THE MARGINAL PRODUCT OF CAPITAL[*]

Francesco Caselli and James Feyrer

June 16, 2006

Abstract

Whether or not the marginal product of capital (MPK) differs across countries is a question that keeps coming up in discussions of comparative economic development and patterns of capital flows. Using easily accessible macroeconomic data we find that MPKs are remarkably similar across countries. Hence, there is no *prima facie* support for the view that international credit frictions play a major role in preventing capital flows from rich to poor countries. Lower capital ratios in these countries are instead attributable to lower endowments of complementary factors and lower efficiency, as well as to lower prices of output goods relative to capital. We also show that properly accounting for the share of income accruing to reproducible capital is critical to reach these conclusions. One implication of our findings is that increased aid flows to developing countries will not significantly increase these countries' capital stocks and incomes. (*JEL codes:* E22, O11, O16, O41. *Keywords:* investment, capital flows).

1

I Introduction

Is the world's capital stock efficiently allocated across countries? If so, then all countries have roughly the same aggregate marginal product of capital (MPK). If not, the MPK will vary substantially from country to country. In the latter case, the world foregoes an opportunity to increase global GDP by reallocating capital from low to high MPK countries. The policy implications are far reaching.

Given the enormous cross-country differences in observed capital-labor ratios (they vary by a factor of 100 in the data used in this paper) it may seem obvious that the MPK must vary dramatically as well. In this case we would have to conclude that there are important frictions in international capital markets that prevent an efficient cross-country allocation of capital.[1] However, as Lucas [1990] pointed out in his celebrated article, poor countries also have lower endowments of factors complementary with physical capital, such as human capital, and lower total factor productivity (TFP). Hence, large differences in capital-labor ratios may coexist with MPK equalization.[2]

It is not surprising then that considerable effort and ingenuity have been devoted to the attempt to generate cross-country estimates of the MPK. Banerjee and Duflo [2005] present an exhaustive review of existing methods and results. Briefly, the literature has followed three approaches. The first is the cross-country comparison of interest rates. This is problematic because in financially repressed/distorted economies interest rates on financial assets may be very poor proxies for the cost of capital actually borne by firms.[3] The second is some variant of regressing ΔY on ΔK for different sets

---

[1]The credit-friction view has many vocal supporters. Reinhart and Rogoff [2004], for example, build a strong case based on developing countries' histories of serial default, as well as evidence by Alfaro, Kalemli-Ozcam and Volosovych [2003] and Lane [2003] linking institutional factors to capital flows to poorer economies. Another forceful exposition of the credit-friction view is in Stulz [2005].

[2]See also Mankiw [1995], and the literature on development-accounting (surveyed in Caselli [2005]), which documents these large differences in human capital and TFP.

[3]Another issue is default. In particular, it is not uncommon for promised yields on "emerging market" bond instruments to exceed yields on US bonds by a factor of 2 or 3, but given the much higher risk these bonds carry it is possible that the *expected* cost of capital from the perspective of

of counties and comparing the coefficient on ΔK. Unfortunately, this approach typically relies on unrealistic identification assumptions. The third strategy is calibration, which involves choosing a functional form for the relationship between physical capital and output, as well as accurately measuring the additional complementary factors – such as human capital and TFP – that affect the MPK. Since giving a full account of the complementary factors is quite ambitious, one may not want to rely on this method exclusively. Both within and between these three broad approaches results vary widely. In sum, the effort to generate reliable comparisons of cross-country MPK differences has not yet paid off.

This paper presents estimates of the aggregate MPK for a large cross-section of countries, representing a broad sample of developing and developed economies. Relative to existing alternative measures, ours are extremely direct, impose very little structure on the data, and are simple to calculate. The general idea is that under conditions approximating perfect competition on the capital market the MPK equals the rate of return to capital, and that the latter multiplied by the capital stock equals capital income. Hence, the aggregate marginal product of capital can be easily recovered from data on total income, the value of the capital stock, and the capital share in income. We then combine data on output and capital with data on the capital share to back out the MPK.[4]

Our main result is that MPKs are essentially equalized: the return from investing in capital is no higher in poor countries than in rich countries. This means that one can rationalize virtually all of the cross-country variation in capital per worker without appealing to international capital-market frictions. We also quantify the output losses

---

the borrower is considerably less. More generally, Mulligan [2002] shows that with uncertainty and taste shocks interest rates on any particular financial instruments may have very low – indeed even negative – correlations with the rental rate faced by firms.

[4]Mulligan [2002] performs an analogous calculation to identify the rental rate in the US time series. He finds implicit support for this method in the fact that the rental rate thus calculated is a much better predictor of consumption growth than interest rates on financial assets.

due to the (minimal) MPK differences we observe: if we were to reallocate capital across countries so as to equalize MPKs the corresponding change in world output would be negligible.[5] Consistent with the view that financial markets have become more integrated worldwide, however, we also find some evidence that the cost of credit frictions has declined over time.

The path to this result offers additional important insights. We start from a "naive" estimate of the MPK that is derived from the standard neoclassical one-sector model, with labor and reproducible capital as the only inputs. Using this initial measure, the average MPK in the developing economies in our sample is more than twice as large as in the developed economies. Furthermore, within the developing-country sample the MPK is three times as variable as within the developed-country sample. When we quantify the output losses associated with these MPK differentials we find that they are very large (about 25 percent of the aggregate GDP of the developing countries in our sample). These results seem at first glance to represent a big win for the international credit-friction view of the world.

Things begin to change dramatically when we add land and other natural resources as possible inputs. This obviously realistic modification implies that standard measures of the capital share (obtained as 1 minus the labor share) are not appropriate to build a measure of the marginal productivity of reproducible capital. This is because these measures conflate the income flowing to capital accumulated through investment flows with natural capital in the form of land and natural resources. By using data recently compiled by the World Bank, we are able to separate natural capital from reproducible capital and calculate the share of output paid to reproducible capital that is our object of interest. This correction alone significantly reduces the gap between rich and poor country capital returns. The main reason for this is that poor countries

---

[5]Our counter-factual calculations of the consequences of full capital mobility for world GDP are analogous to those of Klein and Ventura [2004] for labor mobility.

have a larger share of natural capital in total capital, which leads to a correspondingly larger overestimate of the income and marginal-productivity of reproducible capital when using the total capital-income share. The correction also reduces the GDP loss due to MPK differences to about 5% of developing country GDP, one fifth of the amount implied by the naive calculation. [6]

The further and final blow to the credit-friction hypothesis comes from generalizing the model to allow for multiple sectors. In a multi-sector world the estimate of MPK based on the one-sector model (with or without natural capital) is – at best – a proxy for the average *physical MPK* across sectors. But with many sectors physical MPK differences can be sustained even in a world completely unencumbered by any form of capital-market friction. In particular, even if poor-country agents have access to unlimited borrowing and lending at the same conditions offered to rich-country agents, the physical MPK will be higher in poor countries if the relative price of capital goods is higher there. Intuitively, poor-country investors in physical capital need to be compensated by a higher physical MPK for the fact that capital is more expensive there (relative to output). Or, yet in other words, the physical MPK measures output per unit of physical capital invested, while for the purposes of cross-country credit flows one wants to look at output per unit of output invested. Accordingly, when we correct our measure to capture the higher relative cost of capital in poor countries we reach our result of MPK equalization.[7]

---

[6]We are immensely grateful to Pete Klenow and one other referee for bringing up the issue of land and natural resources. Incidentally, these observations extend to a criticism of much work that has automatically plugged in standard capital-share estimates in empirical applications of models where all capital is reproducible. We plan to pursue this criticism in future work.

[7]In a paper largely addressing other issues, Taylor [1998] has a section which makes the same basic point about price differences and returns to capital, and presents similar calculations for the MPKs. Our paper still differs considerably in that it provides a more rigorous theoretical underpinning for the exercise; it provides a quantitative model-based assessment of the deadweight costs of credit frictions; and it presents a decomposition of the role of relative prices v. other factors in explaining cross-country differences in capital-labor ratios. Perhaps most importantly, in this paper we use actual data on reproducible capital shares instead of assuming that these are constant across countries and equal to the total capital share. This turns out to be quite important. Cohen and Soto [2002] also briefly

We close the paper by returning to Lucas' question as to the sources of differences in capital-labor ratios. Lucas proposed two main candidates: credit frictions – about which he was skeptical – and differences in complementary inputs (e.g. human capital) and TFP. Our analysis highlights the wisdom of Lucas' skepticism vis-a-vis the credit friction view. However, our result that physical MPKs differ implies that different endowments of complementary factors or of TFP are not the only cause of differences in capital intensity. Instead, an important role is also played by two additional proximate factors: the higher relative price of capital and the lower reproducible-capital share in poor countries. When we decompose differences in capital-labor ratios to find the relative contributions of complementary factors on one side, and relative prices and capital shares on the other, we find a roughly 50-50 split.

Our analysis implies that the higher cost of installing capital (in terms of foregone consumption) in poor countries is an important factor in explaining why so little capital flows to them. The important role of the relative price of capital in our analysis underscores the close relationship of our contribution with an influential recent paper by Hsieh and Klenow [2003]. Hsieh and Klenow show, among other things, that the relative price of output is the key source for the observed positive correlation of real investment rates and per-capita income, despite roughly constant investment rates in domestic prices. We extend their results by drawing out their implications – together with appropriately-measured reproducible capital shares – for rates of return differentials, and the debate on the missing capital flows to developing countries.[8]

---

observe that the data may be roughly consistent with rate of return equalization.

[8]Another important contribution of Hsieh and Klenow [2003] is to propose an explanation for the observed pattern of relative prices. In their view poor countries have relatively lower TFP in producing (largely tradable) capital goods than in producing (partially non-tradable) consumption goods. Another possible explanation is that poor countries tax sales of machinery relatively more than sales of final goods (e.g. Chari, Kehoe and McGrattan [1996]). Relative price differences may also reflect differences in the composition of output or in unmeasured quality. None of our conclusions in this paper is affected by which of these explanations is the correct one, so we do not take a stand on this. Of course the policy implications of different explanations are very different. For example, if a high relative price of capital reflected tax distortions, then governments should remove these

Our results have implications for the recently-revived policy debate on financial aid to developing countries. The existence of large physical MPK differentials between poor and rich countries would usually be interpreted as *prima facie* support to the view that increased aid flows may be beneficial. But such an interpretation hinges on a credit-friction explanation for such differentials. Our result that financial rates of return are fairly similar in rich and poor countries, instead, implies that any additional flow of resources to developing countries is likely to be offset by private flows in the opposite direction seeking to restore rate-of-return equalization.[9]

II MPK Differentials

II A MPK Differentials in a One-Sector Model

Consider the standard neoclassical one-sector model featuring a constant-return production function and perfectly competitive (domestic) capital markets. Under these (minimal) conditions the rental rate of capital equals the marginal product of capital, so that aggregate capital income is $MPK\mathrm{x}K$, where K is the capital stock. If α is the capital share in GDP, and Y is GDP, we then have $\alpha = MPK\mathrm{x}K/Y$, or

$$(1) \qquad MPK = \alpha \frac{Y}{K}.$$

In the macro-development literature it is common to back out the "capital

---

distortions, and capital would then flow to poor countries.

[9]Our conclusion that a more integrated world financial market would not lead to major changes in world output is in a sense stronger than Gourinchas and Jeanne [2003]'s conclusion that the welfare effects of capital-account openness are small. Gourinchas and Jeanne [2003] find large (calibrated) MPK differentials, and consequently predict large capital inflows following capital-account liberalization. However, they point out that in welfare terms this merely accelerates a process of convergence to a steady state that is independent of whether the capital-account is open or closed. Hence, the discounted welfare gains are modest. Our point is that, even though differences in physical $MPKs$ are large, differences in rates of return are small, so we should not even expect much of a reallocation of capital in the first place.

share" as one minus available estimates of the labor share in income (we review these data below). But such figures include payments accruing to both reproducible and non-reproducible capital, i.e. land and natural resources. By contrast, the standard measure of the capital stock is calculated using the perpetual inventory method from investment flows, and therefore represents only the reproducible capital stock. As is clear from the formula above, therefore, using standard measures of α leads to an overestimate of the marginal productivity of reproducible capital. In turn, this bias on the estimated levels of the MPKs will translate into a twofold bias in cross-country comparisons. First, it will exaggerate absolute differences in MPK, which is typically the kind of differences we are interested in when comparing rates of return on assets (interest-rate spreads, for example, are absolute differences).[10] Second, and most importantly, since the agricultural and natural-resource sectors represent a much larger share of GDP in poor countries, the overestimate of the MPK when using the total capital share is much more severe in such countries, and cross-country differences will once again be inflated (both in absolute and in relative terms).

Of course equation (1) holds (as long as there is only one sector) whether or not non-reproducible capital enters the production function or not. The only thing that changes is the interpretation of α. Hence, these considerations lead us to two possible estimates of the MPK:

$$(2) \qquad MPKN = \alpha_w \frac{Y}{K},$$

---

[10]As an example, suppose that all countries have the same share of land and natural resources in the total capital share, say 20%. Using the total-capital share instead of the reproducible-capital will simply increase all the MPKs by the same proportion. If the US' "true" MPK is 8% and India's 16% (a spread of 8 percentage points), the MPKs computed with the total capital share are 10% and 20% (a spread of 10 percentage points).

and

$$(3) \qquad MPKL = \alpha_k \frac{Y}{K}.$$

In these formulas, Y and K are, respectively, estimates of real output and the reproducible-capital stock; α_w is one minus the labor share (the standard measure of the capital share); and α_k is an estimate of the reproducible-capital share in income. The suffix "N" in the first measure is a mnemonic for "naive," while the suffix "L" in the second stands for "land and natural-resource corrected."

It is important to observe that, relative to alternative estimates in the literature, this method of calculating MPK requires no functional form assumptions (other than linear homogeneity), much less that we come up with estimates of human capital, TFP, or other factors that affect a country's MPK. Furthermore, the assumptions we do make are typically shared by the other approaches to MPK estimation, so the set of restrictions we impose is a strict subset of those imposed elsewhere. This calculation is a useful basis for our other calculations because it encompasses the most conventional set of assumptions in the growth literature.

II B MPK Differentials in a Multi-Sector Model

The calculations suggested above are potentially biased because they ignore an important fact – the price of capital relative to the price of consumption goods is higher in poor countries than in rich countries. To see why this matters consider an economy that produces J final goods. Each final good is produced using capital and other factors, which we don't need to specify. The only technological restriction is that each of the final goods is produced under constant returns to scale. The only institutional restriction is that there is perfect competition in good and factor markets within each

country. Capital may be produced domestically (in which case it is one of the J final goods), imported, or both. Similarly, it does not matter whether the other final goods produced domestically are tradable or not.

Consider the decision by a firm or a household to purchase a piece of capital and use it in the production of one of the final goods, say good 1. The return from this transaction is

$$(4) \qquad \frac{P_1(t)MPK_1(t) + P_k(t+1)(1-\delta)}{P_k(t)},$$

where $P_1(t)$ is the domestic price of good 1 at time t, $P_k(t)$ is the domestic price of capital goods, δ is the depreciation rate, and MPK_1 is the *physical* marginal product of capital in the production of good 1. When do we have frictionless international capital markets? When the firms/households contemplating this investment in all countries have access to an alternative investment opportunity, that yields a common world gross rate of return R^*. Abstracting for simplicity from capital gains, frictionless international capital markets imply

$$(5) \qquad \frac{P_1 MPK_1}{P_k} = R^* - (1-\delta).$$

Hence, frictionless international credit markets imply that the value of the marginal product of capital in any particular final good, divided by the price of capital, is constant across countries.

To bring this condition to the data let us first note that total capital income is $\sum_j P_j MPK_j K_j$, where K_j is the amount of capital used in producing good j. If capital is efficiently allocated domestically, we also have $P_j MPK_j = P_1 MPK_1$, so total capital income is $P_1 MPK_1 \sum_j K_j = P_1 MPK_1 K$, where K is the total capital stock in operation in the country. Given that capital income is $P_1 MPK_1 K$, the capital share

10

in income is $\alpha = P_1 MPK_1 K/(P_y Y)$,where $P_y Y$ is GDP evaluated at domestic prices. Hence, the following holds:

$$(6) \qquad \frac{P_1 MPK_1}{P_k} = \frac{\alpha P_y Y}{P_k K}$$

In other words, the multi-sector model recommends a measure of the marginal product of capital that is easily backed out from an estimate of the capital share in income, α, GDP at domestic prices, $P_y Y$, and the capital-stock at domestic prices, $P_k K$. Comparing this with the estimate suggested by the one-sector model (equation (1)) we see that the difference lies in correcting for the relative price of final-to-capital goods, P_y/P_k. It should be clear that this correction is fundamental to properly assess the hypothesis that international credit markets are frictionless.

All of the above goes through whether or not reproducible capital is the only recipient of non-labor income or not. Again, the only difference is in the interpretation of the capital share α. Hence, we come to our third and fourth possible estimates of the MPK:

$$(7) \qquad PMPKN = \frac{\alpha_w P_y Y}{P_k K},$$

and

$$(8) \qquad PMPKL = \frac{\alpha_k P_y Y}{P_k K}$$

where P_y/P_k is a measure of the average price of final goods relative to the price of reproducible capital, and the prefix "P" stands for "price-corrected."[11]

---

[11]Since in our model $P_j MPK_j$ is equalized across sectors j, the physical MPK in any particular sector will be an inverse function of the price of output in that sector. Since the relative price of capital is high in poor countries, this is consistent with the conjecture of Hsieh and Klenow [2003] that relative productivity in the capital goods producing sectors is low in poor countries.

Notice that the one-sector based measures, $MPKN$ and $MPKL$, retain some interest even in the multi-sector context. In particular, one can show that

$$(9) \qquad \frac{\alpha Y}{K} = \frac{1}{\sum_j \frac{Y_j/Y}{MPK_j}}.$$

In words, the product of the capital share and real income, divided by the capital stock, tends to increase when physical marginal products tend to be high on average in the various sectors.[12] Hence, the one-sector based measures offer some quantitative assessment of cross-country differences in the average *physical MPK*.

II C   Data

Our data on Y, K, P_y, and P_k come (directly or indirectly) from Version 6.1 of the Penn World Tables (PWT, Heston, Summers and Aten [2004]). Briefly, Y is GDP in purchasing power parity (PPP) in 1996. The capital stock, K, is constructed with the perpetual inventory method from time series data on real investment (also from the PWT) using a depreciation rate of 0.06. Following standard practice, we compute the initial capital stock, K_0, as $I_0/(g + \delta)$, where I_0 is the value of the investment series in the first year it is available, and g is the average geometric growth rate for the investment series between the first year with available data and 1970 (see Caselli [2005] for more details).[13] P_y is essentially a weighted average of final good domestic

---

[12]To obtain this expression start out by the definition of P_y, which is

$$(10) \qquad P_y = \frac{\sum_j P_j Y_j}{Y}.$$

Then substitute $P_j = \frac{\alpha P_y Y}{MPK_j K}$ from the last equation in the text, and rearrange.

[13]A potential bias arises if the depreciation rate δ differs across countries, perhaps because of differences in the composition of investment, or because the natural environment is more or less forgiving. In particular we will overestimate the capital stock of countries with high depreciation rates, and therefore underestimate their MPK. However notice from equation (5) that countries with a high depreciation rates *should* have higher MPKs. In other words variation in δ biases both sides

prices, while P_k is a weighted average of capital good domestic prices. The list of final and capital goods to be included in the measure is constant across countries. Hence, P_y/P_k is a summary measure of the prices of final goods relative to capital goods. As many authors have already pointed out, capital goods are relatively more expensive in poor countries, so the free capital flows condition modified to take account of relative capital prices should fit the data better than the unmodified condition if the physical MPK tends to be higher in poor countries.[14]

The total capital share, α_w is taken from Bernanke and Gurkaynak [2001], who build upon and expand upon the influential work of Gollin [2002]. As mentioned, these estimates compute the capital share as one minus the labor share in GDP. In turn, the labor share is employee compensation in the corporate sector from the National Accounts, plus a number of adjustments to include the labor income of the self-employed and non-corporate employees.[15]

Direct measures of reproducible capital's share of output, α_k, do not appear to be available. However, a proxy for them can be constructed from data on wealth, which has recently become available for a variety of countries from the World Bank [2006]. These data split national wealth into natural capital, such as land and natural resources, and reproducible capital. If total wealth equals reproducible capital plus

---

of (5) in the same direction.

[14]See, e.g., Barro [1991], Jones [1994], and Hsieh and Klenow [2003] for further discussions of the price data.

[15]Bernanke and Gürkaynak use similar methods as Gollin, but their data set includes a few more countries. The numbers are straight from Table X in the Bernanke and Gürkaynak paper. Their preferred estimates are reported in the column labeled "Actual OSPUE," and they are constructed by assigning to labor a share of the Operating Surplus of Private Unincorporate Enterprises equal to the share of labor in the corporate (and public) sector. We use these data wherever they are available. When "Actual OSPUE" is not available we take the data from the column "Imputed OSPUE," which is constructed as "Actual OSPUE," except that the OSPUE measure is estimated by breaking down the sum of OSPUE and total corporate income by assuming that the share of corporate income in total income is the same as the share of corporate labor in total labor. Finally, when this measure, is also unavailable, we get the data from the "LF" column, which assumes that average labor income in the non-corporate sector equals average labor income in the corporate sector. When we use Gollin's estimates we get very much the same results.

natural wealth, $W = P_k K + L$, then the payments to reproducible capital should be $P_k K * r$, and payments to natural wealth should be $L * r$. Reproducible capital's share of total capital income is therefore proportional to reproducible capital's share of wealth (since all units of wealth pay the same return).[16] So,

(11) $$\alpha_k = (P_k K / W) * \alpha_w.$$

We can therefore back out an estimate of α_k from α_w as estimated by Bernanke and Gurkaynak [2001] and $P_k K / W$ as estimated by the World Bank.

Since the World Bank's data on land and natural-resource wealth is by far the newest and least familiar among those used in this paper, a few more words to describe these data are probably in order. The general approach is to estimate the value of rents from a particular form of capital and then capitalize this value using a fixed discount rate. In most cases, the measure of rents is based on the value of output from that form of capital in a given year. For subsoil resources, the World Bank also needs to estimate the future growth of rents and a time horizon to depletion. For forest products, rents are estimated as the value of timber produced (at local market prices where possible) minus an estimate of the cost of production. Adjustments are made for sustainability based on the volume of production and total amount of usable timberland. The rents to other forest resources are estimated as fixed value per acre for all non-timber forest. Rents from cropland are estimated as the value of agricultural output minus production costs. Production costs are taken to be a fixed percentage of output, where that percentage varies by crop. Pasture land is similarly valued. Protected areas are valued as if they had the same per-hectare output as crop and pasture land, based on an opportunity cost argument. Reproducible capital is calculated using the perpetual inventory method.

---

[16]This requires the assumption that capital gains are identical for natural capital and reproducible capital.

14

Table I:
Proportion of Different Types of Wealth in Total Wealth in 2000

Variable	Mean	Stdev	Median	Weighted Mean*	Corr w/ log(GDP)**
Subsoil Resources	10.5	16.4	1.5	7.0	-0.13
Timber	1.7	2.6	0.8	0.9	-0.34
Other Forest	2.2	5.4	1.1	0.3	-0.49
Cropland	11.4	15.2	5.1	3.2	-0.73
Pasture	4.5	5.4	2.7	1.9	-0.00
Protected Areas	1.9	2.5	0.3	1.4	0.01
Urban Land	13.1	4.6	13.5	16.5	0.70
Reproducible Capital	54.8	19.2	56.3	68.6	0.70

*Weighted by the total value of the capital stock.
** GDP is per worker.
Source: Authors calculations using data from World Bank [2006].

Due to data limitations, no good estimates of the value of urban land are available. A very crude estimate values urban land at 24% of the value of reproducible capital.

Summary statistics of the cross-country distribution of the shares of different types of wealth in total wealth are reported in Table I. In the average country in our sample, reproducible capital represents roughly one half of total capital, while various forms of "natural" capital account for the other half. The proportion of reproducible capital is highly correlated with log GDP per worker. All other types of capital (except for urban land, which is calculated as a fraction of accumulated capital) are negatively correlated with log GDP per worker. Cropland is particularly negatively correlated with income. The weighted means are weighted by the total capital stock in each country, so that they give the proportion of each type of capital in the total capital stock of the World (as represented by our sample). The proportion of reproducible capital is much higher in the weighted means, with almost 70% of total capital.

Other data sources provide opportunities for checking the broad reliability of these data. For the US, the OMB published an accounting of land and reproducible

wealth (but not other natural resources) over time (Office of Management and Budget [2005]). They find that the proportion of land in total capital varies between 20 and 26% between 1960 and 2003, with no clear trend to the data. This range is consistent with the World Bank estimate of 26% (when, for comparability with the OMB estimates, one excludes natural resources other than land). Another check is from the sectorial dataset on land and capital shares constructed by Caselli and Coleman [2001]. Our approach to estimate the reproducible capital share in GDP implies a land share in GDP in the US of 8%. According to Caselli and Coleman in the US the land share in agricultural output is about 20%, and the land share in non-agriculture is about 6%. Since the share of nonagriculture in GDP is in the order of 97%, these authors' overall estimate of the land share in the US is very close to ours.

There are a number of studies from the 60's and 70's which perform similar exercises on a variety of countries. Raymond W. Goldsmith collects some of these in Goldsmith [1985]. He finds land shares in total capital in 1978 that average about 20% across a group of mostly rich countries. With the exception of Japan at 51%, the figures range from 12% to 27%.[17] This range is once again broadly consistent with the World Bank data.

The data from Bernanke and Gurkaynak [2001] puts the heaviest constraints on the sample size, so that we end up with 53 countries.[18] The entire data set is reported in Appendix Table VII. Capital per worker, k, the relative price P_y/P_k, the total capital share, and the reproducible capital's share are also plotted against output per worker, y, in Appendix Figures V, VI, VII, and VIII.

---

[17]Japan is not similarly an outlier in the World Bank data. This may reflect the relatively crude way that urban land values is estimated by the World Bank. Lacking a good cross country measure of urban land value, they simply take urban land to be worth a fixed value of reproducible capital. Given the population density of Japan this may substantially understate the value of Japanese urban land.

[18]For the calculations corrected for the reproducible capital share, we also lose Hong Kong.

II D MPK Results

In this section we present our four estimates of the MPK. To recap, the naive version, $MPKN$, does not account for difference in prices of capital and consumption goods, and also uses the total share of capital, not the share of reproducible capital. This calculation is the simplest and will be used as a benchmark for the corrected versions. $MPKL$ is calculated using the share of reproducible capital rather than the share of total capital. $PMPKN$ is adjusted to account for differences in prices between capital and consumption goods, but reverts to the total capital share. Finally $PMPKL$, the "right" estimate, includes both the price adjustment and the natural capital adjustment. These four different versions of the implied MPKs are reported in Appendix Table VII, and plotted against GDP per worker, y, in Figure I.

The overall relationship between the naive estimate, $MPKN$, and income is clearly negative. However, the non-linearity in the data cannot be ignored: there is a remarkably neat split whereby the $MPKN$ is highly variable and high on average in developing countries (up to Malaysia), and fairly constant and low on average among developed countries (up from Portugal). The average $MPKN$ among the 29 lower income countries is 27 percent, with a standard deviation of 9 percent. Among the 24 high income countries the average $MPKN$ is 11 percent, with a standard deviation of 3 percent. Neither within the subsample of countries to the left of Portugal, nor in the one to the right, there is a statistically significant relationship between the $MPKN$ and y (nor with $\log(y)$).

This first simple calculation implies that the aggregate marginal product of capital is high and highly variable in poor countries, and low and fairly uniform in rich countries. If we were to stop here, it would be tempting to conclude that capital flows fairly freely among the rich countries, but not towards and among the poor countries. This looks like a big win for the credit friction answer to the Lucas question.
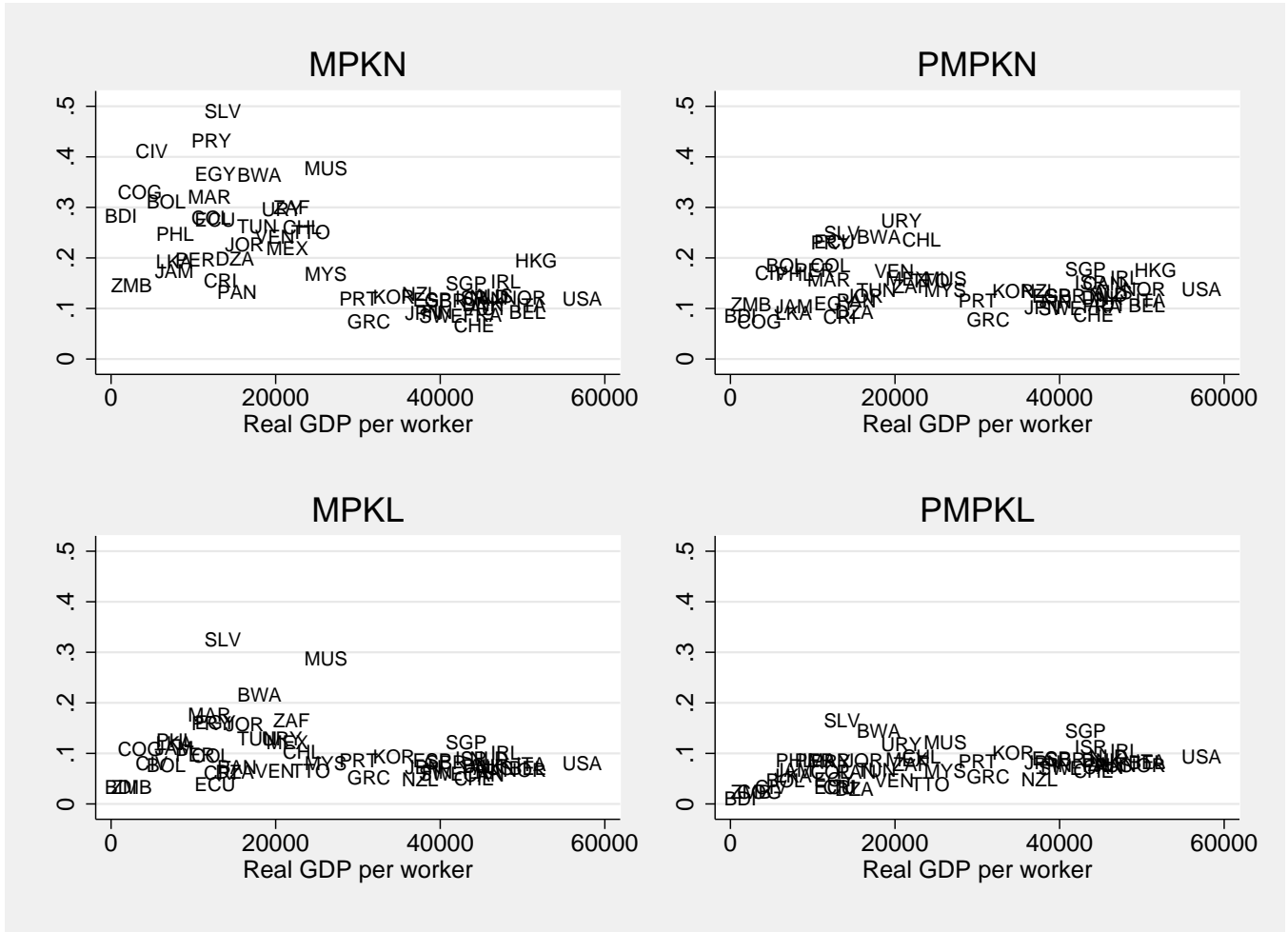
17

Figure I:
The Marginal Product of Capital

MPKN: naive estimate. *MPKL* : after correction for natural-capital.
PMPKN: after correction for price differences. *PMKL*: after both corrections.
Source: Heston et al. [2004], Bernanke and Gurkaynak [2001], and World Bank
[2006]. Authors' calculations.

Once one accounts for prices and the share of natural capital a different story emerges. Figure I shows that each of the adjustments reduces the variance of the marginal product considerably and reduces the differences between the rich and poor countries. Taking both adjustments together eliminates the variance almost completely and the rich countries actually have a higher marginal product on average than the poor countries. Table II summarizes the average marginal products for each of our calculation for poor and rich countries. The differences between the poor and rich

Table II:
Average Return to Capital in Poor and Rich Countries

	Rich Countries	Poor Countries
$MPKN$	11.4 (2.7)	27.2 (9.0)
$MPKL$	7.5 (1.7)	11.9 (6.9)
$PMPKN$	12.6 (2.5)	15.7 (5.5)
$PMPKL$	8.4 (1.9)	6.9 (3.7)

$MPKN$: naive estimate. $MPKL$: after correction for natural-capital.
$PMPKN$: after correction for price differences. $PMPKL$: after both corrections.
Rich (Poor): GDP at least as large (smaller than) Portugal.
Standard Deviations in Parentheses. Source: Authors' calculations.

countries are significant for the first three rows of the table. For the case using both corrections, the difference is only significant at the 10% level.

Interestingly, with both adjustments there is a positive and significant relationship between $PMPKL$ and output within the low income countries. The very lowest income countries in our sample have the lowest $PMPKL$ values. This would be consistent with a model where capital flows out of the country were forbidden, and where some capital flows into the country were not responsive to the rate of return. This may describe the poorest countries in our sample, where aid flows represent a significant proportion of investment capital (and all of the inward flow of capital).

III Assessing the Costs of Credit Frictions

The existence of any cross-country differences in MPK suggests inefficiencies in the world allocation of capital. How severe are these frictions? One possible way to answer this question is to compute the amount of GDP the world fails to produce as a consequence. In particular, we perform the counter-factual experiment of reallocating the world capital stock so as to achieve MPK equalization under our various measures. We then compare world output under this reallocation to actual world output. The difference is a measure of the deadweight loss from the failure to equalize MPKs.

We stress that this is not a normative exercise: our capital reallocation is not a policy proposal. The observed distribution of output is an equilibrium outcome given certain distortions that prevent MPK equalization. The point of this exercise is to assess the welfare losses the world experiences relative to a frictionless first best, not that the first best is easily achievable by moving some capital around.

While our MPK estimates are free of functional form assumptions, in order to perform our counterfactual calculations me must now choose a specific production function. We thus fall back on the standard Cobb-Douglas workhorse. Industry j in country i has the production function

(12)
$$Y_{ij} = Z_{ij}^{\beta_{ij}} K_{ij}^{\alpha_i} (X_{ij} L_{ij})^{1-\alpha_i-\beta_{ij}},$$

where Z_{ij} is the quantity of natural capital, K_{ij} the reproducible capital stock, L_{ij} the input of labor, β_{ij} is the share of natural capital in sector j in country i and X_{ij} is a summary measure of technology and is also sector and country specific. The derivation below makes it clear that to pursue our calculations we must assume that the reproducible-capital share in country i, α_i, is the same across all sectors (though it can vary across countries).

The marginal product of capital in sector j in country i is

$$(13) \qquad MPK_{ij} = \alpha_i Z_{ij}^{\beta_{ij}} K_{ij}^{\alpha_i - 1} (X_{ij} L_{ij})^{1 - \alpha_i - \beta_{ij}}.$$

Taking into account the relative prices of capital and consumption goods, rates of return within a country are equalized when

$$(14) \qquad PMPK_{ij} = \frac{P_{ij}}{P_k} \alpha_i Z_{ij}^{\beta_{ij}} K_{ij}^{\alpha_i - 1} (X_{ij} L_{ij})^{1 - \alpha_i - \beta_{ij}} = PMPK_i \quad j = 1...J.$$

Suppose now that capital was reallocated across countries in such a way that $PMPK_i$ took the same value, $PMPK^*$, in all countries. Assuming for the time being that Z_{ij}, and L_{ij} are unchanged in response to our counterfactual reshuffling of capital (we will check this is indeed the case later in the section), the new value of K_{ij}, K_{ij}^*, satisfies[19]

$$(15) \qquad \frac{P_{ij}}{P_k} \alpha_i Z_{ij}^{\beta_{ij}} (K_{ij}^*)^{\alpha_i - 1} (X_{ij} L_{ij})^{1 - \alpha_i - \beta_{ij}} = PMPK^*.$$

Dividing (15) by (14) we have

$$(16) \qquad K_{ij}^* = \left(\frac{PMPK_i}{PMPK^*} \right)^{\frac{1}{1 - \alpha_i}} K_{ij},$$

which shows that capital increases or decreases by the same proportion in each sector.

Earlier we made the conjecture that all adjustment to the equalization of $PMPK$s was through the capital stock, and not through reallocations of labor or natural capital. Under this conjecture, since the amount of capital per worker changes by the

---

[19]For the remainder of this section, expressions relating to $PMPK$ equalization can be simplified to expressions for MPK equalization by assuming $P_k = P_y$. Calculations will be performed for both cases.

same factor in each sector, the marginal products of labor and natural capital must do the same. Hence, even if labor is not a specific factor, as long as its allocation across sectors depends on *relative* wages, there will be no reshuffling of workers across sectors. In particular, our experiment is consistent with wage equalization across sectors, but also with models in which inter-sectoral migration frictions imply fixed proportional wedges among different sectors' wages. The same is true of natural capital.

We can now aggregate the sectoral capital stocks to the country level:

$$(17) \qquad K_i^* = \sum_j K_{ij}^* = \sum_j \left(\frac{PMPK_i}{PMPK^*} \right)^{\frac{1}{1-\alpha_i}} K_{ij} = \left(\frac{PMPK_i}{PMPK^*} \right)^{\frac{1}{1-\alpha_i}} K_i$$

In order to close the model we need to impose a resource constraint. The resource constraint is that the world sum of counter-factual capital stocks is equal to the existing world endowment of reproducible capital, or

$$(18) \qquad \sum K_i^* = \sum K_i = \left(\frac{PMPK_i}{PMPK^*} \right)^{\frac{1}{1-\alpha_i}} K_i.$$

Taking the values for $PMPK_i$ calculated in the previous section, the only unknown in (18) is $PMPK^*$, which can be solved for with a simple non-linear numerical routine. To recap, $PMPK^*$ is the common world rate of return to capital that would prevail if the existing world capital stock were allocated optimally.[20]

III A   Counterfactual Capital Stocks

With the counterfactual world rate of return, $PMPK^*$, at hand we can use equation (17) to back out each country's assigned capital stock when rates of return are equal-

---

[20]Removing the frictions that prevent $PMPK$ equalization would almost certainly also lead to an increase in the world aggregate capital stock. Our calculations clearly abstract from this additional benefit, and are therefore a lower bound on the welfare cost of such frictions.

ized. As with our initial MPK calculations, four variations are calculated. The base version, labeled $MPKN$, is calculated under the assumption that $P_k = P_y$ and uses the total share of capital, not correcting for natural capital (i.e. it sets $\beta_{ij} = 0$). $MPKL$ is calculated using the share of reproducible capital rather than the share of total capital. $PMPKN$ allows for differences in prices. $PMPKL$ includes both the price adjustment and the natural capital adjustment. Figure II plots the resulting counter-factual distributions of capital-labor ratios against the actual distribution. The solid lines are 45-degree lines. Table III summarizes the change in capital labor ratios under the various calculations for poor and rich countries.

Table III:
Average Changes in Equilibrium Capital Stocks under MPK Equalization

	Unweighted		Weighted by Population	
	Rich Countries	Poor Countries	Rich Countries	Poor Countries
$MPKN$	-12.9%	274.5%	-19.3%	205.8%
$MPKL$	-6.2%	86.6%	-5.6%	59.3%
$PMPKN$	0.1%	71.8%	-4.9%	52.0%
$PMPKL$	0.6%	-10.6%	1.4%	-14.5%

$MPKN$: naive estimate. $MPKL$: after correction for natural-capital.
$PMPKN$: after correction for price differences. $PMPKL$: after both corrections.
Rich (Poor): GDP at least as large (smaller than) Portugal.
Standard Deviations in Parentheses. Source: Authors' calculations.

Not surprisingly, under the naive MPK calculation, most developing countries would be recipients of capital and the developed economies would be senders. The magnitude of the changes in capital-labor ratios under this scenario are fairly spectacular, with the average developing country experiencing almost a 300 percent increase. In the average rich country the capital-labor ratio falls by 13 percent. These figures remain in the same ball park when weighted by population. The average developing country worker experiences a still sizable 206 percent increase in his capital endowment. The average rich-country worker loses 19 percent of his capital allotment. The
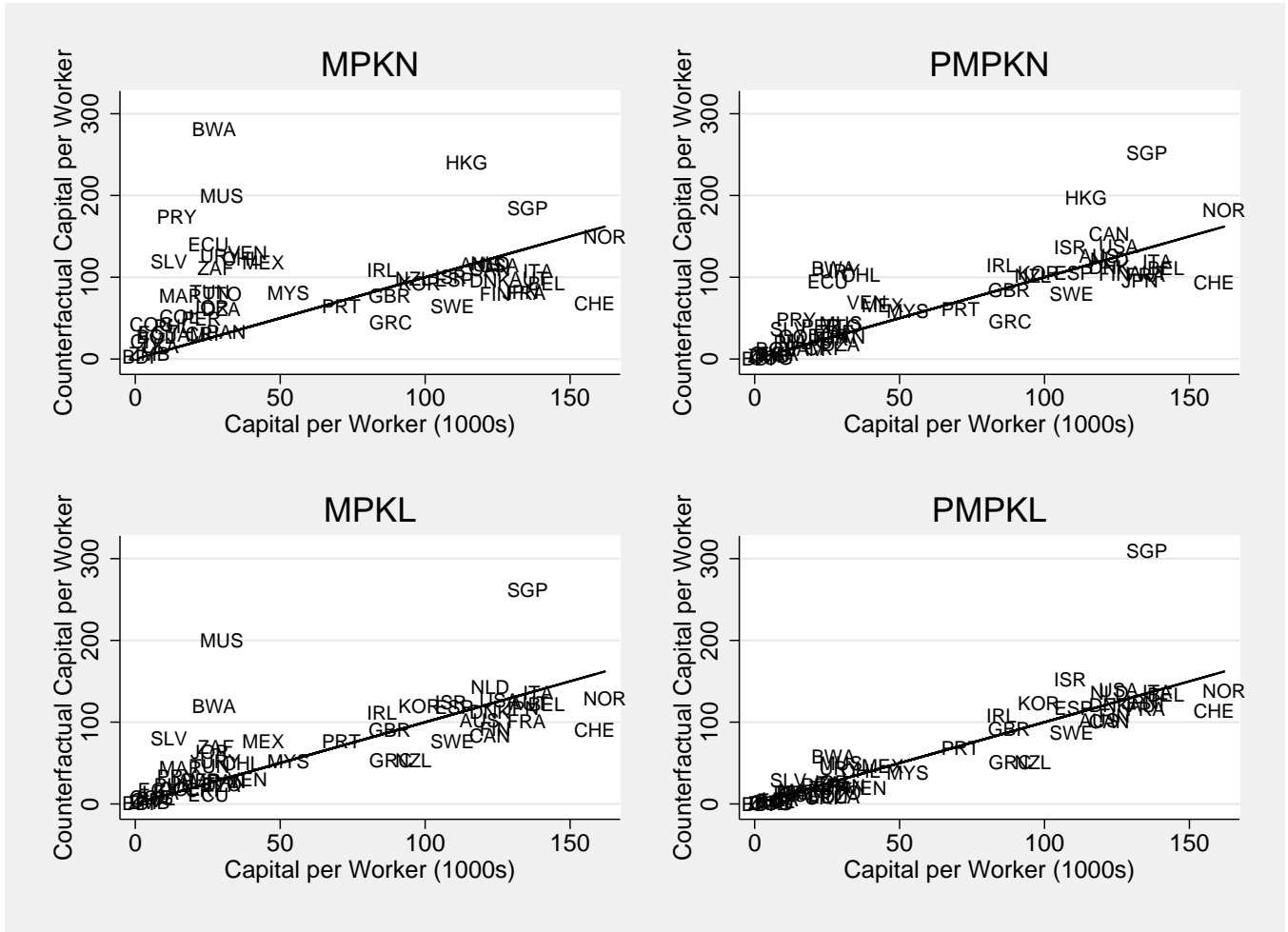
Figure II:
Counterfactual Capital per Worker with Equalized Returns to Capital

$MPKN$: naive estimate. $MPKL$: after correction for natural-capital.
$PMPKN$: after correction for price differences. $PMKL$: after both corrections.
Source: Heston et al. [2004], Bernanke and Gurkaynak [2001], and World Bank
[2006]. Authors' calculations.

scatter plots show that despite this substantial amount of reallocation, many developing countries would still have less physical-capital per worker, reflecting their lower average efficiency levels (as reflected in the X_{ij}s). Similarly, some of the rich countries are capital recipients.

However when we correct the MPK for the natural capital share and relative prices once again rich-poor differences are dramatically reduced. Either the price adjustment or the natural capital adjustment taken alone reduces the averaged weighted gain in the capital stock to about 50% in the poor countries while the rich countries lose about 5% of their capital stock. With both corrections in place the poor countries actually lose capital to the rich countries.

III B   Counterfactual Output

The effect on output of our counter-factual reallocation of the capital stock is easily calculated. Substituting K_{ij}^* into the production function (12), we get

$$(19) \qquad Y_{ij}^* = Z_{ij}^{\beta_{ij}} (K_{ij}^*)^{\alpha_i} (X_{ij} L_{ij})^{1-\alpha_i-\beta_{ij}} = \left(\frac{PMPK^*}{PMPK_i} \right)^{\frac{\alpha_i}{1-\alpha_i}} Y_{ij}.$$

Since all sectorial outputs go up by the same proportion, aggregate output also goes up by the same proportion, and we have

$$(20) \qquad Y_i^* = \left(\frac{PMPK^*}{PMPK_i} \right)^{\frac{\alpha_i}{1-\alpha_i}} Y_i.$$

Hence, plugging values for α_i, $PMPK_i$ and $PMPK^*$ we can back out the counterfactual values of each country's GDP under our various MPK equalization counterfactuals. These values are plotted in Figure III, again together with a 45-degree line. Table IV summarizes the change in output per worker under the various calculations.
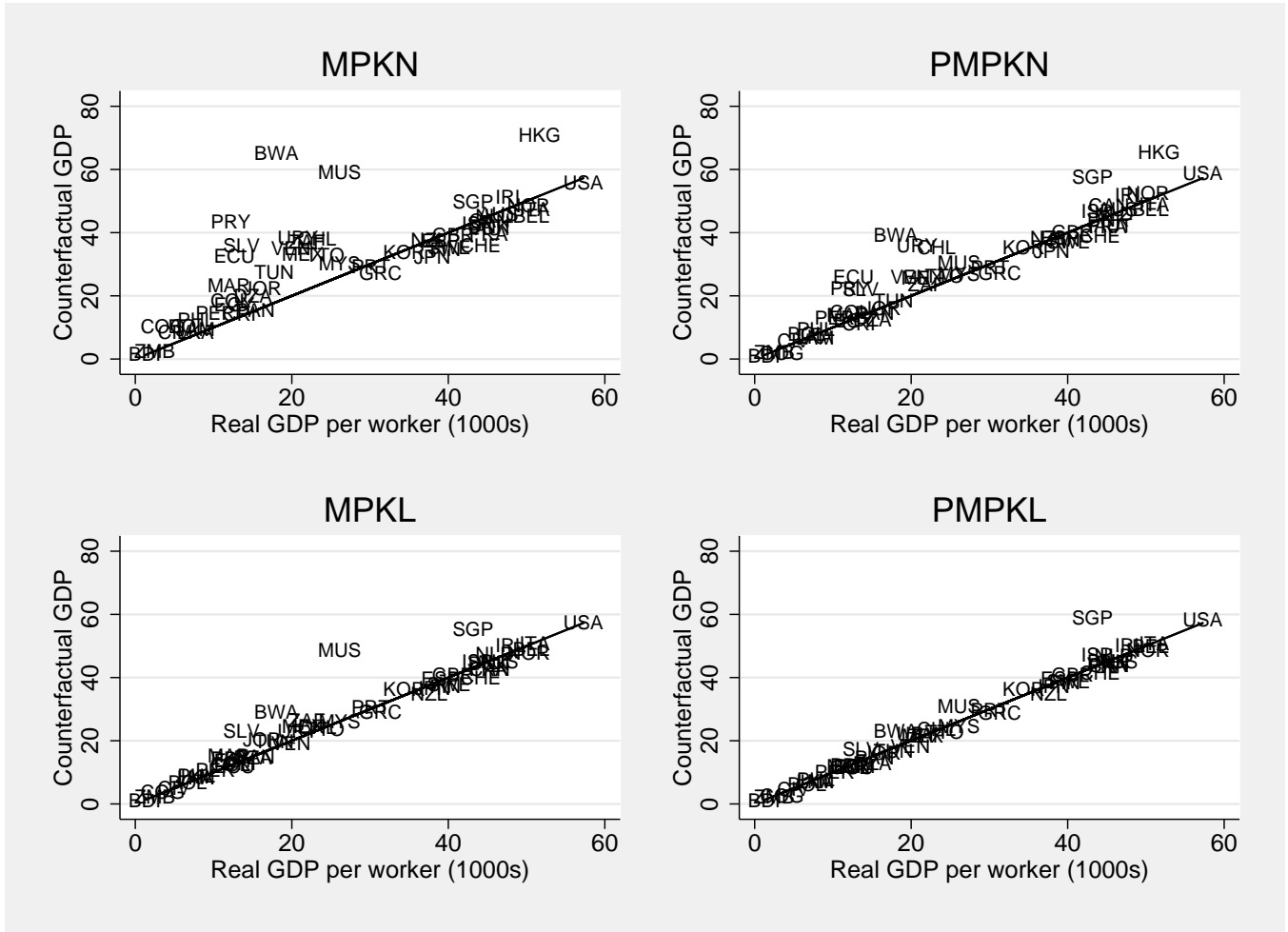
25

Figure III:
Counterfactual Output with Equalized Returns to Capital

$MPKN$: naive estimate. $MPKL$: after correction for natural-capital.
$PMPKN$: after correction for price differences. $PMKL$: after both corrections.
Source: Heston et al. [2004], Bernanke and Gurkaynak [2001], and World Bank
[2006]. Authors' calculations.

Table IV:

Average Changes in Equilibrium Output per Worker under MPK Equalization

	Unweighted		Weighted by Population	
	Rich Countries	Poor Countries	Rich Countries	Poor Countries
$MPKN$	-3.0%	76.7%	-5.5%	58.2%
$MPKL$	-0.7%	16.8%	-1.0%	10.4%
$PMPKN$	1.1%	24.7%	-1.0%	17.4%
$PMPKL$	0.7%	0.0%	0.4%	-2.4%

$MPKN$: naive estimate. $MPKL$: after correction for natural-capital.
$PMPKN$: after correction for price differences. $PMPKL$: after both corrections.
Rich (Poor): GDP at least as large (smaller than) Portugal.
Standard Deviations in Parentheses. Source: Authors' calculations.

Changes in output in our counterfactual world are obviously consistent with the result for capital-labor ratios. For our naive MPK measure, developing countries tend to experience increases in GDP, and rich countries declines. The average developing country experiences a 77 percent gain, while the average developed country only "loses" 3 percent. These numbers fall dramatically when adjustments are made for relative capital prices and natural capital, with increases of less than 25% in both cases. For the scenario with both adjustments, average output in the two groups is essentially unchanged.

III C Dead Weight Losses

To provide a comprehensive summary measure of the deadweight loss from the failure of MPKs to equalize across countries we compute the percentage difference between world output in the counterfactual case and actual world output, or

(21)
$$\frac{\sum_i (Y_i^* - Y_i)}{\sum Y_i}.$$

Table V:
World Output Gain from MPK Equalization

	No Price Adjustment	With Price Adjustment
No Natural-Capital Adjustment	2.9%	1.4%
With Natural-Capital Adjustment	0.6%	0.1%

Source: Authors' calculations.

This can be calculated for each of our measures of the marginal product. Table V summarizes this calculation for our four calculation methods.

For the naive MPK calculation, the result is in the order of 0.03, or world output would increase by 3 percent if we redistributed physical capital so as to equalize the MPK. This number is large. To put it in perspective, consider that the 28 developing countries in our sample account for 12 percent of the aggregate GDP of the sample. This result implies that the deadweight loss from inefficient allocation of capital is in the order of one quarter of the aggregate (and hence also per capita) income of developing countries.

Once one adjusts for price differences and natural capital, however, the picture changes substantially. The natural-capital adjustment alone reduces the dead weight loss to less than a quarter of the base case. The price adjustment alone reduces the dead weight losses by over half. Taken together, the dead weight loss is negligible.

In these calculations, the natural-capital adjustment appears to be of greater importance than the price adjustment. This was not the case for the MPK calculations. This is because the capital adjustment reduces the dead weight losses in two ways. First, like the price adjustment, the natural-capital adjustment tends to reduce the gap between rich and poor MPK. Unlike the price adjustment, the natural capital adjustment reduces the share of capital for our deadweight loss calculations for all countries. This reduces the sensitivity of output to reallocations of capital and

Table VI:
Counterfactual MPK under MPK Equalization

	No Price Adjustment	With Price Adjustment
No Natural-Capital Adjustment	12.7%	12.8%
With Natural-Capital Adjustment	8.0%	8.6%

Source: Authors' calculations.

reduces the dead weight losses further. This can be seen in Table VI which lists the counter-factual MPK for each of our cases.

The main implication of our results thus far is that given the observed pattern of the relative price of investment goods and accounting for differences in the share of reproducible capital across countries, a fully integrated and frictionless world capital market would *not* produce an international allocation of capital much different from the observed one. Similarly, as shown in Figure III, once capital is reallocated across countries so as to equalize the rate of return to reproducible-capital investment (corrected for price differences and using the proper measure of capital's share), the counter-factual world income distribution is very close to the observed one. Hence, it is not primarily capital-market segmentation that generates low capital-labor ratios in developing countries. In the next section we expand on this theme.

IV   Explaining Differences in Capital-Labor Ratios

Since we find essentially no difference in (properly measured) MPKs between poor and rich countries, we end up siding with Lucas on the (un)importance of international credit frictions as a source of differences in capital-labor ratios. But our results also call for some qualifications to Lucas' preferred explanation, namely that rich countries had a greater abundance of factors complementary to reproducible capital, or higher levels of TFP. These factors certainly play a role, but other important proximate causes

29

are the international variation on the relative price of capital and the international variation in the reproducible-capital share.

We cannot accurately apportion the relative contribution of prices, capital shares and other (Lucas) factors without data on each sector's price P_{ij}, efficiency, X_{ij}, and natural-capital share, β_{ij}. But a rough approximation to a decomposition can be produced by focusing on a very special case, in which each country produces only one output good. In this example, clearly, most countries import their capital.[21] With this (admittedly very strong) assumption, we can rearrange equation (15) to read

$$(22) \qquad\qquad k_i^* = \Pi_i \, \text{x} \, \Lambda_i,$$

where

$$(23) \qquad\qquad \Pi_i = \left(\frac{\alpha_i}{PMPK^*} \frac{P_{y,i}}{P_{k,i}} \right)^{\frac{1}{1-\alpha_i}},$$

and

$$(24) \qquad\qquad \Lambda_i = \left[z_i^{\beta_i} \left(X_i \right)^{1-\alpha_i-\beta_i} \right]^{\frac{1}{1-\alpha_i}},$$

where k_i^* is the ratio of reproducible-capital to labor and z_i is the ratio of natural-capital to labor. The first term captures the effect of variation in relative prices and capital shares on the capital-labor ratio. The second term captures the traditional complementary factors identified by Lucas. In the simplest case where α_i and the price ratio are assumed to be the same in all countries, all the variance of capital per worker in a world with perfect mobility would be due to differences in Λ.

In equation (22) the term Π_i is available from our previous calculations, so we

---

[21] As recently emphasized by Hsieh and Klenow [2003], the absolute price of capital does not covary with income.

can , back out the term Λ_i as k_i^*/Π_i. Following Klenow and Rodriguez-Clare [1997] we can then take the log and variance of both sides to arrive at the decomposition:

$$(25) \qquad var\left[\log(k^*)\right] = var\left[\log(\Pi)\right] + var\left[\log(\Lambda)\right] + 2 * cov\left[\log(\Pi), \log(\Lambda)\right].$$

The variance of $\log(k^*)$ for our $PMPKL$ case is 2.46, the variance of $\log(\Pi)$ is 0.82, the variance of $\log(\Lambda)$ is 0.61, and the covariance term is 0.52. If we apportion the covariance term across Π and Λ equally this suggests that 54% of the variance in k^* is due to differences in Π and 46% is due to differences in Λ. Each obviously plays a large role and they are clearly interconnected (the simple correlation between them is 0.73). This analysis can also be done weighting the sample by population. The results are very similar with about 50% attributed to each of Π and Λ. It is also possible to look within Π to determine the relative importance of variation in the share of reproducible capital and relative capital prices. The result of this variance decomposition suggests that they are of roughly equal importance.

These results should come as no large surprise. Hsieh and Klenow [2003] argue that differences in the price ratio are due to relatively low productivity in the capital producing sectors in developing countries. Since Λ in our formulation is comprised of an amalgam of human capital and total factor productivity, it should not be surprising that low Λ correlates with an unfavorable price ratio. Similarly, the proportion of output in land and natural resources will tend to be larger in poor countries, simply because they produce less total output. With rising incomes we would expect to see that proportion fall. The ultimate cause of differences in capital per worker may therefore be productivity differences if productivity differences are the ultimate cause of differences in capital costs and the share of capital. However, failure to account for these factors will falsely suggest that financial frictions play a large role.

V   Time Series Results

In this section we attempt a brief look at the evolution over time of our deadweight loss measures. The results should be taken with great caution for two reasons. First, they are predicated on estimates of the capital stock. Since the capital stocks are a function of time series data on investment, the capital stock numbers become increasingly unreliable as we proceed backward in time. Second, our estimates of capital's share of income are from a single year, so changes over time are not reflected. This is a particular problem in the case of the calculations corrected for natural capital. The share of natural resources was particularly volatile during this period and this is not properly accounted for in the results.

With these important caveats, Figure IV displays the time series evolution of the world's deadweight loss from MPK differentials. We find little – or perhaps a slightly increasing – long-run trend in the deadweight loss from failure to equalize $MPKN$. Once prices are accounted for, however, it appears that the size of the deadweight losses have fallen somewhat over time. Adding in the correction for natural capital causes the trend to be clearly downward. This provides tentative evidence that the deadweight loss from failure to equalize financial returns – the cost of credit frictions – has fallen somewhat over time. This latter result is consistent with the view that world financial markets have become increasingly integrated. [22]

---

[22]The acceleration in the decline of the deadweight losses during the 1980s may reflect historically low $MPKs$ in developing countries during that decade's crisis. If $MPKs$ in poor countries were low the cost of capital immobility would have been less.
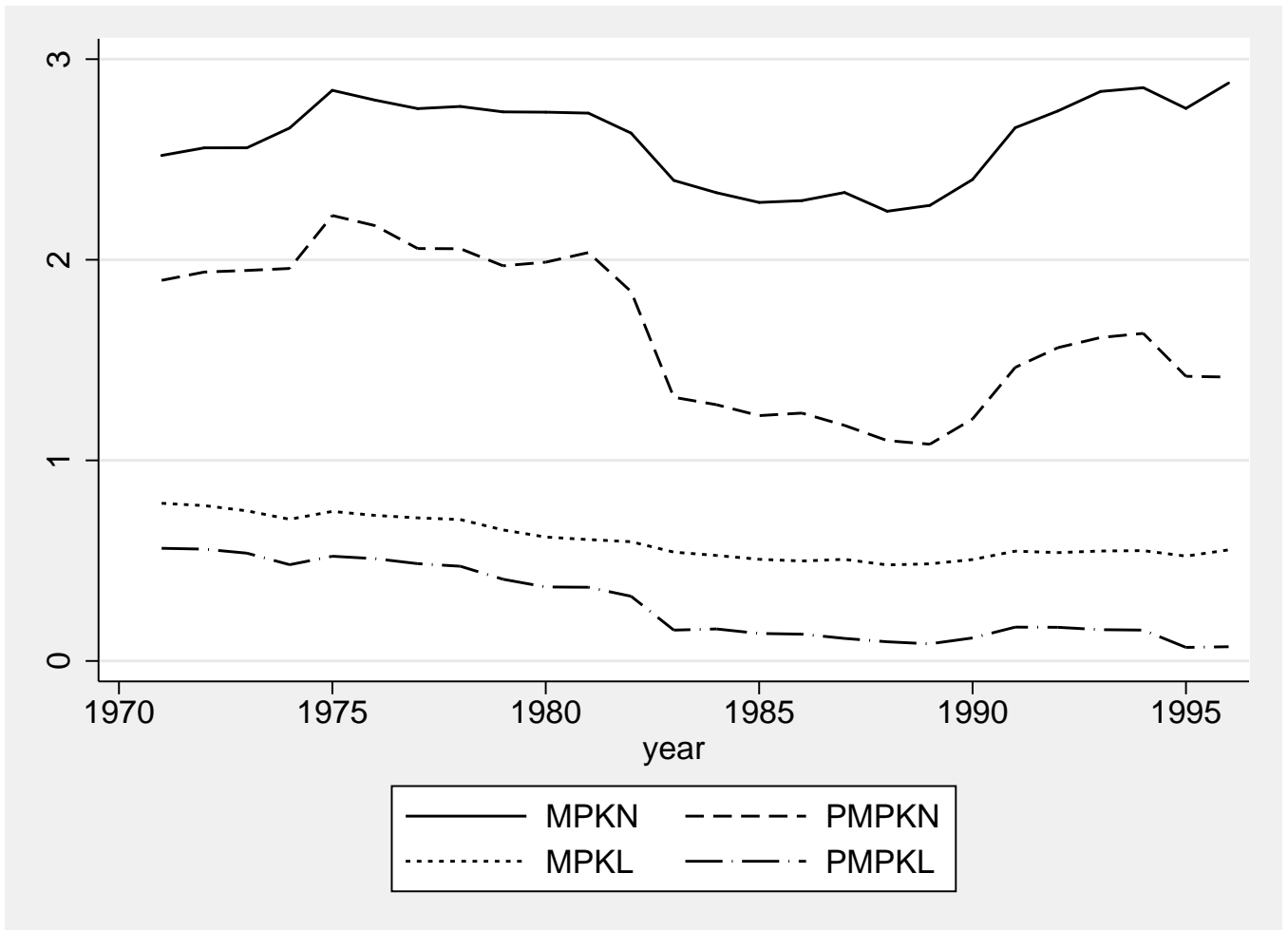
Figure IV:
The Dead Weight Loss of MPK Differentials (percent of world GDP)

$MPKN$: naive estimate. $MPKL$: after correction for natural-capital.
$PMPKN$: after correction for price differences. $PMKL$: after both corrections.
Source: Heston et al. [2004], Bernanke and Gurkaynak [2001], and World Bank [2006]. Authors' calculations.

VI Conclusions

Macroeconomic data on aggregate output, reproducible capital stocks, final-good prices relative to reproducible-capital prices, and the share of reproducible capital in GDP are remarkably consistent with the view that international financial markets do a very efficient job at allocating capital across countries. Developing countries are not starved of capital because of credit-market frictions. Rather, the proximate causes of low capital-labor ratios in developing countries are that these countries have low levels of complementary factors, they are inefficient users of such factors (as Lucas [1990] suspected), their share of reproducible capital is low, and they have high prices of capital goods relative to consumption goods.

As a result, increased aid flows to developing countries are unlikely to have much impact on capital stocks and output, unless they are accompanied by a return to financial repression, and in particular to an effective ban on capital outflows in these countries. Even in that case, increased aid flows would be a move towards inefficiency, and not increased efficiency, in the international allocation of capital.

LSE, CEPR, and NBER

Dartmouth College

References

Alfaro, L., S. Kalemli-Ozcam, and V. Volosovych, "Why Doesn't Capital Flow from Rich to Poor Countries? An Empirical Investigation," unpublished, Harvard University, 2003.

Banerjee, A. and E. Duflo, "Growth Theory through the Lens of Development Economics," in P. Aghion and S. Durlauf, eds., *Handbook of Economic Growth*, North-Holland Press (2005).

Barro, R., "Economic growth in a Cross-Section of Countries," *Quarterly Journal of Economics*, CVI (1991), 407–443.

Bernanke, B.S. and R.S. Gurkaynak, "Is Growth Exogenous? Taking Mankiw, Romer, and Weil Seriously," in B.S. Bernanke and K. Rogoff, eds., *NBER Macroeconomics Annual 2001*, MIT Press, Cambridge (2001).

Caselli, F, "Accounting for Cross-Country Income Differences," in P. Aghion and S. Durlauf, eds., *Handbook of Economic Growth*, North-Holland Press (2005).

Caselli, F. and W.J. Coleman, "The U.S. Structural Transformation and Regional Convergence: A Reinterpretation," *Journal of Political Economy*, CIX (2001), 584–616.

Chari, W., P. J. Kehoe, and E. R. McGrattan, "The Poverty of Nations: A Quantitative Exploration," Working Paper 5414, National Bureau of Economic Research, 1996.

Cohen, D. and M. Soto, "Why Are Poor Countries Poor? A Message of Hope which Involves the Resolution of a Becker/Lucas Paradox," Working Paper 3528, CEPR, 2002.

Goldsmith, Raymond W., *Comparative National Balance Sheets* (The University of Chicago Press, 1985).

Gollin, D., "Getting Income Shares Right," *Journal of Political Economy*, CX (2002), 458–474.

Gourinchas, P-O. and O. Jeanne, "The Elusive Gains from International Financial Integration," Working Paper No. 9684, National Bureau of Economic Research, 2003.

Heston, A., R. Summers, and B. Aten, "Penn World Table Version 6.1," October 2004, Center for International Comparisons at the University of Pennsylvania (CICUP), 2004.

Hsieh, C-T. and P.J. Klenow, "Relative Prices and Relative Prosperity," Working Paper No. 9701, National Bureau of Economic Research, 2003.

Jones, C. I., "Economic Growth and the Relative Price of Capital," *Journal of Monetary Economics*, XXXIV (1994), 359–382.

Klein, P. and G. Ventura, "Do Migration Restrictions Matter?," Manuscript, University of Western Ontario, 2004.

Klenow, P.J. and A. Rodriguez-Clare, "The Neoclassical Revival in Growth Economics: Has It Gone Too Far?," in B.S. Bernanke and J.J. Rotemberg, eds., *NBER Macroeconomics Annual 1997*, MIT Press, Cambridge (1997).

Lane, P., "Empirical Perspectives on Long-Term External Debt," unpublished, Trinity College, 2003.

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

Mankiw, G., "The Growth of Nations," *Brookings Papers on Economic Activity*, I (1995), 275–326.

Mulligan, Casey B., "Capital, Interest, and Aggregate Intertemporal Substitution," Working Paper 9373, NBER, 2002.

Office of Management and Budget, "Analytical Perspectives, Budget of the United States Government, Fiscal Year 2005," Manuscript, Executive Office of The President of the United States, 2005.

Reinhart, C. M. and K. S. Rogoff, "Serial Default and the "Paradox" of Rich-to-Poor Capital Flows," *American Economic Review*, XCIV (2004), 53–58.

Stulz, R., "The Limits of Financial Globalization," Working Paper 11070, NBER, 2005.

Taylor, Alan M., "Argentina and the World Capital Market: Saving, Investment, and International Capital Mobility in the Twentieth Century," *Journal of Development Economics*, LVII (1998), 147–184.

World Bank, *Where is The Wealth of Nations?* (The World Bank, 2006).
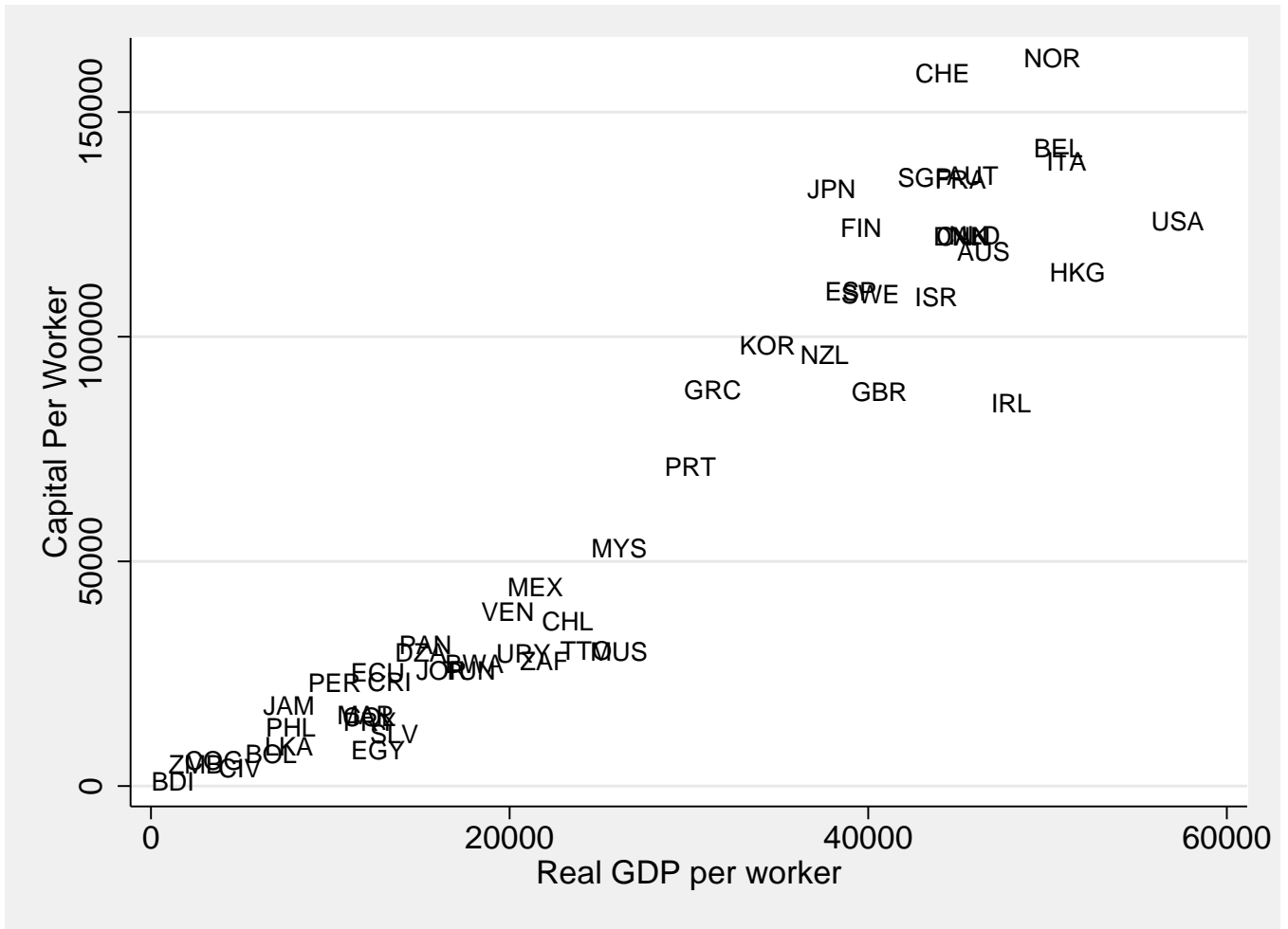
Figure V:
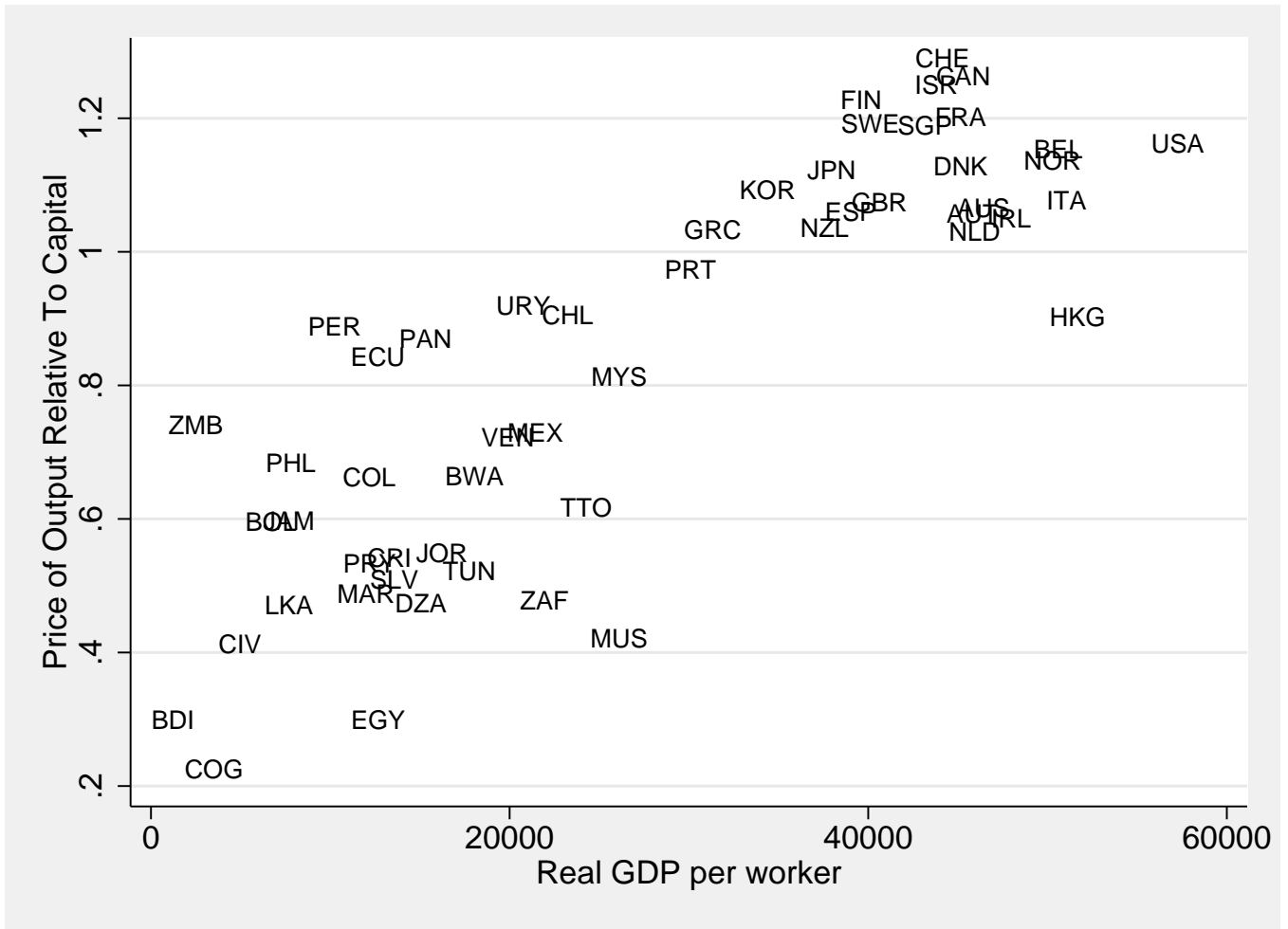Capital per Worker

Source: Penn World Tables 6.1

Figure VI:
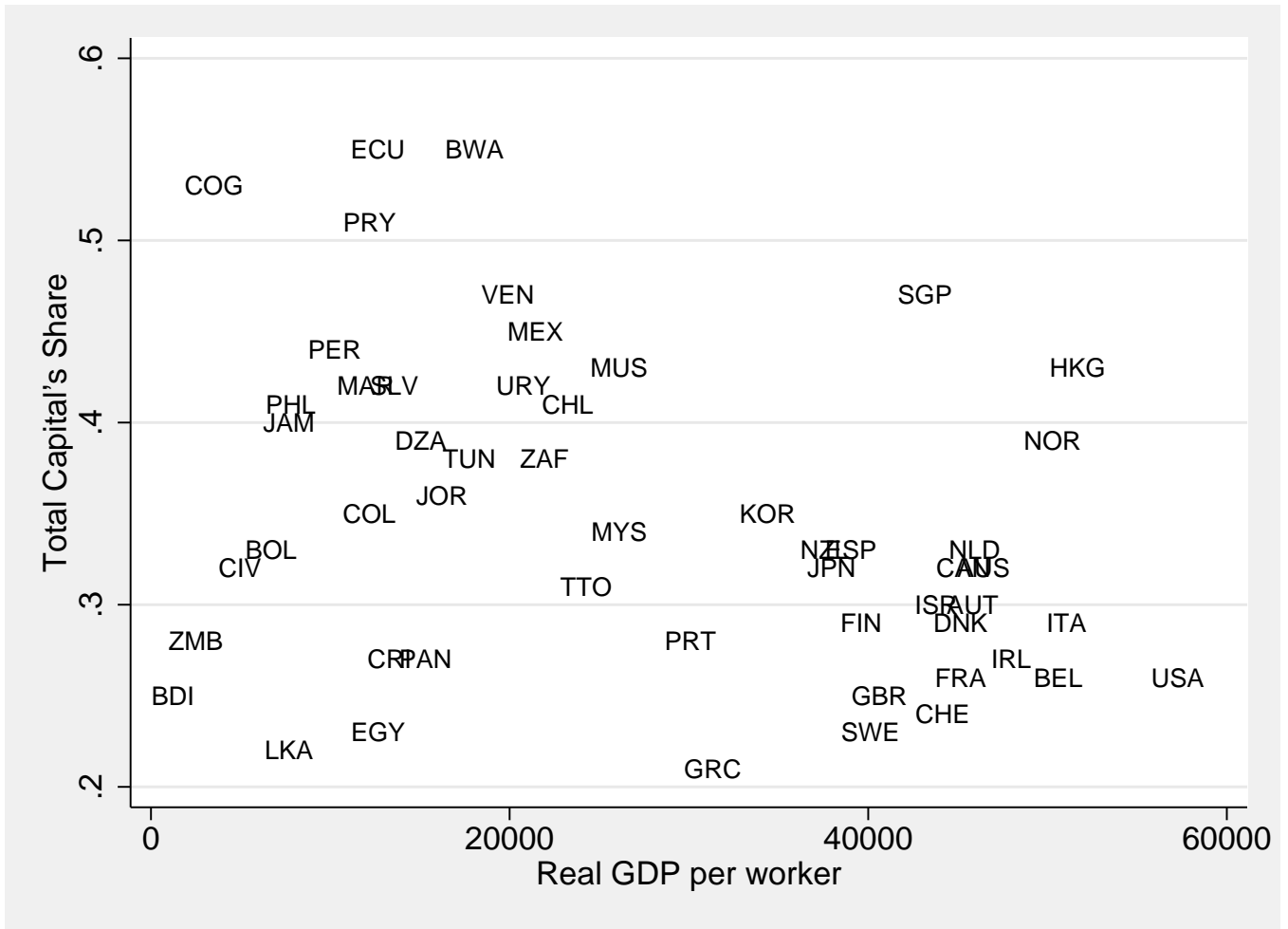Relative Prices

Source: Penn World Tables 6.1

Figure VII:
Total Capital's Share of Income

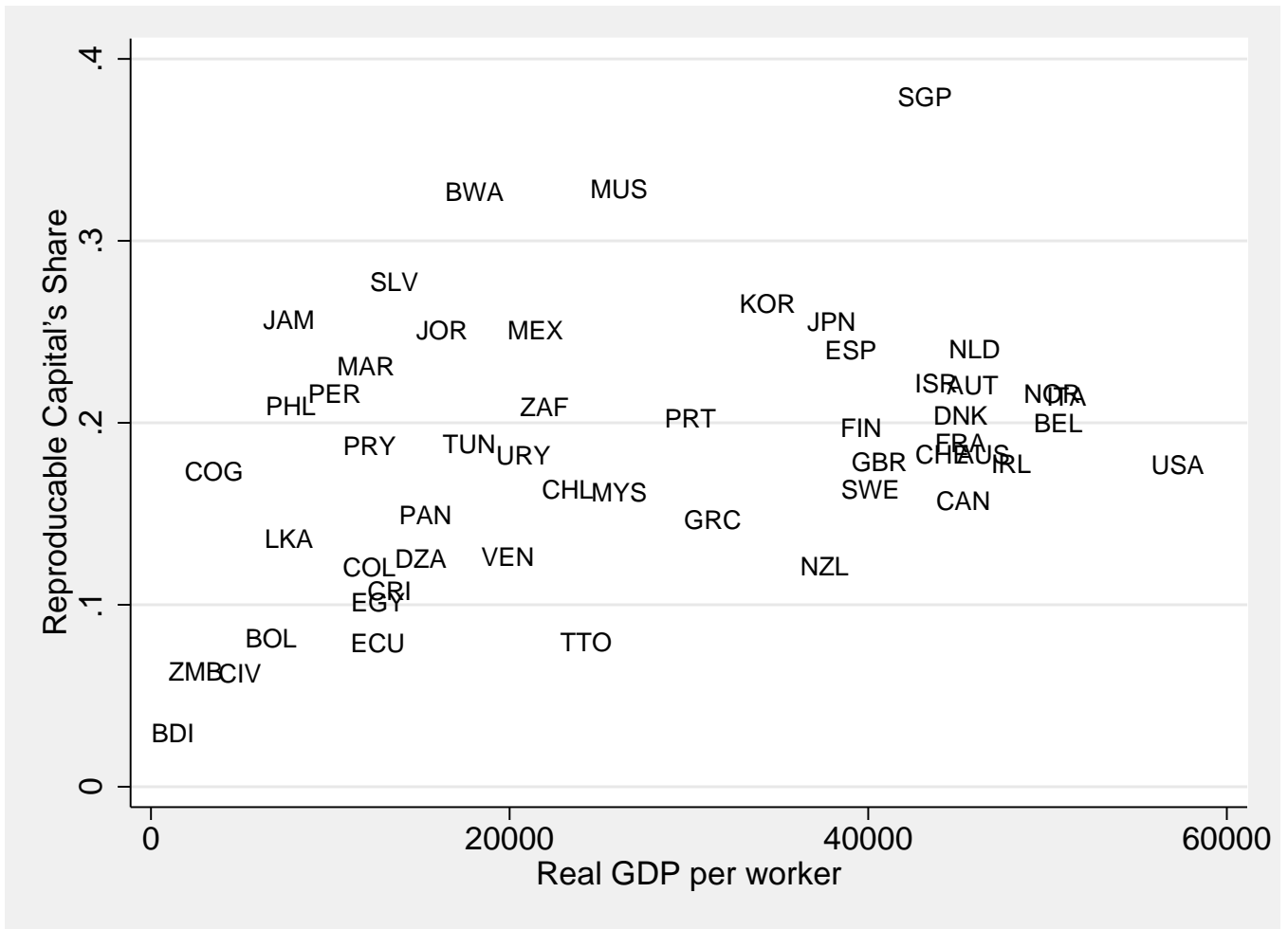Source: Penn World Tables 6.1, Bernanke and Gurkaynak [2001]

Figure VIII:
Reproducable Capital's Share of Income

Source: Penn World Tables 6.1, Bernanke and Gurkaynak [2001], World Bank [2006],
author's calculations

Table VII:
Data and Implied Estimates of the MPK

Country	wbcode	y	k	α_w	α_k	P_y/P_k	$MPKN$	$PMPKN$	$MPKL$	$PMPKL$
Australia	AUS	46,436	118,831	0.32	0.18	1.07	0.13	0.13	0.07	0.08
Austria	AUT	45,822	135,769	0.30	0.22	1.06	0.10	0.11	0.07	0.08
Burundi	BDI	1,226	1,084	0.25	0.03	0.30	0.28	0.08	0.03	0.01
Belgium	BEL	50,600	141,919	0.26	0.20	1.15	0.09	0.11	0.07	0.08
Bolivia	BOL	6,705	7,091	0.33	0.08	0.60	0.31	0.19	0.08	0.05
Botswana	BWA	18,043	27,219	0.55	0.33	0.66	0.36	0.24	0.22	0.14
Canada	CAN	45,304	122,326	0.32	0.16	1.26	0.12	0.15	0.06	0.07
Switzerland	CHE	44,152	158,504	0.24	0.18	1.29	0.07	0.09	0.05	0.07
Chile	CHL	23,244	36,653	0.41	0.16	0.90	0.26	0.24	0.10	0.09
Cote d'Ivoire	CIV	4,966	3,870	0.32	0.06	0.41	0.41	0.17	0.08	0.03
Congo	COG	3,517	5,645	0.53	0.17	0.23	0.33	0.07	0.11	0.02
Colombia	COL	12,178	15,251	0.35	0.12	0.66	0.28	0.19	0.10	0.06
Costa Rica	CRI	13,309	23,117	0.27	0.11	0.54	0.16	0.08	0.06	0.03
Denmark	DNK	45,147	122,320	0.29	0.20	1.13	0.11	0.12	0.08	0.08
Algeria	DZA	15,053	29,653	0.39	0.13	0.47	0.20	0.09	0.06	0.03
Ecuador	ECU	12,664	25,251	0.55	0.08	0.84	0.28	0.23	0.04	0.03
Egypt	EGY	12,670	7,973	0.23	0.10	0.30	0.37	0.11	0.16	0.05
Spain	ESP	39,034	110,024	0.33	0.24	1.06	0.12	0.12	0.09	0.09
Finland	FIN	39,611	124,133	0.29	0.20	1.23	0.09	0.11	0.06	0.08
France	FRA	45,152	134,979	0.26	0.19	1.20	0.09	0.10	0.06	0.08
United Kingdom	GBR	40,620	87,778	0.25	0.18	1.07	0.12	0.12	0.08	0.09
Greece	GRC	31,329	88,186	0.21	0.15	1.03	0.07	0.08	0.05	0.05
Hong Kong	HKG	51,678	114,351	0.43		0.90	0.19	0.18		
Ireland	IRL	47,977	85,133	0.27	0.18	1.05	0.15	0.16	0.10	0.11
Israel	ISR	43,795	108,886	0.30	0.22	1.25	0.12	0.15	0.09	0.11
Italy	ITA	51,060	139,033	0.29	0.21	1.08	0.11	0.11	0.08	0.08
Jamaica	JAM	7,692	17,766	0.40	0.26	0.60	0.17	0.10	0.11	0.07
Jordan	JOR	16,221	25,783	0.36	0.25	0.55	0.23	0.12	0.16	0.09
Japan	JPN	37,962	132,953	0.32	0.26	1.12	0.09	0.10	0.07	0.08

Table VII:
Data and Implied Estimates of the *MPK* (cont.)

Country	wbcode	y	k	α_w	α_k	P_y/P_k	$MPKN$	$PMPKN$	$MPKL$	$PMPKL$
Republic of Korea	KOR	34,382	98,055	0.35	0.27	1.09	0.12	0.13	0.09	0.10
Sri Lanka	LKA	7,699	8,765	0.22	0.14	0.47	0.19	0.09	0.12	0.06
Morocco	MAR	11,987	15,709	0.42	0.23	0.49	0.32	0.16	0.18	0.09
Mexico	MEX	21,441	44,211	0.45	0.25	0.73	0.22	0.16	0.12	0.09
Mauritius	MUS	26,110	29,834	0.43	0.33	0.42	0.38	0.16	0.29	0.12
Malaysia	MYS	26,113	52,856	0.34	0.16	0.81	0.17	0.14	0.08	0.06
Netherlands	NLD	45,940	122,467	0.33	0.24	1.03	0.12	0.13	0.09	0.09
Norway	NOR	50,275	161,986	0.39	0.22	1.14	0.12	0.14	0.07	0.08
New Zealand	NZL	37,566	95,965	0.33	0.12	1.04	0.13	0.13	0.05	0.05
Panama	PAN	15,313	31,405	0.27	0.15	0.87	0.13	0.11	0.07	0.06
Peru	PER	10,240	22,856	0.44	0.22	0.89	0.20	0.18	0.10	0.09
Philippines	PHL	7,801	12,961	0.41	0.21	0.68	0.25	0.17	0.13	0.09
Portugal	PRT	30,086	71,045	0.28	0.20	0.97	0.12	0.12	0.09	0.08
Paraguay	PRY	12,197	14,376	0.51	0.19	0.53	0.43	0.23	0.16	0.08
Singapore	SGP	43,161	135,341	0.47	0.38	1.19	0.15	0.18	0.12	0.14
El Salvador	SLV	13,574	11,606	0.42	0.28	0.51	0.49	0.25	0.32	0.17
Sweden	SWE	40,125	109,414	0.23	0.16	1.19	0.08	0.10	0.06	0.07
Trinidad and Tobago	TTO	24,278	30,037	0.31	0.08	0.62	0.25	0.15	0.06	0.04
Tunisia	TUN	17,753	25,762	0.38	0.19	0.52	0.26	0.14	0.13	0.07
Uruguay	URY	20,772	29,400	0.42	0.18	0.92	0.30	0.27	0.13	0.12
United States	USA	57,259	125,583	0.26	0.18	1.16	0.12	0.14	0.08	0.09
Venezuela	VEN	19,905	38,698	0.47	0.13	0.72	0.24	0.17	0.07	0.05
South Africa	ZAF	21,947	27,756	0.38	0.21	0.48	0.30	0.14	0.17	0.08
Zambia	ZMB	2,507	4,837	0.28	0.06	0.74	0.15	0.11	0.03	0.02

y: GDP per worker; k: reproducible capital per worker; α_w: reproducible capital share; P_y: final goods price level; P_k: reproducible capital price level; $MPKN$: naive estimate of the MPK; $MPKL$: corrected for the share of natural-capital; $PMPKN$: corrected for relative prices; $PMPKL$: both corrections. Authors' calculations using data from Heston et al. [2004], Bernanke and Gurkaynak [2001], and World Bank [2006].