On the Differences Between the Marginal Product of Capital Across Countries

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Abstract

We extended the benchmark neoclassical model of investment in order to account for the case of an open economy under imperfect capital mobility. Our model shows that risk premium reduces the savings rate of the domestic economy and the stock of capital per unit of effective labor when compared to a risk-free country. The riskier market thus presents a lower income per capita, ceteris paribus. We contrast our time-series data with the recent evidence on marginal product of capital differentials presented by Caselli, F. and Feyrer, J. (2008), *Quarterly Journal of Economics*, forthcoming. Our empirical analysis, from 1951 to 2003, lends support to the conclusion that: \(i\) decreasing output to capital ratios with respect to the US were led by capital growth until the 1980s; \(ii\) the evidence against the “credit view” is not convincing; \(iii\) human capital differences and risk are complementary stories for explaining marginal product and income differentials.

*Keywords*: Income; Capital; Investment.

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Introduction

When analyzing the experience of some British ex-colonies before 1945, Lucas Jr. (1990) concluded that political risk could not explain why capital did not flow from rich to poor countries as a way to equalize real returns. The author poses an interesting question: if there was no risk - as laws could be enforced by the colonizer - why income per capita did not converge between countries? His intuition was that human capital differences explained this apparent puzzle. Although poorer countries had more labor relative to capital, labor would be more productive in richer economies because of higher education, for instance. Hence, we would not observe large inflows of capital into poorer economies relative to investment in advanced countries, because their marginal product was similar. Recently, Caselli & Feyrer (2008) have shown that the marginal product of capital (MPK, hereafter - MPKs is used for the marginal product of more than one economy) across countries is not as different as we used to think. Their work proposes a new method to estimate the return to scale parameter of the typical Cobb-Douglas function as well as adjusting the MPK for differences in prices for capital and consumption goods. Results and discussion presented by Caselli & Feyrer (2008) suggests near total convergence of the MPK for most countries in the world (by total convergence or complete equalization, we mean that there are no significant MPK differentials). The authors then conclude in favor of Lucas Jr. (1990)’s intuition, striking a blow to the “credit view” which we understand as the importance of impediments to capital flows for explaining MPK differentials.

Results found by Obstfeld & Talyor (2002) and Goldberg et al. (2003) on the international finance literature lend support to the stationarity of real interest rate differentials for the major industrialized countries, which means that there is a long run equilibrium relationship between these variables across countries and time. The speed of convergence seems to be faster in the most recent period of floating exchange rates. Along the same lines, Ferreira & Leon-Ledesma (2007) presented evidence showing that, although the real interest rate parity hypothesis hold, some emerging economies have higher equilibrium real interest rates (their study comprehends the post openness period). If we put the neoclassical theory and the previous results together we can reach a twofold conclusion: i) that MPKs have been converging and ii) that we do not know whether convergence was total or that there are still some MPK differentials, especially in the case of emerging economies.

Although both Lucas Jr. (1990) and Caselli & Feyrer (2008) point out to human capital as a driving element explaining differences in output per capita for the same stock of capital per capita, we cannot dismiss the “credit friction” view as an explanation for MPK differentials without further investigation on the dynamic behavior of the MPKs. In spite of Lucas Jr. (1990) skepticism regarding political risk in particular, we show that “risk” could explain differences in real returns and also on standards of living.

The current paper investigates the hypothesis of the “credit view” as a reasonable explanation for MPK differences. This is carried out by extending the neoclassical model of investment for the open economy case and by analyzing the time-series behavior of some
crucial variables. On one hand, our simple model shows that MPK across countries will be different by a factor that can be interpreted as risk. We also argue that the estimation of the return to scale parameter of the typical Cobb-Douglas production function is crucial for verifying whether there is total convergence or not. It follows that the validity of Caselli & Feyrer (2008)’s conclusion against the credit view is extremely sensitive to the estimation of the parameter aforementioned, especially because their cross section data results in a unique observation for the US. On the other hand, we employ a time-series analysis using data from 1951 until 2003 from Heston et al. (2006). Our results show that output capital ratio differentials with respect to the US decreased substantially from the 1950s until the 1980s, and that capital growth led this process. This increases the support to the hypothesis that countries are converging to a similar savings function, in other words, that capital flows and market integration matter for closing up differentials\(^2\). The evidence discussed thus casts doubts on the total convergence hypothesis. As explained, MPK differences, according to the credit view, will diverge by an amount that is equal to the size of risk premia differences. This means that those differences could statistically vanish for some countries, but they will be more important for other economies.

Note that the central question of long term growth is not at stake here. MPK differentials could be driven by economic closeness, i.e. barriers to capital flows, while differences in output \textit{per capita} for the same MPK and stock of capital \textit{per capita} could be a result of different levels of education, health and so on (human capital). Our analysis thus suggests that Lucas Jr. (1990) intuition and Caselli & Feyrer (2008)’s conclusion must be put into context. If MPKs were equal on the average by the 1950s, why does the output capital ratio has fallen steadily for many countries in relation to the US? Our evidence supports the conclusion that capital flows have played an important role on the convergence of MPKs, while there is still reasonable doubts about the total convergence hypothesis, a result that is in line with the recent evidence on the equalization of real interest rates.

The paper is divided as follows: in the first part we present a modification of the benchmark investment and Solow (1956) models for the open economy under the assumption of imperfect capital mobility (or with rent-seekers). In the second part, we collect data on the relevant variables and estimate the output capital ratios for the empirical analysis. Finally, we conclude.

1 The open economy investment model

Suppose a representative firm in a competitive market that rents a certain amount of capital represented by \(K_t\) at a nominal cost \(R_t\). Firm’s profits at time \(t\) can be written as

\[
\Pi_t = F(K_t, A_t L_t)P_t - R_t K_t - W_t L_t,
\]

where \(Y_t = F(K_t, A_t L_t)\) and \(A_t, L_t, P_t,\) and \(W_t\) represent output, technology, labor, price

\(^2\)Thus our analysis also lend some support to the results and arguments presented by Reinhart & Rogoff (2004), Alfaro et al. (2005) and Stulz (2005)
level and wages, respectively. The first order condition on the dimension of the capital stock is

\[ Y_{Kt} = \frac{R_t}{P_t}, \quad (2) \]

and \( Y_{Kt} \) is the marginal product of capital, i.e., \( Y_{Kt} = \partial F/\partial K_t \). This is the traditional neoclassical result in which the factor of production is paid its marginal contribution. The rental cost of capital, considering that the price of capital is \( P_{Kt} \), is often given by

\[ R_t = (i_t + \varphi - \Delta P_{Kt+1})P_{Kt}. \quad (3) \]

The parameter \( \varphi \) stands for depreciation and \( \Delta P_{Kt+1} = (P_{Kt+1} - P_{Kt})/P_{Kt} \). The variable \( i_t \) is the nominal interest rate paid on a one-period bond which would be the cost of capital for a firm that borrows money or the opportunity cost of investment otherwise. Our model extends the neoclassical autarky approach to an open-economy by considering that the process for \( i \) is given by the uncovered parity hypothesis (UIP) under imperfect capital mobility and rational expectations\(^3\), i.e.

\[ i_t = i^*_t + \Delta S_{t+1} + \rho + v_t, \quad (4) \]

where the asterisk denotes an exogenous determined foreign variable or the rest of the world which we will alternatively refer to as the larger economy or the foreign economy\(^4\); \( \Delta S_{t+1} = (S_{t+1} - S_t)/S_t \) and we assume that \( S_{t+1} = S_{t} + v_t \), where \( v_t \) is a white-noise forecast error. Imperfect capital mobility is represented by the inclusion of \( \rho \) which prevents an infinite capital flow movement for small differences in expected returns. Assuming that relative prices in this economy are constant, so that percentage changes in capital prices closely track percentage changes in the price level, i.e. \( \Delta P_{Kt+1} = \Delta P_{t+1} = (P_{t+1} - P_t)/P_t = \pi_{t+1} \) which corresponds to the inflation between \( t \) and \( t+1 \), and that the real price of capital is normalized to one \( P_{Kt}/P_t = 1 \), we thus have

\[ \frac{R_t}{P_t} = (i^*_t + \Delta S_{t+1} + \rho + \varphi - \pi_{t+1} + v_t). \quad (5) \]

The relevant process for \( \Delta S_{t+1} \) in an open economy is given by the equilibrium condition in the goods market. Hence, we incorporate the relative purchasing power parity, formalized by \( \Delta S_{t+1} = \pi_{t+1} - \pi^*_t \) in (5) to obtain

\[ \frac{R_t}{P_t} = (i^*_t - \pi^*_t + \rho + \varphi + v_t). \quad (6) \]

\(^3\)Although, empirical evidence on UIP is controversial, there is increasing evidence on its support, especially when one accounts to risk.

\(^4\)By larger economy, we mean that it started with a higher stock of capital per unit of effective labor (and, hence, a higher output per capita). For the empirical analysis, we assume that the US is the larger economy.
Given that $i_t^*$ is the interest that matures at time $t + 1$, $i_t^* - \pi_{t+1}^*$ will be equal to the ex post foreign real interest rate defined as $r_t^*$. Using the definition of $r_t^*$ and substituting (6) into the first order condition\footnote{That is, the real cost of capital (or the price of this factor of production) equals its marginal contribution.}

$$Y_{Kt} = r_t^* + \rho + \varphi + \upsilon_t. \tag{7}$$

The previous result corresponds to the autarky neoclassical standard formulation extended for the cost of capital in an open economy. We have an analogous equation for the rest of the world

$$Y_{Kt}^* = r_t^* + \varphi^*, \tag{8}$$

where we implicitly assumed that the larger economy is risk-free $\rho^* = 0$. The hypothesis that $\rho^* = 0$ is less stringent than what it might appear at first. In fact, what we mean is that the rental cost of capital is larger in the domestic economy because, even when it opens up, the rental cost charged by the rest of the world will include some probability of default. The risk term in equation (7) is the risk present in traditional uncovered interest parity (UIP) formulations. Hence, it could correspond to some probability of debt default, the covariance of the utility of consumption with exchange rate variations, currency risk and political risk\footnote{For a definition of political risk, understood as sudden stops on capital flows imposed by governments, see Dooley & Isard (1980). For a decomposition of the UIP risk premium between political, default and currency risk, see Alper et al. (2007).}.

Intuitively, and following the standard analytical division between firms that produce goods and services and those that rent capital, we can think that if $i_t > i_t^*$ then the rental cost will be higher for domestic firms that borrow capital. On the other hand, for firms that own capital, $i_t$ will be the actual opportunity cost of investment.\footnote{Alternatively one can think of “risk” as being the fraction, $L$, of the marginal product of capital that is lost to rent-seekers or predators, i.e.}

$$Y_{Kt}(1 - L) = Y_{Kt}^*, \tag{9}$$

where we are also supposing that $L^* = 0$. Given that $Y_{Kt} = r_t$ and $Y_{Kt}^* = r_t^*$, we have

$$r_t = r_t^* + r_tL, \tag{10}$$

where $r_tL$ would be the size of the risk premium. Hence, we could also derive a condition similar to (11) from a rent-seeking model.

\footnote{However, the expected opportunity cost will be $(i_t - \rho)P_{Kt}$, and, for the share of companies that own capital, MPK differences will vanish (assuming perfect information and rational agents). The same reasoning applies to the cost for the foreign firm that invests in the domestic economy: $(i_t^* + \Delta S_{t+1})P_{Kt}$. The exchange rate enters the cost of capital in this case, because when the foreign firm invests in the domestic economy, it gains whenever the domestic currency appreciates, i.e. the exchange rate decreases. The reason is that the firm will be able to buy more foreign currency with less units of the domestic one. Hence, a fall in $S$ will decrease rental costs. Note that $(i_t^* + \Delta S_{t+1})P_{Kt}$ is analogous to $(i_t - \rho)P_{Kt}$ by UIP. We do not intend to discuss in depth the types of firms according to their financing structure, investment}
the small open economy is riskier, its real capital cost, when financed abroad, will be
$r^* + \rho$.

By substituting the process for the real interest rate given by (8) into (7) we obtain

$$Y_{Kt} = Y^*_{Kt} + \rho + \nu_t,$$

which is equivalent to $r_t - \rho = r^*_t + \nu_t$ and we assumed, for simplification, that $\varphi = \varphi^*$.

If there was perfect capital mobility, $\rho = 0$, and the following condition would hold in equilibrium

$$Y_{Kt} = Y^*_{Kt}$$

$$r_t = r^*_t.$$  \hspace{1cm} (12)

The underlying idea of (12) is simple and can be better comprehended with an example. Suppose that the autarky has a higher marginal product of capital than the rest of the world because it started with a relatively smaller stock of capital per unit of effective labor. Higher returns in the small open economy (an autarky that opens up to trade and financial flows) would attract foreign capital, thus decreasing the marginal product of capital until there is equalization of real returns. As the stock of capital rises, output per capita also increases, improving living standards in the small economy. However, if there is imperfect asset substitutability and the autarky opens up to financial and trade flows, equilibrium will be reached when risk adjusted real returns are the same in both economies.

The condition expressed by (12) can also be obtained from the real interest rate parity hypothesis, put forward by Roll (1979), according to Mishkin (1984). This hypothesis is based on the three pillars of international finance: relative purchasing power parity, uncovered interest rate parity and rational expectations. Support on the real interest rate parity has been increasingly favorable in the sense that real interest rate differentials of small open economies with respect to larger ones (such as the USA) quickly converge to an equilibrium. For instance, Ferreira & Leon-Ledesma (2007) show that the equilibrium is statistically insignificant for sound European economies, while it is positive for some emerging markets (including Argentina, Brazil, Mexico and Turkey). The finding of an equilibrium differential suggests that the hypothesis of perfect asset substitutability

decision or ownership. Our model assumes that the rental cost for investment in the domestic economy is higher. A careful decomposition of cost of capital by the type of firm is beyond the objectives of the present paper and the needs of the argument. There are other facts, such as the home bias in investment or the Feldstein & Horioka (1980) puzzle that could be invoked in order to justify our assumption. In any case, it is reasonable to assume that a part of the domestic firms need to borrow money domestically for investment and, in that case, capital cost will be higher. We could have also assumed a higher transaction cost in the domestic economy, for which our presumption of higher domestic interest rates would still be valid.

\footnote{We assume the model with imperfect capital mobility in the analysis. If risk is interpreted as rent seek, one would have to suppose no rent seekers, $L = 0$, and that no resources are used for protection from predators.}
is strong and that uncovered interest rate parity under risky assets might be a more reasonable assumption. This suggests the incorporation of risk in the typical equation, \( r = r^* \), as we did above. The condition in (12) is also known as the international Fisher hypothesis\(^{10}\) in which both interest rates and inflation move alongside in the same pace, keeping real rates, supposedly determined by real factors, constant.

The idea of our extended model is that if risk is just enough to compensate for the higher return, capital will not flow from the rest of the world to the small open economy because the higher return would also involve a higher risk. Hence, the term risk impacts on the difference between the stock of capital in both economies and on standards of living. That is, the probability of a country default will impact on the supply of capital for investment.

### 1.1 Differences in Income per Capita

In order to see the impact of marginal product of capital differences on standards of living, assume that goods and services are produced according to a Cobb-Douglas production function of the type

\[
Y_t = K_t^\alpha (A_t L_t)^{1-\alpha}.
\]

(13)

In (12) there are constant returns to capital and labor and we also assume decreasing returns to the individual factors of production, i.e., \( \partial Y_t / \partial K_t < 0 \). Technology and population growth, which are represented by \( g_a \) and \( n \), respectively, are exogenous and constant. The domestic savings rate, as seen later, will depend on the foreign savings rate. The condition in (7) can be written, given (13), as

\[
Y_t = \alpha \left( A_t L_t / K_t \right)^{1-\alpha} = \alpha k_t^{\alpha-1},
\]

(14)

where \( k_t = K_t / (A_t L_t) \) is capital per unit of effective labor.

Substituting equation (14) and its analogous foreign counterpart in (11) while assuming, for simplification, that the small open economy and the rest of the world have similar capital shares\(^{11}\) and that \( \upsilon_t = 0 \) (which implies perfect foresight, solely for ease of exhibition) it follows that\(^{12}\)

\[
k_t = \gamma k_t^*.
\]

\(^{10}\)In other words, the condition that real returns must be equal can be derived in a third way, i.e. through the Fisher hypothesis.

\(^{11}\)Once economies are opened up we could also assume that \( A = A^* \). Although these seem to be strong assumptions, in fact they are innocuous in terms of the main point we want to make, i.e., that risk impacts on the standards of living in an open economy. One might ask why countries that have the same structure would have different risks and the answer could be in the shape of their institutions and, for that reason, we maybe then needed to incorporate risk in the production function. For the purposes of the present paper, we understand that \( \rho \), under the denomination of risk, captures the relevant features of bad economic fundamentals, corruption, rent seeking and so on.

\(^{12}\)The steps needed for obtaining equation (15) are shown in the appendix.
where \( \gamma = \left( \frac{1}{1 + \frac{1}{k^*}} \right)^{\frac{1}{\alpha - 1}} \). Hence, if \( \rho = 0 \), stocks of capital per unit of effective labor would be the same in both economies. That is, if two economies shared a similar level of technology and human capital, perfect capital mobility would ensure the same level of output \textit{per capita} instantaneously. However, if they differed only because \( \rho > 0 \), the stock of capital in the small open economy would not grow in response to higher returns. Given that the production function can be written as

\[
\frac{Y_t}{L_t} = k_t^\alpha A_t, \tag{16}
\]

we can write in steady state

\[
\frac{Y_t}{L_t} = (\gamma k^*)^\alpha A, \tag{17}
\]

where we dropped the time subscript as \( k \) becomes a constant. And \( k^* \) can be substituted accordingly:

\[
\frac{Y_t}{L_t} = \gamma \frac{Y^*_t}{L^*_t} A^*_t. \tag{18}
\]

By making \( A_t = A^*_t \), due to free technology flows, for example, we would have

\[
\tilde{y} = \gamma^\alpha \tilde{y}^*, \tag{19}
\]

where \( \frac{Y_t}{L_t} = \tilde{y} \) corresponds to output \textit{per capita}. We conclude that for \( \rho > 0 \), \( \gamma < 1 \) and \( k < k^* \), thus, \( \tilde{y} < \tilde{y}^* \) in the steady state.

### 1.2 Differences in the Savings Rate

We will show that in terms of the Solow (1956) fundamental equation, the one relating investment \textit{per capita} (and thus saving \textit{per capita}) to depreciation and the growth of population and technology, our model implies that convergence to a different steady state depends on barriers to capital flow (under the name of risk). In the absence of risk and given the model assumptions, the steady state value of capital per unit of effective labor in the small open economy would be the same as in the larger foreign country. This would be true because the domestic savings function would be replaced by the foreign one and a new steady state would be reached instantaneously after openness. In summary, the emerging economy would be in the same savings function of the rest of the world.

We start by recalling (11) which implies, in steady state,

\[
k^\alpha = k^* \alpha - 1 = \frac{\rho}{\alpha}. \tag{20}
\]

Furthermore, we write the fundamental equation of Solow (1956)

\[
s = k^{1-\alpha}(\phi + n + g), \tag{21}
\]

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where $s$ is the savings rate of the small open economy; for the larger country we represent it by $s_l$. We can also write (21) as

$$k^{1-\alpha} = \frac{s}{\varphi + n + g}, \quad (22)$$

and if we assume the same technology and population dynamics for both economies, $k^{1-\alpha} = \frac{s_l}{\varphi + n + g}$. From (20) we then have

$$\frac{\varphi + n + g}{s} = \frac{\varphi + n + g}{s_l} + \frac{\rho}{\alpha}, \quad (23)$$

which, solved for $s$ gives

$$s = \frac{s_l \alpha (\varphi + n + g)}{(\varphi + n + g) \alpha + \rho s_l} \quad (24)$$

and since $\rho > 0$, we will have $s < s_l$. For instance, if $\rho = 0.08$, $\varphi = 0.06$, $n = 0.01$ and $g = 0.01$ and $s_l = 0.4$, the savings rate in the risky country will be $s \approx 0.18$. On the other hand, if $\rho = 0$, then

$$s = s_l.$$

Hence, our model implies that risk will affect standards of living, which, in our model is understood as income per capita.$^{13}$ An unpretentious exercise can provide an idea of the size of the impact. Our discrete time model implies the following approximation in steady state

$$y = \left(\frac{s}{\varphi + n + g}\right)^{\frac{\alpha}{1-\alpha}}, \quad (25)$$

Given (24) and maintaining the numbers of our previous calibration, i.e. $s \approx 0.45s_l$, we can write

$$y \approx 0.67y^* \quad (26)$$

Hence, given the hypothesis about the dynamics of the economy, a 8% risk could explain about 33% of the differences between income per capita, which is not a negligible number.$^{14}$

Finally, differences in human capital remain a potential source of variations in income across countries but not for MPK differentials. A modified version of the production function including human capital was not considered because it does not change the main

$^{13}$ From a microeconomic perspective, the intuition is that risk will favor present consumption in comparison to future consumption.

$^{14}$ This could explain the experience of some Latin American countries in which domestic investment as a proportion of GDP has been low. The case of Brazil might be interesting, since investment has been at about 20% of the GDP and has not grown significantly after financial openness. Furthermore, the country experiences high real ex ante and ex post real interest rates. Income per capita is about a tenth of the richest countries.
result presented above, that MPK differentials are determined from different costs of capital across countries.

**Empirical Analysis**

A major part of this section draws on the work of Caselli & Feyrer (2008) who attempt to unveil whether the higher marginal product of capital in less developed economies in comparison to developed ones is due to biased estimates of the proportion of the reproducible capital stock and a failure to recognize the higher real price of capital in these economies. They argue that less developed countries could have more land and natural resources as production inputs and because $\alpha$ is often estimated as 1 minus the proportion of the labor share in the economy, named $\alpha_w$, while the “true” share, $\alpha_k$, should only consider the stock of reproducible capital, i.e. $\alpha_k = (K_t \bar{r})/Y_t$, where $\bar{r}$ is the equilibrium real interest rate, then $\alpha_k < \alpha_w$ and estimates of the marginal product of capital would be biased upwards. Thus their work was to obtain $\alpha_k$ from $\alpha_w$ by correcting for the income paid to nonreproducible capital (land and natural resources).

In order to see their point regarding the importance of differences between the real price of capital across countries, consider the simple two sector model which is specified using (1) for two goods $i$ and $j$. It follows from the first order conditions of the representative firms for profit maximization that

$$Y_{K_i} P_i t = R_i t$$

and

$$Y_{K_j} P_j t = R_j t,$$  \hspace{1cm} (27)

the subscripts $i$ and $j$ refer to the types of capital $K_{it}$, $K_{jt}$ necessary to produce goods $i$ and $j$ sold at prices $P_i t$, $P_j t$ and where the rental cost of capital equals $R_i t$ and $R_j t$, respectively. If markets are competitive, we can write

$$P_i Y_{K_i} = P_j Y_{K_j} = P Y_K.$$  \hspace{1cm} (28)

Consider that $i$ is the sector that produces capital and $j$ the sector that produces goods. From (28) we can write

$$P_j Y_{K_j} = P \alpha_k \frac{Y}{K}.$$  \hspace{1cm} (29)

Dividing both sides of (29) by $P_i$, we obtain

$$\frac{P_j Y_{K_j}}{P_i} = \alpha_k \frac{YP}{KP_i},$$  \hspace{1cm} (30)
which is equivalent to equation (6) in Caselli & Feyrer (2008)’s paper. The authors then argue that the marginal product of capital should be corrected by the fraction \( \frac{P}{P_i} \) in the right hand side of (29) and also by \( \alpha_k \). Recall that \( P \) is the price of output and \( P_i \) is the price of capital. After correcting for these differences, Caselli & Feyrer (2008) find that the MPK in a group of economies in a determined year (1996 - for which an estimate of \( \alpha_k \) was available), is similar. Based on the intuition underlying Lucas Jr. (1990)’s paper they concluded that the credit constraint hypothesis is not reasonable and that human capital differences would explain the results.

According to them, we would thus have

\[
\frac{\alpha_k Y P}{KP_i} = \frac{\alpha^*_k Y^* P^*}{K^* P_i^*}.
\]

(31)

By taking logarithms of (31) and differentiating the result against time gives

\[
g_Y - g_K + \pi_t - \pi^*_t = g_Y^* - g_K^* + \pi_t^* - \pi^*_t,
\]

(32)

where we considered \( \alpha_k \) and \( \alpha^*_k \) constants; \( g_Y \) and \( g_K \) correspond to the growth rates of the real GDP and the stock of capital, respectively. In this paper, one of our objectives is to analyze the data taking into account equations (31), (32) and (11) in an attempt to verify whether Caselli & Feyrer (2008)’s results are robust and Lucas Jr. (1990)’s intuition correct. For example, if MPKs were equal at the beginning of the sample period, both sides of equations (31) and (32) would be similar. In the following sub-section we explain the construction of our time-series database and present the analysis.

**Results**

Below, we present and discuss some data that lend support to the view that economic openness was important for convergence and that results of complete equalization are very sensitive to the value of the parameter \( \alpha^* \), i.e. the one for the US. By complete equalization or total convergence we mean that there are no significant differences between MPK across countries (in the statistical sense). As shown by our model, these differences in an open economy would be equal to a risk premium.

The graphs and tables that follow were constructed using time series data from Heston et al. (2006) and the methodology of Caselli & Feyrer (2008)

\[15\] The main methodological artifices that we borrowed are i) the method to estimate the first observation of the capital stock, i.e. the perpetual inventory model; ii) the depreciation rate of 0.06 per year; iii) the relative price correction idea.

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on MPK differentials with respect to the US. This first fact can be seen in Graphs 1, 2 and 3. A regression of \(Y^*/K^*\) on a constant and on a time trend gives a value of -0.7 for the trend parameter with a t-value equal to -14.6 (and probability value of 0). Recursive estimates imply that the tendency of the trend parameter is zero, although it is significant throughout the sample. In that regard, given that MPK was higher in the average country at the beginning of the period, results of equalization by the end of the series would not be surprising.\(^{16}\)

Second, in Table 1 we present descriptive statistics of the variables shown in equation (32) for both the US and an average of the countries listed in Table A\(^{17}\). Both statistics in Table 1 and the visual inspection of Graph 4 mean that capital growth has been higher for the average country, this is the main variable putting downward pressure on differentials. Such process could be either a result of convergence to a higher steady state value or that capital flows are in course because of differences in the MPK (a smaller level of capital with respect to the US at the beginning of the sample). Alternatively, the reason could be a combination of both facts\(^{18}\). However, we understand that the decreasing output capital ratio differences between the US and the average country is an evidence that countries had been converging to a similar savings function, a fact that could be due to increased market integration. On the other hand, the economic openness would also imply convergence to an analogous production function if there is higher mobility of technology and labor which also implies more investment. The latter evidence thus lends support to the view that economic openness (elimination of financial and trade barriers) was important for closing the gap between MPKs. Whether all gains from financial integration had already been reaped depends upon the degree of economic integration and the absence of risky choices, according to the model presented in the previous section\(^{19}\).

A third point is that, as mentioned, the conclusion against the credit view is very sensitive to the estimation of \(\alpha^*\). The vertical distance between the line for the US and the average country in Graph 2 is determined by the size of this parameter. We have made an exercise using the following formulae: \(\alpha^* = (\bar{r}^* + \delta^*)(K^*/Y^*)\) where \(\bar{r}^*\) was calculated as the static long run equilibrium of an autoregressive process with one lag,\(^{20}\)

\(^{16}\)As discussed, recent evidence shows that real interest rates across countries do converge [see for example Ferreira & Leon-Ledesma (2007) and Singh & Banerjee (2006)]. Convergence is fast for real interest rates, although some emerging economies tend to revert to a higher equilibrium real interest rate. Given the correspondence between real interest rates and MPK, both results are in line. The question, however, is whether the convergence is complete or if there are still MPK differentials.

\(^{17}\)The choice of the countries is due to the fact that their sum represent a large fraction of the world’s GDP. Furthermore, all countries of the list show a remarkable analogous pattern. We believe that an extension of the sample to the whole population of Heston et al. (2006) would not change our qualitative results.

\(^{18}\)With regard to the importance of capital flows during this period, see Alfaro et al. (2005).

\(^{19}\)Caselli & Feyrer (2008) shows an exercise in which the gains from higher integration (smaller MPK gaps) are small. A counterfactual to the previous study would be the losses of higher disintegration caused by closeness and sensitiveness tests for different values of the parameter \(\alpha^*\). However, this is beyond the objectives of the current paper.
i.e. $\bar{r}^* = \hat{\beta}_0 \left(1 - \hat{\beta}_1^*\right)^{20}$. For $\delta^*$ we also assumed the value 0.06. The estimated regression using ordinary least squares is $r_t^* = \hat{\beta}_0 + \hat{\beta}_1 r_{t-1}^* + \varepsilon_t$ where $\varepsilon_t$ is a white-noise error. The real interest rate series was calculated using annual data of the consumer price index for inflation and the treasury bill rate for nominal interest rates, available at the IFS/IMF. Our estimate of the equilibrium real interest rate is 2.77%, given $\hat{\beta}_0 = 0.56$ and $\hat{\beta}_1 = 0.525$. Both the constant and the autoregressive parameters are significant at the 5% level. The implied $\alpha^*$ is presented in Graph 7. The average parameter is 0.14, smaller than Caselli & Feyrer (2008)'s estimate of 0.18 which might imply a positive equilibrium. In addition, as can be seen, $\alpha^*$ is not exactly constant.

We illustrate equation (11) and the arguments put above using Graph 5. The lower line correspond to the emerging market bond index, EMBI+, which is the spread between a dollar denominated Mexican asset and the equivalent asset for the US. The upper line is the MPK differential, calculate using the values 0.25 and 0.18 for Mexico and the US, respectively, which are the $\alpha$ and $\alpha^*$ parameters calculated by Caselli & Feyrer (2008). We use Mexico for several reasons. First, the country is in the sample of Caselli & Feyrer (2008) and there is data available on EMBI+, which would be a measure of the default risk premia. Second, because the example illustrates the arguments developed above and of the idea expressed in equation (11). We did not perform a regression between both variables because the sample period is small, so there is nuisance from the Tequila crisis at the beginning of the sample and we are unsure about the true values of $\alpha$ and $\alpha^*$. In any case, our main point is that MPKs differences are extremely sensitive to the estimation of the US parameter and that the behavior of the data suggests convergence led by capital growth.

2 Concluding Remarks

We present a model that incorporates the effect of default risk premium on the marginal product of capital and, consequentially, on living standards. The model shows that under risk, the marginal product of capital in a small economy can be below the level prevailing in the rest of the world. It means that capital will not necessarily flow from countries with lower returns to countries with higher returns. This suggests that estimations of conditional convergence should include risk as a control variable. The paper also contributes to the related literature by presenting evidence that tends to rehabilitate the hypothesis of the “credit view”, which we understand as any barriers to capital flows, under the general name of risk.

Our work does not intend to either exclude or diminish the importance of human capital differences in order to explain differences in standards of living. Large human capital differences would imply that higher labor mobility as well as improvement in

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20 The reason is that we ran a unit root regression (of the Augmented Dickey-Fuller type) on the real interest rate. The Dickey-Fuller model was chosen from a less parsimonious specification using the Akaike selection criteria.
education would be the main policy suggestions for development and growth. This view is sympathetic, especially for liberals and academics. Our goal is to stress a different point. If capital mobility is important, then the factors that contribute to higher barriers in emerging economies would also be important for explaining income per capita differences across countries. Hence, the shape of institutions, rent seeking, and economic policies would matter for increasing the standards of living in open markets by their impact on risk. Although some of the world economies have reached levels of per capita income close to the US (for example, in Europe), others, such as in Latin America, have been struggling to increase their GDP. Whether the problem is mainly due to differences in human capital or in the rental cost of capital is of main concern to academics and policy makers. In regard to MPK differentials, however, we showed that the two views are solely complementary.
References


A Appendix

In this appendix, we show the steps to obtain (15) by recalling equation (11) without the error term and the time subscripts

\[ Y_K = Y_K^* + \rho. \]  

(33)

We then substituted the marginal product of capital [according to the production function in (13)] and considered, for simplification, \( \alpha = \alpha^* \)

\[ k^{\alpha-1} = k^{\alpha^*-1} + \frac{\rho}{\alpha}. \]  

(34)

Dividing both sides by \( k^{\alpha-1} \) yields

\[ 1 = \frac{k^{\alpha^*-1}}{k^{\alpha-1}} + \frac{\rho}{\alpha} \frac{1}{k^{\alpha-1}}, \]  

(35)

which can be written as

\[ 1 = k^{\alpha^*-1}k^{1-\alpha} + \frac{\rho}{\alpha}k^{1-\alpha} \]  

\[ 1 = k^{1-\alpha}(k^{\alpha^*-1} + \frac{\rho}{\alpha}). \]  

(36)

Solving for \( k \)

\[ k^{1-\alpha} = \frac{1}{k^{\alpha^*-1} + \frac{\rho}{\alpha}}. \]  

(37)

Multiplying the right-hand side by \( k^{1-\alpha} \) gives

\[ k^{1-\alpha} = \frac{k^{1-\alpha}}{1 + \frac{\rho}{\alpha}k^{1-\alpha}}, \]  

(38)

which can finally be written

\[ k = \left( \frac{1}{1 + \frac{\rho}{\alpha}k^{1-\alpha}} \right)^\frac{1}{1-\alpha} k^*. \]  

(39)

Equation (39) is analogous to (15).
### Table 1: Average Growth (%)

<table>
<thead>
<tr>
<th>Variable</th>
<th>1950s</th>
<th>1960s</th>
<th>1970s</th>
<th>1980s</th>
<th>1990s†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>3.5</td>
<td>4.5</td>
<td>3.3</td>
<td>3.1</td>
<td>2.9</td>
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<tr>
<td>Income per capita</td>
<td>1.8</td>
<td>3.1</td>
<td>2.3</td>
<td>2.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Capital</td>
<td>2.4</td>
<td>3.7</td>
<td>3.9</td>
<td>3.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Capital per worker</td>
<td>1.3</td>
<td>2.0</td>
<td>1.7</td>
<td>2.0</td>
<td>2.8</td>
</tr>
<tr>
<td>$P_Y / P_K$</td>
<td>-0.1</td>
<td>0.1</td>
<td>0.04</td>
<td>0.7</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Other Countries (mean)

<table>
<thead>
<tr>
<th>Variable</th>
<th>1950s</th>
<th>1960s</th>
<th>1970s</th>
<th>1980s</th>
<th>1990s†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>2.8</td>
<td>5.4</td>
<td>4.1</td>
<td>3.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Income per capita</td>
<td>2.4</td>
<td>3.3</td>
<td>2.1</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Capital</td>
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<td>6.6</td>
<td>5.4</td>
<td>3.0</td>
<td>3.1</td>
</tr>
<tr>
<td>Capital per worker</td>
<td>4.1</td>
<td>3.7</td>
<td>3.0</td>
<td>1.0</td>
<td>1.6</td>
</tr>
<tr>
<td>$P_Y / P_K$</td>
<td>1.3</td>
<td>-1.2</td>
<td>-0.6</td>
<td>-0.7</td>
<td>0.1</td>
</tr>
</tbody>
</table>

† Averages calculated until 2003

### Table 2: Sample of Countries

<table>
<thead>
<tr>
<th>Argentina</th>
<th>Finland</th>
<th>Peru</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>France</td>
<td>Portugal</td>
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<tr>
<td>Brazil</td>
<td>India</td>
<td>South Africa</td>
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<tr>
<td>Canada</td>
<td>Ireland</td>
<td>Spain</td>
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<td>Chile</td>
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<td>Turkey</td>
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<tr>
<td>China</td>
<td>Mexico</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Colombia</td>
<td>Netherlands</td>
<td>Uruguay</td>
</tr>
<tr>
<td>Ecuador</td>
<td>Paraguay</td>
<td>Venezuela</td>
</tr>
</tbody>
</table>
Graph 1: Output Capital Ratio

Graph 2: Price Corrected Output Capital Ratio
Graph 3: Output Capital Ratio, $\frac{Y}{K}$

Graph 4: Capital Growth
Graph 5: Corrected MPK differences between Mexico and US and Mexico’s EMBI+.

Graph 6: Corrected MPK differences between Mexico and US (whole series).
Graph 7: The parameter $\alpha^*$ for the US