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Natural Resources and Global Misallocation

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Abstract

Are production factors allocated efficiently across countries? To differentiate misallocation from factor intensity differences, we construct a new dataset of estimates for the output shares of natural resources for a large panel of countries. We find a significant and persistent degree of misallocation of physical capital. We also find a remarkable movement toward efficiency during last 35 years, associated with the elimination of interventionist policies and driven by domestic accumulation. In contrast, we find a much larger and persistent misallocation of human capital. Interestingly, when both production factors can be reallocated, capital would often flow from poor to rich countries.

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1   Introduction

The wide cross-country disparities in output per capita have motivated an extensive literature that decomposes them into total factor productivity (TFP) and factor supply differences.[1] It is well known that such decompositions often carry with them large cross-country disparities in the returns of factors, e.g. Lucas (1990). The impact of the distortions and the barriers that can sustain the cross-country factor returns differences are often left unexplored. Yet, the removal of such distortions, as observed since the early 1980s (Buera et al., 2011) could drastically change the cross-country allocation of factors and the resulting world income distribution.

This paper evaluates the distributional and global efficiency consequences of observed and counterfactual changes in the barriers to factor accumulation and mobility for many countries and years. Our contribution is twofold. First, we construct a new database to measure the income share of natural resources for many countries and years, which are needed to correctly measure the output share of physical and human capital. Our estimates rectify the existent numbers in the literature, which either ignore rents to natural resources or largely overestimate them, as we explain below. Second, we document a number of salient patterns in the global production efficiency over the years. The persistence of a significant degree of global misallocation notwithstanding, these last 35 years witnessed a remarkable movement toward efficiency.

We explicitly consider natural resources as inputs of production and measure their aggregate rents. Natural resources, such as land and minerals, account for a quantitatively relevant share of the net income (added value) for some countries (Caselli and Feyrer, 2007). Thus, the common practice of ignoring these factors inflates the marginal product of physical capital (MPK), as non-labor income ends up being imputed to the traditional measures of physical capital (i.e., equipment and structures). The problem is most severe for lower-income countries where natural resources tend to have a higher share in aggregate income. Indeed, Caselli and Feyrer (2007) argue that after controlling for natural resources and other sources of cross-country differences in the output share of physical capital, the global output gains from reallocating physical capital across countries are negligible. We show that a better measurement of the rents of natural resources overturns this global efficiency result. We find that global output gains from physical capital reallocation are large: roughly five times larger than previous estimates. Additionally, a number of salient global and regional patterns for the misallocation of physical and human capital arise. This paper explores those patterns and assesses the extent to which they can be accounted for by observed changes in distortionary policies across the countries over time.

For each country in our sample (indexed by j), we construct estimates of the output shares of natural resources, $\phi_{j,t}^R$, based solely on *rent flow* data for the country in each period t. For some of the years, we can directly use the rent measures constructed by the World Bank (WB). To extend the estimates for the years from 1970 to 2005, we apply the same methodology used by the WB using data from the United Nations' Food and Agriculture Organization database (FAOSTAT) and the rent share estimates for benchmark countries from the World Bank. Over the sample period, we find that an average share of 6.0% over countries and over years. There is substantial heterogeneity. As expected, the natural resource output shares can be quite high for

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[1]See Caselli (2005), Klenow and Rodríguez-Clare (1997) and references therein.

a handful of oil-producing countries, with an average above 25%. More interestingly, the average share is higher for poorer countries. Excluding oil producing countries, the average share for the poorest quartile of countries is 5.7%, while it is only 0.58% for the richest quartile of countries.

We use our estimates of the output shares of natural resources with the labor income shares, denoted $\theta_{j,t}$, and output $Y_{j,t}$, capital $K_{j,t}$, and other data from the Penn World Table (PWT 8.0) to compute capital output shares, $\phi_{j,t}^K = 1 - \phi_{j,t}^R - \theta_{j,t}$, and corrected measures of marginal products of physical and human capital (MPK and MPH). We consider two concepts of marginal products. The first one is simply the physical or quantity marginal products that applies to reallocation experiments with "zero gravity", in which all barriers are removed and all prices are equalized across countries. The second concept is the revenue or *value* marginal product and incorporates differences in output and input prices. For instance, for physical capital, the differences in output and capital prices, $P_{j,t}^Y/P_{j,t}^K$, observed across countries and over time may be the result of technology (the cost of installing capital) or distortions (legislation on labor practices);[2] the quantity and value MPKs are defined as $QMPK_{j,t} = \phi_{j,t}^K Y_{j,t}/K_{j,t}$ and $VMPK_{j,t} = QMPK_{j,t} P_{j,t}^Y/P_{j,t}^K$, respectively. For human capital, we construct the equivalent measures for MPH, imputing series of real wages from the data as explained below.

We first consider the allocation of physical capital. We start by characterizing the behavior of MPKs over time and across countries. A number of clear patterns arise. First, we show that the median MPK has trended down over the entire sample period 1970-2005. It is particularly noteworthy that the global upward trend in the capital income shares, $\phi_{j,t}^K$, has been outpaced by the increasing capital-to-output ratio, $K_{j,t}/Y_{j,t}$, during the sample period.[3] Second, there is a substantial and persistent dispersion in the MPKs across countries. Despite finding that countries with low K/Y also tend to have low capital output shares of output, the data suggest the presence of barriers to the formation of capital of some countries, especially the poorer ones. This finding holds for both QMPK and VMPK, so relative price corrections alone cannot explain cross-country differences in the return to capital. Third, the dispersion in both notions of MPKs decreased substantially between 1970 and the mid-1980s.

To assess the implied level of global capital misallocation—and how its behavior has changed over time—we conduct counterfactuals of equating the $QMPK$ and $VMPK$ across countries subject to the same amount of global capital as measured in the data. Two major findings arise. First, we find a large amount of global capital misallocation, ranging from around 5% of global output in the early 1970s to a rather stable level around 2% since the 1990s. Our numbers are always significantly different from zero and robust to the alternative measure of MPK, the sample of countries, and are unlikely to arise from measurement errors in the output and capital of countries.[4] To put our results in perspective, the global output gains are 2.52% in 1996, which is five times the global output gains in Caselli and Feyrer (2007). Interestingly,

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[2]This notion recognizes the fact that the output and capital prices differ across countries, as emphasized by Restuccia and Urrutia (2001) and Hsieh and Klenow (2007).

[3]This is consistent with the global labor share decline documented in Karabarbounis and Neiman (2014).

[4]Specifically, our MPKs are strongly related to the observable policies (see Section 4.2). We also dispel the possibility that measurement errors in a frictionless benchmark can account for the observed heterogeneity in observed MPKs and implied deadweight losses unless those measurement errors are implausibly large as argued in Restuccia and Rogerson (2008) (see Appendix).

for some countries and years (e.g., China in the 1970s), the individual country losses from the implied capital wedges are at par with the cost of misallocation for India and China (Hsieh and Klenow, 2009). In 1970, the elimination of all frictions to physical capital would have doubled the total Gross Domestic Product (GDP) of South America or sextupled the GDP of Africa. For 2005, the global gains would still suffice to more than double the GDP for the latter group. The implied global gains from removing barriers to capital are comparable to the other gains from openness studied in the literature. For international trade, Costinot and Rodríguez-Clare (2014) report that, according to the basic models, moving from the current level of tariffs to a globally uniform tariff of 40%, the average country would lose between 1% and 2% of real income. For foreign direct investment (FDI), Burstein and Monge-Naranjo (2009) obtain global gains of 1.1% when barriers to FDI to developing countries are removed.[5]

A second major finding is a global movement toward efficiency from the 1970s to the mid-1980s. We show that such global movement is indeed associated with the worldwide movement toward market liberalization and openness observed during that period (Buera et al., 2011). Specifically, we show that according to an extended Sachs and Warner (1995) indicator, the countries with more interventionist polices (such as trade restrictions, price controls, limited convertibility, and heavy government appropriation) exhibited higher implied wedges in their MPKs according to our model. Much of the global improvement in the allocation of capital takes place when most countries switch to market-oriented regimes. Yet, we also find an indication of a narrowing gap in the wedges for some of the remaining interventionist countries, most notably China and India. To reinforce this finding, we show that capital accumulation closely follows the behavior of the MPKs of countries. Specifically, we find that the initial levels of MPK and the growth of their underlying factors (human capital, augmented TFP, relative price of capital and factor shares) can explain up to 90 percent of the cross-country variation in the growth of physical capital during the sample period. Consistent with the work of Gourinchas and Jeanne (2013) and Ohanian et al. (2013), our results indicate that external capital flows are not driving the world toward an efficient allocation of physical capital. Instead, the internal accumulation of capital closely follows the countries' MPKs and may be the culprit for the apparent inaction and misallocation of external flows.

Physical capital is far from the most interesting aspect of global misallocation. A simple efficiency benchmark consisting of equating the human capital $H_{j,t}$ of countries, $QMPH_{j,t} = \theta_{j,t}Y_{j,t}/H_{j,t}$, leads to global losses an order of magnitude higher from the misallocation of human capital relative to that for physical capital. Thus, our findings resemble those in Klein and Ventura (2009) and Kennan (2013), using different models, countries and data. At any rate, the barriers to reallocating human capital (workers) seem to be more stringent than those for physical capital. Some of the barriers are natural, such as the emotional cost of reallocating human beings across countries with different language, culture and values. Yet, other barriers must exist because of legislation, mainly in more developed countries, where the inflow of foreign workers would reduce wages. In fact, the implied global output gains are in the range of 40% to

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[5]For both trade and FDI, the gains could be significantly higher in models that incorporate intermediate goods, technology spillovers, and the diffusion of nonrival factors. However, introducing the features in our model will also enhance the implied global gains for improving the allocation of physical and human capital.

50% (with an upward trend) but would come at the cost of drastic reductions in the wage rate (per unit of human capital) in developed countries.

To appraise the potential gains in global output without the negative impact on the native workers of developed countries, we construct policy counterfactuals that are constrained so that the real wages of workers must be kept constant (at the implied levels from the data.) By design, if workers were the only factor that could be reallocated across countries, no reallocation would take place and global gains would be zero. However, if *both* human and physical capital could be reallocated, even under such a conservative exercise, the global gains would be substantially higher than reallocating physical capital alone, around 8% to 9% of global output in the 1970s and up to 6% by the 2000s. Interestingly, the reallocation is largely from the richer and poorer countries (first and fourth income quartiles) toward the middle ones (second and third income quartiles.)

A proper assessment of global misallocation considers both human and physical capital. The complementarity between these two factors plays a role as they must be directed toward the countries with higher fixed productivity, either because of TFP or natural resources. Observed allocations deviate from such an alignment. More interestingly, if human and physical capital can be reallocated jointly, the direction of the physical capital flows can be reverted relative to the case when physical capital is the only mobile factor. In fact, the premise that capital should flow from rich to poor countries is unwarranted: When both factors are reallocated, capital and labor would flow from some of the poor and middle-income countries toward some of the richer countries. This simple yet often ignored point could be one of the keys to understanding the consequences of alternative integration schemes with or without labor mobility for countries and regions with different productivities and fixed endowments (e.g. the US and Puerto Rico and the European Community one one side with NAFTA on the other).

The paper is organized as follows. The next section describes our measurement of rents for natural resources. Section 3 presents our organizing model framework. Section 4 describes the behavior of MPKs across countries and policy regimes over time. Sections 5 and 6 examine the allocation of physical capital, and Section 7 does so for human capital. Section 8 shows that domestic accumulation and not internal flows account for the observed trends. Section 9 concludes. The appendices contain numerous extensions, comparisons, and additional details.

2   Natural Resources and Output Factor Shares

Growth models most often abstract from natural resources as factors of production. Such an abstraction is of little consequence for most developed countries. However, in this we show section that natural resources remain a substantial aspect of production in some developing countries. Accounting for the rents to the owners of natural resources can lead to nonnegligible changes on the imputed physical capital share of output and its marginal product in some countries, and, in the end, the assessment of inefficiencies in the allocation of physical and human capital across countries.

2.1 The Rents of Natural Resources

A fairly diverse group of factors of production are not relocatable across countries. Most of these resources can be interpreted as "natural resources". We estimate the payments to the rents accrued by natural resources across countries and over time. The WB's project *Where is the Wealth of Nations?* (World-Bank, 2006), and its sequel,*The Changing Wealth of Nations* (Bank, 2011), classify natural resources into (*a*) energy and mineral (subsoil) resources; (*b*) timber resources, (*c*) croplands and (*d*) pasturelands.[6] We adopt this grouping, but also follow Caselli and Feyrer (2007) by adding an additional category, (*e*) urban land, also as a non-relocatable resource across countries.

For each different natural resource, the WB provides direct estimates of the rate of return using a set of benchmark countries. With these benchmark estimates the WB extrapolates the rents for each natural resource for an extended sample of countries.[7] We further extend the sample of countries using data from the United Nations' FAOSTAT database.[8] Our estimates cover all years from 1970 to 2005. The final objective of the WB's project is to estimate the *stocks of wealth* of countries. In our calculations *we only use their rent flow estimates*, and not their wealth stocks estimates. Indeed, as we show extensively in Appendix B, factor share estimates based on wealth stocks overestimate the importance of natural resources, especially for developing countries.

We now explain how we estimate the factor shares for all natural resource items (*a*)-(*e*). First, the rents for (*a*) energy and mineral (subsoil) resources (which include oil, natural gas, coal nickel, lead bauxite, copper, phosphate, tin, zinc, silver, iron and gold) were taken directly from the WB estimates. Second, the rents for (*b*) timber were also taken directly from the WB.[9] Third, we construct our own estimates for the rents for items (*c*) and (*d*), crop and pasture lands, respectively. For croplands (which includes apples, bananas, coffee, grapes, maize, oranges, rice, soybeans, wheat, and many others), we follow the World-Bank (2006)'s methodology: For each crop, the WB estimates the average rate of return to the land for a set of countries that are major producers of that crop. The cropland rents are equal to output net of intermediate goods, retribution to labor, physical capital, and other factors. The rate of return to the land is then computed as the ratio of total land rents and all the land used in producing this crop.[10] We apply those crop-specific rates of return to the quantities reported in FAOSTAT using the U.S. prices for each crop as proxies for their respective international prices.[11] For each country and

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[6]The WB includes non-timber forest resources and protected areas in the calculation of the estimated countries' stock of natural wealth (World-Bank, 2006; Bank, 2011). We do not include these in our computation of natural rents since they are almost certainly omitted in the GDP accounting of most countries, if not all of them. In any event, the rents for these two items are orders of magnitude smaller than the other categories.

[7]*The Wealth of Nations* dataset is available at http://data.worldbank.org/data-catalog/wealth-of-nations.

[8]Available at http://faostat.fao.org/, respectively.

[9]Both are available at http://data.worldbank.org/sites/default/files/subsoil_and_forest_rents.xls.

[10]For example, rental rates estimated for some benchmark countries are: 27% for soybeans (from China, Brazil, Argentina); 8% for coffee (from Nicaragua, Peru, Vietnam, Costa Rica); 42% for bananas (from Brazil, Colombia, Costa Rica, Ivory Coast, Ecuador, Martinique, Suriname, Yemen); etc.

[11]In earlier versions of *The Wealth of Nations* database, the WB used export unit values to value agricultural output. While export values might be poor predictors of output value when the country's markets are not well connected to the world market, their use to measure output was partly due to the lack of country-specific producer

year, we compute the overall rental rate for croplands as the average rate weighted by the land area used for each crop. Total rents are computed using the estimated weighted rate to total quantities reported in FAOSTAT. For the rents of pasturelands (which include beef, lamb, milk, and wool) we follow the World-Bank (2006) by estimating that 45% of the total value of output from FAOSTAT accrues as rents to land. Last, we follow the World-Bank (2006) and Caselli and Feyrer (2007) and estimate that the rents of (e) *urban land* are equal to 24% of the total rents of physical capital, whose estimates are discussed in the next subsection. While the valuation of urban lands may depend on aspects substantially different from other natural resources, their rents should neither be associated with labor nor physical capital earnings. Therefore, for our purposes they are best seen as factors of productions that are not easily relocatable across countries.

With these estimates, the natural resources rents for each country j in period t, $NRR_{j,t}$, is given by the sum of all rents from items timber, subsoil, cropland, pastureland and urban land for that country and year:

$$NRR_{j,t} = \sum_q \text{rents}_{q,j,t},$$

where $q = \{a, b, c, d, e\}$ are the different forms of non-relocatable capital types, as indexed above. For our analysis, we need these rents as a fraction of the country's GDP. Since these rents are computed in current Purchasing Power Parity (PPP) in millions of 2005USD, then the output share of natural resources for country j in period t is simply

$$\phi_{j,t}^R \equiv \frac{NRR_{j,t}}{Y_{j,t}}, \tag{1}$$

where $Y_{j,t}$, is the country's GDP. To compute $\phi_{j,t}^R$, and for all other purposes, we use the variable *cgdpo* production-side real GDP at current PPPs (in millions of 2005USD) from the PWT 8.0.[12] Our benchmark final sample consists of 79 countries (see Appendix A.1) with consistently available information on natural resources throughout the entire sample period from 1970 to 2005.[13] Later, for the reallocation exercises, the sample is restricted to 76 countries because of the availability of human capital data.

For our purposes, it is important to compare the behavior of the share $\phi_{j,t}^R$ across development levels. To this end, Table 1 presents the output shares of the different natural resources for the year 2000. With the exceptions of oil/natural gas and urban land, the natural resources shares of output co-move negatively with the countries income per worker, as shown in the last column.

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prices for agricultural products. More recently, FAOSTAT has started to provide regular coverage of producer prices/gross value of production, and the newest version of The Wealth of Nations values crop production using the newly available producer prices, which tend to be lower than export values (we thank Esther Naikal at the WB for this insight). We compare new pricing strategies of the World Bank with ours that uses US prices as proxies for crop international prices in the Appendix A. We find very similar quantitative results.

[12]Since we focus on country-specific scales of operation to conduct a global reallocation exercise, we focus on the output measure *cgdpo* from PWT which reflects the production capacity of a country.

[13]Section A.3 presents a further analysis for a larger sample countries with consistent data for 2005.

In 2000, the correlation between the total share of natural resources and the countries' per capita output levels is -0.07 for the whole sample, but it is much more negative, -0.67, for the sample that excludes oil-exporting countries. Disaggregating across natural resources, we find that income per worker is negatively related to the share of output attributed to timber forest with a correlation coefficient of -0.29, subsoil resources other than oil and gas, -0.21; pastureland, -0.27; and, in particular, cropland, -0.55.

Table 1: Natural Resources Shares of Output (%, 2000)

	Mean	Median	Coefficient of variation	$\rho_{x,y}$
Natural Resources:	8.19	4.01	1.44	-0.07
▷ Timber	0.13	0	3.76	-0.29
▷ Subsoil:	5.44	0.73	2.1	0.17
Oil	4.03	0.06	2.42	0.15
Gas	1.21	0.1	2.44	0.19
Other	0.28	0	2.79	-0.21
▷ Cropland	2.26	1.06	1.47	-0.55
▷ Pastureland	0.36	0.17	1.53	-0.27
Natural resources with urban land	17.7	14.7	0.62	-0.1
Obs.	79	79	79	79

Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

Disregarding urban land, the largest component of rents generated from natural capital are subsoil resources. For example, in 2000, they accounted an average of 5.44% of output, with oil and natural gas the major components, representing 4.03% and 1.21% of output, respectively. The second major component of natural resources is cropland with a share of output of 2.26%. Pasture land rents and rents from timber forest account for lower shares, respectively, 0.36% and 0.13% of output on average. Excluding the main oil-exporting countries in our sample, the median share of oil rents in terms of output dramatically drops to 0.02% (i.e., close to 3% of its mean value), while the median share of cropland rents drops to 1.06% (i.e., about 53% of its mean value). This suggests a large dispersion in oil shares across countries, which is confirmed by a large coefficient of variation in the third column for oil, 1.6 times larger than that of cropland shares. For non-oil exporting countries, the largest subcategory is cropland rents, which account for 2.01% on average, with subsoil rents being 1.25% on average. For non-oil countries, the median share of natural resources in output is now close to the mean—the mean-to-median ratio is 1.40; this ratio is 2.04 when oil countries are included. For the non-oil sample, the coefficient of variation in the share is 1.08, while for the entire sample with oil countries it is 1.44.[14]

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[14]We find similar patterns with a larger sample of 122 countries for which $\phi_{j,t}^{R}$ are available from 1990 to 2005. Results available upon request.

Figure 1: Natural Resources (Excluding Urban Land) Output Shares, 2000

All Countries

Non-Oil-exporting Countries
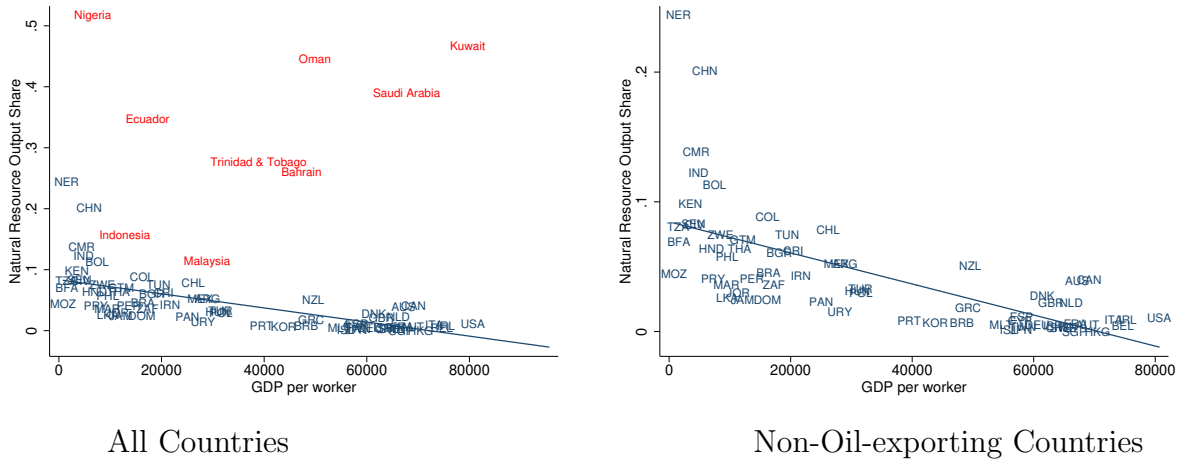
Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

Figure 2: Average Output Share of Natural Resources
(By Income quartiles; non-oil-exporting countries)
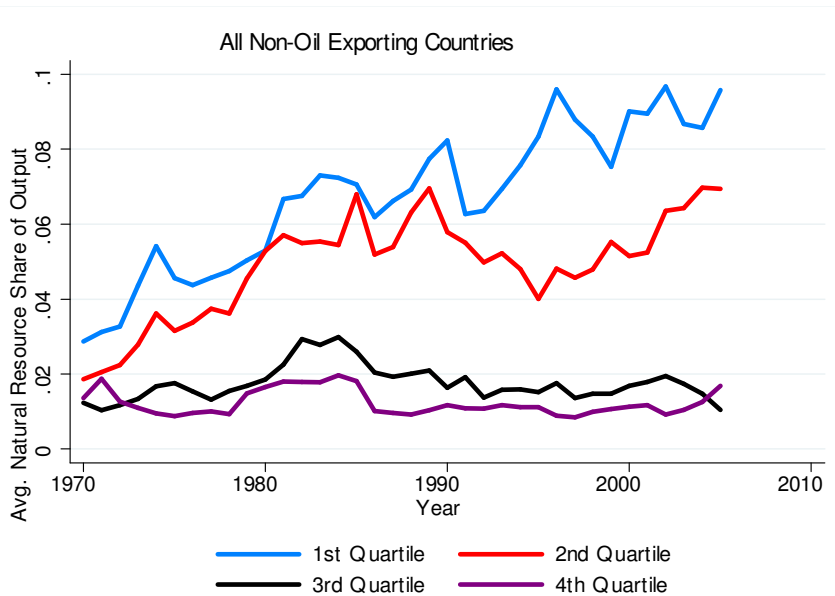
Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

Figure 1 further illustrates the relationship between the output share of natural resources (excluding urban land) and income per worker also for the year 2000. The left panel singles out the oil-exporting countries (marked in red), which we define as those with subsoil shares of output above 10%,[15] Oil-exporting countries have much higher $\phi_{j,t}^R$, averaging 36.80%, versus 4.51% of their non-oil-exporting counterparts and relatively richer than their non-oil counterparts.[16] The right panel focuses on non-oil countries, shows a negative relationship between the natural resources share and output. For non-oil countries with income per worker above \$40,000 in 2000, the natural resources share of output is only 1.13%. The average of this share is much higher, 6.90%, for countries with income per worker below \$40,000 and 9.62% for countries with income per worker below \$10,000.[17] In other terms, the bottom 20% poorest countries in income per worker have a natural resources share of their output that is 8.81 times larger than the natural share of the top 20% richest countries in income per worker.[18]

Figure 2 shows that these cross-sectional patterns are persistent over time. The figure shows the average shares for each different quartile of countries, as ordered by their GDP per capita, for each year from 1970 until 2005. The figure excludes oil-exporting countries, which display a higher and increasing shares. In general, the figure shows clearly that for developed countries (fourth quartile) and higher-income developing countries (third quartile) the output share of natural resources is low and relatively constant, around 1% over the sample years. However, the share is significantly higher for the other half of the countries in the sample (quartiles 1 and 2.) This is particularly stronger by the end of the sample, when natural resources consistently accounted for more than 8% of the income of the countries in the poorest quartile.

2.2 Output Share of Labor and Physical Capital

We now explain how we incorporate our estimates of the factor shares for natural resources for the computation of the output shares for capital and labor. We denote by $\theta_{j,t}$ the labor share of output. In this paper, we use the PWT variable *labsh*. This measure of the labor share aims to correct for the part of ambiguous income, mainly proprietors' income (i.e., the self-employed), that needs to be attributed to labor income in order to avoid underestimating the contribution of labor to output. This is a particularly relevant issue in countries in which a significant amount of labor is allocated to family-owned farms and various forms of self-employment.[19]

In the PWT, as explained in Feenstra et al. (2015), the raw labor share, defined as the ratio of unambiguous compensation of employees (WN) to GDP, $\theta_{j,t} = $ WN/GDP, is adjusted using

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[15]These countries are Bahrain, Ecuador, Kuwait, Nigeria, Oman, Norway, Qatar, Saudi Arabia, and Trinidad and Tobago. Venezuela is not included in our sample due to incomplete information on oil earnings for the most recent years.

[16]The income per worker of oil-exporting countries averages \$51,888, while that of non-oil-exporting countries is \$4,963. That is, the non-oil-exporting countries include a relatively larger share of poor countries.

[17]In this context, and as external validation, it is reassuring that our estimates for cropland rents in poor countries are comparable to those attained from new micro representative farm production data in de Magalhaes and Santaeulàlia-Llopis (2015) and Restuccia and Santaeulàlia-Llopis (2015).

[18]Including oil-exporting countries this factor drops to 1.63.

[19]See Cooley and Prescott (1995) and Gollin (2002).

an algorithm along four different ways to compute ambiguous income (AMB) to select their best estimate of $\theta_{j,t}$, a choice that basically depends on the availability of data on ambiguous income.[20] As we discuss below, the resulting values for $\theta_{j,t}$ from the PWT 8.0 are lower that those in Bernanke and Gurkaynak (2001). Some, but far from all, of the differences are driven by the sample of countries. In the interest of expanding our sample of countries and periods as much as possible, we take the measures from the PWT 8.0 as our benchmark.[21]

For the output share of physical capital, denoted here by $\phi_{j,t}^K$, the standard practice is to equate it to 1 minus the labor share. All non-labor income must be capital income, an assumption driven by a constant returns to scale production function with only physical and human capital as factors. Instead, as proposed by Caselli and Feyrer (2007), correctly accounting for the income shares of natural capital factors, the physical capital share should be calculated as

$$\phi_{j,t}^K = 1 - \theta_{j,t} - \phi_{j,t}^R. \tag{2}$$

This avoids inflating income and the return to physical capital.

3 The Model

We first set out our baseline model and derive the efficiency benchmarks needed to evaluate the degrees of misallocation of mobile factors across countries.

3.1 The Baseline Environment

Consider a world economy, populated by an arbitrary number J of countries, indexed by $j = 1, 2, ..., J$. Given our data, we index the (yearly) time periods by $t = 1970, 1971, ...2005$. Our baseline model assumes a single tradable good, which can be consumed or invested across all the countries. In each country, output is produced using the service flows of the country's stocks of physical capital, $K_{j,t}$, natural resources (land and other natural resources), $T_{j,t}$, and human capital-augmented labor, $H_{j,t} = h_{j,t}L_{j,t}$, where $L_{j,t}$ indicates the number of workers in country j in period t and $h_{j,t}$ their average skills or human capital. Production in the country is also a function of the country's overall TFP, $A_{j,t}$.

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[20]The PWT considers four different adjustments: (i) Add AMB to unambiguous labor compensation, resulting in $\theta_{j,t} = (\text{WN+AMB})/\text{GDP}$; (ii) Assume the labor share, $\theta_{j,t}$, is identical to the labor share of unambiguous output, $\theta_{j,t} = \text{WN}/(\text{GDP-AMB})$; (iii) If proxies for the number of employees (N) and self-employed (SE) are available, then assuming the same average wage for both leads to a labor share is $\theta_{j,t} = (\text{WN/GDP})*(\text{N+SE})/\text{N}$; (iv) Add the value added in agriculture (AGRI) to unambiguous labor income (i.e., $\theta = (\text{WN+AGRI})/\text{GDP}$). The PWT 8.0 constructs its "best estimate" of the labor share using the following procedure: If the unadjusted share is larger than 0.7, no adjustments are used, as the share never excess 0.66 when ambiguous income data are available in national accounts statistics. If the unadjusted share is smaller than 0.7, then if ambiguous income data are available, they use adjustment (ii) because adjustment (i) seems too extreme. Otherwise, if the ambiguous income data are not available, then use the minimum of the resulting shares of adjustments (iii) and (iv).

[21]Table B-2 in the Appendix shows that our choice of labor share is not the main driver of our results.

Our baseline model stems from the standard one-sector growth model, assuming that production of the good in country j at time t is Cobb-Douglas. Specifically, we consider a production function of $Y_{j,t}$ in the form

$$Y_{j,t} = A_{j,t}(K_{j,t}^{\gamma_{j,t}} T_{j,t}^{1-\gamma_{j,t}})^{1-\theta_{j,t}}(H_{j,t})^{\theta_{j,t}}, \tag{3}$$

where $0 < \theta_{j,t} < 1$ is the labor share of output. The non-labor share of output, $1-\theta_{j,t}$, is divided between a share $\gamma_{j,t}(1-\theta_{j,t})$ for produced capital, $K_{j,t}$, and an output share, $(1-\gamma_{j,t})(1-\theta_{j,t})$ for natural resources. This specification extends the standard model in two dimensions. First, it introduces non-produced capital (natural resources) $T_{j,t}$. Second, it allows for country-time variation in the factor shares as documented in the previous section.

Using data on output, $Y_{j,t}$, the stock of physical capital, $K_{j,t}$, labor shares $\theta_{j,t}$, and natural resources shares, $(1-\gamma_{j,t})(1-\theta_{j,t})$, we can readily compute the "quantity" marginal product of physical capital $(QMPK_{j,t})$ as

$$QMPK_{j,t} = (1-\theta_{j,t})\gamma_{j,t}\frac{Y_{j,t}}{K_{j,t}} = \phi_{j,t}^{K}\frac{Y_{j,t}}{K_{j,t}}. \tag{4}$$

Correcting for the output share of non-reallocatable capital (natural resources) leads to significant differences from the findings in the literature on the degree of misallocation of capital across countries. The use of the prefix Q in the measures of MPK is for contrast with the 'value' counterparts developed below. To gauge the economic relevance of cross-country variations, we now specify the efficient benchmark with respect to which we can compare the actual allocations.

3.2 The Baseline Efficiency Benchmark

Throughout the paper, we assume exogenously determined sequences of TFPs $\{A_{j,t}\}$ and service flows of natural resources $\{T_{j,t}\}$ across countries and over time. Cross-sectional distributions of these production factors—and their behavior over time—are what they are, and there is nothing to evaluate. We first take as given the allocation of human capital, $H_{j,t}$, across countries and examine the allocation of the world supply of physical capital, $K_{W,t}$. Then, in Section 7, we examine the joint allocation of the world's physical and human capital. In all the exercises, the quartet $\{A_{j,t}, T_{j,t}, \theta_{j,t}, \gamma_{j,t}\}$ for all countries is taken as given. Similarly, for brevity, we group the fixed factors within a country in a term $Z_{j,t} \equiv A_{j,t}T_{j,t}^{(1-\gamma_{j,t})(1-\theta_{j,t})}$, that embeds TFP $(A_{j,t})$ and the output contribution of natural resources.

Under the assumption that all output is tradable, the optimal allocation of physical capital would maximize global output, that is,

$$Y_{W,t}^{K*} = \max_{\{K_{j,t}\}} \sum_{j=1}^{J} Z_{j,t}(K_{j,t})^{\gamma_{j,t}(1-\theta_{j,t})}(H_{j,t})^{\theta_{j,t}}, \tag{5}$$

subject to not surpassing the world's supply of capital,

$$\sum_{j=1}^{J} K_{j,t} \leq K_{W,t}.$$

Here $K_{W,t} \equiv \sum_{j=1}^{J} K_{j,t}^{O}$ where $K_{j,t}^{O}$, is the observed (PWT 8.0) data for the physical capital for country j in period t.

Naturally, this maximization requires the equalization of the marginal product of physical capital across all countries to common world factor prices r_t^K:

$$QMPK_{j,t} = (1 - \theta_{j,t})\gamma_{j,t}\frac{Y_{j,t}}{K_{j,t}} = \gamma_{j,t}(1 - \theta_{j,t})Z_{j,t}(K_{j,t})^{\gamma_{j,t}(1-\theta_{j,t})-1}(H_{j,t})^{\theta_{j,t}} = r_t^K \qquad (6)$$

for all j and t. In particular, this indicates that countries with higher TFP and/or natural resources, $Z_{j,t}$, a higher supply of human capital, $H_{j,t}$, and a higher output share of physical capital, $\gamma_{j,t}(1 - \theta_{j,t})$, shall receive more physical capital as part of the efficient allocations.

The maximization does not lead to a closed-form solution except when $\gamma_{j,t} = \bar{\gamma}_t$ and $\theta_{j,t} = \bar{\theta}_t$; when the cross-country heterogeneity in factor shares disappears.[22] Although there is not closed-form solution using the heterogeneous values of $\{\theta_{j,t}, \gamma_{j,t}\}$, finding the value $Y_{W,t}^{K*}$ numerically is straightforward. In any event, we assess the degree of *global capital misallocation* according to the global efficiency loss $\ln\left[Y_{W,t}^{K*}/Y_{W,t}^{O}\right]$—that is, the percentage difference between the maximized global output and $Y_{W,t}^{O}$, the sum of the country outputs observed in the data.

3.3 A Benchmark with Prices

Relative prices of capital goods have been highlighted as key to accounting for differences in investment rates (see, e.g., Hsieh and Klenow (2007)), and for differences in the marginal product of capital (see, e.g., Caselli and Feyrer (2007). Since both of these aspects are closely related to our exercise, we incorporate cross-country differences in the relative prices of capital in our analysis.

When the dollar price of output $P_{j,t}^{Y}$ and of capital $P_{j,t}^{K}$ are different across countries, the "value" marginal product of capital, $VMPK_{j,t}$ (i.e., the value of the return to investing in

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[22]In more detail, if factor shares are identical across countries, then the maximized output is equal to

$$Y_{W,t}^{K*} = \left[\sum_{j=1}^{J}\left[A_{j,t}T_{j,t}^{(1-\bar{\gamma}_t)(1-\bar{\theta}_t)}(H_{j,t})^{\bar{\theta}_t}\right]^{\frac{1}{1-\gamma(1-\bar{\theta}_t)}}\right]^{1-\bar{\gamma}_t(1-\bar{\theta}_t)}(K_{W,t})^{\bar{\gamma}_t(1-\bar{\theta}_t)}.$$

capital in country j in period t) is

$$VMPK_{j,t} = \frac{P^Y_{j,t}}{P^K_{j,t}}(1 - \theta_{j,t})\gamma_{j,t}\frac{Y_{j,t}}{K_{j,t}}. \tag{7}$$

Differences in $P^K_{j,t}$ across countries lead to different numbers of machines per dollar invested, $1/P^K_{j,t}$, while differences in $P^Y_{j,t}$ lead to revenue differences for the same units of return physical output. In a world in which investors can freely adjust their portfolios, $VMPK_{j,t}$ would be the criterion for investment across countries, not the quantity $QMPK_{j,t}$ as defined in equation (4.) Thus, the relevant disparities to assess world capital market frictions are in terms of $VMPK_{j,t}$.

An alternative efficiency benchmark that takes $\left\{ P^Y_{j,t}, P^K_{j,t} \right\}$ as given can also be useful to assess the degree of misallocation of physical capital across countries. Consider an environment in which output is entirely tradable, but capital entails installment costs. In fact, assume that to install one unit of capital in country j requires a cost $\varpi_{j,t} = P^K_{j,t}/P^Y_{j,t}$ in units of output goods. Therefore, in terms of goods, the amount of resources required to install the observed $K^O_{j,t}$ in each country j in period t is given by $\left(P^K_{j,t}/P^Y_{j,t} \right) K^O_{j,t}$. In our benchmark with prices, we would like to compare the world output production relative to the optimized one given $K^N_{W,t} \equiv \sum^J_{j=1} \frac{P^K_{j,t}}{P^Y_{j,t}} K^O_{j,t}$, the total amount of goods invested across all countries.

Then, our second benchmark is based on the distance of current output with the upper bound for the maximized world's output (5), but subject to the current global used of resources for physical capital,

$$\sum^J_{j=1} \frac{P^K_{j,t}}{P^Y_{j,t}} K_{j,t} \le K^N_{W,t}. \tag{8}$$

The optimality conditions required the cross-country equalization of the price-corrected marginal product of physical capital, that is,

$$
\begin{aligned}
VMPK_{j,t} &= R^K_t \\
&= \frac{P^Y_{j,t}}{P^K_{j,t}}(1 - \theta_{j,t})\gamma_{j,t}\frac{Y_{j,t}}{K_{j,t}} \\
&= \frac{P^Y_{j,t}}{P^K_{j,t}}\gamma_{j,t}\left(1 - \theta_{j,t}\right) A_{j,t} T^{(1-\gamma_{j,t})(1-\theta_{j,t})}_{j,t}\left(K_{j,t}\right)^{\gamma_{j,t}(1-\theta_{j,t})-1}\left(H_{j,t}\right)^{\theta_{j,t}}.
\end{aligned}
\tag{9}
$$

Under this benchmark, prices also determine the allocation of capital for each country. The higher (lower) the relative price of output (capital) in a country, $P^Y_{j,t}/P^K_{j,t}$, the more physical capital should be allocated to it. For future reference, we will denote by

$$\mu^K_{j,t} \equiv \frac{\left(P^K_{j,t}/P^Y_{j,t} \right) K_{j,t}}{K^N_{W,t}}$$

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the share of the world's investment in physical capital that is allocated to country j in period t. When factor shares differ across countries, neither $Y_{W,t}^{K*}$ nor $\mu_{j,t}^K$ can be solved for in closed form. However, they are easily computed numerically.

4 The Marginal Product of Capital

We now compute the implied marginal products of physical capital MPK. We use the factor share data described in Section 2, along with PWT 8.0 measures of output, physical capital measures, and the prices of output and capital goods.[23]

In particular, the capital stocks in each country/year, $K_{j,t}$, are taken as the variable ck, capital stocks at current PPPs (also in millions of 2005USD).[24] The number of workers in each country and year, $L_{j,t}$, is measured with the variable emp in PWT 8.0 for our measure of aggregate labor—that is, the number of persons (in millions) engaged in production. To estimate the human capital of the country, we use the variable hc in the PWT 8.0; the index of human capital per person, based on years of schooling (Barro and Lee, 2013); and returns to education (Psacharopoulos, 1994). We use that variable to define $h_{j,t}$ for each country and then the aggregate human capital-augmented labor is $H_{j,t} = emp \times hc$. For the price of output, $P_{j,t}^Y$, we use the GDP deflator pl_gdpo; that is, the price level of cgdpo (PPP/XR, normalized so that the price level of USA GDP in 2005 = 1). The price level of capital, $P_{j,t}^K$, is taken to be pl_k, the price level of the capital stock (normalized so that the price for United States in 2005 = 1). Finally, for the price level of consumption, $P_{j,t}^c$, we use the variable pl_c, the price level of household consumption (also normalized so that the price for the United States in 2005 = 1). Next, we describe the behavior of our MPK measures across time and space. Then we relate our MPK measures to observable policies.

4.1 Across Space and Across Time

The panels in Figure 3 present the distribution, across countries, of the quantity and value MPKs over the entire sample period. A number of relevant patterns emerge from these figures. First, the median values of both panels exhibit a clear downward trend, suggesting that capital might have been accumulated across most countries at a faster pace than potential changes in the factor shares. Second, the dispersion of the MPKs has steadily decreased over the sample period. Third, the most dramatic declines in the median and dispersion of MPKs take place in the 1970s to mid-1980s. Fourth, even though some important differences remain, the aforementioned patterns are common across both $QMPK$ and $VMPK$, indicating that none of them are driven by the

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[23]Available online at http://www.rug.nl/research/ggdc/data/penn-world-table; see also Appendix.

[24]For each country, these aggregate stocks are computed applying the perpetual inventory method separately for different types of investment that include structures (residential and nonresidential), equipment (separately for transportation, computers and communication), software, and other machinery and assets. Differences in the composition of investment flows lead to differences in aggregate investment prices and depreciation rates. See the detailed discussion in Feenstra et al. (2015), including a comparison with previous PWT datasets.

Figure 3: Global Evolution of MPKs

$QMPK$ $VMPK$
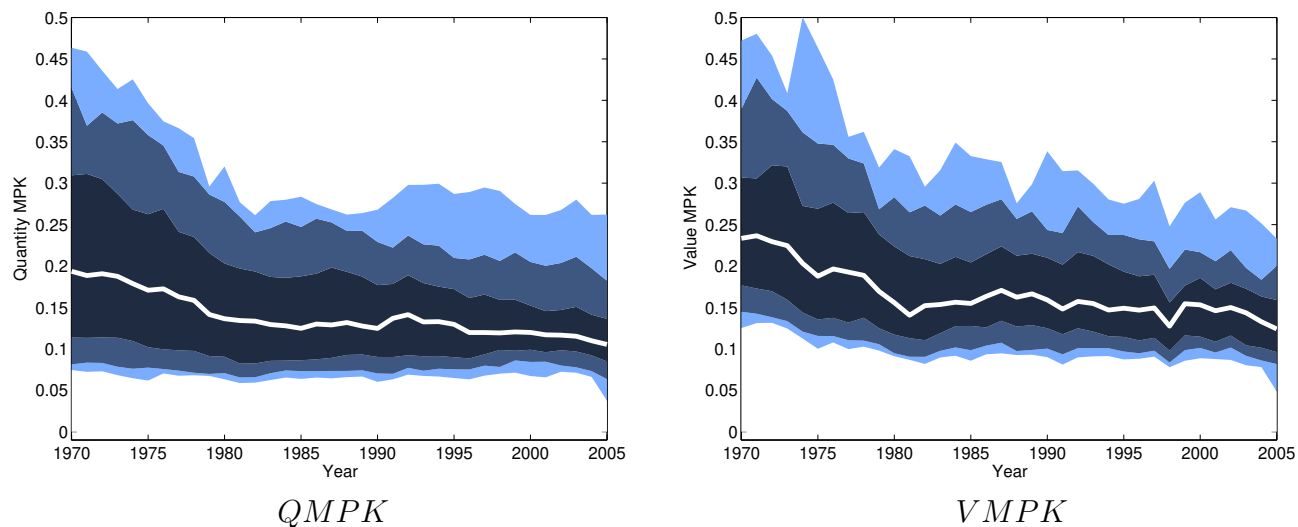
Notes: The white line represents the median, and gradually from dark to light blue shade (i.e., as we move away from the median) we show the interquartile (25th-75th percentile) range, the 10th-90th percentile range, and the 5th-95th percentile range.

Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

relative price of capital to goods across countries. However, the relative price of capital drives significant and persistent differences in levels. For instance, while the median $QMPK$ is about 20 percent in 1970, the $VMPK$ for that year is about 25 percent.

To explore the forces driving the trends in the cross-country dispersion of $MPKs$, we now explore the variance decomposition of the logs of $QMPK_{j,t}$ and $VMPK_{j,t}$. It is straightforward to show that we can decompose those variances in terms of the variance of the (logs) of physical capital output shares, output-to-capital ratios, and the relative price of capital:

$$var\left[\ln QMPK_{j,t}\right] = var\left[\ln \phi_{j,t}^{K}\right] + var\left[\ln \frac{Y_{j,t}}{K_{j,t}}\right] + 2cov\left[\ln \phi_{j,t}^{K}, \ln \frac{Y_{j,t}}{K_{j,t}}\right],$$

and

$$var\left[\ln VMPK_{j,t}\right] = var\left[\ln QMPK_{j,t}\right] + var\left[\ln \frac{P_{j,t}^{Y}}{P_{j,t}^{K}}\right] + 2cov\left[\ln QMPK_{j,t}, \ln \frac{P_{j,t}^{Y}}{P_{j,t}^{K}}\right].$$

The left side of Table 2 shows the variances of the different objects, while the right side presents their pairwise covariances. First, note that there is a downward trend in the dispersion for both $\ln QMPK_{j,t}$ and $\ln VMPK_{j,t}$; for the former, the negative trend runs from 1970 until 2000, while for the latter it runs from 1975 until 2000. Second, these downward trends are mostly driven

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Table 2: Decomposition of the dispersion of $QMPK$ and $VMPK$

Year	Variances (logs of each variable)					Covariances (logs of each variable)			
	$QMPK_{j,t}$	$VMPK_{j,t}$	$\phi_{j,t}^K$	$\frac{Y_{j,t}}{K_{j,t}}$	$\frac{P_{j,t}^Y}{P_{j,t}^K}$	$\phi_{j,t}^K, \frac{Y_{j,t}}{K_{j,t}}$	$\frac{Y_{j,t}}{K_{j,t}}, \frac{P_{j,t}^Y}{P_{j,t}^K}$	$\phi_{j,t}^K, \frac{P_{j,t}^Y}{P_{j,t}^K}$	$QMPK_{j,t}, \frac{P_{j,t}^Y}{P_{j,t}^K}$
1970	0.367	0.147	0.089	0.223	0.161	0.027	-0.160	-0.030	-0.190
1980	0.257	0.174	0.084	0.166	0.062	0.004	-0.073	0.000	-0.073
1990	0.214	0.158	0.065	0.154	0.079	-0.002	-0.074	0.006	-0.068
2000	0.189	0.119	0.071	0.163	0.117	-0.023	-0.114	0.021	-0.093

Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

by both a significant decline in the variation of the log of the output-to-capital ratio $Y_{j,t}/K_{j,t}$ and a decline in the covariance between log-$\phi_{j,t}^K$ and log-$Y_{j,t}/K_{j,t}$. With respect to the former, the contribution of $var\left[\ln\frac{Y_{j,t}}{K_{j,t}}\right]$ to the variance of log $QMPK_{j,t}$ increases from 61% in 1970 to 82% in 2000. With respect to the covariance of $\ln\phi_{j,t}^K$ and $\ln\frac{Y_{j,t}}{K_{j,t}}$, we find that it changes sign between 1970 and 2000. Therefore, from a world in the 1970s where countries with a more capital intensive technology (i.e. high $\phi_{j,t}^K$) were exhibiting relatively lower accumulation of capital (i.e., higher $Y_{j,t}/K_{j,t}$), in the year 2000 we have switched to a world where the more capital-intensive countries are also endowed with relatively more capital. This switch is quantitatively important. In 1970, this covariance *enhanced* the variation in $\ln QMPK_{j,t}$ by 14%. By the end of the sample, it was *reducing* it by a similar magnitude.

A third finding is that between 1970 and 2000, the variation in the log of the capital-income shares $\phi_{j,t}^K$ has a positive but mildly declining contribution on the variance of log $QMPK_{j,t}$. Its contribution lies in a range between 20% and 33%. Factor intensity differences are relevant, but they are the main drivers of the dispersion in the MPK.

We finally explore some simple results from Table 2 on the role of the relative price of capital, $P_{j,t}^Y/P_{j,t}^K$, in the behavior of $VMPK_{j,t}$. First, the dispersion of $\ln QMPK_{j,t}$ is always significantly higher than the dispersion in $\ln VMPK_{j,t}$. In the extreme, in 1970, $var\left[\ln QMPK_{j,t}\right]$ is almost 2.5 times the value $var\left[\ln VMPK_{j,t}\right]$, but this ratio is never below 1.38. This is just a manifestation of the strongly negative correlation between prices and physical marginal products. Indeed, the correlation between $\ln P_{j,t}^Y/P_{j,t}^K$ and $\ln QMPK_{j,t}$ is always between -0.54 and -0.77. Clearly, prices are partially correcting the cross-sectional dispersion in the physical MPK, and countries with high $QMPK$s tend to also have a higher relative cost of installing capital or a relatively lower value of their output (i.e. a low $\ln P_{j,t}^Y/P_{j,t}^K$). However, despite the fact that the countermovement of prices with $\ln QMPK$ can easily overturn by itself the dispersion in $\ln VMPK$ (i.e., the contribution of $2cov\left[\ln QMPK, \ln P_{j,t}^Y/P_{j,t}^K\right]/var\left[\ln VMPK\right]$ is often 100%), this covariance is far from enough to offset the joint dispersion of prices $\ln P_{j,t}^Y/P_{j,t}^K$ and the physical $\ln QMPK$. As a matter of fact, the values for both the physical $\ln QMPK$ and $\ln VMPK$ are always strongly, positively correlated across countries. Their correlation is as high as 0.87 (in 1975) and never below 0.64 (in 2000).

In sum, while the relative price of capital partially offsets the dispersion of physical $MPKs$, these prices are far from eliminating cross-country dispersion (in any point in time) and are not

driving the downward trend in dispersion observed between 1970 and 2005. Even after controlling for the countries' differences in their capital intensity in production and in their observed relative prices of physical capital, there remains a nonnegligible dispersion in the marginal product of physical capital across countries. The overall message from our results is that, despite a downward trend from the early 1970s, there are still significant and persistent distortions in the allocation of capital.

4.2   Relation to Observable Policies

This section briefly explores whether the implied distortions can be related to directly observable measures of policy distortions. To this end, we use a simple indicator, the Sachs and Warner (1995) openness $\{0, 1\}$ indicator (hereafter SW). Specifically, SW require the following five criteria to classify a country as "open": (i) The average tariff rate on imports is below 40%; (ii) Non-tariff barriers cover less than 40% of imports; (iii) The country is not a socialist economy (according to the definition of Kornai (2000)); (iv) The state does not hold a monopoly of the major exports; (v) The black market premium is below 20%. The resulting indicator is a dichotomic variable. If in a given year a country satisfies all five criteria, SW call it open and set the indicator to 1. Otherwise, the indicator takes the value of 0.

While originally SW aimed to design their indicator to classify countries as being open or closed to international trade, the inclusion of criteria (iii) and (iv) allows them to capture forms of government intervention that clearly extend much further beyond restrictions on international trade. Several authors have argued that this indicator is better interpreted as an overall measure toward market friendly versus interventionist policies. In the words of Rodriguez and Rodrik (2000), *"[The] SW indicator serves as a proxy for a wide range of policy and institutional differences,"* where *"trade liberalization is usually just one part of a government's overall reform plan for integrating an economy with the world system. Other aspects of such a program almost always include price liberalization, budget restructuring, privatization, deregulation, and the installation of a social safety net."* In a similar vein, Hall and Jones (1999) use the SW indicator as a proxy for the quality of social infrastructure. Likewise, Buera et al. (2011) use it as an indicator for the adoption of market-oriented versus government interventionist policies. As do these authors, we interpret SW as an indicator not only of barriers to the entry and exit of physical capital, but also to the domestic formation of human and physical capital. To be sure, the black market premium is always joined by many other forms of financial market distortions. Moreover, a socialist government or a government that monopolizes major exports is most likely also a good proxy for government rents that depress the accumulation and/or the effective use of human and physical capital in a country.

Obviously, a dichotomic indicator is at best a stark one and will miss some important liberalizations. Countries with very different degrees of state intervention (e.g. the U.S and France) may end up being classified equally. Moreover, the indicator fails to capture reforms if they do not simultaneously move countries in all five criteria (e.g., China in later years). Indeed, it classifies both India and China as closed economies despite recent notable changes in their policy regimes. The main advantage of the SW indicator is the provision of a simple indicator that is

Table 3: The MPK of Open and Closed Economies: 5-Year Averages (1970-2000)

Year	$QMPK_{j,t}$			$VMPK_{j,t}$			Obs.	
	Open	Closed	t-stat	Open	Closed	t-stat	Open	Closed
1970 - 1975	0.152	0.236	8.39	0.206	0.261	5.80	196	206
1976 - 1980	0.131	0.200	7.84	0.172	0.213	4.87	168	167
1981 - 1985	0.119	0.170	6.32	0.157	0.174	2.16	164	171
1986 - 1990	0.138	0.174	3.70	0.180	0.177	-0.34	207	128
1991 - 1995	0.138	0.185	3.94	0.165	0.195	2.31	294	41
1996 - 2000	0.132	0.235	5.69	0.150	0.186	2.91	310	25

Source: Authors' calculations based on PWT 8.0, WB, FAOSTAT, and Sachs and Warner (1995).

available for most of the country-years in our panel. Richer indicators, are available only for a reduced sample of countries, a cross-section, or only a handful of recent years.

Table 3 compares the MPK of closed and open countries. It compares the averages of both $QMPK$ and $VMPK$ for open and closed countries, splitting the sample in 5-year intervals. The table also presents the t-statistic of a simple test that the average $QMPK$ and $VMPK$ for closed economies are equal to the averages of open economies. The last columns of the table indicate the number of country-years in each window of years.

Some simple conclusions follow from Table 3. First, the marginal product of capital in closed countries is always higher than in open countries. These differences are quantitatively very large and statistically significant. The only exception is that the average $VMPK$ is higher for open countries during the $1986 - 1990$ subperiod, but that difference is not statistically significant. Second, the marginal product of capital for closed countries tends to fall over, while that for open countries remains relatively flat (at lower levels). Third, the number of open countries drastically increases from 1981 onward. The lower MPK of open countries and a higher fraction of them drive the overall downward trend in the average marginal product of capital.[25] Finally, we would also like to emphasize that the fact that our MPK are strongly related to the SW indicator, a good proxy for market-oriented policies (see Rodriguez and Rodrik (2000), Hall and Jones (1999), and Buera et al. (2011)) is reassuring of the low extent of measurement error of our MPK measures.

Table 4 further explores the drivers of the differences between open and closed countries. It lists the averages of capital income shares, $\phi_{j,t}^K$, the average output-to-capital ratio, $Y_{j,t}/K_{j,t}$, and the average output-to-capital price ratio, $P_{j,t}^Y/P_{j,t}^K$, grouping countries into open and closed categories. The table also shows the t-statistic for the test of equality of means for each component. Our results are highly suggestive of how market-oriented countries differ from closed, state interventionist countries. Closed, interventionist countries have much higher output-to-capital ratios than open, market-oriented countries, and these differences are statistically significant. On

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[25]It is worth indicating that essentially the same findings hold if the analysis is done in logarithms as opposed to levels.

Table 4: Factor Shares, Output-to-Capital Ratios, and Relative Prices of Open and Closed Economies: 5-year averages (1970-2000)

Year	$\phi_{j,t}^K$			$\frac{Y_{j,t}}{K_{j,t}}$			$\frac{P_{j,t}^Y}{P_{j,t}^K}$		
	Open	Closed	t-stat	Open	Closed	t-stat	Open	Closed	t-stat
1970 - 1975	0.308	0.342	4.11	0.484	0.699	7.84	1.484	1.236	-5.41
1976 - 1980	0.303	0.334	3.40	0.420	0.609	7.84	1.401	1.139	-8.27
1981 - 1985	0.302	0.318	1.83	0.383	0.559	6.42	1.409	1.102	-8.92
1986 - 1990	0.322	0.318	-0.47	0.421	0.562	4.92	1.399	1.084	-8.91
1991 - 1995	0.331	0.324	-0.59	0.420	0.609	5.06	1.272	1.064	-3.92
1996 - 2000	0.333	0.335	0.17	0.407	0.766	5.80	1.197	1.038	-2.56

Source: Authors' calculations based on PWT 8.0, WB, FAOSTAT, and Sachs and Warner (1995).

the other hand, the relative cost of capital is higher in closed countries than in open countries, suggesting that some of the interventionist policies probably act as a wedge in the cost of investment goods, which is highly plausible, given the fact that much of the equipment is produced (and exported) by a handful of industrialized countries (Mutreja et al., 2014). Interestingly, the capital intensity differences, $\phi_{j,t}^K$, between open and closed economies are neither large nor statistically significant, especially in the second part of the sample. This finding lends support to our approach that factor shares are less distorted by policies and barriers than factor accumulation and the return to production factors.

5   Assessing Global Misallocation

In this section, we present the global output gains of physical capital reallocation. Our results are summarized in Figure 4, which presents the evolution of quantity and value global gains from 1970 to 2005. We find that global misallocation is large with output gains roughly between 5 and 2 percent for entire sample period. Note that 2 percent global output gains are quantitatively important. For instance, in this period the total output in South America is around 5 percent and in Africa is around 2 percent of global output value; that is, if the full 2 percent global gains (i.e., roughly our minimum) were geared toward Africa, its output size would double. In terms of accuracy, we find that the global gains we obtain are significantly different from zero; see the bootstrapped confidence intervals in Table 5. In Appendix B, we further show that our estimates for global output gains are roughly five times larger and also significantly different from those obtained by Caselli and Feyrer (2007) who use *natural resources stocks* to proxy for the natural resources share of output.

In terms of the evolution of global misallocation, there is an unambiguous movement toward more efficiency over time. The equalization of quantity MPK yields gains that start at 5.18 percent in 1970 and decrease to 2.43 percent in 1985 (see Table 5). Since the early 1990s, quantity

Figure 4: Global Output Gains of Physical Capital Reallocation
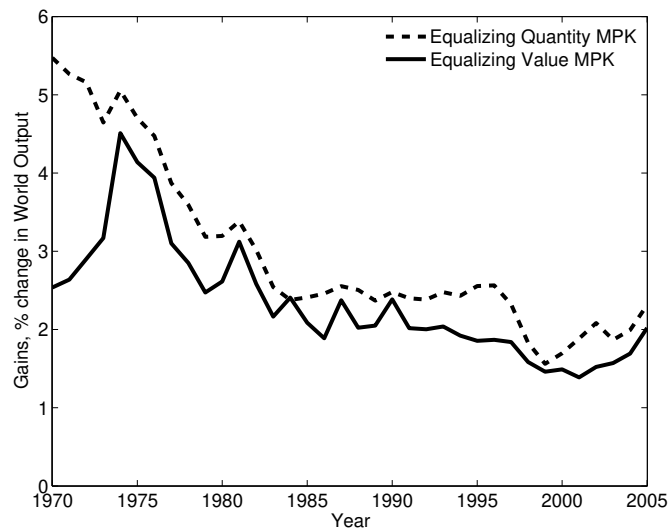
Notes: Our results are based on our measures of MPKs computed using natural resources rents, factor shares, capital, output, and prices as described in section 2. The global output gains are defined as the log difference between the efficient global output implied by the quantity and value models posed in Section 3 and the actual global output.

Table 5: Global Output Gains of Physical Capital Reallocation: Bootstrap Estimates

	1970	1975	1980	1985	1990	1995	2000	2005
Quantity MPK	5.18	4.55	3.13	2.43	2.51	2.47	1.66	2.29
	[3.35,8.27]	[2.87,6.52]	[2.04,4.52]	[1.52,3.58]	[1.59,3.78]	[1.44,4.00]	[0.98,2.44]	[1.34,3.46]
Value MPK	2.38	4.01	2.56	2.10	2.35	1.79	1.46	1.99
	[1.45,3.73]	[2.20,6.30]	[1.57,3.74]	[1.24,3.23]	[1.38,3.76]	[1.06,2.91]	[0.88,2.16]	[1.22,3.00]

Notes: The global output gains refer to the median value of 1,000 bootstrap simulations with 100 percent replacement. The confidence intervals (in brackets) refer to the 10th and 90th bootstrapped percentiles.

global gains have also declined but at a slower pace: from 2.51 percent in 1990 to 2.29 in 2005. The equalization of value MPK shows a similar trend pattern, starting with gains that average 3.20 percent during the 1970s and decrease to roughly 2 percent in 2005. Not surprisingly, the value global gains are always somewhat lower—by an average of 20 percent—than the quantity global gains, indicating the role of prices in accounting for income differences across countries.[26] In addition, for any particular year, quantity and value gains are highly correlated at the country level.[27] We discard the notion that these patterns are driven by measurement error. Instead, as we now discuss, the global movement toward efficiency is strongly associated with the worldwide movement towards market-oriented policy regimes as observed since the early 1980s (see also Appendix C).

## 5.1 Global Policy Movements and Misallocation

Figure 5 shows the fraction of open countries—that is, those with market-oriented policy regimes (right scale) and the median of the implied wedges for physical capital (left scale) in market-oriented countries (blue) and heavily interventionist countries (red.) These wedges were computed as follows: For every year, we compute the allocation of capital resulting from the quantity and value marginal product of capital and obtain the efficient worldwide MPK_t^*. Then, we construct country-specific wedges as: $\Delta_{j,t} = \frac{MPK_{j,t}^o}{MPK_t^*}$, where $MPK_{j,t}^o$ is the observed MPK for country j in period t according to the quantity and value definitions. The patterns for the averages are very similar to those for the medians.

Figure 5 shows very clearly that, along the sample period, the world moved toward openness and market orientation. On the one hand, the number of open countries almost doubled, from just about 50% of the countries in our sample during the 1970s, and the fraction of market-oriented countries reached 92.5% by the end of the sample. The most dramatic increment in the share of market-oriented countries take place during the 1980s. On the other hand, the gap between the implied wedges of market-oriented and government interventionist countries also declined

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[26]Excluding the year 1970, for which the differences between value and quantity gains are the largest, the gap between value and quantity gains slightly drops to 15 percent.

[27]Running a regression of country-specific value gains on quantity gains by year, we find an intercept that remains very close to 0 and a significant slope coefficient that oscillates between 0.6 and 0.8.

Figure 5: Wedges and Number of Market-Oriented and Interventionist Countries

$QMPK$ $VMPK$
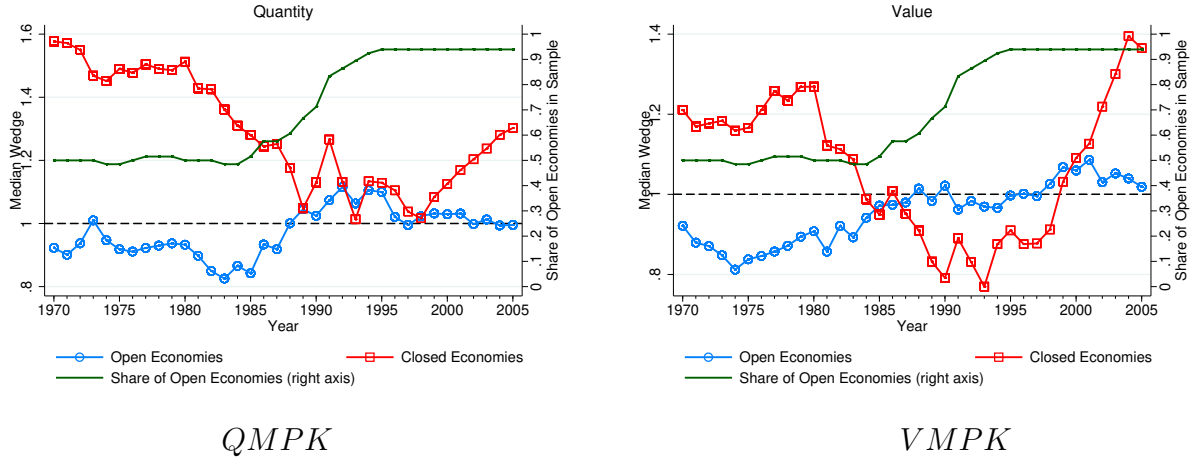
substantially during the 1970s. During the 1980s, the gap completely disappears according to the quantity benchmark, and becomes negative under the value 1. Such a gap becomes positive for both cases for the later part of the sample period, but at that point it applies to only a handful of countries.

Thus, both margins, the number of open countries and the gap in the wedges between closed and open countries, seem relevant for the global movement toward efficiency. To explore further how the global movement in policies may drive changes in global misallocation, we perform a counterfactual simulating how much reallocation would be reduced if all interventionist countries had adopted market-oriented policies. In particular, Figure 6 compares our estimated global misallocation with those when all closed countries are assumed to have the median wedge of market-oriented countries.[28] Three main conclusions arise: First, the degree of the degree of misallocation would have been significantly lower for all years. Second, practically all misallocation would disappear by the end of the sample period. Third, the above conclusions hold for both the quantity and value benchmarks.

5.2 Distributional Patterns: Regions and Income Levels

Interestingly, the global patterns are quite similar under both quantity and value exercises. In both gains of capital reallocation vary greatly across countries. Figure 7 shows the distribution of quantity and value gains for each year from 1970 to 2005. In general, the figures are quite similar. The white line represents the median, the dark green region the interquartile range, the lighter green region the 10th-90th percentile range, and the lightest region the 5th-95th percentile range. The distribution of gains is asymmetric: the percentiles 5th, 10th and 25th are relatively

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[28]Note that the gains in Figure 6 are different from those in 4 because our sample of countries is reduced to 67 countries with information on the SW variable.

Figure 6: Counterfactual Gains in a Market-Oriented World

QMPK

VMPK
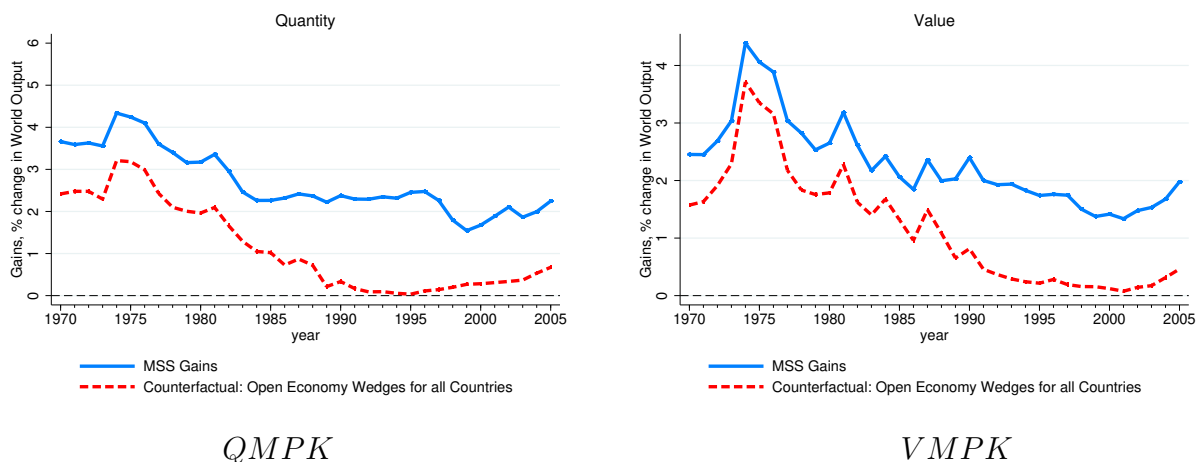
close to the median and percentile 75th, 90th and 95th are further away. For instance, in 1970 the median quantity gains are around 20 percent, the 5th percentile of gains is around minus 20 percent, and the 95th percentile of gains is more than 80 percent. The median quantity gains decrease from about 20 percent in 1970 to around 0 in 2005. The pattern for value gains is similar, but the median gains increase again at the end of the 1990s and the beginning of the 2000s.

To characterize the global output gains further, we compute the gains by regions (Figure 8). Regional differences are striking. First, using the counterfactuals based on QMPK, output gains in Africa would have been roughly 30 percent in 1970, fallen to 10 by the mid-1990s, and then climbed to 20 percent in 2005, even when the global gains are in the 2 percent range. For Latin American and the Caribbean countries (LAC), the gains would also be quite large: 30 percent in 1970, around 20 percent for most of the years between 1980 and 2000, falling to 10 percent at the end of the period. Asian countries (excluding Japan) would initially have much larger gains, around 40 percent in the early 1970s, which is consistent with the findings of Ohanian et al. (2013); then the gains for the Asian countries would consistently fall down to 10 percent in 2005, a reflection of the rapid accumulation of capital observed for these countries. Using the counterfactual with VMPK (i.e. including price differences) would lead to very similar results for Asia and Latin America. The notable difference is that the gains would be much smaller for Africa, driven by the relatively high cost of installing capital in those countries. For 2005, both counterfactuals lead to very similar numbers for almost all regions.

As for developed countries, we find that overall, regardless of using the quantity or value counterfactuals, developed countries (the US, Canada, Europe, and Oceania) will export capital and reduce their domestic production, mostly around 10 percent. The notable exception to this pattern is Japan, which during most years between 1970 and the early 1990s would be a net recipient of capital. These high MPK values for Japan reflect the fast growth experienced by the country during the first 25 years in our sample. Then, from the early 1990s onward,

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Figure 7: Winners and Losers: Distribution of Output Gains of Physical Capital Reallocation
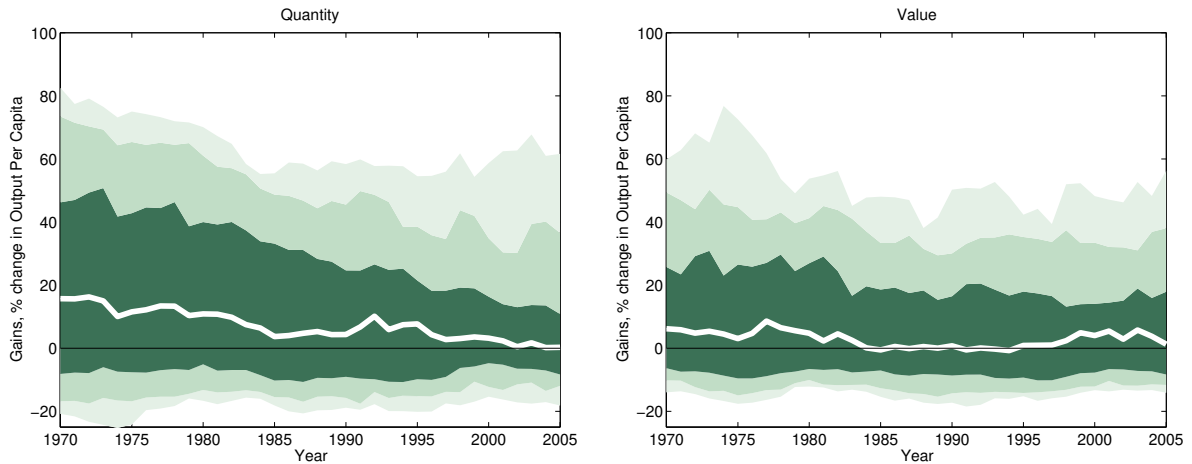
Notes: Results of equalizing QMPK (left panel) and VMPK (right panel) across countries, 1975-2005. The white line represents the median, and gradually from dark to light blue shades (i.e., as we move away from the median) we show the interquartile (25-75 percentile) range, the 10-90 percentile range, and the 5-95 percentile range.

the stagnation of Japan's economy, and perhaps the aging of its population, made the country exhibit a behavior similar of the other developed countries.

A complementary look at the distributional implications of the barriers and distortions to physical capital allocations is shown in Figure 9, in which the set of countries is divided into per capita income quartiles (1st quartile composed by the poorest countries; 4th quartile by the richest ones). As before, the vertical axes indicate the counterfactual gains (in percent) for each group of countries and the horizontal axis the year; the left panel shows the results for QMPK and the right one for VMPK. Four patterns are very clear from these figures. First, as hypothesized by Lucas (1990), some capital would flow out of the rich countries to be allocated to the rest. Second, this pattern of reallocation does not depend on whether we use prices or not. Third, the amount of capital that would be reallocated from developed countries declines over time in both counterfactuals, consistent with movement toward efficiency. Finally, and most interestingly, the gains are not monotonic in income. For most periods, the countries that would gain the most are in the middle, the second, and third income quartiles, and not the poorest countries.

6   Examining the Reallocation of Capital, 1970-2005

A main finding in Section 5 is the improvement in the efficiency of the allocation of world physical capital over the sample period. Such a result might seem to contradict those in the literature, particularly the work of Gourinchas and Jeanne (2013) on international capital flows. In the words of those authors "Capital flows from rich to poor countries are not only low (as

Figure 8: Regional Gains of Physical Capital Reallocation
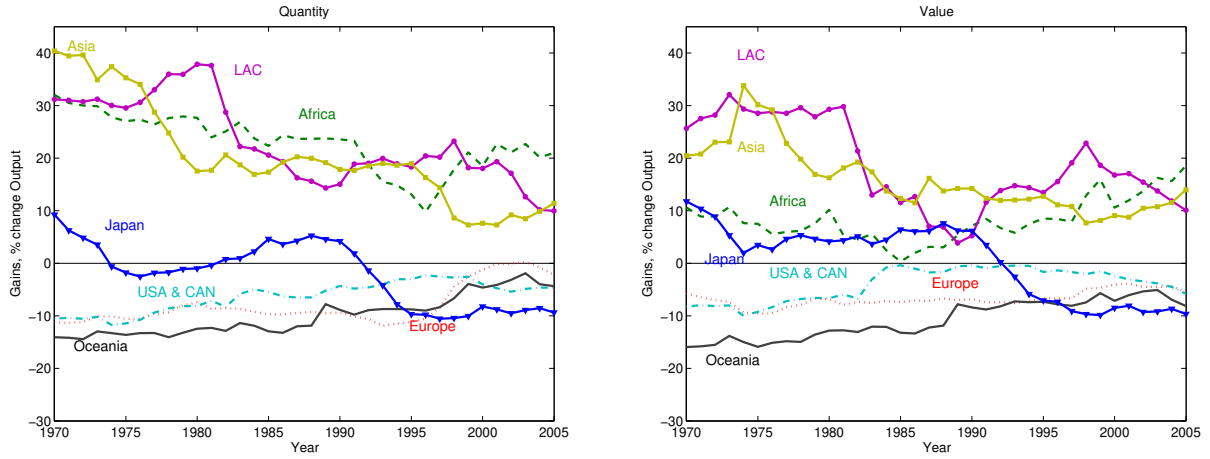
Note: Results of equalizing QMPK (left panel) and VMPK (right panel) across countries from 1975 to 2005. See Appendix A for a list of countries in each region.
Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

Figure 9: Gains of Physical Capital Reallocation across Income Quartiles
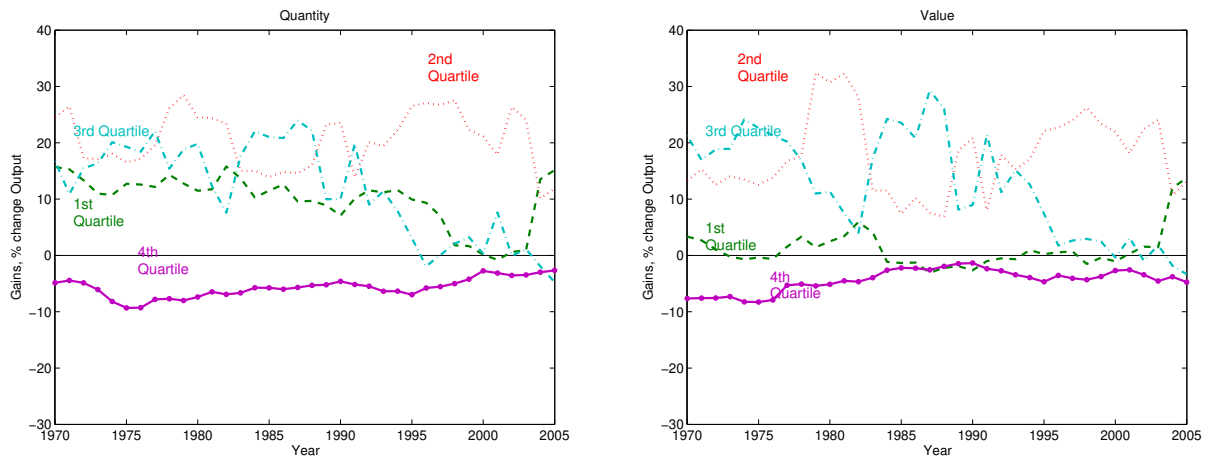
Note: Results of equalizing QMPK (left panel) and VMPK (right panel) across countries from 1975 to 2005. Authors' calculations based on PWT 8.0, WB, and FAO.

argued by Lucas, 1990), but their allocation across developing countries is negatively correlated or uncorrelated with the predictions of the standard textbook model." They call this the "allocation puzzle." In this section, we synthesize these two seemingly contrary views.

The efficient allocation of capital, in our basic framework as well as in many others, does not distinguish between internal (domestic) or external (foreign) sources of capital. Looking at the changes in the total stock of capital in each country is the most direct—if not the only—test of whether, over time, allocations are moving in an inefficient direction. To this end, we perform two exercises. First, we report regressions in the spirit of Gourinchas and Jeanne (2013), but for changes in capital stocks instead of capital flows. Second, we report the results of simple counterfactuals holding the shares of capital as of the beginning and end of the sample period.

6.1   Does Capital Accumulation follow MPKs?

Table 6 shows the results of regressing the growth rate of the capital stock of countries on the initial value of the marginal product of capital and its growth rate. The dependent variable is the cumulative growth rate (log differences) of the capital of each country in 2005 relative to the stocks in 1970. We also report the results using $VMPK$ or $QMPK$ as the measure for MPK. We report the results for the whole sample of countries and for a sample without the OECD countries, to be consistent with the focus of Gourinchas and Jeanne (2013) on developing countries.

The results in Table 6 strongly indicate that from 1970 to 2005, capital accumulation has been positively—and rather strongly—aligned with the direction of the marginal product of capital. First, capital is accumulated at a faster pace in countries with an initially higher marginal return to capital. Regardless of whether we use either values of $VMPK$ or $QMPK$ in 1970 as the relevant measure for the initial marginal product of capital or the ratio of Y/K in 1970 as a proxy of initial capital scarcity, we find that capital flows accumulate faster when the MPK is higher. The effects are quantitatively substantial and statistically significant.

Second, and even more importantly, capital accumulates at a faster pace in countries in which the marginal product of capital, *ceteris paribus*, would have grown at a faster pace. To see this, note that the growth in TFP $(\Delta \ln Z)$,[29] the growth in the share of physical capital $(\Delta \ln \phi^K)$, and the ratio of the output to capital prices $(\Delta \ln P_Y/P_K)$ all have positive, and statistically and quantitatively significant coefficients. A notable exception is with respect to $\Delta \ln H$, the accumulation of human capital, which sometimes exhibits the wrong sign and is statistically insignificant. A positive and marginally significant coefficient is attained only in our least preferred specification, which includes only $(\Delta \ln Z)$, ignore all other components that drive MPK, using only Y/K in 1970 as a proxy for initial capital scarcity, and excluding all the OECD countries.

Third, it is worth highlighting a number of other ancillary results. The first one is that the overall fit of the regression is rather high. In fact, in our preferred specifications, columns (1) and

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[29]Recall the definition $Z_{j,t} \equiv A_{j,t} T^{\phi^R_{j,t}}$. Here, using our values of $\theta_{j,t}$ and $\phi^K_{j,t} = 1 - \theta_{j,t} - \phi^R_{j,t}$, we impute the value of these TFP-like terms as $Z_{j,t} \equiv A_{j,t} T^{\phi^R_{j,t}} = Y_{j,t} / \left[K^{\phi^K_{j,t}}_{j,t} H^{\theta_{j,t}}_{j,t} \right]$.

Table 6: Population-Weighted OLS Regression, $\Delta \ln K$ (1970-2005)

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln Z$	0.425***	0.750***	0.358***	0.504***	0.817***	0.428***
	(0.095)	(0.164)	(0.094)	(0.092)	(0.157)	(0.104)
$\Delta \ln H$	-0.024	-0.034	0.074	0.185	0.300	0.371*
	(0.144)	(0.224)	(0.181)	(0.126)	(0.253)	(0.203)
$\Delta \ln \phi^K$	1.270***	1.631***	-	1.348***	1.597***	-
	(0.269)	(0.458)	-	(0.266)	(0.442)	-
$\Delta \ln \frac{P_Y}{P_K}$	1.687***	-	-	1.665***	-	-
	(0.124)	-	-	(0.110)	-	-
$VMPK_{1970}$	2.188***	-	-	2.055**	-	-
	(0.804)	-	-	(0.786)	-	-
$QMPK_{1970}$	-	6.729***	-	-	6.340***	-
	-	(1.081)	-	-	(1.124)	-
$\left(\frac{Y}{K}\right)_{1970}$	-	-	2.610***	-	-	2.400***
	-	-	(0.438)	-	-	(0.457)
Includes OECD	Y	Y	Y	N	N	N
Observations	76	76	76	53	53	53
R^2	0.876	0.725	0.737	0.890	0.739	0.736

Note: Robust standard errors are listed in parentheses. One asterisk means $p < 0.1$; two asterisks mean $p < 0.05$; and three asterisks mean $p < 0.01$.

Source: Authors' calculations based on PWT 8.0, WB, and FAO.

(4), in which we regress growth of physical capital with initial $VMPK$ and the growth of the factors driving $VMPK$ growth, the regressors account for almost 90% of the variation in $\Delta \ln K$. Needless to say, the high goodness of fit of the regressions does not contradict our findings that important inefficiencies remain at the end of the sample period. The high goodness of fit simply indicates the correlation in the direction of capital accumulation with the drivers of the MPK and does not imply anything about whether the efficient magnitudes coincide with the observed ones.

Another relevant observation is that the main regression results are invariant to the inclusion of OECD countries. Indeed, the fit is marginally better when the OECD countries are excluded. From here, there does not seem to be an allocation puzzle for capital in emerging and developing countries vis-a-vis developed countries.

Finally, our preferred specification is based on the value marginal product of capital, $VMPK$, as the driver of capital accumulation. Our simple model indicates that changes in both capital intensities, $\Delta \ln \phi^K$, and the relative price of output to capital, $(\Delta \ln P_Y/P_K)$, should be included as explanatory variables, if anything to avoid a missing variable bias. Such indication is vindicated by the regression results. Both regressors are not only statistically significant at any confidence level, but also greatly improve the predictive power of the regression.

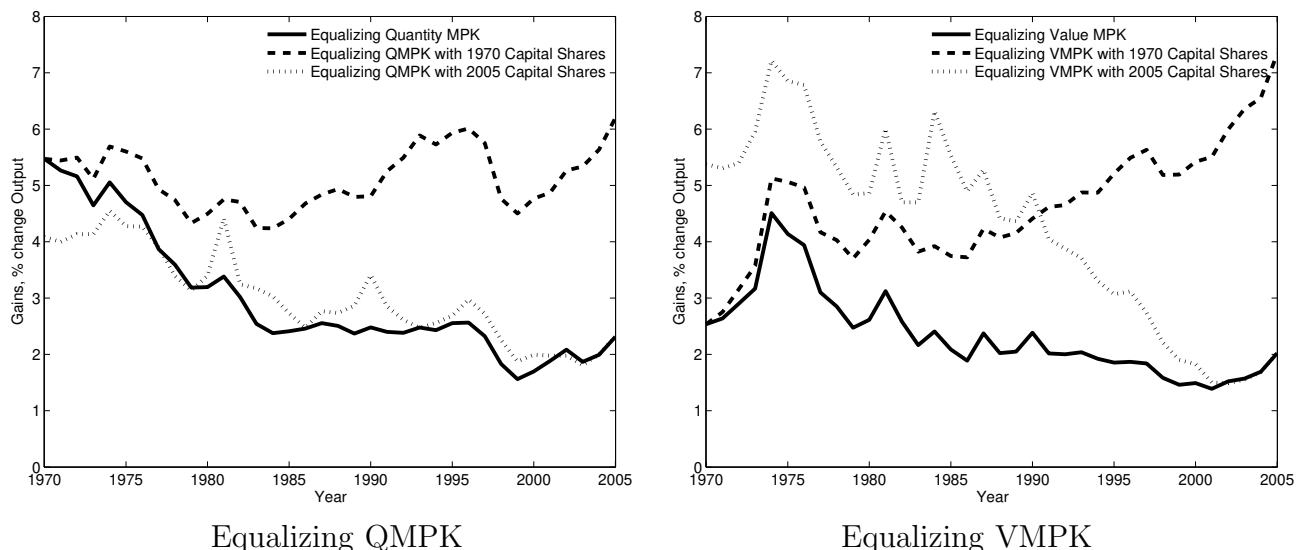## 6.2   Evaluating Counterfactual Allocations

We now use our model to conduct simple reallocation counterfactuals that provide different— and complementary—examination of whether the allocation of capital has improved or worsened during our sample period 1970 to 2005. In these counterfactual exercises, we compute the amount of capital that each country would have if the shares of all countries, relative to the world's total, remain fixed at the levels observed in a given year. Then, we compare the implied efficiency losses with that counterfactual with those based on the actual series, as reported in the previous section. The difference between the gains starting from the actual allocation and those starting from this counterfactual allocation serves as a metric, measured in terms of global output, to evaluate the importance of the changes in capital stocks over time.

In the first counterfactual exercise, we assume that the relative allocation of capital across countries remains fixed at the values observed in 1970, $\mu_{j,1970}^K \equiv K_{j,1970}^O/K_{W,1970}$, where $K_{W,1970} = \sum_j K_{j,1970}^O$ is the world's total physical capital as of 1970. Then, we construct a counterfactual sequence of capital stock for each country j as

$$\tilde{K}_{j,t}^{1970} = \mu_{j,1970}^K K_{W,t}.$$

With the series $\left\{\tilde{K}_{j,t}^{1970}\right\}$, we compute the counterfactual levels of output $\{\tilde{Y}_{j,t}^{1970}\}$ for each country and the implied world's total $\tilde{Y}_{W,t}^{1970}$, assuming that everything in the world economy—that is, the technologies $\{Z_{j,t}, \phi_{j,t}^K, \theta_{j,t}\}$ and labor inputs $H_{j,t}$ for all countries—evolve according to the observed levels. Then, by comparing the attainable gains from the actual allocations,

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Figure 10: Comparing Gains of Counterfactual Allocations

Equalizing QMPK   Equalizing VMPK

Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

$\ln\left[Y_{W,t}^{K*}/Y_{W,t}\right]$ with those from the counterfactual allocation $\ln\left[Y_{W,t}^{K*}/\tilde{Y}_{W,t}^{1970}\right]$, we can discern whether changes in the relative allocation of capital since 1970 have moved the world allocation of capital closer or farther from efficiency. Exactly the same calculations are done for the value benchmarks as defined in Section 3, where the shares are defined as $\mu_{j,t}^{K} \equiv \left(P_{j,t}^{K}/P_{j,t}^{Y}\right)K_{j,t}/K_{W,t}^{N}$ and $K_{W,1970}^{N} = \Sigma_{j}\left(P_{j,t}^{K}/P_{j,t}^{Y}\right)K_{j,t}$.

The second set of counterfactual exercises is done from the vantage view of 2005. That is, we compute the shares $\mu_{j,2005}^{K} \equiv K_{j,2005}/K_{W,2005}$, compute the shares

$$\tilde{K}_{j,t}^{2005} = \mu_{j,2005}^{K}K_{W,t},$$

and follow the same steps to compute the world outputs $\tilde{Y}_{W,t}^{2005}$ and the counterfactual global efficiency loss $\ln\left[Y_{W,t}^{K*}/\tilde{Y}_{W,t}^{2005}\right]$. These second set of countefactuals complements the first ones by indicating how efficient the current distribution of capital would have been for the first years in our sample.

Figure 10 displays the results for the counterfactuals based on physical and value marginal products of capital, $QMPKs$ and $VMPK$. In each panel, the solid lines represent the global efficiency losses from actual allocations, the dashed and dotted lines represent, respectively, the global counterfactual efficiency loses from an allocation that keeps constant the shares as of 1970 and 2005.

In terms of $QMPK$, the left panel of Figure 10 unambiguously shows that the global efficiency losses would have remained approximately flat over time, around 5.5% of global output. The

changes over time in the allocation of capital across countries has more than halved the efficiency losses by the end of the sample. Interestingly enough, if the allocation of capital over the sample period had been that of 2005, the global efficiency losses would have been the same, except for the early 1970s and a handful of years in the early 1980s and early 1990s.

As shown in the right panel of Figure 10, the counterfactuals based on the value marginal products of capital, $VMPK$, convey an only slightly different message. As with $QMPK$, this counterfactual shows that keeping the relative capital allocations constant as in 1970 would have led to a much more inefficient world, with three times the global output losses by the end of the sample. The difference is that the counterfactual using the relative allocation of 2005 would have led to a much more inefficient for any of the years prior to 2000. Overall, both counterfactual exercises coincide in their verdict that the reallocation caused by capital accumulation between 1970 and 2005 was conducive to higher efficiency.

7   The Allocation of Human Capital

We now switch the attention to human capital and the cross-country distribution of its marginal product. Our treatment of human capital is different than, and to some extend subordinate to, that of the physical capital for a number of reasons. First, to be sure, reallocating humans is more complex than reallocating machines. Machines do not have attachments, do not require compensating differences and are not resisted by the pre-existent machines installed in countries. Yet, human capital is reallocated across countries. Not only universities, hospitals, research institutions, but also stores, restaurants, and farms in the US and many other countries agglomerate workers from all over the world. Second, contrary to physical capital (for which we have $P_{j,t}^K/P_{j,t}^Y$, the goods cost for physical capital), we do not have a direct measurement of the relative cost of human capital in each country and period. To overcome this limitation, we conduct experiments that take two extreme and opposite views about the observed cost of labor across countries.

7.1   The Marginal Product of Human Capital

First, we report salient differences in the behavior of the cross-country dispersion in human capital and its marginal product (MPH) relative to what we see for physical capital. The dispersion of MPH is large and growing over time, and the accumulation of human capital does not track the behavior of the determinants of MPH. Second, to the extent that differences in MPH are driven by barriers to the mobility of labor across countries, the global gains of reallocating human capital would be an order of magnitude higher than those of reallocating physical capital. Third, the ability to reallocate workers would not only enhance the gains in global output from reallocating physical capital, but, more interestingly, also induce a reversal in the direction of reallocation of capital across countries. Instead of flowing from richer to poorer countries, capital from poorer countries would follow some of their workers in the direction of richer countries. This simple result could be useful in understanding the difference between integration agreements with labor mobility (e.g., the EU) and without it (e.g., NAFTA.)

Table 7: Decomposition of the Variance of $\ln QMPH_{j,t}$ (1970-2000)

Year	Variances (logs of each variable)			Covariances (logs of each variable)				
	$QMPH_{j,t}$	$\theta_{j,t}$	$\frac{Y_{j,t}}{H_{j,t}}$	$\theta_{j,t},\frac{Y_{j,t}}{H_{j,t}}$	$QMPH_{j,t},QMPK_{j,t}$	$QMPH_{j,t},\frac{P^Y_{j,t}}{P^K_{j,t}}$	$QMPH_{j,t},\frac{Y_{j,t}}{H_{j,t}}$	$QMPH_{j,t},\frac{Y_{j,t}}{K_{j,t}}$
1970	0.756	0.064	0.788	-0.048	-0.082	-0.019	0.740	-0.042
1980	0.713	0.061	0.726	-0.037	-0.169	0.058	0.689	-0.105
1990	0.748	0.058	0.642	0.024	-0.149	0.111	0.666	-0.107
2000	0.978	0.059	0.899	0.010	-0.038	0.029	0.909	-0.021

In our framework, the marginal product of one unit of human capital in terms of quantity of goods ($QMPH_{j,t}$) is simply given by

$$QMPH_{j,t} = \theta_{j,t}\frac{Y_{j,t}}{H_{j,t}}.$$

Therefore, as we did with MPK, we can simply decompose the cross-sectional variance of $\ln RMH_{i,j}$ in terms of the labor share of output and the output-to-human capital ratios:

$$var\left[\ln QMPH_{i,j}\right] = var\left[\ln \theta_{j,t}\right] + var\left[\ln \left(Y_{j,t}/H_{j,t}\right)\right] + 2cov\left[\ln \theta_{j,t}, \ln \left(Y_{j,t}/H_{j,t}\right)\right].$$

Table 7 reports the values of these variances and the covariance for a number of years over the sample period. The right side of the panel also reports a number of covariances of interest with respect to the joint reallocation of human and physical capital across countries.

Contrary to physical capital, there is an upward trend in the dispersion in the $\ln QMPH$. From a low value of 0.713 in 1980, the variance in $\ln QMPH$ grows thereafter until reaching its highest value of 0.978 in 2000. Almost all of the variation is driven by the dispersion in $\ln\left[Y_{j,t}/H_{j,t}\right]$. Indeed, the cross-country correlation $\ln QMPH$ and $\ln\left[Y_{j,t}/H_{j,t}\right]$ is always above 0.95. Differences in the labor share of output, $\ln \theta_{j,t}$, account for at most 9% of this variations, a contribution that remains flat around 7%-8% during the sample period. The covariance between $\ln \theta_{j,t}$ and $\ln\left[Y_{j,t}/H_{j,t}\right]$ provides a negligible contribution.

The cross-country covariation between the marginal products of human and physical capital is key for the potential gains of jointly reallocating these factors. We find that while negative, the magnitude of this covariation is rather weak. From the variances and covariances of $\ln QMPH$ and $\ln QMPK$ (reported in Tables 2 and 7), we see that $\ln QMPH$ and $\ln QMPK$ are always negatively correlated. The magnitude of this correlation increases and then decreases at the end of the sample. A very similar pattern is followed by the correlation between $\ln QMPH_{j,t}$ and $\ln\left[Y_{j,t}/K_{j,t}\right]$. Conversely, the correlations of $\ln QMPH_{j,t}$ with $\ln\left(P^Y_{j,t}/P^K_{j,t}\right)$ and with $\ln VMPK_{j,t}$ exhibit quite the opposite pattern. Their correlations are negligible at the beginning and the end of the sample but reach levels about 0.4 in the middle of the sample period.

7.2 Gains of Human (and Physical) Capital Reallocation

We now use the same framework to analyze the efficiency losses from misallocating both, capital and labor. In our setting, the fixed factors in each country are the TFP and the natural resources, group in the term $Z_{j,t} \equiv A_{j,t} T_{j,t}^{(1-\gamma_{j,t})(1-\theta_{j,t})}$. Note that the output share of natural resources is important for our computations because it determines the returns to scale of mobile factors, human and physical capital, in each of the countries.

Baseline. The optimal global allocation is defined by the same objective as before—that is,

$$Y_{W,t}^{K^*,H^*} = \max_{\{K_{j,t},\, H_{j,t}\}} \sum_{j=1}^{J} Z_{j,t} \left(K_{j,t}\right)^{\gamma_{j,t}(1-\theta_{j,t})} \left(H_{j,t}\right)^{\theta_{j,t}},$$

but instead of setting human capital at observed levels, $H_{j,t} = H_{j,t}^O$, the constraint becomes

$$\sum_{j=1}^{J} H_{j,t} \leq H_{W,t}$$

where $H_{W,t} \equiv \sum_{j=1}^{J} H_{j,t}^O$ for all t. In addition to equalizing the $QMPK_{j,t}$ of all countries to a common world price, r_t^K, efficiency requires that all $QMPH_{j,t}$ be equalized to a common price

$$r_t^H = \theta_{j,t} Z_{j,t} \left(K_{j,t}\right)^{\gamma_{j,t}(1-\theta_{j,t})} \left(H_{j,t}\right)^{\theta_{j,t}-1}. \tag{10}$$

Thus, the world supply levels $K_{W,t}$ and $H_{W,t}$, and the productivities and endowments of natural resources $Z_{j,t}$ of all countries pin down the equilibrium r_t^K and r_t^H. These prices and the factor shares determine the factor intensity of each country,

$$\frac{K_{j,t}}{H_{j,t}} = \frac{\gamma_{j,t} \left(1-\theta_{j,t}\right)}{\theta_{j,t}} \frac{r_t^H}{r_t^K}.$$

The efficient allocation implies that human and physical capital are allocated across countries to complement their TFP and natural resources as allowed by their country-specific returns to scale to mobile factors. As before, there is not a closed-form solution except for the case of common (time-varying) factors shares, but the numerical optimization is trivial.

Value benchmark. The previous benchmark presumes that workers are indifferent as to where to work, and cross-country differences in output per worker are sustained by barriers to worker migration. The completely opposite view is that barriers are not the key limitation, and wage differences are sustained by compensating differences; Differences in QMPK, and thus in wages, are sustained because workers demand different wages to live in different places.

Attempting to model and empirically discipline the behavior of compensating differences lies outside the limits of this paper.[30] Instead, we focus on a simple exercise that reallocates workers and capital but subject to keeping constant the real wages of workers, in terms of consumption goods, $w_{j,t}^h P_{j,t}^C / P_{j,t}^Y$, as inferred in the data in each country in each period. Since we do not have direct measurements on wages in terms of output, $w_{j,t}^h$, we use our model and infer it as $w_{j,t} = \theta_{j,t} Y_{j,t} / H_{j,t} = QMPH_{j,t}$. Thus, by fixing real wages of all countries at a point in time, this counterfactual is consistent with any decomposition of those wages arising from compensating differentials or barriers to mobility of workers. Notice also that if only workers, but no physical capital, are allowed to move, the reallocation would be minimal, due only to the small variation in the data for the relative price $P_{j,t}^C / P_{j,t}^Y$. For the maximization in this benchmark, the natural resource constraint is that the global amount of goods paid for human capital services in each period is equal to the one inferred in the data:

$$\sum_{j=1}^{J} \frac{P_{j,t}^C}{P_{j,t}^Y} w_{j,t}^h H_{j,t} \leq H_{W,t}^N, \tag{11}$$

where $H_{W,t}^N \equiv \sum_{j=1}^{J} \frac{P_{j,t}^C w_{j,t}^h}{P_{j,t}^Y} H_{j,t}^O$ and $H_{j,t}^O$ is the observed data value for country j in period t. As in the case when only capital can move, we impose the restriction

$$\sum_{j=1}^{J} \frac{P_{j,t}^K}{P_{j,t}^Y} K_{j,t} \leq K_{W,t}^N, \tag{12}$$

subject to providing the same amount of consumption goods to workers as implied by the data.

There is an intuitive interpretation for this exercise. Imagine a firm owner who is able to reallocate resources across countries and his firm is small enough that takes prices as given. In terms of wages, imagine this person is limited by country-specific regulations (unions, minimum wages, and so on) to pay the period t wage in country i for any worker that he reallocates to country i in period t. She is given the task of reallocating workers across countries to maximize real output subject to keeping the company's payroll constant. Since we measure wages by $QMPK$ (disregarding $P_{j,t}^C / P_{j,t}^Y$ differences), the firm's owner has no incentives to reallocate workers if capital cannot be reallocated. In this sense, this exercise provides a lower bound for the global gains of human capital reallocation. Once capital can also be reallocated, there are potential gains of reallocating workers even subject to the constraint of keeping wages constant in each country.

The optimality conditions required the equalization across countries of the price-corrected

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[30]For that, see Klein and Ventura (2009).

marginal product of physical and human capital across countries; that is,

$$R_t^K = \frac{P_{j,t}^Y}{P_{j,t}^K}\gamma_{j,t}\left(1-\theta_{j,t}\right)A_{j,t}T_{j,t}^{(1-\gamma_{j,t})(1-\theta_{j,t})}\left(K_{j,t}\right)^{\gamma_{j,t}(1-\theta_{j,t})-1}\left(H_{j,t}\right)^{\theta_{j,t}}, \tag{13}$$

for physical capital and

$$R_t^H = \frac{P_{j,t}^Y}{P_{j,t}^C w_{j,t}^h}\theta_{j,t}A_{j,t}T_{j,t}^{(1-\gamma_{j,t})(1-\theta_{j,t})}\left(K_{j,t}\right)^{\gamma_{j,t}(1-\theta_{j,t})}\left(H_{j,t}\right)^{\theta_{j,t}-1}. \tag{14}$$

Note that, given the world's returns R_t and R_t^H, the physical-to-human capital ratio in country j should be
$$\frac{K_{j,t}}{H_{j,t}} = \frac{\gamma_{j,t}\left(1-\theta_{j,t}\right)}{\theta_{j,t}}\frac{P_{j,t}^C w_{j,t}^h}{P_{j,t}^K}\frac{R_t^H}{R_t^K}.$$

Thus, in the efficient allocation, the physical capital intensity, relative to human capital, varies across countries according to their (i) factor shares in production, (ii) relative price of consumption and capital goods, and (iii) effective cost of labor. While natural resources $T_{j,t}$ and pure TFP $A_{j,t}$ enhance the amount of human and physical capital a country should receive, the cost in terms of output of both factors, respectively $P_{j,t}^K/P_{j,t}^Y$ and $P_{j,t}^C w_{j,t}^h/P_{j,t}^Y$, reduces them. It is trivially true that this maximization dominates the one where only capital can be reallocated. The interesting question is how much and whether capital flows change in magnitude and direction.

Results. Figure 11 shows the global output gains of reallocating both physical and human capital and human capital only, respectively. In each panel, the dashed lines represent the gains from the benchmark. The solid lines represent the gains from the value benchmark as defined above.

The most salient result is that the global gains of reallocating workers and physical capital can be much higher—more than one order of magnitude higher—than the global gains of reallocating only physical capital. The quantity benchmark indicates that, for all the years in the sample, the global gains would be approximately 55% of world output. Those gains remain relatively flat over the sample period. The value benchmark also indicates a larger gain, but only around twice that of reallocating capital only.

A second important result is that the complementarity between human and physical capital is a key determinant for the larger gains from their joint reallocation. As shown in the right panel, reallocating human capital per se leads to very large gains in the quantity benchmark counterfactual, but they are far from accounting for the difference between the joint reallocation and the physical capital only reallocation. This finding is even clearer in the value benchmark, where the gains of reallocating labor only would be negligible.

Yet, perhaps the most interesting result is a reversal of the direction of capital flows. When only capital can be reallocated, capital would tend to flow from richer to poorer countries. Instead, when both factors can be reallocated, capital would flow from poorer to richer countries.

Figure 11: Global Output Gains of Production Factors Reallocation

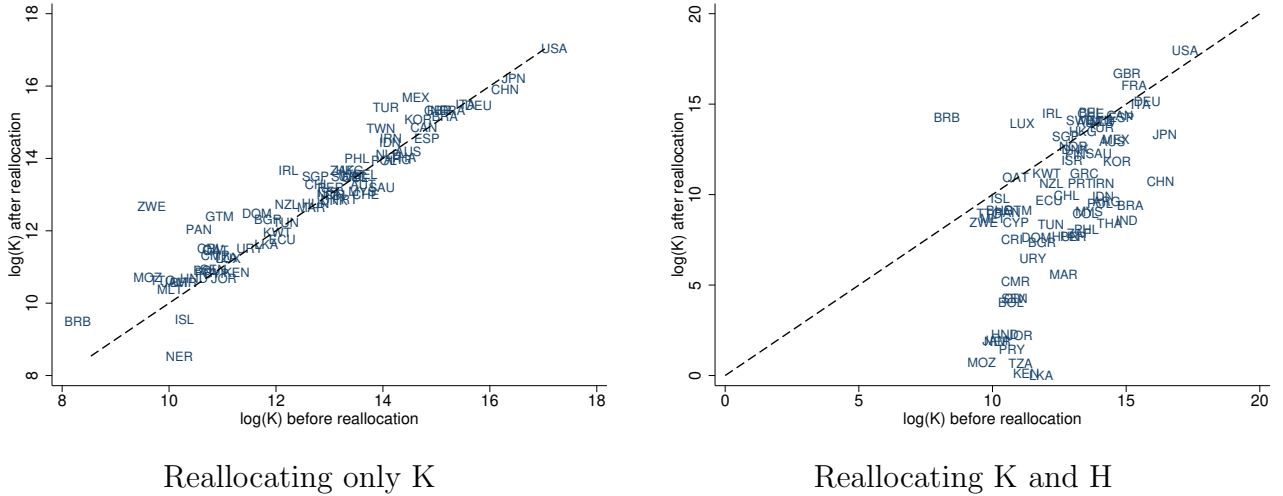Reallocating H and K   Reallocating only H
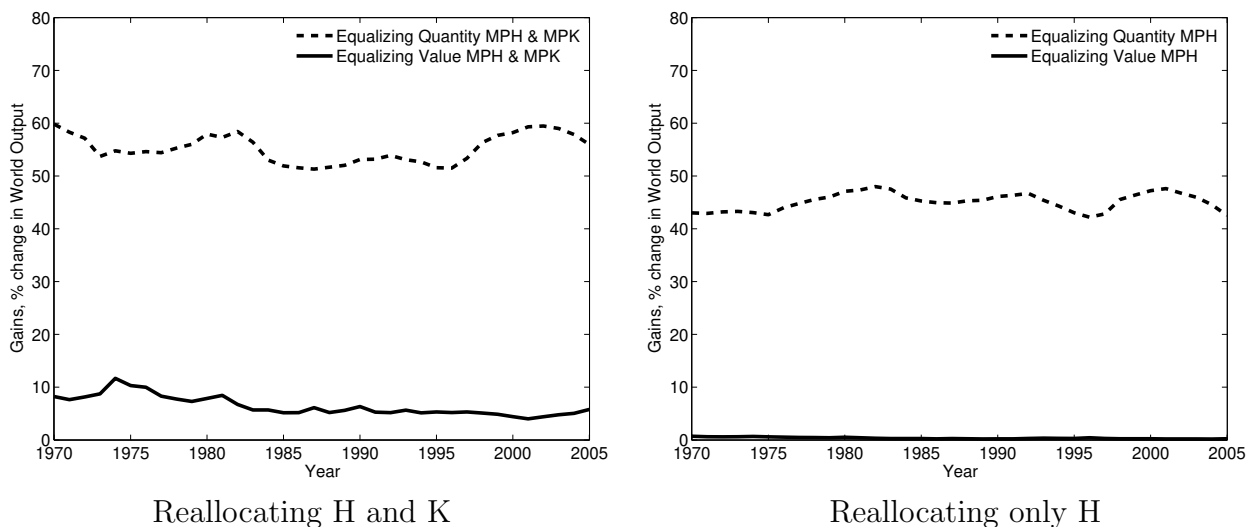
Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

Figure 12 illustrates this for 1996 by comparing actual physical capital stocks (in logs) for that year, with the resulting physical capital stocks after the two different reallocations. In the first case, most countries in the data would increase their physical capital, receiving it from a smaller group of the countries, including a handful of the rich ones. In the second case, most of the countries would lose physical capital, sending it, along with part of their human capital, to the United States and a handful of rich countries because of their high TFP and endowment of natural resources.

We finish this section by examining the distributional implications of the counterfactual efficient reallocations. In Figure 13, we show the change in the output of the country groups by income quartiles. In the left panel, we show the results of equating both quantity marginal products—$QMPK$ and $QMPH$—across countries. The right panel shows the results for the counterfactual with prices—that is, equating $VMPK$ and $VMPH$ across countries, where we impose that the wages of workers across countries must remain constant at the level before the reallocation.

A number of interesting patterns are evident. First the magnitude of the gains or losses is much larger than when only one factor is reallocated, especially in the quantity counterfactual. Second, in the quantity counterfactual, the richer countries (fourth income quartile) and sometimes the middle-to-high income countries (third quartile) would expand production, while the poorer countries (first and second quartiles) always contract. Such a reallocation from poor to rich necessarily involves physical capital. Clearly, the required reallocation is exactly the opposite from Lucas (1990). This simple result could prove useful for understanding the resulting capital flows from economic integrations, differentiating between those in which workers can be reallocated (e.g., the European Community and the US-Puerto Rico), and those in which they

Figure 12: Changes in the Allocation of Production Factors (1996)

Reallocating only K

Reallocating K and H

Note: The results here correspond to the benchmark setup without differences in prices.
Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

Figure 13: Gains of Reallocating Human and Physical Capital across Income Quartiles
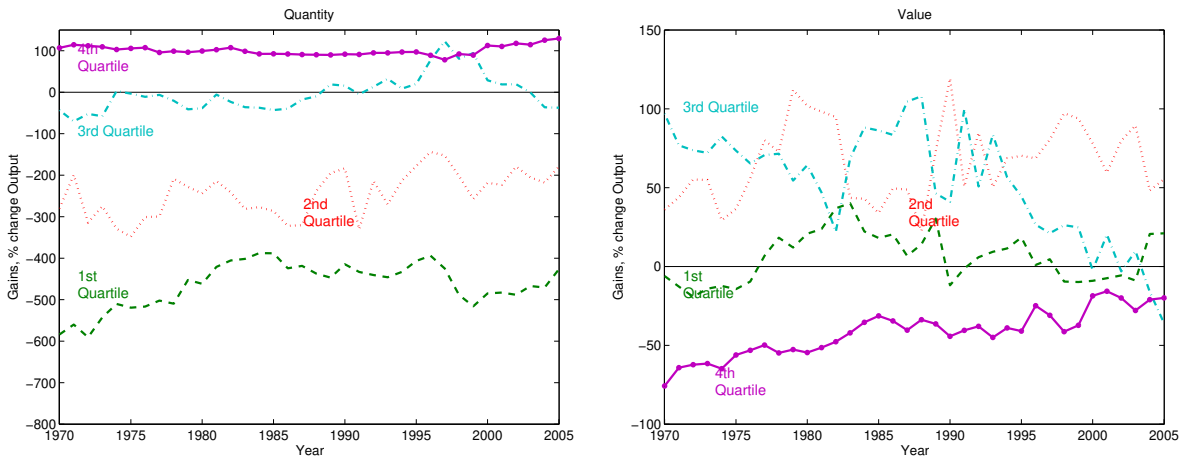
Note: Results of equalizing QMPK and QMPH (left panel) and VMPK and VMPH (right panel) across countries
from 1975 to 2005.
Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

cannot (e.g., NAFTA and Central America Free Trade Agreement, CAFTA). This simple result could also be useful in understanding the allocation of physical and human capital across regions within large countries (e.g., USA, Brazil and China).

Another stark difference with the physical capital only reallocations is that in this case the quantity and the value counterfactuals lead to very different patterns from each other. Once we impose the distributional restriction that foreign workers must earn the same income as domestic ones, the direction of global reallocation reverts, from rich to poor. Wage restrictions of the form imposed here endogenously make the human capital of countries behave as fixed factors, and reallocations tend to be similar as when physical capital is the only mobile factor. The wages of developed countries are too high, resulting in factor flows to countries in the second and third income quartiles, but not to the poorest ones because of their lower productivity and larger curvature.

7.3   A Human Capital Reallocation Puzzle

To examine whether there is a reallocation puzzle for human capital, we now perform the same analyses we did for physical capital. In this case, however, there is little evidence that the countries with the largest increase in human capital were those with the highest return. In general, the measure of the initial MPH appears insignificant in the regression to account for the change in human capital (displayed in Table 8). Changes in TFP and physical capital are also insignificant in accounting for changes in human capital. The R-squared values of these regressions are also much lower than those for physical capital, indicating that these driving forces are much less important in driving investment in human capital.

These results seem to be in line with Easterly (2002), who argues that "The growth response to the dramatic educational expansion of the last four decades has been distinctly disappointing ... creating skills where there exists no technology to use them is not going to foster economic growth."

8   External Flows Versus Domestic Accumulation

For physical capital, Sections 5 and 6 documented a strong trend toward global efficiency. Section 7 showed that such a trend is not present for human capital. In this final section, we explore the role of external flows in shaping up these findings.

8.1   Physical Capital

We first show that domestic savings drive the movement toward efficiency in the allocation of physical capital from 1970 to 2005. In essence, the countries whose MPK grows the faster were also the ones saving the most. Then, rather than contradicting, our findings reinforce and

Table 8: Population-Weighted OLS Regression, ΔH (1970-2005)

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln Z$	0.081	0.098	0.044	-0.044	-0.021	-0.067
	(0.085)	(0.091)	(0.093)	(0.095)	(0.089)	(0.083)
$\Delta \ln K$	0.092	0.033	0.070	0.117*	0.065	0.109
	(0.069)	(0.070)	(0.106)	(0.067)	(0.062)	(0.081)
$\Delta \ln \phi^H$	-1.133**	-0.935**	-	-0.706	-0.568	-
	(0.429)	(0.385)	-	(0.429)	(0.383)	-
$\Delta \ln \frac{P_Y}{P_C}$	1.157**	-	-	1.083***	-	-
	(0.455)	-	-	(0.373)	-	-
$VMPH_{1970} \times 10^{-3}$	-0.015	-	-	-0.025	-	-
	(0.014)	-	-	(0.015)	-	-
$QMPH_{1970} \times 10^{-3}$	-	-0.024*	-	-	-0.030	-
	-	(0.014)	-	-	(0.018)	-
$\left(\frac{Y}{H}\right)_{1970} \times 10^{-3}$	-	-	-0.014	-	-	-0.011
	-	-	(0.013)	-	-	(0.013)
Includes OECD	Y	Y	Y	N	N	N
Observations	76	76	76	53	53	53
R^2	0.411	0.340	0.176	0.471	0.349	0.174

Note: Robust standard errors are listed in parentheses. One asterisk means $p < 0.1$; two asterisks mean $p < 0.05$; and three asterisks mean $p < 0.01$.

Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

transcend the negative results of Gourinchas and Jeanne (2013) on the role of foreign capital flows in attaining efficiency. We argue that, at least for the second part of our sample period, foreign capital flows have been all but irrelevant for the cross-country capital allocation, echoing the old result of Feldstein and Horioka (1980).

To this end, we perform an additional simple counterfactual exercise. We compute how the changes in the allocation of capital across countries would change over time solely on the basis of external capital flows. As in the previous exercises, we compute this for the initial year and for the final year in a given period.[31] For the former, the shares $\mu_{j,1982}^K = K_{j,1982}/K_{W,1982}$ describe the relative world capital allocation that year. Then, for each country, we construct the counterfactual capital series for 1983 to 2000, as augmented or reduced by net capital inflows $\{XK_{j,s}\}_{s=1982}^{2000}$—outflows if negative—defined by

$$\bar{K}_{j,t} = \mu_{j,1982}^K K_{W,t} + \sum_{s=1982}^{t} (1-\delta)^{s-1982} XK_{j,s}.$$

The counterfactuals from the vantage point of 2000, are derived from exactly the same formula but using $\mu_{j,2000}^K$.

For $XK_{j,s}$ we use the negative of the trade balance of the countries.[32] We depreciate the capital flows at $\delta = 4.64\%$, the depreciation rate for the US in PWT 8.0.

Figures 14 reports the results for the exercises based on $QMPK$ and $VMPK$, respectively. In each graph, the exercises with 1982 shares are in darker lines and lighter ones for 2000. Dashed lines are used for the counterfactuals with the observed $XK_{j,s}$. The finer, solid lines are the cases when $XK_{j,s} = 0$.

The most striking result is how little foreign flows change the allocation of capital and the potential global output losses. External capital flows are dwarfed by domestic savings and the overall capital formation of countries. The irrelevance of external capital flows for global efficiency is succinctly shown by almost undistinguishable dashed and solid lines in both graphs. If anything, the magnitude of the external flows is so small that, effectively, it does not really matter whether they are misallocated or not.
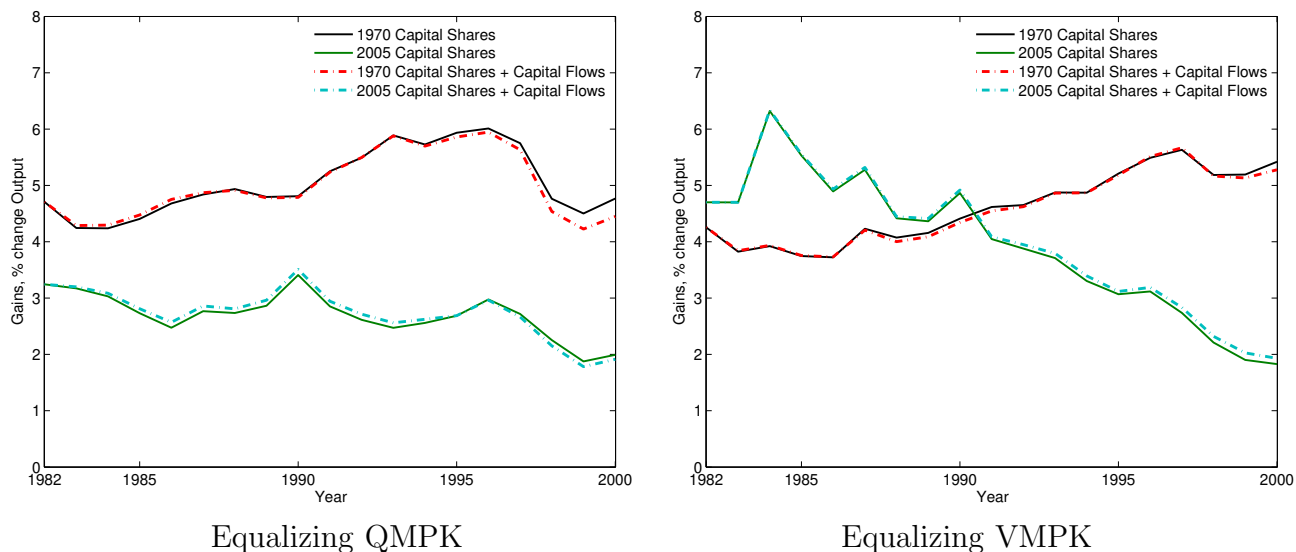
8.2   Human Capital

To measure the role of human capital flows we also construct a counterfactual sequence of human capital stock for each country $\tilde{H}_{j,t}$, as we did for physical capital. More precisely, the stock of

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[31]Data limitations, in particular the desire to include China, restricts us to the period $1982 - 2000$ and only 69 countries.

[32]The USD figures from the IMF are converted to PPP units using $P_{j,t}^K$ and $P_{j,t}^K$ from the PWT 8.0. To attain global balance, we need an adjustment. We multiply all the positive net inflows by a ratio greater than 1 so that the sum of $XK_{j,s}$ over all countries in the sample adds up to 0. Very similar results are attained using the current account deficits to measure $XK_{j,s}$, but the required adjustment for global balance is much larger in that case.

Figure 14: Comparing Gains of Counterfactual Allocations: Role of Capital Flows

Equalizing QMPK   Equalizing VMPK

Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

human capital of country j in year t is

$$\tilde{H}_{j,t} = s_{j,1970} \cdot H_{W,t},$$

where $H_{W,t}$ is the world stock of human capital and $s_{j,1970} = \frac{H_{j,1970}}{H_{W,1970}}$. We also examined the flows of human capital by analyzing net migration flows to each particular country $\{f_{j,t}^H\}$. In this case, however, we do not have information about the human capital of the migrants. Therefore, we assume that migration changes the number of persons living in a country but not the average human capital index or the share of people employed.[33]

    We find that the changes in human capital since 1970 made the global allocation of human capital significantly worse (Figure 15). If in 2005 human capital was distributed according to the shares per country of 1970, the gains of reallocation would be 30 percent instead of 43 percent. The difference, 13 percent of global output, is a measure of much worse is the allocation of human capital due to changes that have taken place since 1970. Adding migration flows does not change the picture, so the changes in human capital that worsen the allocation of human capital are internal.

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[33]For example, that would be the case if the net flows from each country have the same characteristics as the population of that country.

Figure 15: Counterfactual Global Output Gains of Production Factors Reallocation

Reallocating H and K

Reallocating only H
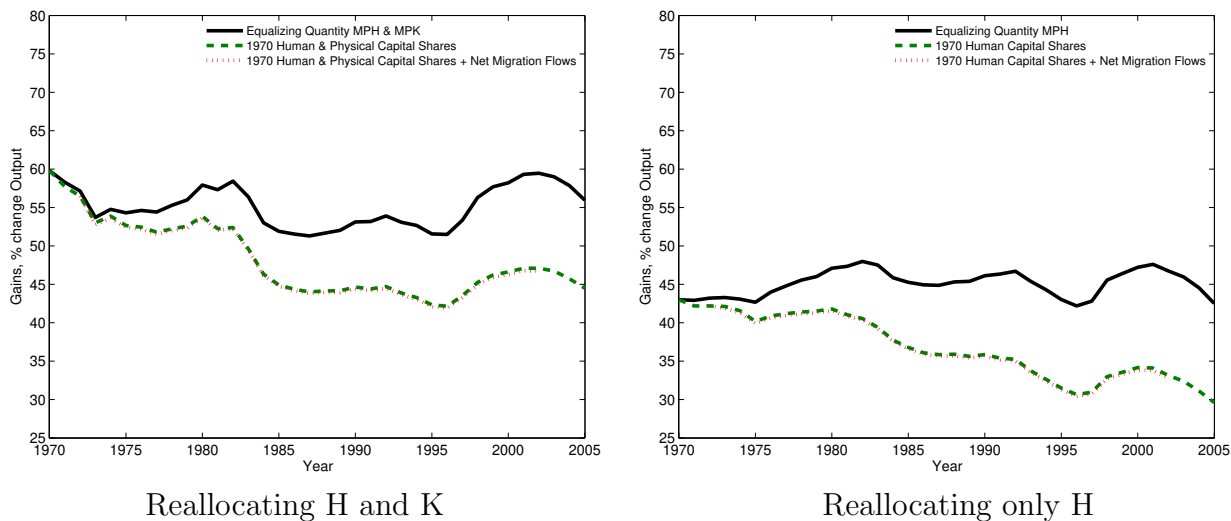
Source: Authors' calculations based on PWT 8.0, WB, and FAOSTAT.

9 Conclusions

We constructed estimates for the rents of natural resources for a large panel of countries for the past 35 years. These estimates are useful for uncovering a number of patterns on the global allocation of resources. First, while the substantial global misallocation of physical capital persists over time, we found a clear indication that the global allocation of physical capital has improved over time. Specifically, global output losses were around 6% in the 1970s, while these losses were on the order of 2% in 2005. The latter number is still five times the previous estimates and easily comparable with the estimates from other forms of international relationship such as the gains of trade and FDI.

A second important finding is that disparities in the MPK are associated with observed policies. Countries with more interventionist policies, which a priori inhibit and distort the accumulation of capital, exhibit larger and more dispersed marginal products. Our results suggest that the trends toward global efficiency are clearly aligned to the observed worldwide trend toward market orientation. A third key result is that during the sample period the movement toward global efficiency is accounted for by the strong association between the accumulation of capital and the changes in the MPK. Initial MPK and changes in the factor shares, TFP-cum-natural resources and relative prices explain almost 90% of the accumulation of capital. This movement is driven by domestic capital accumulation, not external flows.

Finally, the most pressing issues concern human capital. The implied global efficiency losses of the misallocation of human capital are one order of magnitude higher, around 60%, which remains constant over the sample period. If anything, the misallocation of human capital seems to have worsened. Some interesting patterns arise when we explore the joint reallocation of physical and human capital. First, the gains are substantially higher. Second, the direction

of reallocation can change and, instead of capital flowing from rich to poor countries, as first explored by Lucas (1990), we find that capital—and workers—should flow from poor to rich countries.

References

BANK, W., *The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium* (The World Bank, Washington, D.C., 2011).

BARRO, R. J. AND J. W. LEE, "A New Data Set of Educational Attainment in the World, 1950–2010," *Journal of Development Economics* 104 (2013), 184–198.

BERNANKE, B. S. AND R. S. GURKAYNAK, "Is Growth Exogenous? Taking Mankiw, Romer and Weil Seriously," NBER Working Paper 8365, National Bureau of Economic Research, July 2001.

BUERA, F. J., A. MONGE-NARANJO AND G. E. PRIMICERI, "Learning the Wealth of Nations," *Econometrica* 79 (01 2011), 1–45.

BURSTEIN, A. T. AND A. MONGE-NARANJO, "Foreign Know-How, Firm Control, and the Income of Developing Countries," *Quarterly Journal of Economics* 124 (February 2009), 149–195.

CASELLI, F., in P. Aghion and S. Durlauf, eds., *Handbook of Economic Growth* volume 1 of *Handbook of Economic Growth*, chapter 9 (Elsevier, 2005), 679–741.

CASELLI, F. AND J. FEYRER, "The Marginal Product of Capital," *Quarterly Journal of Economics* 122 (05 2007), 535–568.

COOLEY, T. F. AND E. C. PRESCOTT, "Economic Growth and Business Cycles," in T. F. Cooley, ed., *Frontiers of Business Cycle Research* (Princeton, NJ: Princeton University Press, 1995), 1–38.

COSTINOT, A. AND A. RODRÍGUEZ-CLARE, *Trade Theory with Numbers: Quantifying the Consequences of Globalization*, volume 4 of *Handbook of International Economics*, chapter 0 (Elsevier, 2014), 197–261.

DE MAGALHAES, L. AND R. SANTAEULÀLIA-LLOPIS, "The Consumption, Income, and Wealth of the Poorest: Cross-Sectional Facts of Rural and Urban Sub-Saharan Africa for Macroeconomists," World Bank Policy Research Working Paper 7337, June 2015.

EASTERLY, W., *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics*, volume 1 of *MIT Press Books* (The MIT Press, 2002).

FEENSTRA, R. C., R. INKLAAR AND M. TIMMER, "The Next Generation of the Penn World Table," Technical Report 10, 2015, forthcoming, in *American Economic Review*.

FELDSTEIN, M. AND C. HORIOKA, "Domestic Saving and International Capital Flows," *Economic Journal* 90 (June 1980), 314–329.

GOLLIN, D., "Getting Income Shares Right," *Journal of Political Economy* 110 (April 2002), 458–474.

GOURINCHAS, P.-O. AND O. JEANNE, "Capital Flows to Developing Countries: The Allocation Puzzle," *Review of Economic Studies* 80 (2013), 1484–1515.

HALL, R. E. AND C. I. JONES, "Why Do Some Countries Produce So Much More Output Per Worker Than Others?," *Quarterly Journal of Economics* 114 (February 1999), 83–116.

HSIEH, C.-T. AND P. J. KLENOW, "Relative Prices and Relative Prosperity," *American Economic Review* 97 (June 2007), 562–585.

———, "Misallocation and Manufacturing TFP in China and India," *Quarterly Journal of Economics* 124 (2009), 1403–1448.

KARABARBOUNIS, L. AND B. NEIMAN, "The Global Decline of the Labor Share," *Quarterly Journal of Economics* 129 (2014), 61–103.

KENNAN, J., "Open Borders," *Review of Economic Dynamics* 16 (April 2013), L1–L13.

KLEIN, P. AND G. VENTURA, "Productivity Differences and the Dynamic Effects of Labor Movements," *Journal of Monetary Economics* 56 (November 2009), 1059–1073.

KLENOW, P. AND A. RODRÍGUEZ-CLARE, "The Neoclassical Revival in Growth Economics: Has It Gone Too Far?," in *NBER Macroeconomics Annual 1997, Volume 12* NBER Chapters (National Bureau of Economic Research, Inc, 1997), 73–114.

KORNAI, J., "What the Change of System from Socialism to Capitalism Does and Does Not Mean," *Journal of Economic Perspectives* 14 (Winter 2000), 27–42.

Lucas, R. E., "Why Doesn't Capital Flow from Rich to Poor Countries?," *American Economic Review* 80 (May 1990), 92–96.

Mutreja, P., B. Ravikumar and M. J. Sposi, "Capital Goods Trade and Economic Development," Working Paper 2014-12, Federal Reserve Bank of St. Louis, May 2014.

Ohanian, L. E., P. Restrepo-Echavarria and M. L. J. Wright, "Bad Investments and Missed Opportunities? Capital Flows to Asia and Latin America, 1950-2007," Working Paper 2014-38, Federal Reserve Bank of St. Louis, November 2013.

Psacharopoulos, G., "Returns to Investment in Education: A Global Update," *World Development* 22 (September 1994), 1325–1343.

Restuccia, D. and R. Rogerson, "Policy Distortions and Aggregate Productivity with Heterogeneous Plants," *Review of Economic Dynamics* 11 (October 2008), 707–720.

Restuccia, D. and R. Santaeulàlia-Llopis, "Land Misallocation and Productivity," Unpublished Manuscript, University of Toronto and Washington University in St. Louis, 2015.

Restuccia, D. and C. Urrutia, "Relative Prices and Investment Rates," *Journal of Monetary Economics* 47 (February 2001), 93–121.

Rodriguez, F. and D. Rodrik, "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence," in *NBER Macroeconomics Annual 2000, Volume 15* NBER Chapters (National Bureau of Economic Research, 2000), 261–338.

Sachs, J. D. and A. Warner, "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity* 26 (1995), 1–118.

World-Bank, *Where is the Wealth of Nations? Measuring Capital for the 21st Century* (World Bank, 2006).

A Data: Details and Extensions

In this appendix we explain additional aspects of our data. We also report on an alternative pricing of crops and our results for an extended sample of countries for more recent years.

A.1 List of Countries

We compute the share of natural resources of output for a benchmark set of 79 countries for which data are available for every year from 1970 to 2005. We organize these countries by regions: **Africa:** Burkina Faso, Côte d'Ivoire, Cameroon, Kenya, Morocco, Mozambique, Niger, Nigeria, Senegal, Tunisia, Tanzania, South Africa, and Zimbabwe. **Asia:** Bahrain, China, Hong Kong, Indonesia, India, Iran, Israel, Jordan, Republic of Korea, Kuwait, Sri Lanka, Malaysia, Oman, Philippines, Qatar, Saudi Arabia, Singapore, Thailand, Turkey, and Taiwan. **Europe:** Austria, Belgium, Bulgaria, Switzerland, Cyprus, Germany, Denmark, Spain, Finland, France, the United Kingdom, Greece, Hungary, Ireland, Iceland, Italy, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, and Sweden. **Latin America and the Caribbean:** Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Ecuador, Costa Rica, Dominican Republic, Guatemala, Honduras, Jamaica, Mexico, Panama, Peru, Paraguay, Trinidad & Tobago, and Uruguay. **Oceania: Australia and New Zealand**. Japan and the United States, and Canada were left separated for their substantial role in the world economy.

We exclude Burkina Faso, Nigeria, and Oman from our reallocation exercises because these countries do not have data on human capital. This implies a total of 76 countries for our benchmark sample. In Section A.3 we expand our analysis to countries for which we can retrieve information on rents of natural resources, factor shares, physical capital, human capital, and output for the year 2005. The improvement on data collection and sources over time and the presence of new countries since the early 1990s (e.g., from Eastern Europe), implies more countries for which the required data are available. This new set of countries includes Armenia, Benin, Botswana, Central African Republic, Croatia, Czech Republic, Estonia, Fiji, Gabon, Kazakhstan, Kyrgyzstan, Latvia, Lesotho, Lithuania, Macao, Mauritania, Mauritius, Moldova, Mongolia, Namibia, Romania, Russia, Rwanda, Serbia, Sierra Leone, Slovak Republic, Slovenia, Swaziland, Tajikistan, Togo, and Ukraine. This yields a total sample of 107 countries for the year 2005.

A.2 Valuation of Crops at Producer Prices

As discussed in Section 2, we extend previous estimates of natural resources rents from the World Bank (henceforth, WB) to an annual basis and for a larger sample period starting in 1970. *The Wealth of Nations* database data were available only at a quinquennial frequency and only since 1990. Currently, *The Wealth of Nation* (forthcoming 2015) is working on an expansion of previous database to an annual frequency and starting 1970.
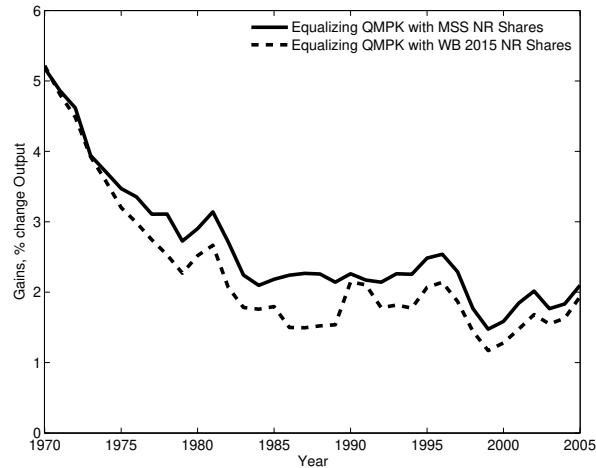
The Wealth of Nations group at the WB has kindly shared their new (but still unpublished) data with us.

Figure A-1: Benchmark at US Prices versus World Bank (Unpublished Data, 2015) at Producer Prices

(A) Natural Resources Shares of Output
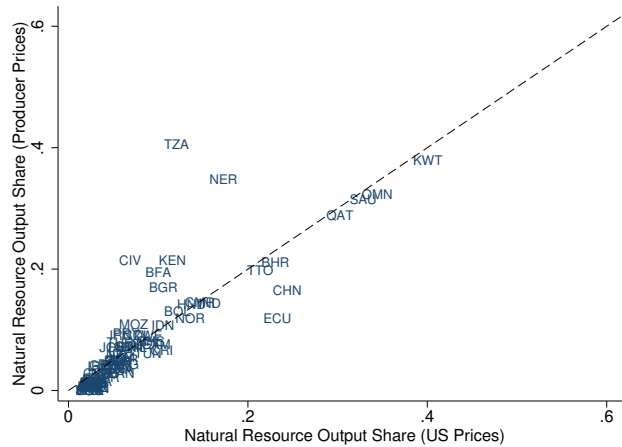
(B) Global Gains of Physical Capital Reallocation

Source: In panel (A), the definition of natural resources share of output that uses US prices to value agricultural production refers to our benchmark, while the definition that uses producer prices to value agricultural production corresponds to the most updated World Bank measurement (unpublished data, 2015). In panel (B), these two measures of natural resources are used to compute global output gains from a physical capital reallocation exercise where equalizing QMPK with MSS shares refers to our benchmark with US prices, while equalizing QMPK with WB 2015 data refers to the producer prices analog.

In expanding their data, the WB has also introduced a new relevant feature in the valuation of natural resource rents in terms of crop pricing. While in previous versions the WB used export unit values to value agricultural output, they are currently using producer prices to conduct these valuations. While export values might be poor predictors of output value when the country's markets are not well connected to the world market and/or the quality of what is traded, their use to measure output was partly due to the lack of country-specific producer prices for agricultural products. More recently, FAOSTAT has started to provide regular coverage of producer prices/gross value of production, and the newest version of *The Wealth of Nations* (forthcoming 2015) values crop production using the newly available producer prices, which tend to be lower than export values. This implies that the WB estimates for cropland rents will tend to be lower than their previous estimates. This also affects the rents from pastureland that are assumed to be a fraction of those from cropland rents (see Section 2) by the WB. The rents from natural resources, other than crop and pastureland, remain unchanged in the new version of *The Wealth of Nations* database.

Here, we compare our benchmark estimates of natural resources shares of output in which cropland rents are computed using US prices as a proxy for international prices (see our Section 2) with the new estimated WB data in which cropland rents use producer prices instead of export unit values. By large, both natural resources shares are very similar, see panel (A) in Figure A-1, which scatters plots these shares for our benchmark (US prices) against the new WB benchmark (producer prices). Not surprisingly, the implied global gains of physical capital reallocation are also very similar across both pricing schemes. Our benchmark output gains are slightly above those from the gains obtained using producer prices (see panel (B) in Figure A-1).

A.3 Results for the Extended Sample

In the main text, we focused on a sample of 76 countries for which we were able to consistently retrieve information on rents of natural resources, factor shares, physical capital, human capital, and output from 1970 to 2005. With improvement on data collection with time, as well as the emergence of new countries in the 1990s (for example, after the fall of communism in Eastern Europe), data for more countries are available in the present than in the past. In this section, we extend our benchmark sample to the set of 107 countries for which we can retrieve all necessary information to perform our analysis for the year 2005. Thus, we explore the robustness of our main results to the increased sample size.

We compare the global output gains from equalizing physical and human capital between our benchmark sample and the extended sample in Table A-1. We find minor differences across samples or, if at all, our benchmark sample tends to underestimate the global gains or reallocation compared with the extended sample. First, if we equalize only the quantity $MPKs$, our benchmark sample implies global gains of 2.31% of output in 2005, while these gains are 3.56% for the extended sample. In value terms the gains of equalizing $MPKs$ is 2.02% for the benchmark sample and 3.78% for the extended sample in 2005. Second, equalizing MPH yields similar insights. Third, the joint global reallocation of physical and human capital implies that, in quantity

terms, our output gains in the benchmark sample are 56.0%, while in the extended sample these are 57.2%. That is, extending our sample to more countries implies more global output gains. These underestimation are more apparent in value terms where output gains are 5.78% in our benchmark sample and 7.74% in our extended sample.
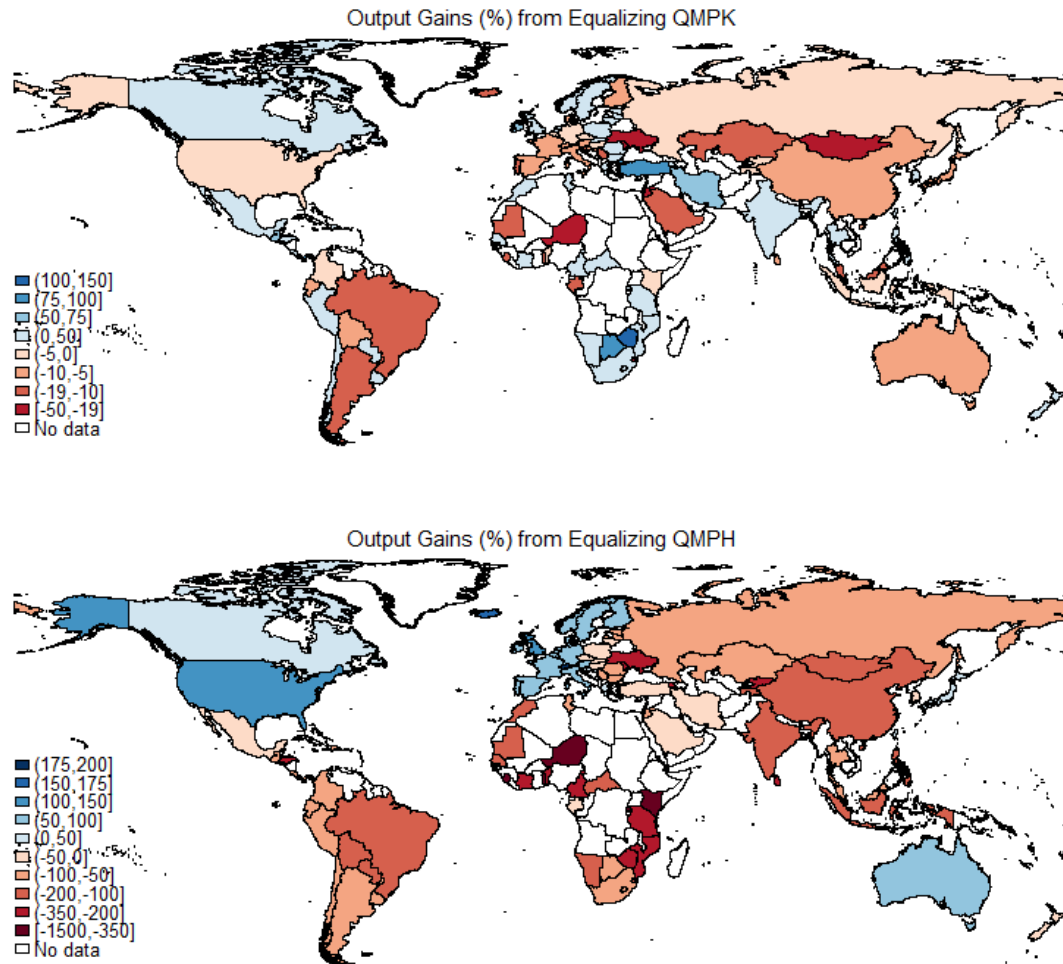
Table A-1: Comparing Gains (%) in Output in 2005

	Quantity		Value	
	Benchmark	Extended Sample	Benchmark	Extended Sample
Equalizing MPK	2.31	3.56	2.02	3.78
Equalizing MPH	42.52	42.18	0.25	0.25
Equalizing MPK & MPH	55.96	57.32	5.78	7.74
Number of countries	76	107	76	107

Source: Authors' calculations based on PWT 8.0, WB, and FAO stat.

With the extended sample, we use maps in Figure A-2 to describe winners and losers of reallocation. The reallocation of physical capital (top panel) is from large countries (red in the map) such as Australia, Brazil, China, Russia, the United States, and Southern European countries, toward several African countries, India, Eastern and Northern Europe, Canada, and Mexico, among others (blue in the map).

The pattern of reallocation of human capital (bottom panel of Figure A-2) is quite different. The countries receiving migrants (blue in the map) are all developed: the United States, Canada, Western Europe, and Australia. The countries sending human capital abroad are China, India, Ukraine, Brazil, and other Eastern European and African countries.

Output Gains (%) from Equalizing QMPK

Output Gains (%) from Equalizing QMPH

0 Source: Authors' calculations based on PWT 8.0, WB, and FAO stat.

B   Comparison with Caselli and Feyrer (2007)

In their seminal paper, Caselli and Feyrer (2007), henceforth, CF use the WB's *stocks of wealth* estimates to compute the output share of natural resources for the year 1995. In this appendix, we briefly review their method and assumptions and compare their results with ours.

First, for the different natural resources items $q \in \{a, b, c, e, f\}$ (detailed in Section 2), the WB computes natural stocks, $WSNR_{q,j,\mathbf{1995}}$, for each country j, in their sample. They obtain their estimates by multiplying

their data on the flow of rents $\text{rents}_{q,j,1995}$ by a present value term $PVF_{j,q}$:

$$WSNR_{q,j,\mathbf{1995}} = \text{rents}_{q,j,1995} \times PVF_{j,q},$$

where the present value factor $PVF_{j,q}$ depends not only on the natural resources q but also on the country j,

$$PVF_{j,q} = \sum_{s=0}^{\mathbf{T}_{j,q}} \frac{(\mathbf{G_{j,q}})^s}{(1+\mathbf{r^*})^s},$$

where r^* is the discount rate, $\mathbf{G_{j,q}}$ is the growth rate in the rent flows, and $\mathbf{T}_{j,q}$. Unfortunately, the WB does not have direct measures of r^*, $\mathbf{G_{j,q}}$, and $\mathbf{T}_{j,q}$ is the terminal or exhaustion date of the resource. Thus, computing the stocks requires making additional assumptions. WB assumes that the discount rate r^* is the same across all countries, 4%. More importantly, they assume that the growth rate in the rent flows, $\mathbf{G_{j,q}}$, and the terminal or exhaustion date of the resource $\mathbf{T}_{j,q}$ both vary by country j and resource q. In particular, they group countries into developed and developing countries and assume that the rents for the developing countries grow significantly faster ($\mathbf{G_{developing,\ q}} > \mathbf{G_{developed,\ q}}$) and exhaust later ($\mathbf{T_{developing,\ q}} > \mathbf{T_{developed,\ q}}$) than for developed countries. Table B-1 shows the implied values for $PVF_{j,q}$ for a range of values of $\mathbf{G_{j,q}}$ and $\mathbf{T}_{j,q}$ assumed by the WB.

Table B-1: World Bank's Present Value Factors, $PVF_{j,q}$

Resources	Developed Countries			Developing Countries		
	$G_{j,q}-1$	$T_{j,q}$	$\mathbf{PVF_{j,q}}$	$G_{j,q}-1$	$T_{j,q}$	$\mathbf{PVF_{j,q}}$
	(%)			(%)		
Subsoil Resource.	0	13	10.5	0	17	12.7
Timber	0	25	16.3	0	25	16.3
Croplands	0.97	25	17.9	1.94	25	19.9
Pasturelands	0.89	25	17.8	2.95	25	22.2

Table B-1 shows two important aspects in the resulting values for $PVF_{j,q}$. First, their numbers are fairly large, meaning that given the rents, the present value factors can lead to very large wealth stock estimates. Second, even given the same rents, the implied PVF are larger for poorer countries. This second assumption is important because it implies that the natural resources shares estimated with this method (using stocks) will be larger for poorer countries than for richer countries even if the natural recourses rents are the same proportion of GDP.

In any event, summing over all the natural resources, the WB estimates a country's total natural wealth stock

in 1995 to be

$$N_{j,1995} = \sum_q NRR_{q,j,1995}.$$

The WB estimation ends in this step. CF take those natural resources stocks and recover the rents using the following method. They notice that on the basis of these stocks, it is possible to compute the fraction of non-labor income that should accrue to natural resource owners. In particular, if $r^K_{j,1995}$ and $r^N_{j,1995}$ represent the rental rate of physical and natural capital respectively, and $K_{j,1995}$ indicates the stock of physical capital in country j in 1995, then one could compute the output share of natural resources as

$$\phi^R_{j,1995} = \frac{r^N_{j,1995} N_{j,1995}}{r^N_{j,1995} N_{j,1995} + r^K_{j,1995} K_{j,1995}} \times \left[1 - \text{labor share}_{j,1995}\right].$$

However, the required cross-country data for $r^K_{j,1995}$ and $r^N_{j,1995}$ are simply not available. The key assumption in CF's method is that $r^N_{j,1995} = r^K_{j,1995}$ for all countries j. Notice that this is not a non-arbitrage condition, since N and K (as well as human capital, H), are two different production factors.

With this assumption, their estimate of the share of natural resources is simply

$$\phi^R_{j,1995} = \frac{N_{j,1995}}{N_{j,1995} + K_{j,1995}} \times \left[1 - \text{labor share}_{j,1995}\right]. \tag{15}$$

We view our measure of $\phi^R_{j,t}$ are superior to that derived by CF for a number of important reasons. First, it is available for many years, not only for 1995. Second, it does not rely on the assumptions on growth rates and exhaustion dates to construct wealth stock estimates. Third, it does not rely on the assumption made by CF that the rental rates for natural resources and physical capital are the same. Our strong prior is that these two assumptions strongly overestimate the importance of natural resources, specially for developing countries.

Figure B-1: Comparing Alternative Methods

(A) Natural Resources Shares of Output   (B) Marginal Product of Physical Capital
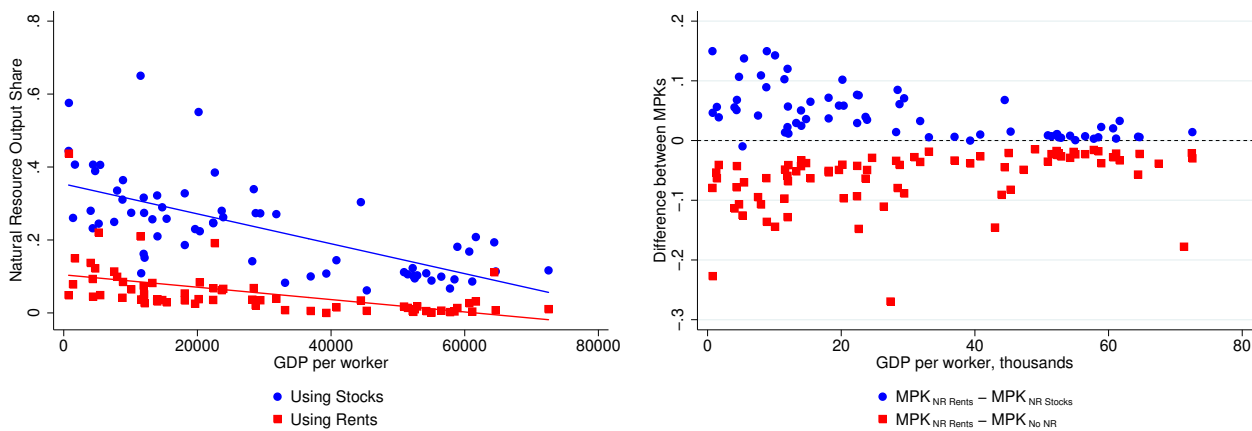
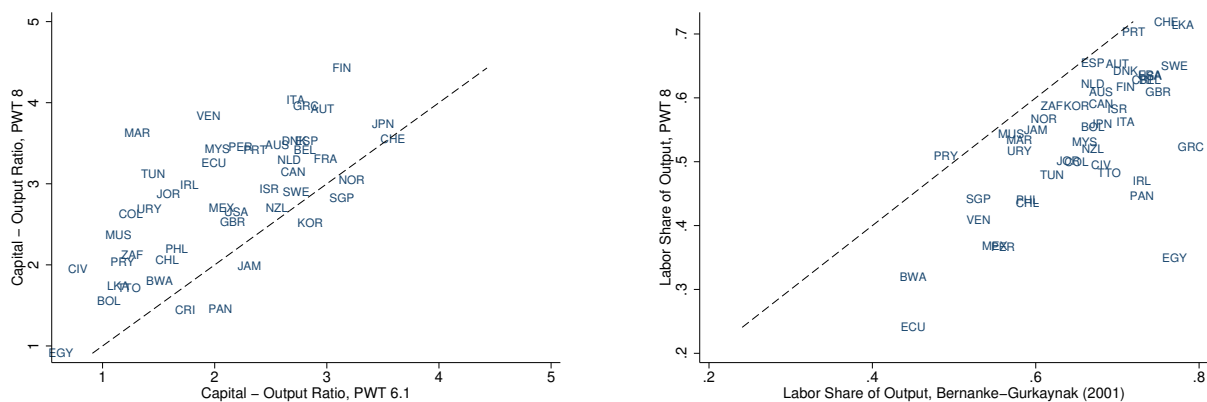Source: Authors' calculations based on PWT 8.0, WB, and FAO stat.

The Natural Resources Shares of Output. Panel (A) in Figure B-1 compares our measure $\phi_{j,t}^R$ with that implied by the formula (15) from CF using data from PWT 8.0 for physical capital stocks and labor shares. The differences are striking. Our measure indicates that for countries with per capita income levels below $15,000, the output share of natural resources is on average 7%. The average using the measurement of CF is much higher, above 30%. This stark difference reinforces our prior that the additional assumptions made in the measurement using wealth stocks overestimate the relevance of natural resources. The overestimation of natural resources comes at the cost of the underestimation of the output share of physical capital. As shown by Panel (A) in Figure B-1, this bias seems stronger for the poorest countries. For instance, countries with per capita incomes below $20,000, the difference between our implied output share of $\phi_{j,t}^K$ and those using wealth stocks is around 15% of GDP.

The Marginal Product of Physical Capital. Not surprisingly, these differences translate into large differences in the implied $MPK_{j,t}$. As depicted in Panel (B) in Figure B-1, the differential of MPKs computed with rents with respect to those proxied with stocks (i.e., as in CF) is positive and largest for the poorest countries. Albeit smaller, accounting for natural resources has a substantial impact on the implied MPK relative to the standard model (i.e. Lucas, 1990). Panel (B) in Figure B-1 also shows that our implied measures of MPK are substantially lower than the standard measure using uniform physical capital shares, while the gap between richer and poorer countries is less pronounced than in the standard model.

There are additional reasons for the difference between our MPKs and those obtained by CF. These are the data sources for physical capital, output, and labor shares. While we use PWT 8.0, CF use data on physical

53

capital and output from PWT 6.1 and on labor shares from Bernanke and Gurkaynak (2001). Figure B-2 shows there are differences between those sources. The most obvious patterns are (i) the K/Y ratios are higher in PWT 8.0 than in PWT 6.1 and (ii) the labor shares are larger in PWT 8.0 than in Bernanke and Gurkaynak (2001). While each of these items has implications for the size of global misallocation, the main discrepancy between the global gains attained in CF and those we find in our benchmark scenario are in its major part driven by the differences in the measurement of natural resources shares of output, as we discuss next.

Figure B-2: Differences in K/Y and θ

Source: Authors' calculations based on PWT 6.1 and 8.0 and Bernanke and Gurkaynak (2001).

The Global Output Gains. We conduct two exercises to compare the magnitude of global misallocation obtained in CF with that obtained in our benchmark environment and that we label as MSS. First, we show a discrepancy between the results in CF and MSS in a direct manner by comparing the global output gains in both environments. Figure B-3 shows the global output gains for both environments, CF and MSS, separately for quantity and value units from 1970 to 1996.[34,35] The CF environment simply replicates the global gains obtained in Caselli and Feyrer (2007) based on their data and sample size, while the MSS environment shows the global gains from our benchmark based on our data and sample size as described in Section 2.[36]

A clear message emerges: The global gains in MSS are roughly five times larger than those in CF. We emphasize that these differences between MSS and CF are not only large but also statistically significant. In terms of the evolution of global misallocation across time, the dynamics between the MSS and CF environments also differ dramatically. While we find a clear movement toward efficiency from global gains of roughly 5 percent in the 1970s to roughly 2 percent in the 2000s under the MSS environment, there is no evidence of a trend toward

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[34]The sample is restricted to 1996—i.e., that is up to the year for which CF data (PWT 6.1) are available.

[35]As in Caselli and Feyrer (2007), we assume that the labor share constructed by Bernanke and Gurkaynak (2001) circa 1996 remains constant across all years for the CF environment.

[36]Again, the global output gains are defined as the ratio between the efficient global output implied by the quantity and value models posed in Section 3 and the actual global output.

Figure B-3: Global Output Gains of Physical Capital Reallocation: CF versus MSS
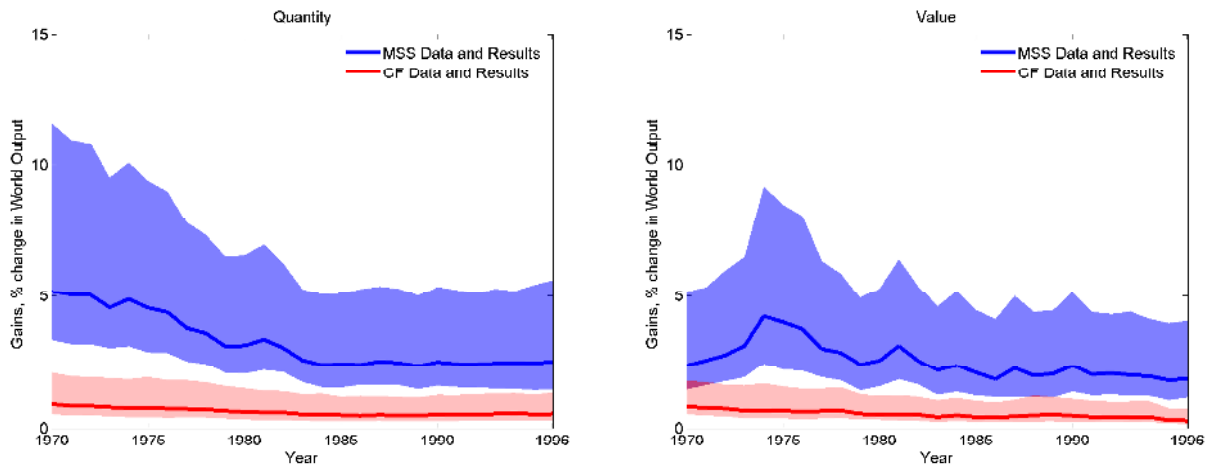
Notes: The CF environment reproduces the global gains in Caselli and Feyrer (2007) from the equalization of $MPKs$ computed from *natural resources stocks* and their data sources for factor shares, capital, output, and prices available for 51 countries (mainly PWT 6.1, WB, and Bernanke and Gurkaynak (2001)). The MSS environment refers to the global gains from our benchmark equalization of $MPKs$ computed from *natural resources rents*, factor shares, capital, output, and prices available for 76 countries, as described in Section 2. The global output gains are defined as the ratio between the efficient global output implied by the quantity and value models posed in Section 3 and the actual global output. In both environments, CF and MSS, we report the median global gains and their associated 10th and 90th confidence intervals from 1,000 bootstrap simulations with 100 percent replacement.

Source: Authors' calculations based on PWT 6.1 and 8.0, Bernanke and Gurkaynak (2001), WB, and FAOSTAT.

efficiency over time under the CF environment.

Table B-2: Comparing Alternative Data Sources and Samples: CF versus MSS (1996)

Sample	Data Source			Gains	Sample
	$\phi_{j,t}^R$	(K,Y)	θ	[CI]	Size
CF:	CF	CF	CF	0.52%	47
				[0.29,0.95]	
	CF	CF	MSS	1.01%	47
				[0.48,2.05]	
	CF	MSS	MSS	0.98%	47
				[0.51,1.87]	
	MSS	MSS	MSS	2.32%	47
				[0.90,5.31]	
MSS, Benchmark:	MSS	MSS	MSS	2.51%	76
				[1.45,4.17]	
MSS, Extended:	MSS	MSS	MSS	3.35%	107
				[1.63,6.45]	

Notes: CF refers to Caselli and Feyrer (2007) and MSS for this paper with data sources described in Section 2. Recall that ϕ^R refers to the natural resources share of output data, (K, Y) to the capital and output data, and θ to labor share data. The global output gains refer to the median value of of 1,000 bootstrap simulations with 100 percent replacement. The confidence intervals refer to the 10*th* and 90*th* bootstrapped percentiles.

Second, to explore in detail the sources of our discrepancy with CF, Table B-2 presents the global output gains of physical capital reallocation from alternative combinations of data sources (either from CF or MSS), and associated country-sample sizes for the year 1996 (i.e., the base year in Caselli and Feyrer (2007)). We start by restricting the comparison for the 47 countries available in both the CF and MSS data sets, which we label as the CF sample.[37] The first row of Table B-2 reproduces CF's results for these 47 countries and for which we find median gains of 0.52 percent. In the second and third rows, we gradually impose the MSS labor share and capital and output on the CF environment. We find that adding the MSS labor share increases the global gains to roughly 1 percent, and the MSS capital and output data barely change these gains. Note that up to this point, the global gains are not significantly different from the CF benchmark (with an estimated overlapping range from 0.51 to 0.91 percent). In the fourth row, we add the MSS natural resources shares of output, ϕ^R, computed from *natural resources rents* instead of *natural resources stocks* as in the original CF benchmark. We find that the global gains

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[37]This restriction binds mostly for the availability of labor share data from Bernanke and Gurkaynak (2001). Note that while the CF environment in Figure B-3 has 51 countries, in Table B-2 we use 47 countries. This is due to the fact that in MSS (i.e., PWT8.0) we do not have labor share data in 1996 for the Democratic Republic of Congo, El Salvador, and Zambia. Further, in MSS we do not have ϕ^R for Burundi, while CF does. However, we find that the presence of these four countries makes no quantitative difference for the CF results.

substantially rise to 2.32 percent—that is, the difference in ϕ^R between CF and MSS contributes the most to amplify the gains of reallocating physical capital by roughly a factor of five in MSS compared with CF. Further, as per the confidence intervals in these two environments, there is now a negligible overlapping amount of gains for the range 0.90 to 0.95 percent. Finally, in the fifth and sixth rows, we respectively increase the sample size to our MSS benchmark of 76 countries and to our extension of 107 countries described in Appendix A. We find that increasing the sample size from 47 to 76 countries slightly increases the global gains to 2.51 percent and, at the same time, increases the accuracy of our estimated gains, making the MSS results significantly different from CF—that is, the confidence intervals between the MSS and CF benchmarks do not overlap. Finally, increasing the sample size to 107 countries further increases the global gains to 3.51 percent and also increases the significance in the differential global gains between MSS and CF.[38]

To sum up, the different construction of natural resources shares of output, ϕ^R, is the major component driving the large differential in global gains between MSS and CF, and this differential between MSS and CF gains becomes more accurate and significant as we increase the sample size.

C   Misallocation versus Measurement Error

In this section, we explore the potential role of measurement errors in driving our results. We consider the hypothesis that the world is fully efficient and that our measured misallocation is driven entirely by measurement error. Since measurement error seems a more daunting possibility at the beginning of the sample, here we assume that each country has the efficient allocation of capital in 1970, K^*, but we actually observe a noise measure $K = (1 + \epsilon)K^*$, where ϵ is a country-specific measurement error. We explore the results for two different forms of ϵ : (a) an i.i.d normally distributed measurement error term $\epsilon \sim N(0, \sigma)$. Alternatively, (b) we consider the case of a tax/subsidy rate that with probability $\frac{1}{2}$ is positive (tax) and with probability $\frac{1}{2}$ is a subsidy. This second representation follows Restuccia and Rogerson (2008). We generate the stocks of capital for each country as $K = (1 + \epsilon)K^*$ and then compute the gains in terms of global output of reallocating capital.

Figure C-1 show the results. The dashed line represents the gains obtained in our benchmark reallocation exercise, which are above 5%. The x-axis represents the size of the standard deviation of ϵ in the first exercise, and the size of the ϵ (the tax) in the second case. The black line represents the median size of the gains for the different values on the x-axis (the blue area represents the standard errors bands). When the black line crosses the dashed line, that is the value on the x- axis that would generate gains as in our benchmark exercise. The results show that to account for the gains obtained in 1970, measurement error would have to be very large, between 50 and 60 percent of the capital stock.

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[38]Note that our extension to 107 countries refers to the year 2005, not 1996. Nevertheless, under the MSS benchmark, the global gains are very similar for these two years: 2.51 percent in 1996 and 2.29 percent in 2005.

Figure C-1: Measurement Errors
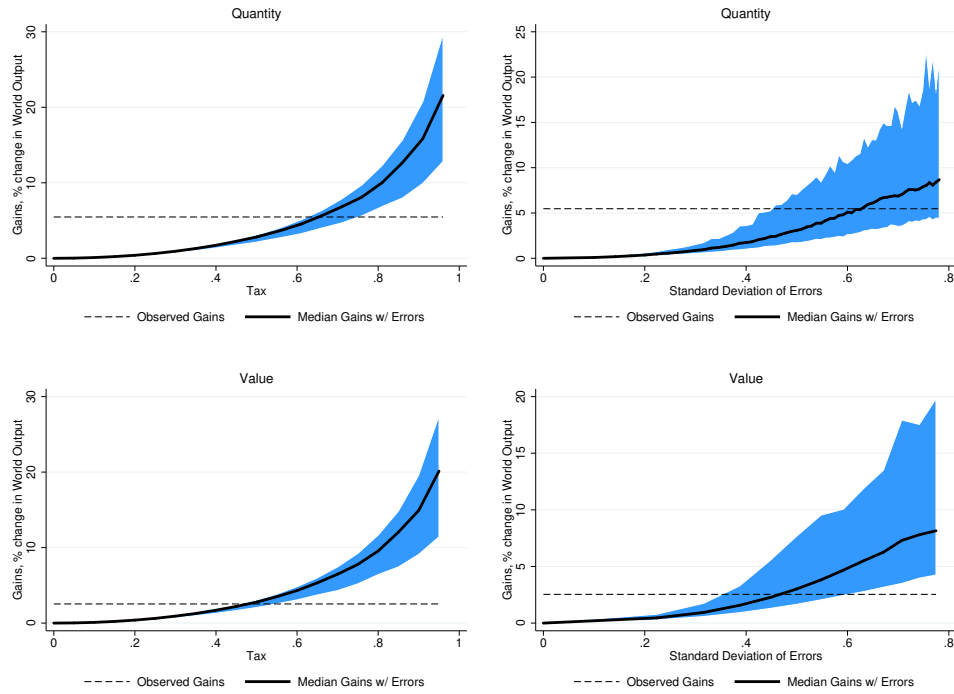
D Multilateral versus Unilateral Counterfactuals

In this section, we show that, for all but the largest countries, the counterfactual output gains of removing barriers unilaterally would be very similar to that in our benchmark, multilateral counterfactuals. Interestingly, this is different than trade and FDI liberalization exercises, more commonly found in the literature.

For a given year, by removing the barriers to the allocation of capital capital we obtain an efficient marginal product of capital, MPK_t^*. Given this efficient return to capital, we can construct country-specific wedges as:

$$\Delta_{j,t} = \frac{MPK_{j,t}^o}{MPK_t^*},$$

where $MPK_{j,t}^o$ is the observed MPK.

The graphs below show the gains in output from this counterfactual exercise in which we remove one wedge at a time as compared to our benchmark results, in which all wedges removed at the same time. Strikingly, the gains for most of countries are of similar magnitude in both exercises.

Figure D-1: Unilateral versus Multilateral Gains
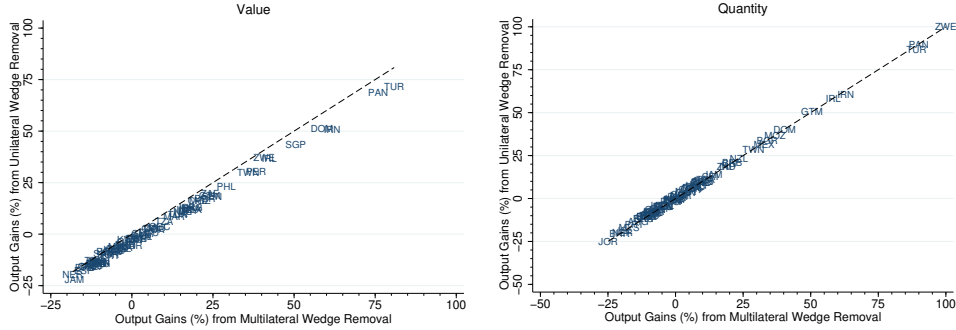
E External Flows and Counterfactual Allocations

Here we explain the construction of the counterfactual series of physical and human capital based on external net flows of physical capital (current accounts) or human capital (migration).

Physical Capital. Data on net exports are from the International Monetary Fund International Financial Statistics (IFS). We exclude 7 countries (Belgium, Greece, Hong Kong, Luxembourg, Qatar, Taiwan, and Zimbabwe) from our sample because of data limitations.

The sum of net exports across countries in our sample does not add up to zero; this is not surprising as we include only a subset of global capital flows. We address this issue by adjusting net exports so they sum to zero and countries maintain their status as senders or receivers of capital. For instance, we can adjust net exports by a factor λ_t and define the adjusted flows as $\hat{f}^K_{j,t} = \lambda_t \mathbf{1}_{f_{j,t} \geq 0} \cdot f_{j,t} + f_{j,t} \cdot \mathbf{1}_{f_{j,t} < 0}$. Results from equalizing the quantity marginal product of physical capital using the adjusted flows are similar to those shown in Figure 9,

$$\text{where } \lambda_t = \frac{| \sum_{j}^{N} \mathbf{1}_{f_{j,t} < 0}\ f^K_{j,t} |}{\sum_{j}^{N} \mathbf{1}_{f_{j,t} \geq 0}\ f^K_{j,t}}.$$

Human Capital. Data on net migration are taken from the WB and are available at 5-year intervals starting in 1972; we use linear interpolation to infer missing flows. To construct human capital flows $\hat{f}^H_{j,t}$ from population flow data $f^H_{j,t}$, we make several assumptions.

We assume that a share d_t of migrants $f^H_{j,t}$ are employees. This share is equal to the average employment-to-population ratio: $d_t = \dfrac{\sum_{j}^{N} \frac{L_{j,t}}{P_{j,t}}}{N}$. To convert these employment flows $d_t f^H_{j,t}$ to human capital-augmented labor $\hat{f}^H_{j,t}$, we assume that migrant human capital is equal to the human capital in the country $h_{j,t}$ into/out of which labor is flowing, so that $\hat{f}^H_{j,t} = h_{j,t} \cdot (d_t f^H_{j,t})$. Assuming migrant human capital is equal to the global mean yields

similar results.

As with physical capital, the sum of human capital flows does not add up to zero. Adjusting the flows to ensure these flows add up to zero does not change our results.