framework 7: Caselli capital shares

| Ratio of MPK poor/rich countries | | N |
|----------------------------------|---------------------------|---------|
| F1 | Basic calibration | 6.6 142 |
| F2 | + Schooling capital | 2.8 141 |
| F3 | + Health capital | 2.6 141 |
| F5 | + Imperfect substitution | 2.2 141 |
| F6 | + Bernanke capital shares | 21.8 53 |
| F7 | + Caselli capital shares | 1.0 53 |

A possible issue here is the smaller sample of countries with respect to the previous

²⁷See Appendix A for a detailed description of the different types of capital and how they are estimated.

²⁸By the way, in a world of perfect capital markets, perfect equalization is what economic theory say should happen.

frameworks²⁹. To check if sample selection is what drives the result I replicate all calculations done so far using only those countries for which there is an estimate of reproducible capital share in Caselli and Feyrer [2007]³⁰. Results are reported in table 1.9 and confirm that return equalization is not driven by sample issues.

Table 1.9 Ratio of MPK poor/rich countries: check samples

| | All countries | Only F7 sample (53) |
|------------------------------|---------------|---------------------|
| F1 Basic calibration | 6.6 | 5.4 |
| F2 + Schooling capital | 2.8 | 4.1 |
| F3 + Health capital | 2.6 | 3.8 |
| F5 + Imperfect substitution | 2.2 | 3.4 |
| F6 + Bernanke capital shares | 21.8 | 21.8 |
| F7 + Caselli capital shares | 1.0 | 1.0 |

Figure 1.15 Relationship between MPK and GDP per worker under framework 1 (basic calibration) and 7 (Caselli capital share)

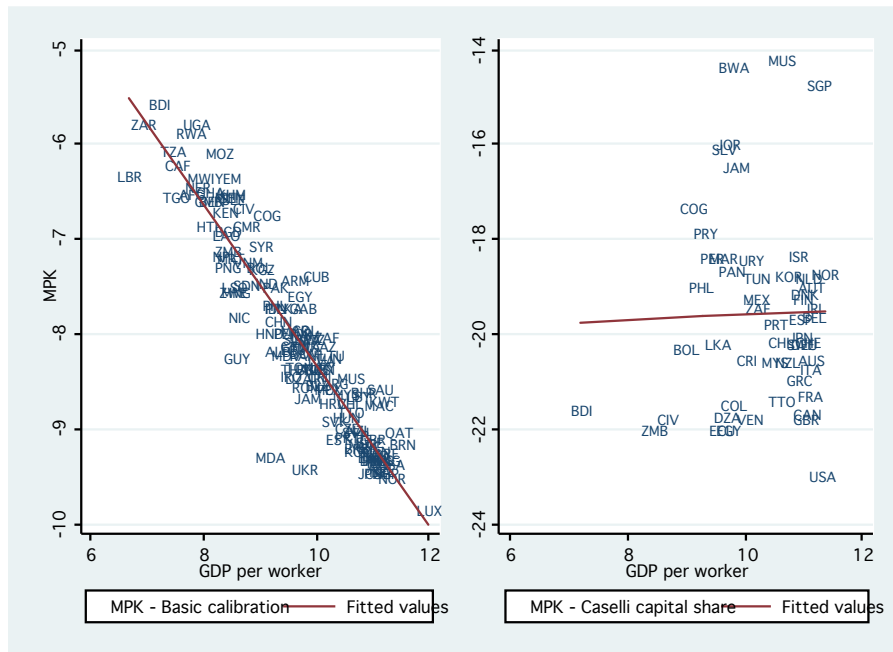


Figure 1.15 compares the relationship between MPK and GDP per worker under the basic calibration of *MPK* I started from (framework 1) and the last calibration of *MPK*

²⁹The same concern emerged in framework 4 when I introduced test score results to control for quality of schooling/parenting

³⁰A total of 53 countries

that controls for human and health capital, imperfect substitutability of workers with different skills and country-specific reproducible capital shares. The relationship is strongly negative in the left side graph, where capital per worker ratio is the driving force of capital return differential. The same relationship is a flat line (maybe, interestingly, positive?) in the right side graph, once I take into account a bunch of other elements that seems, at the end of this analysis, determinants of capital returns as important as the standard capital per worker measure.

1.7 Summing up chapter 1

This chapter shows that a simple calibration approach that correct for differences in human capital and in the capital share of output can deliver as a result the equalization of the returns to physical capital between rich and poor countries. The main finding of this chapter is consistent with the empirical evidence presented at the beginning: capital flows are quite a small fraction of World GDP when compared to the differences in capital per worker we observe between rich and poor countries.

My calibration exercise suggests that the relative small capital flows observed in data are not the result of international financial market frictions, they are instead the result of scarce differences in the productivity of physical capital, when this productivity is properly measured. Similar productivities of physical capital across countries implies that, even if capital could move relatively freely across countries, it wouldn't.

The result basically originates from taking into account differences across countries in the share of physical capital on output and in the quality of labor, the factor of production complementary to physical capital. Each new unit of physical capital have to be used by workers, and workers' characteristics change a lot across countries. In this chapter I take into account some of the characteristics that the literature sees as crucial in determining workers' productivity like the quantity and quality of their education, their health status or their degree of substitutability.

One might object that there are other characteristics of a country not taken into account here that can certainly influence capital movements across countries. The quality of institutions is the first that comes to mind. Countries with better institutions - e.g. low

risk of expropriation, financial stability, property rights protection - are certainly more likely to receive foreign capital even if their capital to labor ratio is high. This is the case for example of US and Europe. However, better institutions are positively correlated with higher educational attendance of workers, better schools and better hospitals. In other words, countries where workers on average go to school for more years, are assisted by better teachers and are more healthy, usually are countries with better institution. In a way, the measure of physical capital productivity I propose here already takes institutional quality into account through all a set of dimensions that are crucially affected by it. It is a simple - but nonetheless interesting - result, that, once one takes into account these dimensions, all the arbitrage opportunities that we thought could have been there, suddenly disappear.

Chapter 2

Misallocation and TFP in the Manufacturing Sector: the case of Chile and Mexico in the 1980s

In this chapter I measure the potential effect of misallocation on manufacturing TFP in Chile and Mexico during 1980s applying the methodology proposed by Hsieh and Klenow [2009]. My results suggest that in Chile capital and labor were more efficiently allocated across manufacturing firms with respect to Mexico during that period. I estimate potential gains in aggregate manufacturing TFP from moving Mexico to the level of efficiency observed in Chile to be up to 11% in the mid-1980s. This new fact could help explain the different paths of recovery experienced by these two countries after the crisis of 1982. I also find suggesting evidence that sectors where firms depend more from external finance show less misallocation.

2.1 Aim and main results of the chapter

We suspect that a relevant part of TFP differences across countries is related to how countries allocate factors of production across firms. Hsieh and Klenow [2009] estimate

potential manufacturing TFP gains of 30-50% in China and 40-60% in India deriving by the reallocation of capital and labor across firms to the level of efficiency observed in the United States.

In this chapter I apply their methodology to plant level data of Chile and Mexico during 1980s. The case study I propose try to shed new light on why, in the aftermath of the severe crisis that hit Latin America in 1982-83, Chile recovered quickly why Mexico stagnated until the mid-1990s. Bergoeing et al. [2002] document how different patterns of recovery were mainly due to different patterns of TFP growth. They claim that a key explanation behind TFP growth in Chile are the structural reform undertaken by the Chilean government in the early 1980s. In particular: the reform of the banking sector implemented at different stages between 1982 and 1986, and the reform of the bankruptcy law of 1982. The former made credit allocation across firms be driven mostly by the market, and not by the government. The latter speeded up the bankruptcy procedure, avoiding the use of subsidies by government and making easier for less efficient firms to exit the market.

The results of this chapter are consistent with the "structural reforms boosting TFP" story, and show how Chile did a better job allocating resources across its manufacturing firms during that period. I estimate potential gains in aggregate manufacturing TFP from moving Mexico to the level of efficiency observed in Chile to be up to 11%. In addition, I find a strong negative relationship between dependence on external credit and misallocation. This suggests that the implementation of a credit market reform that allows a larger fraction of credit to be assigned on the grounds of firms' productivity (and not on political ties) like the one undertaken in Chile in the early 1980s, could have reduced misallocation across firms by assigning more credit to more productive firms and letting the less productive go bankrupt.

To perform the empirical exercise I use plant level data collected by national statistical offices. The same type of data used by Hsieh and Klenow [2009] are available in these two datasets so that I am able to perform a consistent replication of their exercise in a different framework.

The structure of the chapter is as follows: Section 2.2 presents a short description of the model of monopolistic competition with heterogeneous firms taken from Hsieh and

Klenow [2009] where heterogeneity in firm level productivity is due to output and capital distortions; Section 2.3 describes the datasets used for Chile and Mexico; Section 2.4 presents the main empirical results on misallocation; Section 2.5 shows suggestive evidence of the role of reforms in decreasing misallocation; Section 2.6 concludes. A series of robustness checks performed on the main results is reported in the Appendix.

2.2 Model from Hsieh and Klenow (2009)

Hsieh and Klenow [2009] propose a model where distortions at firm level (like firm specific taxes or subsidies) can lower TFP at aggregate level. They design firm specific distortions as wedges between factor returns and factor payments. In their setting efficiency requires equalization of marginal products of factors across firms in the same sector. Should distortions non homogeneously hit all firms operating in the same sector, the marginal products of factors of these firms will not equalize, creating a misallocation of resources.¹ It is worth notice that they assume there are no distortions on the labor market:² the only types of distortions that can affect marginal products are those affecting capital or output.

Given the lack of plant-specific price deflator the model uses *revenue* measures of marginal products and productivities.³ As equation 2.1 shows, if marginal revenue products of factors are equalized, then also *revenue total factor productivities* ($TFPR_{si}$, where i identify the single firm and s the industrial sector) are equalized across firms in each sector.

$$TFPR_{si} \propto (MRPK_{si})^{\alpha_s} (MRPL_{si})^{1-\alpha_s} \propto \frac{(1 + \tau_{K_{si}})^{\alpha_s}}{(1 - \tau_{Y_{si}})} \quad (2.1)$$

Equation 2.1 also shows that high $TFPR_{si}$ is a symptom of high distortions faced by the

¹As an example take two firms operating in the same sector (i.e. using the same production function) that are equally productive and assume that one of them can borrow at a preferential rate, maybe because of its political connections. Both firms will invest until their marginal product of capital equalize the interest rate they face. Since the firm with political connections will enjoy a lower interest rate, the marginal products of the two firms will differ, and the allocation of resources will be inefficient.

²Labor is free to flow across sectors, the marginal product of labor is the same in all sectors and is set equal to 1. How realistic this assumption is will be checked in Section ??.

³The main issue of prices is to disentangle their productivity component (marginal cost) from their market power component (markups). This issue will be further discussed in the robustness check in Section (??)

firm ($\tau_{Y_{si}}$ and $\tau_{K_{si}}$ are, respectively, output and capital distortions⁴). More distorted firms can not reach their efficient size and, therefore, have higher marginal products of capital and labor.

At sectoral level, firm specific $TFPR_{si}$ are aggregated using equation (2.2)

$$TFP_s = \left(\sum_{i=1}^{M_s} \left\{ A_{si} \frac{\overline{TFPR}_s}{TFPR_{si}} \right\}^{\sigma-1} \right)^{\frac{1}{\sigma-1}} \quad (2.2)$$

where A_{si} stands for firm specific *physical total factor productivity*, \overline{TFPR}_s is an industry mean of $TFPR_{si}$, M_s is the number of firms operating in sector s and σ is the elasticity of substitution⁵. Equation 2.2 has the following implications: (i) each firm contribution to sectoral TFP depends positively from its physical TFP and negatively from its revenue TFP , this in turns implies that (ii) each firm contribution to sectoral TFP is higher the lower the distortions faced, and (iii) if marginal products, and, consequently, $TFPR_{si}$, were equalized across plants in the same sector, TFP_s would be equal to its efficient counterpart $\bar{A}_s = \left(\sum_{i=1}^{M_s} A_{si}^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$.

Finally, aggregate output is defined in the Hsieh and Klenow [2009] model as in equation (2.3):

$$Y = \prod_{s=1}^S Y_s^{\theta_s} = \prod_{s=1}^S (TFP_s K_s^{\alpha_s} L_s^{1-\alpha_s})^{\theta_s} \quad (2.3)$$

where θ_s is the weight given to each sector's contribution to total output and is calculated as the value added share of each sector on total value added.

Using equation (2.3) it is possible to write an expression of TFP at country level as a Cobb-Douglas aggregation of sectoral $TFPs$:

$$TFP = \prod_{s=1}^S \left[\sum_{i=1}^{M_s} \left(A_{si} \frac{\overline{TFPR}_s}{TFPR_{si}} \right)^{\sigma-1} \right]^{\frac{\theta_s}{\sigma-1}} \quad (2.4)$$

What Klenow and Hsieh measure is the potential percentage growth in manufacturing output that would occur if we could get rid of output and capital distortions ($\Delta Y =$

⁴Hsieh and Klenow [2009] define distortions that increase marginal products of the two factors by the same proportion as output distortions, and distortions that increase marginal product of capital relative to labor as capital distortions.

⁵Following Hsieh and Klenow [2009] σ is set equal to 3.

$\left(\frac{Y^* - Y}{Y}\right)$, where Y is the actual manufacturing output and Y^* is its efficient counterpart). The potential output growth is nothing but the percentage gain in TFP obtained by equalizing $TFPR_{si}$ across firms inside each sector, therefore $\Delta Y = \Delta TFP$.

Using equation (2.4) it is possible to write the potential percentage gain in TFP in each country as:

$$\Delta TFP = \left(\frac{TFP^*}{TFP} - 1\right) = \left(\prod_{s=1}^S \left[\sum_{i=1}^{M_s} \left(\frac{A_{si} \overline{TFPR}_s}{\bar{A}_s \overline{TFPR}_{si}}\right)^{\sigma-1} \right]^{\frac{-\theta_s}{\sigma-1}} - 1\right) = \Delta Y \quad (2.5)$$

Equation (2.5) is the key equation of this empirical work. In order to estimate equation (2.5) a measure of physical productivity (A_{si} , or $TFPQ_{si}$, meaning *quantity total factor productivity*) and a measure of revenue productivity ($TFPR_{si}$) are needed for each firm. These two measures are defined exactly as in Hsieh and Klenow [2009].

$$TFPR_{si} = \frac{P_{si} Y_{si}}{(K_{si}^{\alpha_s})(wL_{si})^{1-\alpha_s}} \quad (2.6)$$

Where K_{si} and wL_{si} are respectively capital and the wage bill at firm level, $P_{si} Y_{si}$ is total revenues of the firm, α_s is capital share in sector s calculated using US data⁶.

Solving the model it is possible to express physical productivity A_{si} as:

$$A_{si} = \frac{Y_{si}}{(K_{si}^{\alpha_s})(wL_{si})^{1-\alpha_s}} = \frac{w^{1-\alpha} (P_s Y_s)^{-\frac{1}{\sigma-1}}}{P_s} \frac{(P_{si} Y_{si})^{\frac{\sigma}{\sigma-1}}}{(K_{si}^{\alpha_s})(wL_{si})^{1-\alpha_s}} \quad (2.7)$$

The point here is that, since the focus is on firm-specific relative productivities with respect to sectoral means, once those variables that are common to all firms in a sector are normalized (i.e. setting the expression in equation (2.7) $w^{1-\alpha} (P_s Y_s)^{-\frac{1}{\sigma-1}} / P_s = 1$) it is possible to express:

$$TFPQ_{si} \equiv A_{si} = \frac{(P_{si} Y_{si})^{\frac{\sigma}{\sigma-1}}}{(K_{si}^{\alpha_s})(wL_{si})^{1-\alpha_s}} \quad (2.8)$$

With these equations in hand what is needed is, for each firm, data on value added, capital stock and wage bill.

⁶data on factor shares at sector level are from the NBER Productivity Database. I adjusted the value of each industry labor share scaling up by 3/2 as in Hsieh and Klenow [2009] to take into account non-wage forms of compensation

2.3 Plant-level data for Chile and Mexico

The data for Chile are from *Encuesta Nacional Industrial Annual* (ENIA) carried out annually by the Chilean Instituto Nacional de Estadística (INE). The data set is an unbalanced panel including an average of 4,672 plant observation per year from 1979 to 1996. The survey covers all manufacturing plants in the country with at least 10 workers. Many variables in the original data set were recorded in nominal terms and have been transformed in constant 1980 prices using appropriate price deflators for output, intermediate materials, energy and capital goods. For a complete description of the data cleaning process the reference is Roberts et al. [1996]. The information I use from the Chilean data are the plant's four-digit industrial sector of production,⁷ value added, labor compensation and total capital stock net of depreciation. Labor compensation is the sum of wages and non-wage compensations such as gifts, supports and charges. As for capital stock, it is calculated as the sum of the book value of fixed assets (machineries, buildings, transportations, other) at their end of year value net of specific depreciation

The raw data for Mexico are from a survey of manufacturing plants collected by Mexico's *Instituto Nacional de Estadística y Geografía* (INEGI). The original sample provided a balanced panel of 3,218 plant observations per year from 1984 to 1990⁸. The completion of the questionnaire is compulsory and only for statistical purpose (meaning it is not linked to tax collection). The survey attempts to cover the three fourths of value added in manufacturing, raising the issue of a selection bias towards larger and more profitable firms⁹. I will discuss how some of the results of this chapter could be affected by this bias. The main variables of the INEGI database that I used are again the plant's four-digit industrial sector,¹⁰ value added, capital stock and labor compensation. All monetary variables are deflated using appropriate price deflators: for inputs there are more general price indices while gross value of products is deflated using four digit precision. The measure

⁷INE classify industries according to the ISIC rev.2 code

⁸Each observation is a single plant, I will use the working hypothesis that all plants are single establishment firms. For a detailed description of the data cleaning process of the original database the reference is Tybout and Westbrook [1995]

⁹It has to be noticed also that, in order to have a balanced panel, exiting plants are excluded from the survey by INEGI.

¹⁰The industrial sectors in the INEGI database are classified according to the 1975 Mexican Censo Industrial. I converted this code into the ISIC rev.2 code to make it comparable with the other two countries.

of value added is calculated subtracting the cost of material and energy inputs by the real gross value of output (both deflated by mid-year price index) and it is corrected by *maquila* related flows¹¹. Labor compensation is the sum of wages, benefits, social security contributions and profit sharing. The capital stock is the sum of all types of fixed capital (machinery, buildings, land, transport equipment and other assets) valued at end of year replacement cost and deflated by the appropriate end of year price indices.

In both countries I dropped all plant-year observations with the following characteristics: (1) missing or negative values in plant's value added, capital stock or labor remuneration; (2) reporting less than 10 employees; (3) operating in an industrial sector with no US correspondence in the NBER productivity database, and therefore for which it was impossible to back out factor shares; (4) having physical ($TFPQ_{si}$) or revenue ($TFPR_{si}$) total factor productivities (after demeaning and taking logs) either in the top or in the bottom 1% of all plants in each country.

2.4 Chile and Mexico distributions of physical and revenue productivities across firms

Figure (2.1) shows the distribution of physical productivity ($TFPQ_{si}$) at firm level in Chile (straight line) and Mexico (dashed line), data refers to 1986. Mexico shows a thicker left tail in $TFPQ_{si}$ distribution, suggesting that, in the aftermath of the crisis, there is a bigger mass of less efficient plant operating in the market with respect to Chile. Notice that if there was no selection problem of successful plants in Mexico this result would probably be even stronger.

Figure (2.2) shows the distribution of $TFPR_{si}$ in Chile (straight line) and Mexico (dashed line), data again refers to 1986. According to the model presented in Section (2.2), the more $TFPR_{si}$ is dispersed, the more distortions drive factor allocation in a country. The higher peak at zero reported in Figure (2.2) suggests that Chilean firms are more concentrated around their industry means in terms of revenue total factor productivities,

¹¹Maquilas are factories that import materials and equipment on a duty-free and tariff-free regime for assembly or manufacturing and then re-exports the assembled product, usually to the original country. For each plant I added income and subtracted costs deriving from maquila services since these data are reported in the record of the plant asking for the subcontracted work and of the plant that is actually doing it

and therefore that their marginal products are less apart than those of Mexican firms inside each sector.

Figure 2.1 Distribution of physical productivity (TFPQ)

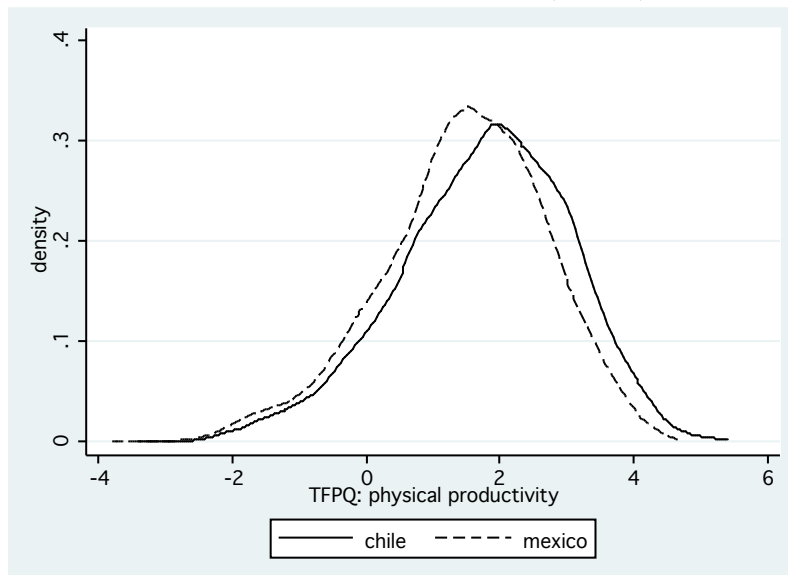


Figure 2.2 Distribution of revenue productivity (TFPR)

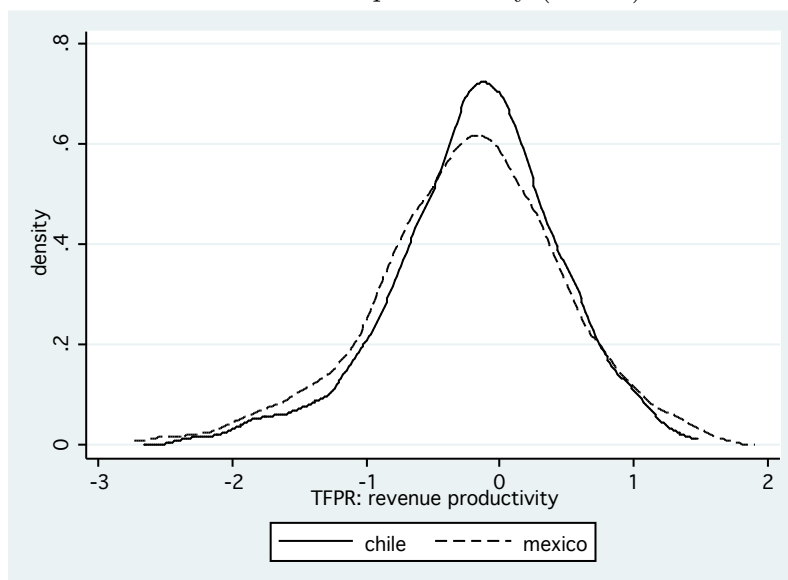
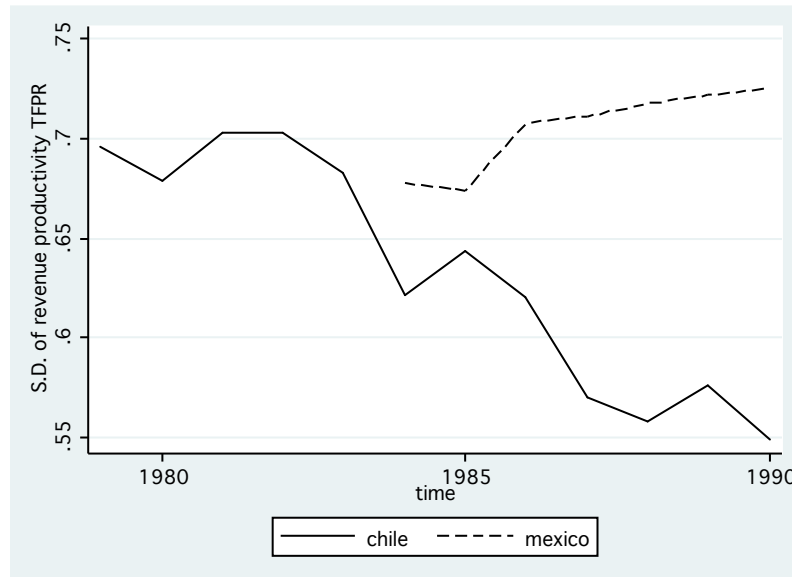


Figure (2.3) shows the evolution over time of the dispersion in $TFPR_{si}$, measured by the standard deviation of $\log(TFPR_{si})$ around industry means. $TFPR_{si}$ dispersion has decreased in Chile from 1979 to 1990, while it has been stable or, if anything, increased, in Mexico during the 1980s.

Figure 2.3 Evolution over time of misallocation measured as dispersion (st.dev.) in revenue productivity



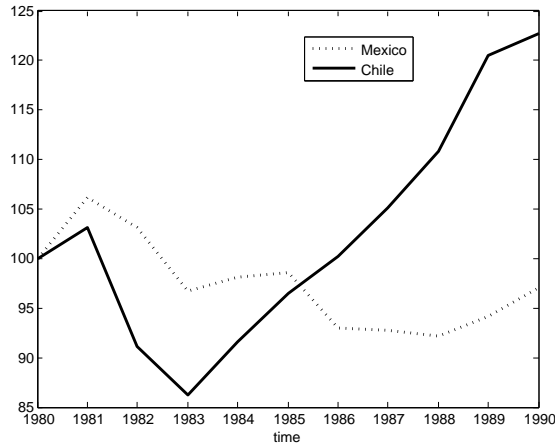
Note: Statistics are for deviations of $\log(TFPR_{s,i})$ from industry means.

This decade of 1980s has been characterized in the majority of Latin American countries by the economic crisis of 1982-83. Between 1982 and 1983 GDP per capita fell by almost 12% in Chile and 7% in Mexico. If the crisis hit hard both countries, the recovery followed very different paths. Chile recovered rapidly: in 1986 real GDP per capita was already back at the pre-crisis level. Mexico did not recover for a long time: real GDP per capita stagnated during all the 1980s and only in 1998 real GDP per capita was back at the level of 1981. Bergoing et al. [2002] revise different possible explanations of why the 1980s was a "lost decade" for Mexico and one of spectacular recovery for Chile. They find that different patterns of recovery were mainly due to different patterns of TFP growth (see Figure (2.5)). The structural reforms undertaken by Chile in the early 1980s, in particular those affecting banking and the bankruptcy procedures, are, according to Bergoing et al. [2002], the main explanation behind the sustained growth in TFP observed in Chile, and its consequent rapid recovery. On the other hand Mexico undertook a set of reforms only from the mid-1980s or later and, even after that, was unable to fully recover.

The numbers showed in this chapter are consistent with the effectiveness of structural reforms in Chile in preparing the ground for a rapid recovery after the crisis. The growth in GDP per capita observed in Chile from 1984 onwards seems associated with a decrease

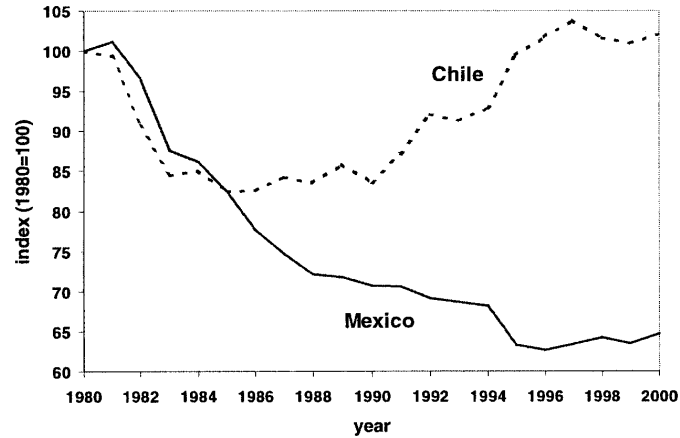
ing misallocation across Chilean manufacturing firms. In the next section I will provide new evidence linking the dependence on external finance to lower misallocation, and the consequent positive effect that the banking and bankruptcy reforms could have had on Chilean manufacturing aggregate TFP.

Figure 2.4 GDP per capita in Chile and Mexico 1980 - 1990



Note: Data from World Development Indicator, GDP per capita in 2005 international dollars

Figure 2.5 Evolution over time of TFP in Chile and Mexico



Note: Total factor productivity detrended by 1.4% a year, source: Bergoeing et al. [2002]

Table (2.1) compares $TFPR_{si}$ dispersion in Chile and Mexico with the numbers reported in Hsieh and Klenow [2009] for India, China and US. The table reports the year closest to 1986 in each country. US (1987) shows by far the less dispersed distribution of $TFPR_{si}$, with a standard deviation of 0.41, consistently with its role of benchmark

country in terms of efficiency in the allocation of resources across firms. The other four countries look more similar to each other, with Chile - that in 1986 report a standard deviation in $TFPR_{si}$ of 0.64 - showing not only less dispersion than Mexico (0.71 in 1986) but also than India (0.69 in 1987) and China (0.74 in 1998).

Table 2.1 Measures of dispersion of TFPR across countries

| country: | Chile | Mexico | India | China | US |
|----------|-------|--------|--------|--------|---------|
| year: | 1986 | 1986 | 1987 | 1998 | 1987 |
| S.D. | 0.64 | 0.71 | 0.69 | 0.74 | 0.41 |
| 75-25 | 0.76 | 0.90 | 0.79 | 0.97 | 0.41 |
| 90-10 | 1.57 | 1.77 | 1.73 | 1.87 | 1.01 |
| N | 2,189 | 2,476 | 31,602 | 95,980 | 173,651 |

Note: data for India, China and US are from Hsieh and Klenow [2009]

What would happen to Mexican manufacturing TFP if resources were to be allocated across firms as efficiently as in Chile during the 1980s? To answer this question I follow the Hsieh and Klenow [2009] methodology. First I compute the hypothetical efficient manufacturing output - the output that would be produced if all firms had the same $TFPR_{si}$ - in the two countries for each year. Then I take the ratio of the efficient versus actual output (Y^*/Y). Finally I divide the ratio calculated for Mexico by the ratio calculated for Chile. The results are reported in Table (2.2). By virtually moving to the Chilean level of efficiency in resource allocation across manufacturing firms Mexican manufacturing TFP could have boosted on average by 8.5% between 1984 to 1990, with a minimum of 2.4% in 1984 and a maximum of 11.4 in 1987.

Table 2.2 TFP gains relative to Chile

| Mexico | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | sample avg |
|---------------|------|------|------|------|------|------|------|------------|
| % TFP gain | 2.4 | 6.7 | 10 | 7.8 | 11.4 | 10.5 | 10.6 | 8.5 |

2.5 Dependence on external finance and misallocation

In this section I present suggesting evidence of a link between the dependence on external finance and misallocation. The aim is to check whether structural reforms, such as those of the banking system and bankruptcy law, can help explain the lower misallocation observed in Chile after the crisis. Bank reform was aimed at liberalizing the credit market. During the crisis insolvent bank were liquidated while solvent banks were re-privatized immediately after. The allocation of credit coming from this reformed system was based on market interest rates and not (or less than before) on political links. This, along with easier bankruptcy procedures, had consequences in terms of firm turnover. Less productive firms that wasn't able to match their returns on investment with the market interest rates (that were high after the crisis) were more likely to exit than before the reform¹². If firms in the lower tail of the productivity distribution exit the market, dispersion and, therefore, misallocation, should decrease. To test this hypothesis I use the variation between sectors in terms of their dependence on external credit to finance investment. If inefficient firms that rely mainly on their cash-flow can survive a strong credit tightening, inefficient firms that relies mainly on external credit are less likely to stay in the market during a period of high interest rates. I use as dependent variable the measure of dependence on external finance by Rajan and Zingales [1998]. The higher the Rajan and Zingales measure is in a given sector and country, the more that sector in that country depends on external financing to invest and produce. My claim is that misallocation, measured as dispersion in $TFPR_{si}$ within sectors, should be lower in sectors that depend more on external finance, because in those sectors less efficient firms are less likely to survive. Table (2.3) report the results of regressing the standard deviation in $\log(TFPR_{si})$ at sectoral level on the measure of dependence on external finance proposed by Rajan and Zingales in a pooled sample of Chilean and Mexican firms. The coefficient is negative and remains strongly significant when I add time, country and industry fixed effects.

¹²On the other hand the Mexican banking system was still highly regulated, preferred industries were protected by government that lent at lower-than-market interest rates.

Table 2.3 Regression of misallocation on dependence on external finance, pooled regression

| | (1) | (2) |
|-------------------------------|-----------------------|------------------------|
| st.dev. $(\log(TFPR_{si}))_s$ | | |
| fin dep | -0.112*** (0.0283) | -0.0963*** (0.0309) |
| country fixed effects | no | yes |
| year fixed effects | no | yes |
| industry fixed effects | no | yes |
| Constant | 0.681*** (0.0127) | 0.756*** (0.0302) |
| Observations | 440 | 440 |
| R^2 | 0.048 | 0.409 |

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses

2.6 Summing up chapter 2

The main goal of this chapter is to perform a cross country comparison applying the misallocation approach proposed by Hsieh and Klenow [2009] to plant level data of Chile and Mexico during the 1980s. My results suggest that there are less distortions operating on average in the Chilean manufacturing sector with respect to the Mexican one. A plausible explanation is the set of liberalization reforms undertaken in Chile in the early 1980s. I estimate potential gains in aggregate manufacturing TFP to be up to 11% in Mexico if it was to move overnight to the level of efficiency observed in Chile in the 1980s. These results are robust to changes in variables and parameters' values, as described in the robustness checks performed in the Appendix.

The misallocation approach is motivated by the heterogeneity observed at firm level, even between firms that produce very similar product, and read this heterogeneity as a symptom of misallocation. I think that areas for future research in this framework are the investigation of sources of heterogeneity that differ in intensity between developed and developing countries and the policy implications deriving from this analysis.

In section (2.5) I propose a possible source of heterogeneity: efficiency of financial markets in allocating credit to firms. In terms of policy implication, the link between external financial dependence and misallocation suggests that policy reforms that deal with credit market failures can have a significant impact on aggregate outcomes.

Conclusions

This Thesis provides new evidence on the relationship between the allocation of factors of production and differences in productivity across economic agents. The two chapters deal with this issue from two different perspectives, and have to be read as two separate papers.

In the first chapter I focus on the allocation of physical capital across countries. In a textbook neoclassical framework the allocation of physical capital per worker affects its productivity. All other things equal, the lower is the ratio of physical capital per worker in a country, the higher is the return of the next unit of physical capital invested in that country. Along the first chapter I assume equal TFP across countries. The aim is to check whether we can explain the small flows of capital across countries by properly taking into account the allocation of factors of production, namely capital and labor, instead of appealing to important TFP differences. Clearly, in this framework, how one measures capital and labor is crucial for the result. I use a standard measure of returns to physical capital that takes into account differences in human capital and in the physical capital share on output across countries. Applying this calibration approach to new data I show that once returns to physical capital are computed with a more accurate measure, the allocation of physical capital is one in which returns are close to be equalized between rich and poor countries.

The main finding of the first chapter -i.e. very similar returns to physical capital in rich and poor countries - is consistent with the relatively small capital flows observed in data. The result also suggests that the current allocation of physical capital per worker across countries is not driven by distortions such as international financial market frictions. It is instead the result of scarce differences in the productivity of physical capital, when this

productivity is properly measured.

The second chapter instead focuses on the allocation of capital and labor across firms. Here I investigate whether a more efficient allocation of factors across firms can affect productivity at country level.

I perform a cross country comparison applying the misallocation approach proposed by Hsieh and Klenow [2009] to plant level data of Chile and Mexico during the 1980s. The results suggest that there are less distortions operating on average in the Chilean manufacturing sector with respect to the Mexican one. I estimate potential gains in aggregate manufacturing TFP to be up to 11% in Mexico if factors of production were reshuffled across firms to the level of efficiency observed in Chile in the mid-1980s.

At the end of the second chapter I propose a possible story for the more efficient allocation observed in Chile with respect to Mexico: the implementation by the Chilean government of the banking system reform and of the new bankruptcy law. To support the potential importance of this channel, I present empirical evidence suggesting that misallocation is lower in sectors that depend more on external finance. This could be because less efficient firms are more likely to exit when they operate in sectors that structurally relies more on external credit¹³. When less efficient firms exit the market, the factors of production they free are redistributed among the more efficient firms that stay in the market. Reforms such those carried out in Chile in the wake of the crisis favor an allocation of credit based more on actual productivity than on political links. Such reforms can therefore help explain the lower dispersion observed across Chilean firms in terms of productivity in the mid-1980s and the fast recovery experienced by Chile with respect to Mexico in that decade.

Establishing a link between external financial dependence and misallocation has important policy implications. It suggests that there is scope for policy reforms¹⁴ to help the recovery of a country by favoring the reallocation of the available resources from less to more productive firms. Something that could turn out to be useful in the next future also in Europe.

¹³This is even more true in a period of crisis

¹⁴In particular those addressed to deal with important market failures such as those observed in the credit market

Appendix A

Appendix to Chapter 1: Description of the Database

This appendix 1 describes all variables contained in the database used in the computation carried out in the first chapter. It is divided into 4 sections: the first section describes basic data on national accounts (e.g. GDP, capital stock, number of workers), the second section describes variables related to quantity of education (e.g. attainment ratios, duration, years of schooling and Mincerian coefficients), the third section describes variables related to quality of educationl (e.g. pupil-teacher ratios, public spending in education, test scores), the fourth section describes variables related to different types of capital (produced versus natural capital).

The database includes 142 countries with complete data for GDP, capital stock estimates and years of schooling in 1995 and 2005.

A.1 Basic data on national accounts

A.1.1 GDP

There are two variables for Y according to the data source used.

A.1.1.1 GDP from WDI 2009 (Y_{wdi})

Y from World Development Indicators 2009 (hereafter WDI(2009)) is GDP in 2005 international dollars, i.e. in PPP. The PPP adjustment is made using the last International Comparison Program (ICP, 2005 round). Among the 142 countries in the dataset there are 7 countries in 1995 (Afghanistan, Barbados, Cuba, Iraq, Libya, Qatar, Taiwan) and 3 countries in 2005 (Cuba, Iraq, Taiwan) for which Y is not available in WDI(2009).

A.1.1.2 GDP from Penn World Tables 6.3 (Y_{pwt})

Y from Penn World Tables version 6.3 (hereafter PWT63) is constructed using the following variables from the original PWT63 dataset: real GDP per capita (constant prices: chain series) ($RGDPCH$) and population (in thousands) (POP). Therefore $Y_{pwt} = rgdpch * pop * 1000$. Notice that in PWT63 "real" means "PPP converted", but it does not incorporate the 2005 ICP. Y_{pwt} is available for all the 142 countries in the dataset for both 1995 and 2005.

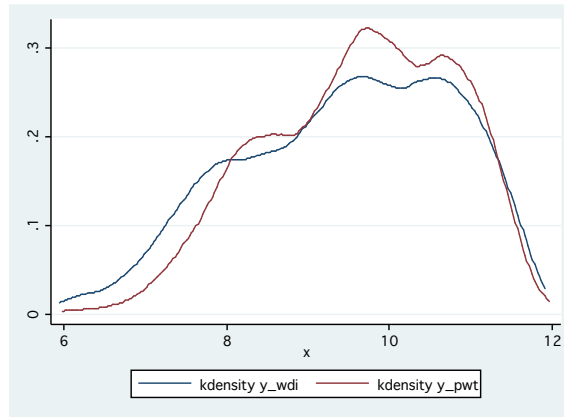
A.1.1.3 Main differences between Y_{wdi} and Y_{pwt}

The main difference between these two estimates is in the way the purchasing power parity (PPP) deflator is constructed. The PPP adjustment in WDI (2009) is made with ICP data. The ICP uses the EKS method (Elteto, Koves, and Szulc) to construct aggregated PPPs for GDP and its major aggregates (consumption, investment, government consumption) between countries within a region¹, and then a *ring comparison* to make regional results comparable on a global scale. The EKS method has two important characteristics: first, it is not additive; second, it uses an implicit weighting that is equal across countries. On the other hand the PPP adjustment in PWT 6.3 is made using the Geary-Khamis (GK) methodology. This methodology tends to inflate the income of poor countries relative to rich countries, and this is due to the weighting system used to construct the international price of each item (e.g. food). The weights used are the expenditures of each country (converted to the currency of a numeraire country) in that item. This implies that the international price of an item like food, to which is devoted a larger

¹EKS method was used in all regions other than Africa (Ikle' method)

share of expenditure in poor countries, will be closer to the price of food in rich countries. Since food is more expensive in rich countries, their price will receive an higher weight with respect to the poor countries' price, and when the international price constructed in this way is multiplied by the large quantities of food consumed by poor countries to construct the GDP in PPP, the GDP in PPP of poor countries will be "overestimated". As a result, if we compare the distribution of GDP per worker obtained with EKS and GK methods, the distribution obtained with the EKS method is larger and fatter in the left tail, while the right tail is much closer to the one you obtain with GK method.

Figure A.1 Distribution of GDP per worker across countries using WDI or PWT



A.1.2 Capital Stock (K)

Estimates of the capital stock are constructed using the perpetual inventory method. I applied the standard capital accumulation equation:

$$K_t = I_t + (1 - \delta)K_{t-1}$$

where K_t is the capital stock, I_t is investment and δ the yearly depreciation rate of capital.

The series of I_t , real aggregate investment in PPP, is constructed using data from PWT63. The series of I_t from PWT63 is generated multiplying the investment share of real GDP per capita (KI) by the real GDP per capita (constant prices: Laspeyeres)

$(RGDPL)^2$.

The initial capital stock (K_0) is constructed as in Caselli (2005) as $I_0/(g + \delta)$ where I_0 is the value of investment in the initial year, δ is the yearly depreciation rate of capital set to 0.06 and g is:

- (i) avg growth rate between the first year available and 1970 for those countries whose series of I_t starts before 1970 (100 countries)
- (ii) avg growth rate during the first 10 years of the I_t series starting from the first year available for those countries whose series of I_t starts after 1970 (42 countries)

The following table sum up the number of countries by initial year of the I_t (and therefore K_t) series (the dataset includes a variable named *ini_year_k* that reports the initial year of the I_t series for each country).

| ini_year_K | Freq. | Percent | Cum. |
|------------|-------|---------|--------|
| 1950 | 51 | 35.92 | 35.92 |
| 1951 | 6 | 4.23 | 40.14 |
| 1952 | 1 | 0.70 | 40.85 |
| 1953 | 2 | 1.41 | 42.25 |
| 1954 | 3 | 2.11 | 44.37 |
| 1955 | 4 | 2.82 | 47.18 |
| 1959 | 2 | 1.41 | 48.59 |
| 1960 | 29 | 20.42 | 69.01 |
| 1961 | 2 | 1.41 | 70.42 |
| 1970 | 28 | 19.72 | 90.14 |
| 1987 | 1 | 0.70 | 90.85 |
| 1989 | 1 | 0.70 | 91.55 |
| 1990 | 4 | 2.82 | 94.37 |
| 1992 | 1 | 0.70 | 95.07 |
| 1993 | 6 | 4.23 | 99.30 |
| 1995 | 1 | 0.70 | 100.00 |
| Total | 142 | 100.00 | |

²The formula I use is $KI * RGDPL * POP * 1000$, since population is in thousands.

A.1.3 Population (*POP*)

The variable population from WDI(2009) is an estimate made by the World Bank for mid-year population which counts "all residents regardless of legal status or citizenship". For Taiwan there is no available estimate of population in WDI(2009) so I used data from PWT63 and I constructed POP as: $POP*1000$ (since population is in thousands in the original dataset).

A.1.4 Number of workers (*L*)

The number of workers is from WDI(2009) and the variable in the original dataset is called "Labor force, total". According to World Bank definition "Labor force comprises people who meet the ILO definition of the economically active population: all people who supply labor for the production of goods and services during a specified period. It includes both the employed and unemployed". For Taiwan there is no available estimate of labor force in WDI(2009) so I used data from PWT63 and I constructed L as: $(RGDPCH*POP*1000)/RGDPWOK$.

A.1.5 Current Account (*CA*)

Current Account data are from WDI(2009). The original variable I used is current account as a share of GDP, this variable is expressed in current local currency units (LCU). To transform it in PPP international dollars I multiplied it by the GDP current LCU and divided the result by the PPP conversion (LCU per current international dollar). Since I wanted *CA* to be expressed as a GDP share I then divided by GDP in PPP current international dollars. Since most of the calculation are performed for the year 2005, current international dollars correspond to 2005 international dollars. It has to be taken into account, however, that the PPP conversion factor used in WDI is not the same as the one used in the PWT63.

A.1.6 FDI

Data on FDI are from the WDI (2009) that use as sources: International Monetary Fund, International Financial Statistics and Balance of Payments databases, World Bank,

Global Development Finance, and World Bank and OECD GDP estimates. Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series is calculated as net outflows (flows to the rest of the world) minus net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, and is divided by GDP. A positive number means that the country is a net exporter of private capital to the rest of the world, a negative number means that the country is a net importer of private capital from the rest of the world.

The original variable I used is FDI as a share of GDP, where GDP is expressed in current local currency units (LCU). To transform it in PPP international dollars I multiplied it by the GDP current LCU and divided the result by the PPP conversion (LCU per current international dollar). Since I want *fdi* to be expressed as a GDP share I then divided by GDP in PPP current international dollars. Since most of the calculation are performed for the year 2005, current international dollars correspond to 2005 international dollars. It has to be taken into account, however, that the PPP conversion factor used in WDI is not the same as the one used in the PWT63.

A.1.7 Adult survival rate (*sr*)

To construct the adult survival rate I used data from WDI (2009), in particular: female and male adult mortality rate and female and male shares in total population. Adult mortality rate is the probability of dying between the ages of 15 and 60—that is, the probability of a 15-year-old dying before reaching age 60, if subject to current age-specific mortality rates between those ages. To create the adult survival rate I weighted the mortality rate out of 1,000 persons of each sex by the share of each sex in total population and then compute the survival rate as 1 minus the weighted mortality rate of adults. Note that for 1995 I used the mortality rate of female and male for 1998, due to the large number of missing in 1995.

A.1.8 Prices (*py pc pi pg*)

Prices of gross domestic product, consumption, investment and government consumption are from PWT63. Price level of GDP and each of its components are the relative PPP divided by the exchange rate and multiplied by 100. The PPP of GDP or any component is the national currency value divided by the real value in international dollars. The PPP and the exchange rate are both expressed as national currency units per US dollar. This implies that:

$$p_i = \frac{PPP_i}{EXRATE} * 100 \quad i = y, c, i, g$$

The value of price of GDP (*py*) for the United States is made equal to 100, this is not true for the component shares.

A.2 Quantity of Education

This section includes the following variables for years 1995 and 2005: educational attainment ratios, duration in years of schooling of each education level, average years of schooling, Mincerian coefficients.

A.2.1 Educational attainment ratios (*lu, lp, lpc, dsi, ls, lsc, lh, lhc*)

Data for educational attainment ratios are from Barro and Lee (2010)³. There are seven categories of educational attainment: no education (*lu*), some primary education (*lp*), completed primary education (*lpc*), some secondary education (*ls*), completed secondary education (*lsc*), some higher education (*lh*), completed higher education (*lhc*). Each educational attainment ratio is the share (in percentage points) of the adult population⁴ whose highest level of educational attainment is one these 7 categories. The share of adult population who completed each level of education (primary, secondary, higher) is a subgroup of the share of adult population that has at least some of each level of education (e.g. this implies that people with completed primary are also included in the share of population with some primary education).

³These data are available on line at <http://www.barrolee.com/> last update: 2010.07.07

⁴Adult population includes people aged above 15, the subscript 1599 in each educational variable indicate this age group

A.2.2 Duration (*dpi, dpc, dsi, dsc, dhi, dhc*)

Data on duration of primary and secondary schooling are from WDI (2009) and refers to 1995 and 2005, taking into account changes in the duration of each level of schooling over time in a country. WDI (2009) does not have data on duration of higher education. Data on duration of higher education are from Cohen Soto (2007)⁵ and from UNESCO. Countries not covered by these sources are assigned the average duration of higher education of their geographical region. For each level of education the fraction of population that does not complete each level is assigned half the years of schooling of the full duration of that level.

A.2.3 Years of schooling (*yr_sch_1599*)

Country average years of schooling is from Barro Lee (2010). For a detailed description of how this variable is constructed please refer to section D of the Barro Lee paper.

A.2.4 Mincerian coefficients (*mincoef, minyear, mincoef_source*)

The Mincerian coefficient is the coefficient on years of schooling in a log-wage regression⁶. For each country I collected up to 3 estimates of the mincerian coefficient at different points in time:

1. *mincoef0*: mincerian coefficient estimated with data older than 1989 (62 observations)
2. *mincoef1*: mincerian coefficient estimated with data between 1989-1999 (70 observations)
3. *mincoef2*: mincerian coefficient estimated with data from 2000 onwards (31 observations)

For each coefficient I report the year it refers to (*minyear0, minyear1* and *minyear2*) and the source from which it is taken (*mincoef0_source, mincoef1_source* and *mincoef2_source*). The source variable is a number, and each number correspond to one of the following papers:

⁵Available in Soto's personal webpage <http://www.iae-csic.uab.es/soto/data.htm>

⁶in the most basic formulation wage is regressed on years of schooling, experience and experience squared.

- 1 : Psacharopoulos and Patrinos [2004]
- 2 : de la Fuente and Jimeno [2009]
- 3 : Bils and Klenow [2000]
- 4 : Kaboski [2007]
- 5 : Patrinos and Sakellariou [2006]
- 6 : Miller et al. [1995]
- 7 : Biagetti and Scicchitano [2009]
- 8 : Asadullah [2009]
- 9 : Lucas and Stark [1985]
- 10 : Psacharopoulos [1994]
- 11 : Patrinos [1995]
- 12 : Flabbi et al. [2008]
- 13 : Appleton [2000]
- 14 : Vujcic [2009]
- 15 : Cohn and Addison [1998]
- 16 : Brunelli Comi Lucifera [1999]
- 17 : Bart Roed [1999]
- 18 : Luo and Terada
- 19 : Rutkowski [1997]
- 20 : Keswell and Poswell [2004]
- 21 : Tunaer
- 22 : Appleton et al. [1998]

- 23 : Mason and Khandker [1995]
- 24 : Appleton et al. [1999]

A.3 Quality of education

A.3.1 Pupil-Teacher Ratios (*ptr*)

1. We are interested in computing pupil-teacher ratios during the years when the average worker in each country attended primary and secondary school. Therefore, first of all I constructed an estimate of the age of the average worker in each country. To do that I followed these steps: (i) I take data from LABORSTA on economically active population broken down in 5 years age intervals from 15-19 to 70-74 and on the total economically active population aged above 15 years; (ii) for each group I take the middle year of the age interval (e.g. 17 for the group aged [15-19]) and weight it by the fraction of the economically active population in that interval with respect to the total above 15 years; (iii) summing over the groups I get an estimate of the average age of a worker in each country. Notice that I carry out this procedure using the closest estimates provided by LABORSTA to 1995 and to 2005 in order to take into account changes in the demography of the labor force during the 10 years between the 2 observations. Among the 142 countries of the dataset it is possible to construct this variable for 114 countries in both 1995 and 2005. The average age of the average worker within our sample is 35.3 years in 1995 and 36.1 in 2005.
2. Then I compute the year at which the average worker starts primary and secondary school in each country. As in Caselli (2005) I assume that children begin primary schooling at the age of 6. The relevant year in which the average worker starts primary school is computed as : $1995 - age_avgworker + 6$ for 1995 and as: $2005 - age_avgworker + 6$ for 2005. I then compute the relevant year in which the average worker starts secondary school using duration data on (completed) primary school: $1995 - age_avgworker + 6 + dpc$ for 1995 and as: $2005 - age_avgworker + 6 + dpc$ for 2005.
3. Since pupil-teacher ratios and other education variables are collected at five years

intervals I target the observation of the five years interval that is closest to the year in which the average worker went to school. The target years in which average worker went to primary school are (in parenthesis number of countries): 1960 (16), 1965 (67), 1970 (31) for 1995, and 1970 (31), 1975 (56) 1980 (27) for 2005. Target years for secondary school are: 1965 (18), 1970 (50), 1975 (46) for 1995, 1975 (23), 1980 (55), 1985 (36) for 2005.

4. Data sources for pupil-teacher ratios for primary and secondary school are available from 1970 onwards in WDI(2009) and for years 1960 and 1965 in Lee and Barro (2001)⁷.
5. To construct a unique statistic for each country-year I weight pupil-teacher ratios in primary and secondary school using new data from Barro and Lee (2010) on average years of primary and secondary schooling attained in each country. These data are available from 1960 onwards at 5 years intervals. The procedure is the same as in Caselli (2005): weight each ratio by the fraction of schooling time the average worker spent in primary and secondary schooling at the time he attended primary and secondary school. The formula I used to construct the final variable pupil teacher ratio (ptr) is the following (the example refers to the average worker in 2005 who attended primary in 1970 and secondary in 1975):

$$ptr_{2005} = \left(ptr(pri)_{1970} * \frac{yrsch(pri)_{1970}}{yrsch(total)_{1970}} \right) + \left(ptr(sec)_{1975} * \frac{yrsch(sec)_{1975}}{yrsch(total)_{1975}} \right)$$

There are 88 observations for 1995 and 93 for 2005 for pupil teacher ratios (87 for 1996 in Caselli (2005)).

A.3.2 Public Spending in Education (*expedu*)

I construct this variable using the same data as in Caselli (2009). WDI(2009) provides estimates on public education expenditure for primary and secondary school, and, for some countries, also the shares of spending in teaching materials and teacher compensation. However these data can be converted in PPP only from 1980. Since also for spending we

⁷I filled some missing values of pupil teacher ratios from 1970 onwards with data from Lee and Barro (2001) when data is available in Lee and Barro (2001) and not in WDI (2009)

focus on years when the average worker went to school, most of the observations we need are before 1980. I have therefore used the Lee and Barro (2001) database who reports real government current education expenditure per pupil in primary and secondary school converted in PPP terms (1985 international dollars) starting from 1960. Dating and weights for primary and secondary are the same as for pupil-teacher ratios. There are 64 observations in 1995 and 70 in 2005 for public spending in education (64 for 1996 in Caselli (2005)).

A.3.3 Test Scores (*timss_matsci*, *pirls_rea*, *pisa_matsci*, *pisa_rea*)

Test scores data are from WDI (2009) and cover results from the following international programs: TIMSS (Trends in International Mathematics and Science Studies), PIRLS (Progress in International Reading Literacy Study) and PISA (Program for International Student Assessment). The original score of TIMSS, PIRLS and PISA tests is in a proficiency scale going from 0 to 1000, with an international average set at 500 and a standard deviation of 100.

The database includes four variables on test scores:

1. The first is the average score over TIMSS mathematics and science test imparted to 8th grande students. Rounds of these two tests have been carried out in 1995, 1999, 2003 and 2007 . The variable *timss_matsci* is an average over the four rounds rescaled on a range 0-100⁸. The number of countries covered is 37 in 1995, 35 in 1999, 42 in 2003 and 45 in 2007. Among the 142 countries of the database, 62 have at least one observation in the TIMSS science test ⁹, and 61 of those¹⁰ have also at least one observation in the TIMSS maths test¹¹. There are no countries for which are available the results of the TIMSS maths test and not of the TIMSS science test.
2. The second variable is the PIRLS test score in reading imparted to 8th grande students (*pirls_rea*). Data for this test are available only for 2006 and for 32 countries

⁸Note that test scores obtained in each country in different rounds are highly correlated

⁹The original variable in WDI (2009) is "TIMSS: Mean performance on the science scale for eight grade students, total"

¹⁰The only exception being Belgium, so for Belgium the variable only includes results of the TIMSS science test.

¹¹the original variable in WDI (2009) is "TIMSS: Mean performance on the mathematics scale for eighth grade students, total"

among those in the database. Here again I rescaled test scores to 0-100.

3. The third variable is the average score over PISA mathematics and science test (*pisa_matsci*). PISA rounds have been carried out in 2000, 2003 and 2006. The variable is an average over these three sessions rescaled to the range 0-100. There are 54 countries for which data are available in all the three rounds (no country participated only in one or two rounds).
4. The fourth variable is the PISA reading test score (*pisa_rea*). Test scores are available for 2000, 2003 and 2006, I take the average score over the three rounds and rescale it to the range 0-100. There are 54 countries for which data are available in all the three rounds (no country participated only in one or two rounds).

A.4 Types of Capital

Data by type of capital are from Hamilton and Ruta [2006]. The World Bank provides estimates at country level of produced capital, natural capital and intangible capital as a residual (i.e. the difference between the total wealth of a country and the sum of produced and natural capital). The World Bank data refer to year 2000 and cover 118 countries, 100 of which are also in the dataset presented here. I included in the dataset the estimates of produced (*producedplusurban*) and natural capital (*natcap*) with their respective components. Produced capital is the sum of machinery, equipment and structures (*produced*), calculated with the perpetual inventory method, and urban land (*urban*), a fixed 24% of produced capital. Natural capital is the sum of the estimated value of energy and mineral resources (*subsoil*), timber resources (*timber*), nontimber forest resources (*ntfr*), cropland (*cropland*), pastureland (*pasture*) and protected areas (*pa*). The Appendix A of "Where is the wealth of nations?" World Bank (2006) provides details on the estimation of all these variables.

Appendix B

Appendix to Chapter 2: Robustness Checks

In this appendix I test the robustness of my results to changes in some key variables and parameters' values. The main concern is that the heterogeneity observed across firms, and all the results in terms of misallocation deriving from that, could come from sources other than distortions: measurement errors (that I check by using different set of variables to see if main results hold) or variation in variables assumed to be fixed across firms like wages, markups, elasticities of substitution, adjustment costs.

B.0.1 Alternative measures of capital

In the baseline version of this empirical exercise I used the book value of capital stock as a proxy for capital used in production. A natural question is whether the value of stocks like buildings, machineries, or transportation equipments is a good proxy for the flow of capital services that is what the K that enters the production function actually stands for, and that is certainly hardly observable. The main concern is that the book value of capital stocks reported by firms could not capture the intensity with which this capital is used in production. A natural alternative candidate for K is then the electricity consumed by each firm. Electricity consumption has the following advantages: it takes into account the intensity of capital used in production and allows to avoid the problem of fixed costs of production, meaning how much of the capital is invested as a fixed cost and

how much is invested in actual production. This alternative proxy has also drawbacks: old capital could be more energy-consuming than new capital (while the second is probably more effective); energy prices are subject to high volatility and appropriate price deflators are essential; the amount of electricity consumed could in part be specific of the sector of operation, so that in those sectors that consume more electricity one could overestimate the role of capital (i.e. underestimate productivity) and vice versa. It is worth reminding that both these proxies of K do not take into account any differentiation in quality of the capital equipments.

Table B.1 TFP gains from equalizing $TFPR_{si}$ within industries setting $K=$ energy consumption

| | | | |
|--------|------|------|------|
| Chile | 1979 | 1983 | 1986 |
| | 36.2 | 33.4 | 34.9 |
| Mexico | 1984 | 1986 | 1990 |
| | 28.9 | 35.3 | 35.2 |

Table (B.1) reports aggregate TFP gains using energy consumption as a proxy for K . For both Chile and Mexico aggregate TFP gains increase with respect to the baseline version. This is especially true for Chile whose TFP gains are now 50% higher. This is mainly due to the higher dispersion in energy consumption across Chilean firms with respect to the book value of capital stock. The coefficient of variation¹ over the whole Chilean sample is 10.3 for energy consumption, two times higher than the coefficient of variation for book value of capital stock (5.4).

B.0.2 Alternative measures of labor

All the results presented in the last section are obtained using the wage bill for the factor of production L . The wage bill is often used to heroically take into account human capital of workers, based on the idea that wages should reflect marginal products, and that more trained workers are more productive. Clearly this measure also presents drawbacks.

¹To compare the dispersion of the two proxies of capital I used the coefficient of variation, defined as the ratio of the standard deviation σ to the mean μ .

The first is that wages could not reflect the true marginal productivity of workers because of distortions affecting the labor market, exactly as the prices of final goods or capital goods could simply reflect distortions in goods or capital markets.² Another problem is that wages could reflect not simply the salary but also rent or profit sharing. This implies I could have underestimated the dispersion of $TFPR_{si}$ by using the wage bill for L because more profitable plants might share more profits, and therefore they could be more productive than they seem. A first natural alternative is to use the simple number of workers. What I expect in this case is an increase in dispersion and therefore an increase in potential gains from removing distortions. As Table (B.2) shows this is exactly what happens.

Table B.2 TFP gains from equalizing $TFPR_{si}$ within industries setting L =number of employees

| | | | |
|-------------------------|------|------|------|
| Chile | 1979 | 1983 | 1986 |
| | 42.1 | 48.4 | 45.7 |
| Mexico | 1984 | 1986 | 1990 |
| (L=number of employees) | 40.5 | 47.4 | 52.6 |
| (L=hours worked) | 40.4 | 48.4 | 48.8 |

Since workers not only differ in the quality of their work (something I tried to take into account using the wage bill) but also in the number of hours they work per week, another possible proxy for L is hours worked. The number of hours worked by employees in each firm is available only for Mexico. As Table (B.2) shows, at least for Mexico, the results do not change much with respect to when we use number of workers.

B.0.3 Wage variation

Hsieh and Klenow [2009] assume wages are equal for all firms and normalize $w = 1$ in their model. However they do not test this hypothesis. In my dataset for Mexico I have both real wage and hours worked per firm, so that I can construct a rough measure of the hourly wage in each firm and then test whether variation in wages are associated or not

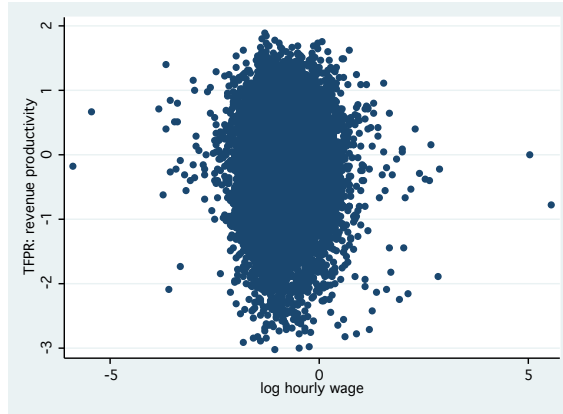
²This remains true in reality even if, following Hsieh and Klenow [2009] along this chapter I have assumed all wages to be equal to 1 and distortions to affect only output and capital.

with variation in $TFPR_{si}$. It is possible to write an expression for $TFPR_{si}$ as:

$$TFPR_{si} = \frac{\sigma}{\sigma - 1} \left(\frac{w}{1 - \alpha} \right)^{1 - \alpha} \left(\frac{R}{\alpha} \right)^{\alpha} \frac{(1 + \tau_{K_{si}})^{\alpha}}{1 - \tau_{Y_{si}}} \quad (\text{B.1})$$

According to this expression variations in $TFPR_{si}$ within sectors could be due to varying markups, varying factor prices, varying factor shares and, clearly, capital and output distortions. Having assumed that factor shares do not vary within sectors, and not having any available estimate for the price of capital what is left to test is wages and markups. As Figure (B.1) shows, there is no clear relationship between $TFPR_{si}$ and log hourly wages, at least in Mexico. This implies that by assuming equal wages across sectors I am not losing any important cause of dispersion in $TFPR_{si}$.

Figure B.1 Relation between $TFPR_{si}$ and log hourly wages in Mexico



Note: data are for years 1984-1989, all plant-observations pooled together.

B.0.4 Varying markups with plant size

As I stated in the previous paragraph on wage variation, another source of variation in $TFPR_{si}$ could be variation in firm-specific markups. So far I assumed a CES function such that all firms in all sectors (in all countries) will charge the same markup over their marginal cost. However, if this assumption is clearly refused by data one could impute the variance of $TFPR_{si}$ to different markups charged by single firms.

Something I can check to verify this assumption is the relationship between size of a firm and its $TFPR_{si}$. Theory suggests that smaller firms should face higher elasticity of substitution for their goods, because they usually operate in very competitive markets.

High elasticity of substitution implies low markups. If different markups play an important role in explaining variations in $TFPR_{si}$ we should observe a positive and clear relationship between the size of a firm and its $TFPR_{si}$. On the other hand, if the hypothesis of constant markups is not a crucial one, we should observe a flat line when checking this relationship. Table (B.3) reports the results of regressing TFPR (in log deviation from sectoral means) on firms' size (measured as log value added) by size quartile. In both countries coefficients on size are positive and significant in the first quartile. This means that for smallest firms there is a somewhat positive relationship between size and TFPR. However, all coefficients on size decrease and become insignificant as one looks at bigger firms. With few exceptions (Chile showing a significant and positive coefficient in the second quartile), for firms in the second, third and fourth quartiles the relationship between size and TFPR is very weak in both countries.

Table B.3 Estimates of the relationship between $TFPR_{si}$ and size

| dependent variable: $TFPR_{si}$ independent variable: firm size | size 1-25th | size 25-50th | size 50-75th | size 75-100th |
|--|----------------------|--------------------|--------------------|----------------------|
| Chile | 0.628*** (0.0479) | 0.264** (0.109) | 0.0881 (0.0677) | -0.00240 (0.0254) |
| Observations | 548 | 547 | 547 | 547 |
| R^2 | 0.240 | 0.011 | 0.003 | 0.000 |
| Mexico | 0.163*** (0.0425) | 0.140 (0.0928) | 0.115 (0.0873) | 0.0640* (0.0365) |
| Observations | 544 | 544 | 544 | 543 |
| R^2 | 0.026 | 0.004 | 0.003 | 0.006 |

*** p<0.01, ** p<0.05, * p<0.1

Standard errors in parentheses

B.0.5 Elasticity of substitution

The elasticity of substitution describes how easily people preferences change across the products produced by each sector when the prices of these products change. Elasticity of substitution also determines the value of the markup charged by firms over the marginal cost of production. Following Hsieh and Klenow [2009] I assumed the elasticity

of substitution to be constant across industries and across countries. This is a very strong assumption indeed. There are two main issues related to this assumption. First, if one opts for a unique value of the parameter σ , convincing arguments are needed to justify the value chosen since, as I will show, the value of σ influences a lot the magnitude of the results. Second, one might think that products produced by different sector do not have the same elasticity of substitution because of the intrinsic characteristics of these products. A variation of bread's price will probably not have the same effect on my demand for bread as it could have a variation of the price of glass products on my demand for glasses.

As for the first issue Hsieh and Klenow [2009] set the elasticity of substitution to 3 for all sectors and countries. As explained in their paper this value is at the low end of empirical estimates (that give values from 3 to 10), but, since aggregate TFP gains are positively correlated with σ by construction, they opt for the most conservative choice. As Table (B.4) shows the estimates of aggregate TFP gains for Chile and Mexico are highly sensitive to the value of this elasticity.

Table B.4 Robustness check: TFP gains from equalizing $TFPR_{si}$ within industries

| | | | |
|---------------|-------|-------|-------|
| $\sigma = 5$ | | | |
| Chile | 1979 | 1983 | 1986 |
| | 43.8 | 42.6 | 42.9 |
| Mexico | | | |
| | 1984 | 1986 | 1990 |
| | 54.6 | 66.5 | 78.9 |
| $\sigma = 10$ | | | |
| Chile | 1979 | 1983 | 1986 |
| | 78.2 | 78.3 | 78.9 |
| Mexico | | | |
| | 1984 | 1986 | 1990 |
| | 114.7 | 124.2 | 147.8 |

As for the second issue - different elasticities of substitution in each sector - the main problem is that there are no available estimates of these elasticities of substitution at sectoral level for the countries object of this study.³

³An attempt to estimate the elasticities of substitution at industry level for the US has been made by Broda and Weinstein [2006] who compute elasticities of substitution between varieties of each good for the 20 largest 3-digit sectors in US imports.

B.0.6 Sensibility to outliers

Since all measures of variance are very sensible to outliers, I need to check the robustness of my results to different cut-offs for outliers. Table (B.5) shows TFP gains from cutting 10% of outliers (5% on each side of the distribution). With respect to the baseline version where I cut only 1% of firms on each side of the $TFPR$ and $TFPQ$ distribution, the TFP gains are now much lower. In 1986 they decrease from 20.2 to 2.1 for Chile and from 32.1 to 10.6 for Mexico. This implies that results are highly sensible to the cut-off chosen. At the same time, deciding which cutoff is the right one - considering that before cutting tails an accurate data cleaning process has already been made - is not an innocent choice and being excessively prudent (cutting the more, the better) could lead to lose an important part of the story.

Table B.5 Robustness check: TFP gains from equalizing $TFPR_{si}$ within industries cutting 5% upper and lower tails in both $TFPR$ and $TFPQ$ distributions

| cut 5% top/bottom outliers | | | | |
|----------------------------|------|------|------|--|
| Chile | 1979 | 1983 | 1986 | |
| | 7.0 | 4.3 | 2.1 | |
| Mexico | 1984 | 1986 | 1990 | |
| | 8.1 | 10.6 | 10.8 | |

B.0.7 Adjustment costs

Another possible source of variation in $TFPR_{si}$ apart from distortions are the different adjustment costs that could be faced by young and old firms. The idea is the following: for young firms it could take a while before to understand how productive they are, and once they discover to be more productive than they thought they will need some time to increase the amount of inputs used for production. This implies we could observe some firms to be very productive just because they are very young and still need to adjust the amount of input they use to their productivity. If this is true we should observe TFP decreasing with age. Given firm's age is not available for neither of the two countries this robustness check can not be performed, even though this is clearly an issue.

B.0.8 To sum up on robustness checks

Table (B.6) reports the TFP gains from equalizing $TFPR_{si}$ within industries in 1986 under the different parameters' values I checked in this section. What comes up is that the choice of Chile as benchmark country is robust to changes in parameters' values: Chile is the closest country to its efficient benchmark in manufacturing output under all robustness checks.

Table B.6 Robustness check: TFP gains from equalizing $TFPR_{si}$ within industries in 1986

| year=1986 | baseline | K=energy | L=employment | $\sigma = 5$ | $\sigma = 10$ | cut 5% t/b outliers |
|-----------|----------|----------|--------------|--------------|---------------|---------------------|
| Chile | 20.2 | 34.9 | 45.7 | 42.9 | 78.9 | 2.1 |
| Mexico | 32.1 | 35.3 | 47.4 | 66.5 | 124.2 | 10.6 |

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