University of Vermont
UVM ScholarWorks

UVM Honors College Senior Theses | Undergraduate Theses

2022

Cross-Country Differences in Marginal Product of Capital and the Efficient Allocation of the World's Capital Stock

Oliver George Tidswell
The University of Vermont

Follow this and additional works at: https://scholarworks.uvm.edu/hcoltheses

Recommended Citation

Tidswell, Oliver George, "Cross-Country Differences in Marginal Product of Capital and the Efficient Allocation of the World's Capital Stock" (2022). *UVM Honors College Senior Theses*. 503.
https://scholarworks.uvm.edu/hcoltheses/503

This Honors College Thesis is brought to you for free and open access by the Undergraduate Theses at UVM ScholarWorks. It has been accepted for inclusion in UVM Honors College Senior Theses by an authorized administrator of UVM ScholarWorks. For more information, please contact scholarworks@uvm.edu.

Cross-Country Differences in Marginal Product of Capital and the Efficient Allocation of the World's Capital Stock

Oliver George Tidswell
THE UNIVERSITY OF VERMONT

Faculty Advisor: Michael J. Tomas III

Abstract:

Since his original publication in 1990, Robert E Lucas Jr's observation of capital failing to flow between rich and poor countries has stoked debate across international development economics over its theoretical explanation. Since then, economists have sought to rationalize this observation through two explanations: fundamental production structure differences and capital market imperfections. This paper serves to build upon the marginal product of capital (MPK) compositions presented by Caselli and Feyrer (2007) to provide updated and refined data on national accounts. In reassessing cross-country MPK's, near equalized differentials between rich and poor countries are observed.

1. Introduction

1988 data pointing towards Marginal Product of Capital (MPK) in the United States being 58 times greater than that of India at the time, opened avenues of intrigue for the role of capital flow in development economics (Lucas, 1990). Since this finding, development economists have sought to rationalize the cross-country production disparity given the advent of late 20th-century global trade. Economists continue to debate whether this disparity is a result of inefficient markets or simply models which omit important factors in the production function. This paper will utilize the marginal product of capital (MPK) compositions set out by Caselli and Feyrer to assess the cross-country relationship and efficiency of capital allocation (Caselli & Freyer, 2007). In doing so, this piece of work addresses the question of whether or not Caselli and Feyrer's adjusted Marginal Product of Capital compositions still result in near cross-country parity.

This study replicates and updates the study established in Caselli and Feyrer's 2007 work *The Marginal Product of Capital* to consider whether near parity of MPK among Developed and Developing countries still holds. Like the original piece, the aggregate MPK for a large cross-section of countries is presented. In performing this analysis, updated and expanded data on 137 countries from the Penn World Table 10.0 edition are utilized. The written piece concludes by newly reemphasizing the 2007 result in that the MPK's are practically equalized across countries (i.e. return on capital is no different when invested in poor vs rich countries).

Marginal Product, often referred to as marginal physical product for its absence of price change in the presence of change in output, is the additional output resulting from a small increase in an input. Measured in both terms of capital(K) $\partial f(K, L)/\partial K$ and terms of labor(L) $\partial f(K, L)/\partial L$, Marginal Product of Capital(MPK) and Marginal Product of Labor(MPL) are key micro- and macro-economic components of the production function used to assess allocative efficiency and income distribution (Hashimzade, 2017). While often used on a microeconomic scale to assess a firm's allocative efficiency, aggregate production functions are often utilized to frame an entire economy's economic growth resulting from capital and technological progress. While the economic theory of aggregate MPK is found within the curriculum of any intermediate macroeconomic course and prevalent across macroeconomic literature; debate over the validity of measures regarding the aggregate of heterogeneous capital goods has persisted since the early 20th century (Cohen & Harcourt, 2003). Specifically, throughout macroeconomic literature, marginal product of capital is a frequently used concept to gauge the efficient allocation of capital stock (Caselli & Freyer, 2007). One would suspect cross-country MPK to be equal should global capital stock be perfectly allocated among individual countries. In deriving equalized results across nations with differing capital-labor ratios, a number of methods are often employed.

This is relevant as it further rejects the credit-frictions hypothesis in which capital market imperfections contribute to the failure of capital flows from reallocating. Moreover, this outcome has broad policy implications when dealing with the flow of capital in the form of aid across countries. This paper contributes to the growing literature on the role of capital misallocation within development economics. Motivation to undertake a thesis of this kind is to pursue an inquiry into the broader concepts of efficient resource allocation, utility maximization, and the effects of increased globalization. In short, this work will consist of retrieving domestic macroeconomic data, inputting these variables into predefined MPK models, interpreting the MPK output relative to other countries, and lastly assessing the relationship the result may have with other countries. The result of comparing adjusted MPK values across 137 countries is an observed differential near

parity between developed and developing countries. This piece further clarifies nuances found within the neoclassical growth model which display large MPK differentials resulting from large differentials in capital-labor ratios.

2. Literature Review and Theory Development

In his landmark 1990 piece "Why Doesn't Capital Flow from Rich to Poor Countries?", economist Robert E. Lucas, Jr. set out to better understand the cross-country differences in capital-labor ratios and thus the returns which are generated as a result. Diminishing returns to scale imply that capital produced per worker is greater in countries with less productive (poorer) economies. Back of the envelope calculations performed by the author, using 1988 data from Summers and Heston, suggest that the MPK of India was 58 times larger than that of the United States. Standard neo-classical theory on capital-flows would suggest that these large cross-country, MPK differentials would lead to swift reallocation of capital flows to areas with higher production per person. In seeking to answer the question of *why do capital flows not reallocate?*, Lucas brought forth the "*Lucas Paradox*" to the economic development literature, in which the standard neoclassical model does not sufficiently account for the difference in capital flows as a result from the difference in MPK. To address this *paradox* Lucas suggests making small adjustments to the original neo-classical production function by considering international capital market imperfections (credit frictions) and changes in the fundamental inputs of the production structure (Lucas, 1990).

It is here that Lucas postulates two main causes for this paradox – fundamental differences in the production structure (differences in types of capital, differences in levels of technology, knowledge spillovers, etc.) and international capital market imperfections (political risk and information asymmetry). Here arises a divergence between the way in which economists perceive the origin of this paradox. One being the result of low and inefficient levels of complementary factors and the other resulting from credit-market frictions.

In the latter, it is believed that credit market functionality is poor for a number of reasons. Macroeconomists, Abhijit Banerjee and Esther Duflo provide a comprehensive summary of MPK estimates and in doing so conclude that credit markets frequently function poorly in developing counties as a result of poor information systems, reduced contract enforcement and increased political pressure (Banerjee & Duflo, 2005). While these constraints provide a compelling argument for the poor functionality of credit markets, the argument is yet to be settled on whether the poor functionality of this markets sufficiently explains the lack of capital flow reallocation. It is worth noting additional arguments account for cross-country technology adoption rate differences to these credit market limitations (Aghion et al., 2005).

In the past, an argument was made that low and inefficient levels of complimentary factors account for the difference in capital-labor ratios. Almost two decades later, authors Francesco Caselli and James Feyrer set out to analyze the complementary input explanation and determine that complementary factors and total factor productivity only partially cause capital intensity differences. The inclusion of two proximate factors – relative price of capital and reproducible-capital share , are important in explaining capital intensity differences.

In Caselli and Feyrer's original piece, the authors comment upon three current approaches used in the prevailing literature to generate cross-country MPK estimates. These three approaches take the form of examining interest rates, regressing change in output against change in capital and lastly calibration through the use of a functional form. Opting for the third approach, the authors begin with a "naïve" MPK estimate that consists of a one-sector model with labor and reproducible capital as the sole inputs.

Initial results from this naïve MPK estimate show large MPK differentials between productive (rich) and less productive (poorer) economies with the implication being that this is a result of international capital market imperfections (i.e. credit frictions). From this naïve estimate, the authors recognize the larger share of natural capital (land, natural resources, etc.) in poorer countries and thus isolate reproducible capital share in income, allowing for the calculation of a land/natural resource corrected marginal product of capital (MPKL). This method for calculating marginal product of capital, reduces the cross-country differentials and weakens the argument for cross-country differentials only resulting from international market imperfections.

In an attempt to scrutinize cross country MPK differences, the results drawn by Caselli and Feyrer have been reassessed multiple times, with a number of different approaches. As recently as 2017, the authors' rejection of the credit-market frictions hypothesis has been retested with updated data found within the Penn World Table 9.0 (Mcguigan, 2017).

3. Defining Widely Applicable Parameters

Since Caselli and Feyrer's original 2007-piece, Penn World Table (PWT) 6.1 has gone through a number of iterations over the last decade and a half. Now in its tenth iteration, PWT 10.0 has a taken a page from a number of publications to now include over 180 countries with new data (as of 2019) on each. Below in table I. are the relevant variables and descriptions either included in or derived from the Penn World Table (PWT) 10.0.

Variable	**Description**
rgdpo	Output-side real GDP at chained PPPs (in mil. 2017US$)
emp	Number of persons engaged (in millions)
Y	**Output-side real GDP per person engaged (rgdpo/emp)**
cn	Capital stock at current PPPs (in mil. 2017US$)
K	**Capital Stock per person engaged (cn/emp)**
labsh	Share of labour compensation in GDP at current national prices
$\boldsymbol{\alpha_w}$	**Total Capital Share (1- labsh)**
csh_i($\boldsymbol{\alpha_k}$)	Reproducible Capital Share - Share of gross capital formation at current PPPs
pl_gdpo	Price level of CGDPo (PPP/XR), price level of USA GDPo in 2017=1
pl_i	Price level of capital formation, price level of USA GDPo in 2017=1
$\boldsymbol{P_y/P_k}$	**Prices of Final Goods Relative to Capital Goods (pl_gdpo/pl_i)**

Table I. Relevant variables and corresponding descriptions from the Penn World Table
Source: PWT 10.0; variables as listed in the PWT 10.0 with **bolded variables** calculated by the author

In order to derive the multiple measures of marginal product of capital, a number of summary variables are required to be employed using data provided by the PWT 10.0. Real GDP per person (Y) is calculated by taking the quotient of Output-side real GDP at chained PPPs in 2017 USD (rgdpo) and the number of persons engaged (emp). Capital Stock per person (K) is also calculated by taking the quotient of capital stock at current PPPs in 2017 USD (cn) and the number of persons engaged (emp). These methods of calculating Real GDP per person and capital stock per person are the same as utilized by Caselli and Feyrer.

Among the relevant literature, it is common practice to back out capital share ($\boldsymbol{\alpha_w}$) from the labor share in income (labsh). Whereas backing out capital share from labor share includes the amassed

payments towards non-reproducible capital, *the standard measure* excludes payments towards capital, such as land, by substituting the backed-out labor share for the share of gross capital formation using the perpetual inventory method. In Caselli and Feyrer's original 2007 work, the authors identify the discrepancy between macro-development literature and *the standard measure* in deriving capital share.

Not present in edition 6.1 of the Penn World Table, reproducible capital share (α_k) was originally computed by Caselli and Feyrer using national wealth account data published by the world bank in 2006. In their original publication, reproducible capital was originally calculated from WB data which split total national wealth into natural capital and reproducible capital. This is the first of two proximate factors which the authors identify as playing an important role in explaining the MPK differential. The statistic is now available through the PWT (under the variable csh_i) denoting the share of gross capital formation at current PPPs.

At the time of the original publication, PWT 6.1 did not include reproducible share statistics (denoted as csh_i in the PWT 10.0 or in this piece from here on out as α_k). It was not until the eighth edition of the Penn World Table that capital and labor share were included in the database, as a result of the contributions by Caselli to the macroeconomic literature (Feenstra, et al, 2015). Acting as a large source of data constraint in the original piece, the reproducible capital share (α_k) statistic published within the PWT is a welcome addition. Whereas total capital share in this piece is the complement of the share of labor compensation in GDP at current national prices (labsh), Caselli and Feyrer were restricted to using data from sources outside of the Penn World Table. Labor share in the original 2007 piece came from work by Bernanke and Gurkaynak (2001) and confined the sample size to 53 countries. With the inclusion of reproducible capital share (α_k) into the Penn World Table, a number of sample size constraints were lifted. The entire data set now includes figures from 137 developed and developing countries.

This consideration is important as it (appropriately) accounts for the higher price of capital goods relative to consumption goods in developing countries. Prices of Final Goods Relative to Capital Goods (P_y/P_k) are obtained by taking the difference of the output-side real GDP price level (pl_gdpo or in this piece from here on out as P_y) and the price level of capital formation (pl_i or in this piece from here on out as P_k). As presented in the following data, these figures are also from the PWT as shown in Caselli and Feyrer's original published piece.

4. Research Methodology

4.1. Compositions of the Marginal Product of Capital (MPK)

Below is the base model for a single-sector neoclassical Marginal Product of Capital (MPK), shown as the product of overall GDP capital share (α) and output (Y) as a share of capital (K). This composition is conventional across introductory economic concepts as being the additional output generated from an additional unit of capital (K). Elementary in nature, the base model disregards any effects of price and labor on output and is frequently utilized by firms to rationalize investment in additional units of capital (Mankiw, 2018). While this functional form of MPK serves as a fitting basis for microeconomic analysis of a single sector, the composition is problematic as it overstates the absolute (not marginal) differences in marginal productivity of reproducible capital. This difference is most prevalent when observing countries with larger shares of non-reproducible capital (i.e. Natural Capital: agricultural and natural resource-based sectors) in developing countries.

$$MPK = \alpha \frac{Y}{K}$$

In Section 3.0 the two differing derivations of capital share were defined. The first being calculated from the labor share of income ($\boldsymbol{\alpha_w}$) and the second being the share of gross capital formation under the perpetual inventory method ($\boldsymbol{\alpha_k}$). These differing derivations of MPK are reflected below in the Marginal Product of Capital Naïve (MPKN) and Marginal Product of Capital Land and natural-resource corrected (MPKL). Beginning with the MPKN, the base model of MPK is adapted to include one minus the labor share of income. Again, this functional form is still plagued by the lack of adjustment, in the form of reproducible capital, as seen in the single-sector model above.

$$MPKN = \alpha_w \frac{Y}{K}$$

Beginning to offset the potential bias caused by the inclusion of reproducible capital, the MPKL composition is introduced. Rather than calculating capital share from labor share, capital share is represented by PWT 10.0's reproducible capital share of output variable (as discussed in section 3.0).

$$MPKL = \alpha_k \frac{Y}{K}$$

Price effects, entirely neglected by the single-sector neoclassical MPK model, become a very influential factor when analyzing cross-country MPK outputs. To account for cross country differences in prices of capital relative to consumption, Caselli and Feyrer derive a ratio in prices (Py/Pk) using the price level of GDP output (pl_gdpo) and the price level of capital formation (pl_i). Correcting for the relative price of final goods to capital goods, eliminates potential bias caused by the ratio of final-to-capital goods being higher in rich vs poor countries. In keeping with Caselli & Feyrer's notation, price-corrected compositions of MPKN and MPKL are denoted with the prefix "P".

$$PMPKN = \frac{\alpha_w \mathrm{P}_y Y}{\mathrm{P}_k K}$$

$$PMPKL = \frac{\alpha_k \mathrm{P}_y Y}{\mathrm{P}_k K}$$

4.2. Addressing Outliers

The most current cross-country MPK analysis, performed by McGuigan in 2017, includes 114 countries (or all available PWT 9.0 counties) with data barring "small island nations, city-states and sparsely populated outlier countries" (McGuigan, 2017). This paper expands the sample size while building off previous studies with updated 2019 data. In the work presented here, all 137 countries with available data are included within the analysis. In addition, cross-country MPK analysis is run again excluding outliers. As a rule of thumb, data points (countries) with MPK values outside of three standard deviations of the mean are defined as outliers. This process is repeated for each composition of MPK with outliers presented in table II below.

Composition	Outlier
MPKN	Azerbaijan (AZE)
	Egypt (EGY)
	Sierra Leone (SLE)
PMPKN	Trinidad and Tobago (TTO)
	Côte d'Ivoire (CIV)
MPKL	Djibouti (DJI)
	Ireland (IRL)
PMPKL	Djibouti (DJI)
	Ireland (IRL)

Table II. Outliers identified within each composition of MPK

One particular result of note was the capital land and natural resource adjusted MPK value of Djibouti (DJI). The MPKL and PMPKL values of DJI are .33 and .44 respectively, more than 8 standard deviations above the mean. This occurrence is of particular interest given its inclusion in McGuigan's 2017 piece, using PWT 9.0 data from 2014.

The implication for these results is that the country of Djibouti (DJI) has a typical total capital share, but a larger reproducible capital share relative to other countries measured. This assertion is corroborated with PWT 10.0's entry of Djibouti with a reproducible capital share of .62 or more than one standard deviation above the median reproducible capital share of .22. Yet, this implication fails to account for the additional input variables and overlooks the differences between DJI's data from PWT 9.0 (2014) and PWT 10.0 (2019). On closer observation, it is clear that capital share of income ($\boldsymbol{\alpha_w}$) has remained almost constant in the 5-year difference and that while the share of gross capital formation under the perpetual inventory method ($\boldsymbol{\alpha_k}$) has increased from 0.41 to 0.62, more is clearly at play. By far, the largest contribution to DJI's increase in MPK is the country's change in capital stock per engaged worker. Between 2015 and 2019, the country has seen more than a two-and-a-half-fold increase in its engaged workers (0.14 M to 0.37 M) while simultaneously seeing a decrease in its overall capital stock at current PPPs (15.868 billion USD to 11.176 billion USD). In other words, capital stock per person in 2019 is almost a quarter of what it was in 2014 ($30,007 vs $116,846) as a result of absolute capital stock slightly decreasing and the number of persons engaged almost tripling.

5. Results & Analysis

Summing up the measures derived so far, four distinct compositions of Marginal Product of Capital (MPK) are presented. MPKN, the naïve measure, offers a simple calculation for MPK on an aggregate level. In seeking to accurately account for inter-country difference in land and natural resources, a secondary model is presented, denoted MPKL. Within the MPKL model, share of gross capital formation has been included in order to attain an output which is only representative of reproducible capital stock. Lastly, both the MPKN and MPKL estimates are presented with additional configurations which account for differing cross-country price levels, denoted as PMPKN and PMPKL respectively. These results are present in Appendix table IV and figure 5 below.

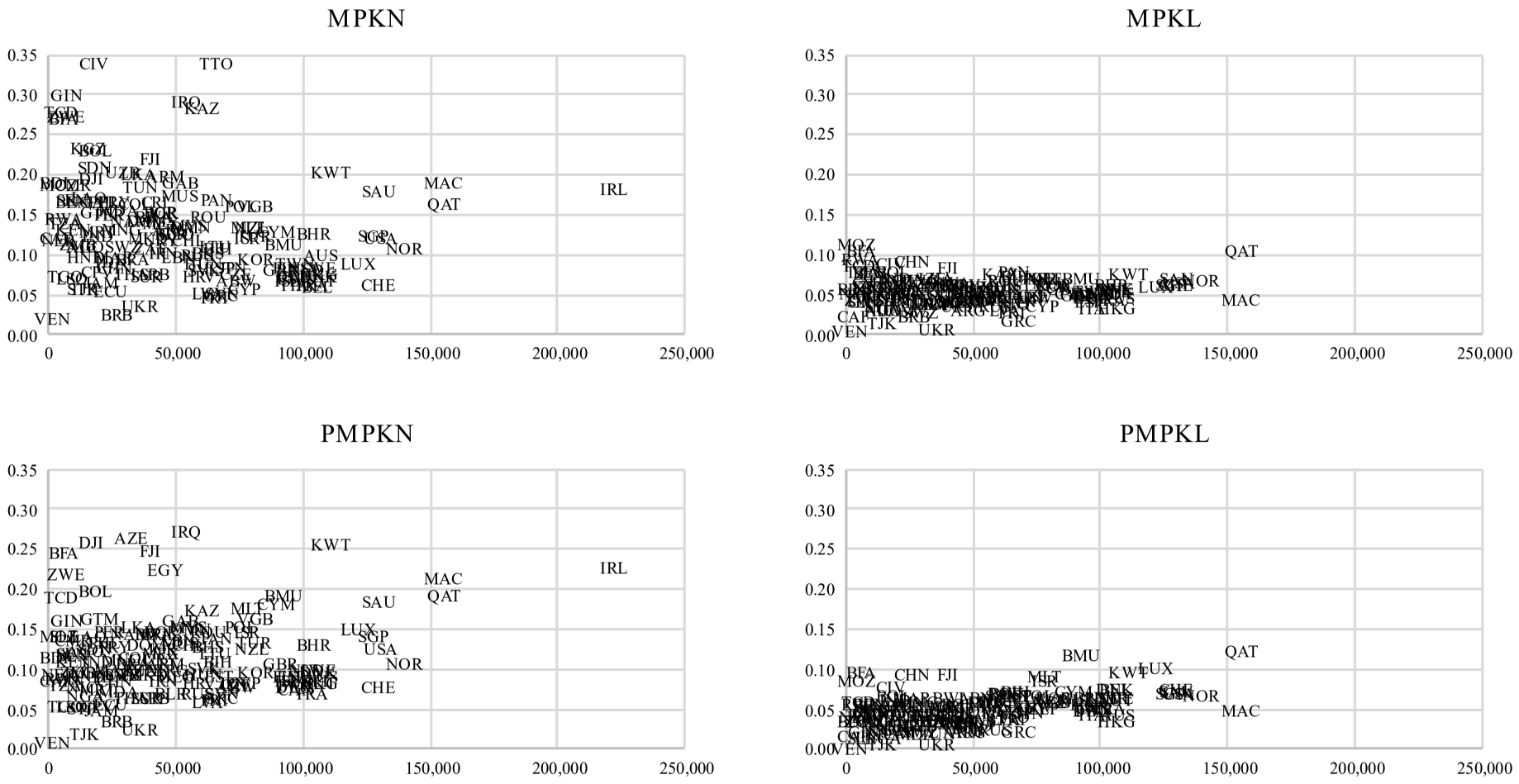

Figure 5. Outliers Removed

Not unlike Caselli and Feyrer's original findings, the Naïve estimate of Marginal Product of Capital (MPKN) exhibits a distinct negative relationship with income (see figure 5). Unlike the data shown in the original 2007 piece, an observable split between MPKN in developing countries and MPKN in developed countries is absent. No distinguishable differences in variability are present. On further investigation, by consulting the summary statistics table, it is shown that the difference in mean MPKN between developed and developing countries is less than 3%, well within a single standard deviation for both developed and developing countries. In comparison, summary data from the 2007 piece (table below) shows a greater than 15% difference between the MPKN of rich and poor countries.

	Caselli/Feyrer		**McGuigan**		**Tidswell**	
	Rich	Poor	Rich	Poor	Rich	Poor
MPKN Average	11.40%	27.20%	11.75%	17.22%	11.67%	14.29%
MPKN Standard Deviation	*(2.70%)*	*(9.00%)*	*(5.94%)*	*(8.20%)*	*(5.71%)*	*(6.52%)*
PMPKN Average	7.50%	11.90%	13.21%	14.65%	12.16%	11.36%
PMPKN Standard Deviation	*(1.70%)*	*(6.90%)*	*(6.69%)*	*(5.99%)*	*(4.82%)*	*(5.39%)*
MPKL Average	12.60%	15.70%	5.70%	7.13%	5.37%	5.43%
MPKL Standard Deviation	*(2.50%)*	*(5.50%)*	*(1.73%)*	*(2.13%)*	*(1.40%)*	*(2.15%)*
PMPKL Average	8.40%	6.90%	6.43%	6.45%	5.87%	4.35%
PMPKL Standard Deviation	*(1.90%)*	*(3.70%)*	*(2.02%)*	*(2.75%)*	*(2.00%)*	*(2.03%)*

Table III. Summary Statistics Table, Caselli/Feyrer(2007), McCuigan(2017), Tidswell(2022)

Summary statistics figures of the four MPK compositions largely reflect changes in the capital-output ratio of each stratified group. Caselli/Feyrer, and Mcguigan each computed capital-output ratios for rich countries of 2.74 and 4.38 respectively. This analysis computed a capital-output ratio of 4.77 for rich countries. Additionally, both authors computed capital-output ratios for poor countries of 1.51 and 3.29 respectively. This analysis computed a capital-output ratio of 4.20 for poor countries. Increasing capital-labor ratios are reflected in smaller MPK outputs and narrower differentials across poor and rich countries. Narrowing price adjusted MPK differentials between rich and poor countries is also a reflection of changing trends in price of capital ratios. In Caselli/Feyrer's original piece the relative price of capital to consumer goods for both rich and poor countries was 1.12 and 0.60 respectively. In this analysis the relative price of capital to consumer goods for both rich and poor countries is 1.10 and 0.80 respectively. Differences between the average reproducible capital (α_k)of rich countries (0.25) and the average reproducible capital (α_k) of poor countries (0.20) remains. As such, the land/natural resource corrected marginal product of capital (MPKL) continues to play a significant role in accounting for cross country MPK differences.

When interpreting these results, it is important to remain cognizant of the differences between the research methodology of this paper's findings and the methodology of the findings by Caselli and Feyrer. As previously discussed, the original 2007 piece did not draw reproducible capital share or labor share data from the Penn World Table. As a result of Caselli & Feyrer's data limitations on labor share and McGuigan's PWT 9.0 data (excluding island nations, city-states, and *outlier countries*) both authors analyzed data sets of 53 and 114 countries respectively. Likewise, PWT 10.0 data now allows for the inclusion of 137 countries. Differences in regards to the size of the

dataset can have an impact on the placement of median GDP shifting and what countries are deemed to be rich (above the median) and poor (below the median).

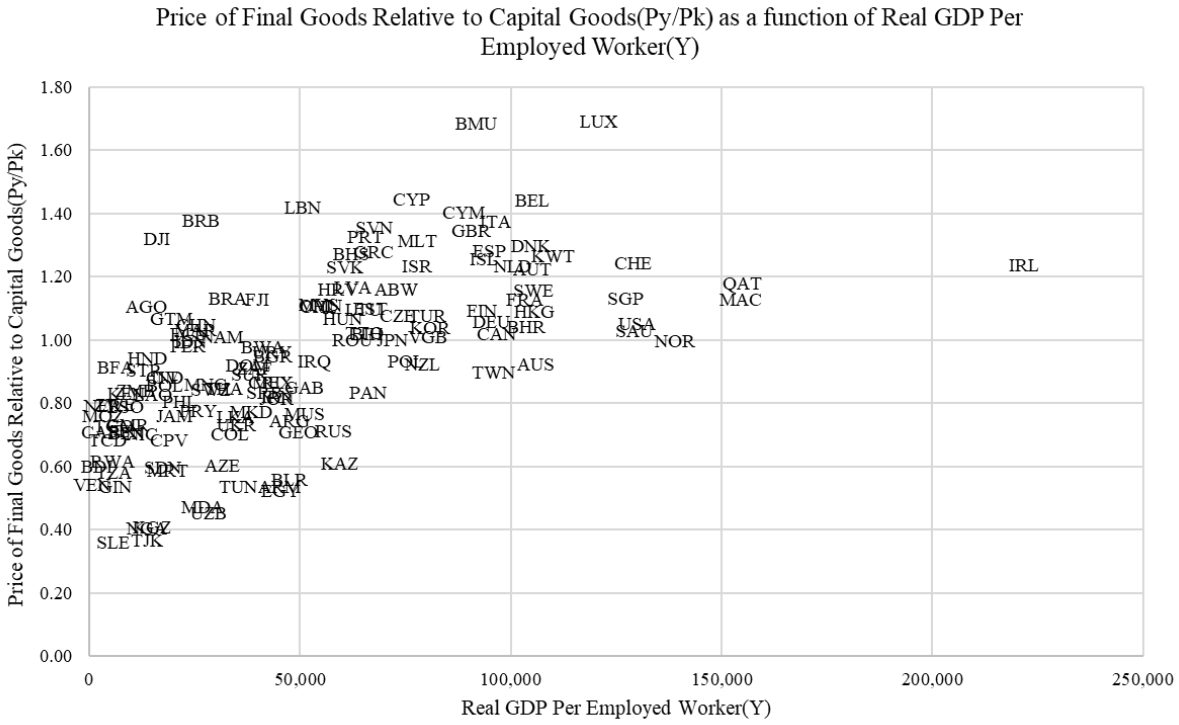

Figure 1. Price of Final Goods relative to Capital Goods (Py/Pk)

With the inclusion of capital stock and labor share to the Penn World Table 8.0, differences arise between the method in which Caselli and Feyrer calculated initial capital stock in 2006 and the method utilized by the PWT. As discussed in the 2007 piece, initial capital stock calculations utilized the perpetual inventory method, also known as the steady-state relationship of the Solow growth model, and a depreciation rate of 0.06. While this method was considered standard at the time, as acknowledged in the original piece, a potential bias arises when assuming that all countries have the same depreciation rate. Authors Robert Inklaar and Marcel P. Timmer perform an adequate review of capital and labor share calculation methodologies going so far as to summarize differences between the updated PWT 8.0 and Caselli's 2005 work (Inklar Timmer, 2013). It is here that the authors favor Nehru and Dhareshwar's (1993) method ($K_0 = Y_0 \, x \, k$) over Harberger's (1978) steady-state relationship. While they outline a number of considerable benefits in their own piece, this calculation methodology better accounts for economies with turbulent early years found in the sample.

In Lucas' original 1990 piece, the author acknowledges the *troublesome* assumption of benefits deriving from human capital stock being a total result of domestic producers, yet continues to assume no knowledge spillover effects due to the lack of evidence on these difficult to quantify effects. Further areas of research investigating the effects of knowledge spillovers and the relationship between cross-country capital differences among like countries is needed. Specifically, with sufficient adjustment to real GDP per person differences, clustering of countries with similar MPK results could assist in understanding the roles of close geographic proximity and low CAGE distance (Ghemawat, 2011).

6. Conclusion

This piece, contributes to the field of development economics by means of reexamining Marginal Product of Capital (MPK) across a multitude of countries. Following a brief summary of the history of the Lucas paradox, and the introduction of Caselli and Feyrers' work in capital flows, this study updates and expands upon previous explanations of why capital does not flow from developed to developing countries. Updated variables and parameters are presented. Caselli and Feyrer's works are replicated utilizing updated and expanded 2019 data from the PWT 10.0. Findings from this research offer potential insight and the opportunity for more robust inquiry into cross-country capital allocation and the role it plays.

The analysis presented above examines marginal product of capital differentials across a number of different countries. Four distinct compositions of MPK are utilized in assessing cross-country differenced using 2019 PWT 10.0. The MPK adjustments shown are consistent with Caselli and Feyrer's original work which bring MPK differentials closer to unity as the standard deviations are much greater than the difference between countries. In line with previous works, the difference between the average rich country output and average poor country output is greater in the MPKN composition relative to the PMPKL composition. Akin to the 2007piece, parity among MPKL and PMPKL of rich and poor countries strengthens the argument against international credit frictions as sources of differences in capital-labor ratios. International financial markets seem to efficiently allocate capital across countries and the resulting low MPK ratios in developing countries are a result of high capital-output ratios and low reproducible capital share.

Works Cited

Aghion, Philippe, Peter Howitt, and David Mayer-Foulkes. "The Effect of Financial Development on Convergence: Theory and Evidence." The Quarterly Journal of Economics 120.1 (2005): 173-222. Web.

Banerjee, A. V., & Duflo, E. (2004). Growth Theory through the Lens of Development Economics. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.651483

Bernanke, B. S., & Gürkaynak, R. S. (2001). Is Growth Exogenous? Taking Mankiw, Romer, and Weil Seriously. *NBER Macroeconomics Annual*, *16*, 11–57. https://doi.org/10.1086/654431

Caselli, F., & Feyrer, J. (2007). The Marginal Product of Capital. *The Quarterly Journal of Economics*, *122*(2), 535–568. https://doi.org/10.1162/qjec.122.2.535

Cohen, A. J., & Harcourt, G. C. (2003). Retrospectives Whatever Happened to the Cambridge Capital Theory Controversies? *Journal of Economic Perspectives*, *17*(1), 199–214. https://doi.org/10.1257/089533003321165010

Feenstra, R. C., Inklaar, R., & Timmer, M. P. (2015). The Next Generation of the Penn World Table. *American Economic Review*, *105*(10), 3150–3182. https://doi.org/10.1257/aer.20130954

Ghemawat, P., & Siegel, J. I. (2011). *Cases about redefining global strategy*. Harvard Business Pub.

Hashimzade, N. (2017). *A dictionary of economics: Marginal Product*. Oxford University Press.

Inklaar, R., & Timmer, M. P. (2013). *Capital, labor and TFP in PWT8.0* [(Unpublished)].

Lucas, Robert E., Jr. (1990). Why Doesn't Capital Flow from Rich to Poor Countries? The American Economic Review, 80(2), 92-96.

Mankiw, N. G. (2018). *Macroeconomics*. Worth Publishers, Incorporated. https://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=6643895

McGuigan, L. (2017). *The Cross-Country Marginal Product of Capital and the Great Recession*. 29.

7. Appendix

Country	*wbcode*	*y*	*k*	*αw*	*αk*	*Py/Pk*	*MPKN*	*PMPKN*	*MPKL*	*PMPKL*
Aruba	ABW	72,841	387,769	0.35	0.25	1.16	0.07	0.08	0.05	0.05
Angola	AGO	13,689	82,387	0.67	0.19	1.11	0.11	0.12	0.03	0.04
Argentina	ARG	47,348	163,483	0.46	0.11	0.75	0.13	0.10	0.03	0.02
Armenia	ARM	45,112	102,419	0.45	0.09	0.54	0.20	0.11	0.04	0.02
Australia	AUS	106,092	458,603	0.43	0.21	0.93	0.10	0.09	0.05	0.04
Austria	AUT	104,984	631,930	0.42	0.31	1.23	0.07	0.08	0.05	0.06
Azerbaijan	AZE	31,697	54,432	0.75	0.12	0.61	0.43	0.26	0.07	0.04
Burundi	BDI	1,821	3,759	0.39	0.12	0.60	0.19	0.11	0.06	0.04
Belgium	BEL	105,125	710,325	0.41	0.36	1.44	0.06	0.09	0.05	0.08
Benin	BEN	8,905	20,465	0.38	0.18	0.71	0.17	0.12	0.08	0.06
Burkina Faso	BFA	6,191	12,412	0.54	0.21	0.92	0.27	0.25	0.11	0.10
Bulgaria	BGR	43,688	133,983	0.47	0.19	0.95	0.15	0.15	0.06	0.06
Bahrain	BHR	103,646	576,473	0.70	0.34	1.05	0.13	0.13	0.06	0.06
Bahamas	BHS	62,163	369,611	0.60	0.33	1.28	0.10	0.13	0.06	0.07
Bosnia and Herzegovina	BIH	65,973	200,355	0.33	0.22	1.02	0.11	0.11	0.07	0.07
Belarus	BLR	47,556	152,405	0.41	0.16	0.56	0.13	0.07	0.05	0.03
Bermuda	BMU	91,863	331,349	0.41	0.25	1.69	0.11	0.19	0.07	0.12
Bolivia (Plurinational State of)	BOL	17,828	38,887	0.50	0.17	0.86	0.23	0.20	0.08	0.07
Brazil	BRA	32,782	145,570	0.42	0.17	1.13	0.10	0.11	0.04	0.04
Barbados	BRB	26,514	256,227	0.25	0.22	1.38	0.03	0.04	0.02	0.03
Botswana	BWA	41,206	202,230	0.72	0.33	0.98	0.15	0.14	0.07	0.07
Central African Republic	CAF	2,517	17,254	0.84	0.16	0.71	0.12	0.09	0.02	0.02
Canada	CAN	96,702	451,902	0.35	0.23	1.02	0.07	0.08	0.05	0.05
Switzerland	CHE	129,095	643,690	0.32	0.31	1.25	0.06	0.08	0.06	0.08
Chile	CHL	54,405	256,269	0.56	0.25	1.11	0.12	0.13	0.05	0.06
China	CHN	25,360	127,120	0.41	0.45	1.05	0.08	0.09	0.09	0.10
Côte d'Ivoire	CIV	17,242	33,982	0.67	0.18	0.88	0.34	0.30	0.09	0.08
Cameroon	CMR	9,116	24,110	0.50	0.17	0.74	0.19	0.14	0.06	0.05
Colombia	COL	33,381	103,519	0.50	0.16	0.71	0.16	0.11	0.05	0.04
Cabo Verde	CPV	18,847	90,271	0.37	0.24	0.69	0.08	0.05	0.05	0.03
Costa Rica	CRI	41,435	104,640	0.42	0.16	0.87	0.17	0.14	0.06	0.05
Cayman Islands	CYM	88,808	356,119	0.52	0.21	1.41	0.13	0.18	0.05	0.07
Cyprus	CYP	76,532	584,354	0.45	0.28	1.45	0.06	0.08	0.04	0.05
Czech Republic	CZE	73,169	433,341	0.45	0.29	1.08	0.08	0.08	0.05	0.05
Germany	DEU	95,441	466,743	0.36	0.23	1.06	0.07	0.08	0.05	0.05
Djibouti	DJI	16,029	30,007	0.37	0.62	1.32	0.20	0.26	0.33	0.44
Denmark	DNK	104,931	536,665	0.38	0.30	1.30	0.07	0.10	0.06	0.08
Dominican Republic	DOM	37,551	151,086	0.57	0.24	0.92	0.14	0.13	0.06	0.06
Ecuador	ECU	23,671	141,014	0.33	0.25	1.02	0.06	0.06	0.04	0.04
Egypt	EGY	45,183	68,004	0.64	0.09	0.53	0.42	0.22	0.06	0.03
Spain	ESP	94,937	595,185	0.44	0.27	1.29	0.07	0.09	0.04	0.05
Estonia	EST	66,683	326,080	0.41	0.31	1.10	0.08	0.09	0.06	0.07
Finland	FIN	92,961	479,184	0.43	0.27	1.10	0.08	0.09	0.05	0.06
Fiji	FJI	39,709	92,676	0.51	0.20	1.13	0.22	0.25	0.08	0.10
France	FRA	103,284	630,411	0.38	0.27	1.13	0.06	0.07	0.04	0.05
Gabon	GAB	51,151	195,176	0.73	0.18	0.85	0.19	0.16	0.05	0.04
United Kingdom	GBR	90,651	463,963	0.41	0.25	1.35	0.08	0.11	0.05	0.07
Georgia	GEO	49,682	216,690	0.55	0.19	0.71	0.13	0.09	0.04	0.03
Guinea	GIN	6,240	12,149	0.58	0.08	0.54	0.30	0.16	0.04	0.02
Greece	GRC	67,270	605,834	0.45	0.16	1.28	0.05	0.06	0.02	0.02
Guatemala	GTM	19,258	63,559	0.51	0.16	1.07	0.15	0.16	0.05	0.05
China, Hong Kong SAR	HKG	105,485	664,158	0.48	0.21	1.09	0.08	0.08	0.03	0.04
Honduras	HND	13,800	61,520	0.44	0.21	0.95	0.10	0.09	0.05	0.04
Croatia	HRV	59,084	331,412	0.41	0.26	1.16	0.07	0.08	0.05	0.05
Hungary	HUN	60,096	303,085	0.44	0.30	1.07	0.09	0.09	0.06	0.06
Indonesia	IDN	23,923	138,551	0.54	0.34	1.00	0.09	0.09	0.06	0.06

India	IND	18,429	70,987	0.48	0.27	0.89	0.12	0.11	0.07	0.06
Ireland	IRL	221,661	826,650	0.68	0.57	1.24	0.18	0.23	0.15	0.19
Iran (Islamic Republic of)	IRN	44,638	277,477	0.64	0.32	0.82	0.10	0.09	0.05	0.04
Iraq	IRQ	53,417	129,058	0.70	0.15	0.94	0.29	0.27	0.06	0.06
Iceland	ISL	93,443	487,215	0.36	0.25	1.26	0.07	0.09	0.05	0.06
Israel	ISR	77,690	289,987	0.45	0.26	1.24	0.12	0.15	0.07	0.09
Italy	ITA	96,355	736,661	0.48	0.25	1.38	0.06	0.09	0.03	0.04
Jamaica	JAM	19,975	122,241	0.41	0.19	0.76	0.07	0.05	0.03	0.02
Jordan	JOR	44,317	146,584	0.51	0.18	0.82	0.15	0.13	0.06	0.05
Japan	JPN	71,980	373,022	0.44	0.25	1.00	0.08	0.08	0.05	0.05
Kazakhstan	KAZ	59,533	130,216	0.62	0.16	0.61	0.28	0.17	0.08	0.05
Kenya	KEN	8,883	21,550	0.32	0.15	0.83	0.13	0.11	0.06	0.05
Kyrgyzstan	KGZ	14,741	32,810	0.52	0.14	0.41	0.23	0.10	0.06	0.02
Republic of Korea	KOR	80,702	416,609	0.48	0.33	1.04	0.09	0.10	0.06	0.07
Kuwait	KWT	110,038	407,686	0.75	0.28	1.27	0.20	0.26	0.08	0.10
Lao People's DR	LAO	15,028	52,875	0.60	0.24	0.83	0.17	0.14	0.07	0.06
Lebanon	LBN	50,512	291,436	0.56	0.26	1.42	0.10	0.14	0.05	0.06
Sri Lanka	LKA	34,643	101,238	0.59	0.21	0.76	0.20	0.15	0.07	0.05
Lesotho	LSO	8,589	41,957	0.34	0.27	0.79	0.07	0.05	0.06	0.04
Lithuania	LTU	64,980	274,883	0.46	0.19	1.10	0.11	0.12	0.05	0.05
Luxembourg	LUX	120,936	598,848	0.44	0.30	1.70	0.09	0.15	0.06	0.10
Latvia	LVA	62,548	513,818	0.43	0.26	1.17	0.05	0.06	0.03	0.04
China, Macao SAR	MAC	154,394	557,001	0.68	0.16	1.13	0.19	0.21	0.04	0.05
Morocco	MAR	25,082	132,930	0.51	0.33	1.04	0.10	0.10	0.06	0.07
Republic of Moldova	MDA	26,708	81,253	0.47	0.13	0.48	0.15	0.07	0.04	0.02
Mexico	MEX	43,465	198,815	0.64	0.19	0.87	0.14	0.12	0.04	0.04
North Macedonia	MKD	38,287	161,193	0.51	0.27	0.78	0.12	0.09	0.06	0.05
Malta	MLT	77,819	283,575	0.49	0.25	1.32	0.13	0.18	0.07	0.09
Mongolia	MNG	27,882	126,625	0.60	0.31	0.86	0.13	0.11	0.07	0.06
Mozambique	MOZ	3,387	10,556	0.59	0.35	0.76	0.19	0.14	0.11	0.09
Mauritania	MRT	18,744	86,467	0.60	0.24	0.59	0.13	0.08	0.05	0.03
Mauritius	MUS	51,060	167,070	0.57	0.15	0.77	0.18	0.14	0.05	0.04
Malaysia	MYS	54,387	238,009	0.60	0.23	1.11	0.14	0.15	0.05	0.06
Namibia	NAM	31,431	107,554	0.49	0.13	1.01	0.14	0.14	0.04	0.04
Niger	NER	3,182	14,672	0.55	0.24	0.80	0.12	0.09	0.05	0.04
Nigeria	NGA	13,716	43,876	0.53	0.11	0.41	0.17	0.07	0.03	0.01
Nicaragua	NIC	12,352	50,547	0.45	0.12	0.71	0.11	0.08	0.03	0.02
Netherlands	NLD	100,464	501,782	0.40	0.26	1.24	0.08	0.10	0.05	0.07
Norway	NOR	138,858	603,809	0.47	0.29	1.00	0.11	0.11	0.07	0.07
New Zealand	NZL	79,249	262,028	0.45	0.22	0.93	0.14	0.13	0.07	0.06
Oman	OMN	54,992	282,747	0.70	0.23	1.11	0.14	0.15	0.04	0.05
Panama	PAN	66,088	273,245	0.69	0.33	0.84	0.17	0.14	0.08	0.07
Peru	PER	23,553	86,844	0.55	0.21	0.98	0.15	0.15	0.06	0.05
Philippines	PHL	21,530	64,900	0.50	0.21	0.81	0.17	0.14	0.07	0.06
Poland	POL	74,995	194,823	0.42	0.19	0.94	0.16	0.15	0.07	0.07
Portugal	PRT	65,535	587,309	0.41	0.25	1.33	0.05	0.06	0.03	0.04
Paraguay	PRY	25,843	85,902	0.55	0.17	0.78	0.17	0.13	0.05	0.04
Qatar	QAT	155,062	780,929	0.82	0.53	1.18	0.16	0.19	0.10	0.12
Romania	ROU	62,215	208,035	0.50	0.23	1.00	0.15	0.15	0.07	0.07
Russian Federation	RUS	58,060	271,016	0.46	0.16	0.71	0.10	0.07	0.04	0.03
Rwanda	RWA	5,457	9,668	0.26	0.17	0.62	0.15	0.09	0.09	0.06
Saudi Arabia	SAU	129,212	516,085	0.72	0.29	1.03	0.18	0.19	0.07	0.07
Sudan	SDN	17,548	30,767	0.37	0.07	0.60	0.21	0.13	0.04	0.03
Senegal	SEN	8,616	26,337	0.51	0.23	0.72	0.17	0.12	0.07	0.05
Singapore	SGP	127,117	571,597	0.56	0.28	1.13	0.12	0.14	0.06	0.07
Sierra Leone	SLE	5,778	6,689	0.45	0.05	0.36	0.39	0.14	0.04	0.01
Serbia	SRB	41,459	213,834	0.40	0.21	0.84	0.08	0.06	0.04	0.03
Sao Tome and Principe	STP	12,599	58,709	0.26	0.16	0.91	0.06	0.05	0.04	0.03
Suriname	SUR	38,117	288,708	0.55	0.38	0.89	0.07	0.06	0.05	0.04
Slovakia	SVK	60,725	314,858	0.43	0.29	1.23	0.08	0.10	0.06	0.07
Slovenia	SVN	67,700	471,859	0.36	0.28	1.36	0.05	0.07	0.04	0.05
Sweden	SWE	105,203	548,523	0.44	0.29	1.16	0.09	0.10	0.06	0.07

Eswatini	SWZ	28,757	101,235	0.39	0.10	0.85	0.11	0.09	0.03	0.02
Chad	TCD	4,325	7,900	0.51	0.16	0.69	0.28	0.19	0.09	0.06
Togo	TGO	5,695	15,032	0.19	0.13	0.73	0.07	0.05	0.05	0.04
Thailand	THA	31,745	149,972	0.36	0.20	0.85	0.08	0.07	0.04	0.04
Tajikistan	TJK	13,529	133,095	0.56	0.14	0.37	0.06	0.02	0.01	0.01
Trinidad and Tobago	TTO	65,106	127,398	0.66	0.08	1.03	0.34	0.35	0.04	0.04
Tunisia	TUN	35,177	95,348	0.50	0.11	0.54	0.18	0.10	0.04	0.02
Turkey	TUR	80,044	364,425	0.56	0.27	1.08	0.12	0.13	0.06	0.06
Taiwan	TWN	95,946	370,325	0.35	0.21	0.90	0.09	0.08	0.05	0.05
U.R. of Tanzania: Mainland	TZA	5,618	16,793	0.42	0.23	0.58	0.14	0.08	0.08	0.05
Ukraine	UKR	35,050	429,469	0.44	0.09	0.74	0.04	0.03	0.01	0.01
Uruguay	URY	43,490	195,029	0.53	0.16	0.96	0.12	0.11	0.03	0.03
United States	USA	130,107	436,256	0.40	0.22	1.05	0.12	0.13	0.07	0.07
Uzbekistan	UZB	28,361	79,521	0.57	0.18	0.46	0.20	0.09	0.06	0.03
Venezuela (Bolivarian Republic of)	VEN	612	18,633	0.57	0.11	0.55	0.02	0.01	0.00	0.00
British Virgin Islands	VGB	80,364	309,138	0.62	0.22	1.01	0.16	0.16	0.06	0.06
South Africa	ZAF	39,377	155,434	0.43	0.16	0.91	0.11	0.10	0.04	0.04
Zambia	ZMB	10,867	58,124	0.61	0.31	0.84	0.11	0.10	0.06	0.05
Zimbabwe	ZWE	5,977	10,187	0.47	0.08	0.80	0.27	0.22	0.05	0.04

Table IV. Country level data and MPK composition

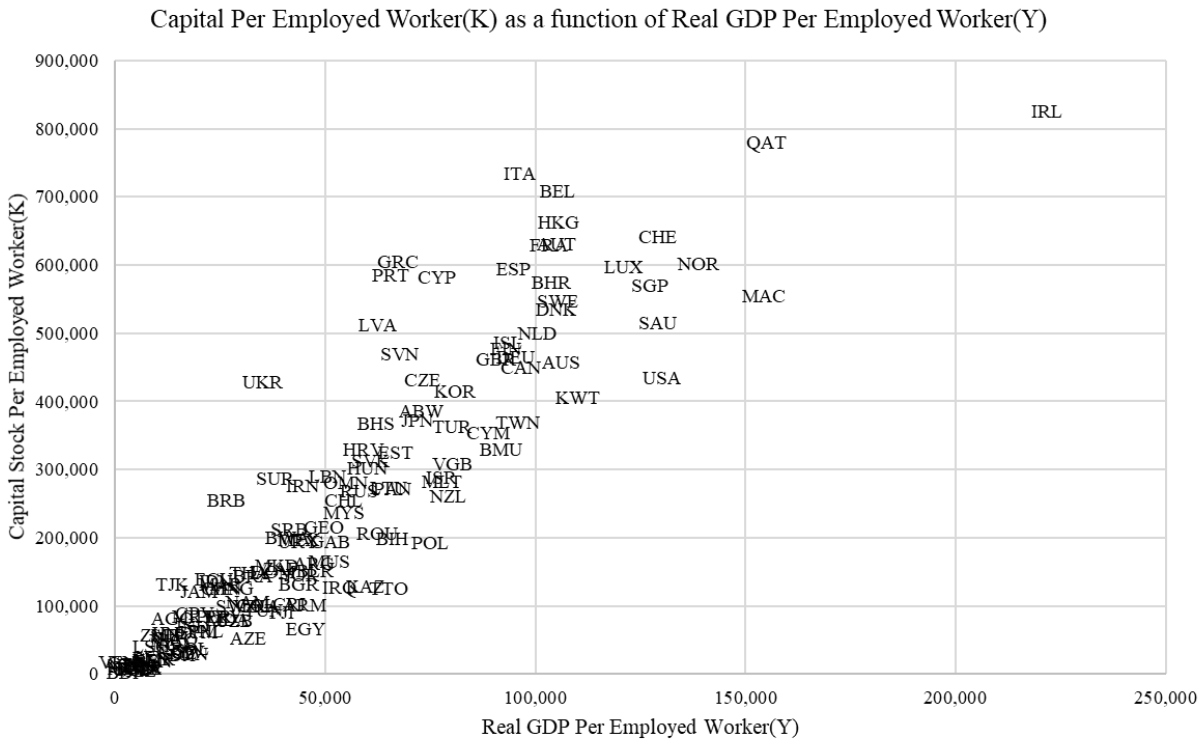

Figure 2. Capital per Employed Worker(K)

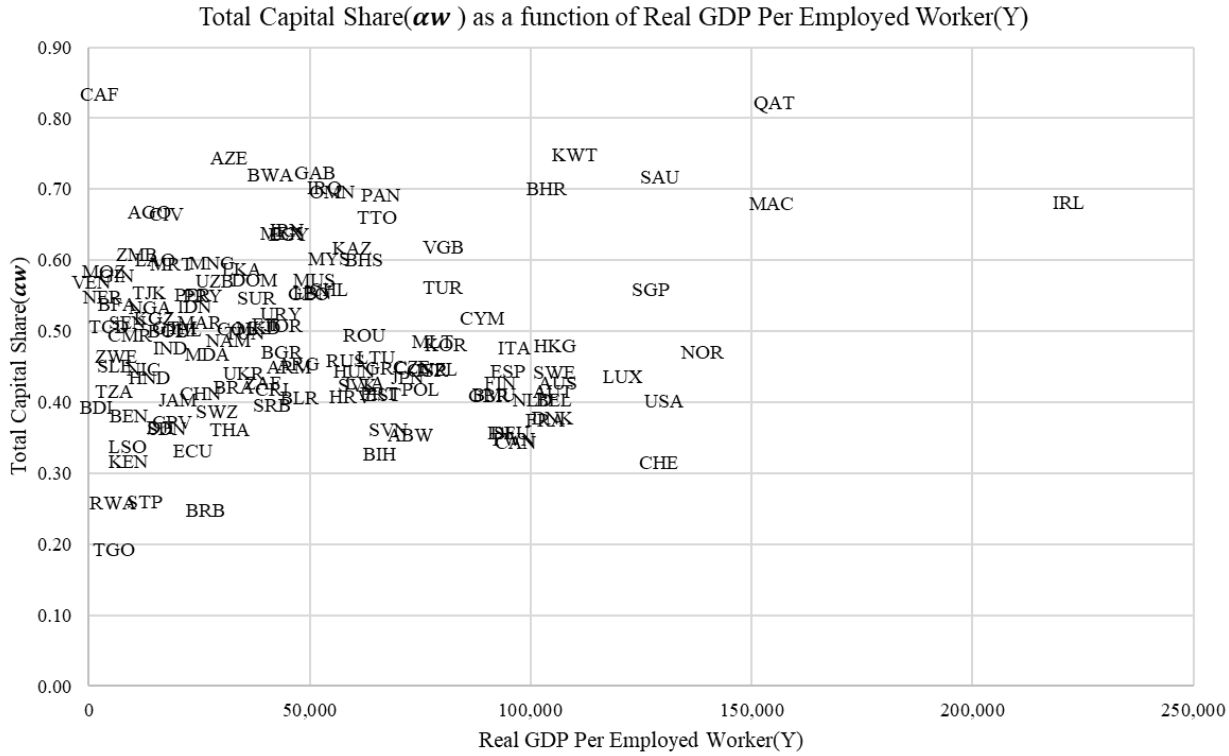

Figure 3. Total Capital Share (α_w)

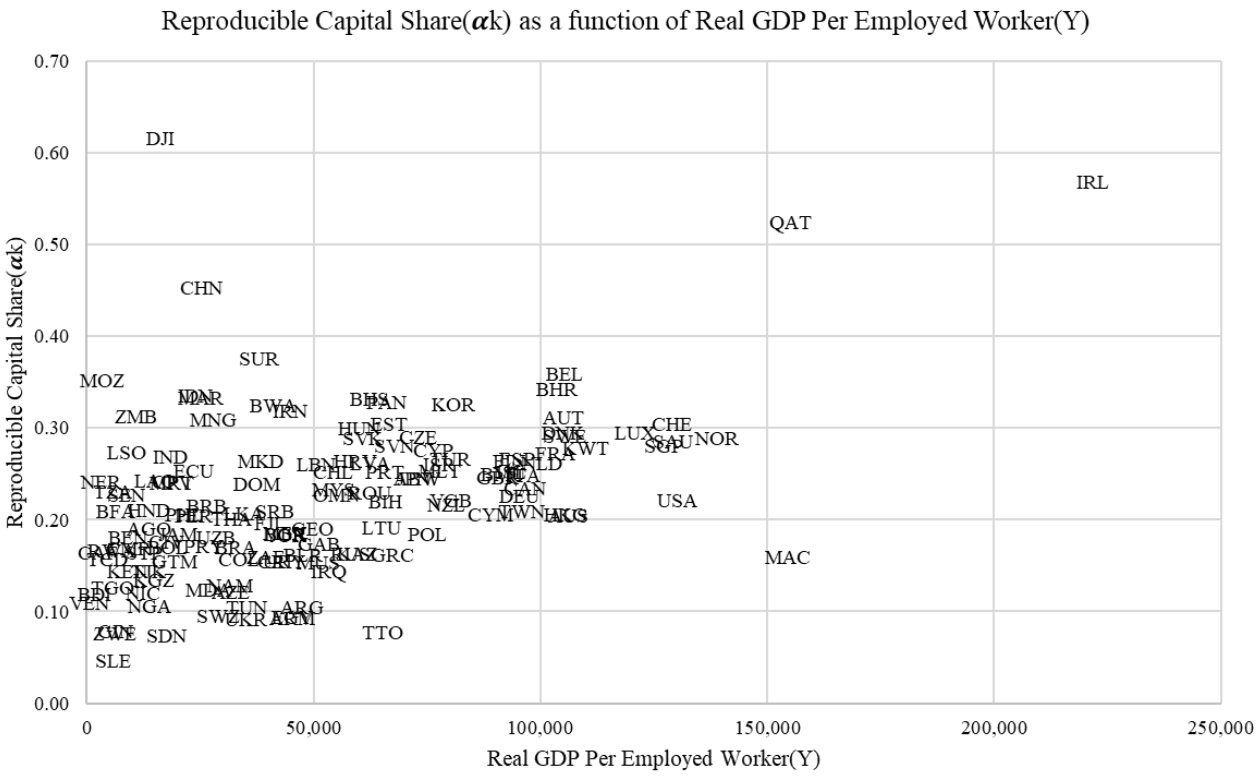

Figure 4. Reproducible Capital Share ($\boldsymbol{\alpha_k}$)

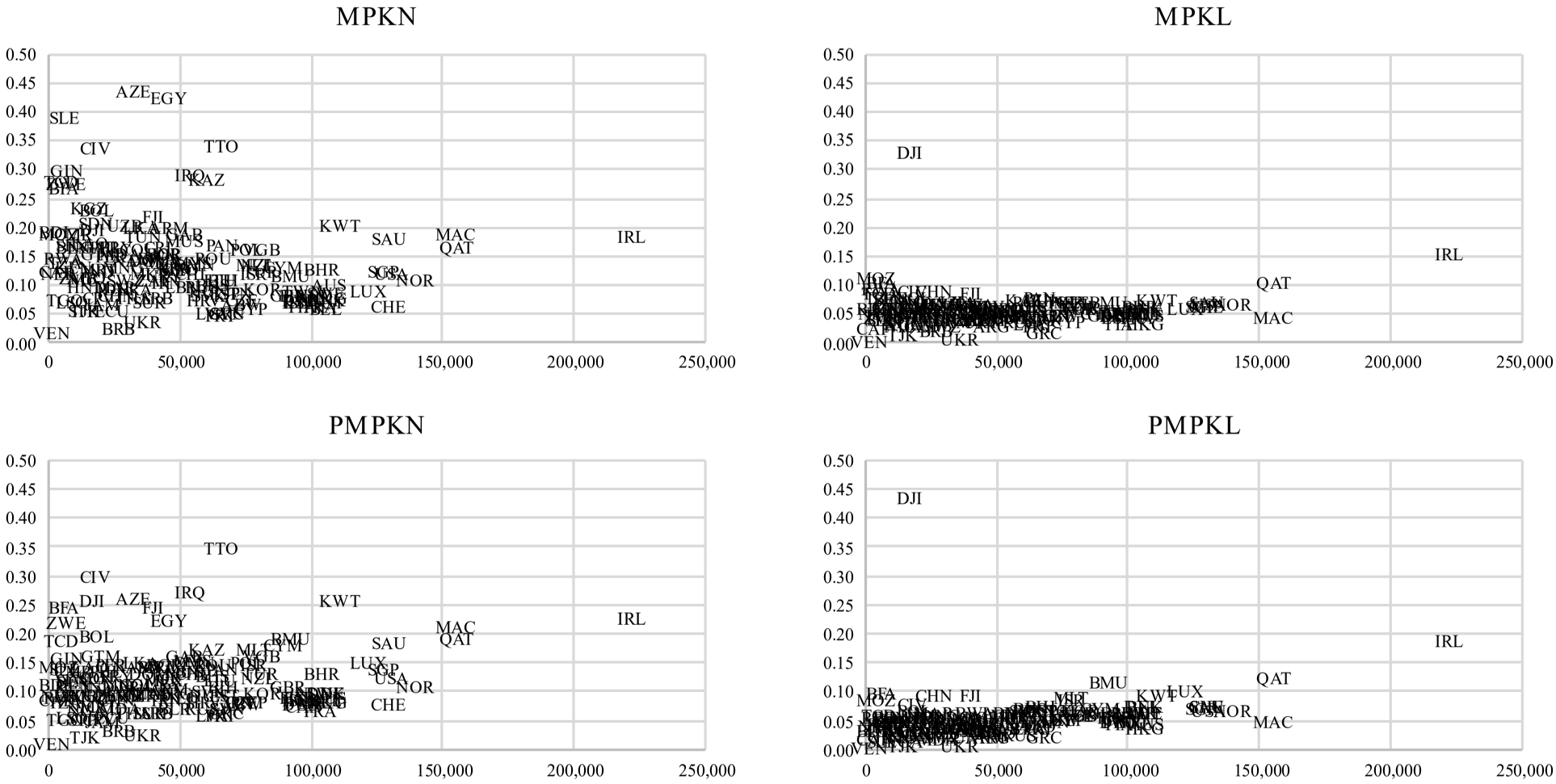
MPKN
MPKL
PMPKN
PMPKL
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
50,000
100,000
150,000
200,000
250,000
AZE
EGY
SLE
CIV
TTO
IRQ
KAZ
KWT
SAU
MAC
QAT
IRL
DJI
FJI
BRB
UKR
VEN
TJK
BMU
LUX
NOR
CHE
BHR
GRC

Figure 5.