When Does Domestic Saving Matter for Economic Growth?[1]

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1 Introduction

Can a country grow faster by saving more? This question has been raised by policy makers, for example when discussing the contrast between the high growth in East Asia and the slow growth in Latin America, two middle-income regions with comparable levels of per capita GDP in the 1960s. This contrast could hardly be explained by differences in property right protection or in financial development. Moreover, most Latin American countries have subscribed to the so-called Washington consensus policies (namely, the idea of combining macroeconomic stability, trade and financial liberalization, and privatization), but so far to little avail. On the other hand, if one looks at savings rates in the two regions, we do see a sizeable difference, with East Asian rates being much higher than Latin American rates. Specifically, for the East Asian countries in the sample described in section 3 below the average saving rate from 1960 to 2000 was 25%, whereas for Latin American countries in the same sample the average saving rate was only 14%.

Standard macroeconomic theories have little to say about the impact of domestic saving on growth. Growth models emphasizing capital accumulation (Solow and AK models), tell us that higher savings rates should foster growth because higher savings imply higher capital investment. But these are closed economy models, and extending them to the case of small open economies with international capital markets would eliminate the effect of local saving on growth. More recent models emphasizing innovation as the main engine of growth (Romer, 1990; and Aghion and Howitt, 1992), either ignore capital accumulation, in which case there is no role for saving even in a closed economy, or they emphasize the complementarity between capital accumulation and innovation (Howitt and Aghion, 1998), in which case the equilibrium growth rate depends positively upon domestic saving. But even in the latter case the theory does not apply to the case of an open economy with capital mobility.

In this paper, we develop a theory of local saving and growth in an open economy with domestic and foreign investors. In our model, growth in relatively poor countries results mainly from innovations that allow local sectors to catch up with the current frontier technology. But catching up with the frontier in any sector requires the involvement of a foreign investor, who is familiar with the frontier technology, together with effort on the part of a local entrepreneur, who knows the local conditions to which the technology must be adapted. Local saving matters for innovation, and therefore growth, because it can serve as collateral to attract foreign investment; first, for a given level of local entrepreneurial effort, this collateral accrues to the foreign investor in case the project fails, which makes it easier to satisfy the investor's participation constraint (otherwise, the investor might choose to invest its funds elsewhere at world market interest rates); second, it encourages local entrepreneurial effort by giving the local entrepreneur a stake that she will lose if the project fails for want of effort on her part.

The theory also delivers predictions on when domestic saving should matter most for economic growth. In particular it focuses on the interaction between saving and the country's distance to the technological frontier. The main prediction of our model is that saving affects growth only in those countries that are not too close to the technological frontier. The reason is that in a relatively poor country higher saving increases the collateral that can be pledged by the local entrepreneur, which in turn makes it easier to induce entrepreneurial effort while guaranteeing a sufficient share of profits for a foreign investor to participate in an innovation project. However, in countries sufficiently close to the frontier the local entrepreneur is more likely herself to be familiar with the frontier technology, and therefore does not need to attract foreign investment in order to undertake an innovation project; in such a case every ex ante profitable innovation project will be undertaken regardless of the level of domestic saving because there is no need for collateral when there is just one agent participating in the project.

The idea that saving from the periphery can serve as collateral is not new. In particular, Dooley, Folkerts-Landau and Garber (2004) argue that capital flows from poor to rich countries may partly reflect poor countries' choices to transfer wealth to a "center or reserve currency country" in order to make it easier for foreigners to get their hands on that wealth should the poor countries expropriate the foreigners' capital; this in turn should encourage foreign direct investment in poor countries, thereby fostering development. However, Dooley et al. do not explore this idea in the context of a full-fledged endogenous growth model. Nor do they analyze its implications for the relationship between local saving and growth across countries with different levels of technological development.

Our theory relates not only to the growth literature but also to an important debate in international finance around the so-called "Lucas puzzle", namely why poorer countries or regions, where capital is scarce and therefore the marginal productivity of capital should be high, do not attract investments that would make them converge towards the frontier countries or regions. Lucas (1990) points to the role of human capital externalities that would favor capital investments in richer countries. However, Gertler and Rogoff (1990), and more recently Banerjee and Duflo (2005), point to the importance of contractual imperfections (whether these result from local contractual enforcement problems or from ex ante moral hazard on the part on local investors). Gertler and Rogoff provide supporting evidence in favor of the contracting explanation, in particular the positive and significant correlation between the volume of private external debt and the log of per capita income in a cross-country regression. More recent evidence in Alfaro et al (2003) to the effect that private lending by foreign investors is correlated with various institutional indicators, in particular with a lower degree of corruption, is consistent with the contracting explanation, as is the evidence in Reinhart and Rogoff (2004) that poorer countries exhibit a higher rate of defaults on their foreign debt. Our paper contributes to this literature by linking endogenous growth and contracting considerations, while using an endogenous growth model quite different from those used by Lucas.

We also confront the theory with empirical data, using a sample of 95 countries over the 1960-2000 period. We first show that in a standard cross-country regression there is a large and highly significant positive coefficient on a country's own saving rate. We are not the first to have detected this strong cross-country correlation between saving and growth. Houthakker (1961, 1965) and Modigliani (1970) noted it long ago, and more recent evidence has been provided by Carroll and Weil (1994) using data from the Penn World Tables. However, there is little agreement as to how one should interpret this correlation. Given the difficulty of providing a causal link from saving to growth in a world of capital mobility, several observers have sought to explain the correlation as reflecting an effect of growth on saving. But this interpretation runs counter to mainstream economic theory in which the representative household's consumption-Euler equation implies that growth should have a *negative* effect on saving. Thus for example Carroll, Overland and Weil (2000) depart from convention by developing a model of habit persistence which they argue is consistent with a wide body of evidence to the effect that increases in growth precede increases in saving.

In contrast to these observers we are seeking evidence with respect to the causal link running from saving to growth, namely the one that our theory implies should operate even in a world of capital mobility. To that end we make use of the above-mentioned prediction of the model, to the effect that saving should affect growth positively in some countries but not at all in those that are close to the technological frontier. Specifically, we show that the coefficient on saving in the cross-country growth equation is much smaller for countries that were among the richest, and hence probably closest to the technology frontier, in 1960.

Section 2 below develops a model embodying our theory and derives the above-mentioned theoretical prediction to the effect that saving has a positive effect on growth in all but the most technologically advanced countries. Section 3 presents our empirical evidence, and section 4 concludes.

2 A simple model

2.1 Basic environment

We consider a discrete-time model of a small open economy, populated by two-period lived individuals. Individuals work and save when young to invest in innovation and consume when old, and we denote by σ their savings rate when young. We do not distinguish here between private and public savings, and thus in particular we do not model savings as resulting from intertemporal utility maximization or from the government taxing the young to subsidize the old. There is a unique final good which is produced using labor and a continuum of intermediate inputs, according to the production function:

$$y_t = L^{1-\alpha} \int_0^1 A_{it}^{1-\alpha} x_{it}^{\alpha} di,$$

where L is the supply of labor, taken as an exogenous constant, and A_{it} is the productivity of the current input i at time t.

Intermediate goods are produced by local monopolists, using final good as capital with one unit of capital producing one unit of intermediate input. The amount of intermediate input x_{it} is chosen by producer i to maximize monopoly profits

$$p_{it} x_{it} - (r + \delta) x_{it}$$

subject to the inverse demand schedule

$$p_{it} = \frac{\partial y_t}{\partial x_{it}} = \alpha (A_{it} L / x_{it})^{1-\alpha},$$

where r is the world interest rate and δ is the depreciation rate of capital. This yields

$$x_{it} = A_{it} L \left(\frac{\alpha^2}{r + \delta}\right)^{\frac{1}{1-\alpha}} \equiv A_{it} L \kappa,$$

with equilibrium profits correspondingly equal to

$$\pi_{it} = \alpha(1-\alpha)\kappa^{\alpha} L A_{it} \equiv \theta A_{it}.$$

Using these results to substitute for x_{it} in the above production function yields the familiar Cobb-Douglas aggregate production function:

$$y_t = (A_t L)^{1-\alpha} (K_t)^{\alpha}$$

where the labor-augmenting productivity factor A_t is the average of the A_{it}'s across all sectors i in the economy and

$$K_t = \int_0^1 x_{it} di = \kappa A_t L$$

is the (endogenous) total capital used in all intermediate sectors. Assuming perfect competition in the labor market implies yields an equilibrium wage that is proportional to aggregate productivity:

$$w_t = (1-\alpha) \kappa^{\alpha} A_t = \omega A_t.$$

Substituting from the above expression for total capital input back into the aggregate production function shows that per-capita GDP is strictly proportional to labor-augmenting productivity:

$$y_t / L = \kappa^{\alpha} A_t$$

as it would be according to the neoclassical growth model in a world of capital mobility.

2.2 Innovation technology

Our theory of productivity growth takes into account that every sector in every economy has access to a global stock of technological knowledge. However, as argued at greater length by Howitt (2000) and Howitt and Mayer-Foulkes (2005), accessing this global stock is not costless. Instead, technology transfer requires investments to be made on the part of the receiving sector. Here we also take into account that technology transfer also may require the input of someone familiar with how frontier technologies operate in other sectors and/or other countries.

Suppose accordingly that at any point in time in each sector there is one local entrepreneur, not the current incumbent monopolist, who has the potential to displace the incumbent by innovating and thus being able to produce a superior intermediate product in that sector. Specifically, a successful innovator in any sector i can produce with a productivity parameter $\overline{A}_t$ that embodies the current global frontier technology. Suppose that the frontier technology $\overline{A}_t$ grows at the constant rate g, which depends on the pace of innovation in the richest countries. (For our purposes we can take g as given.)

There are two inputs to the innovation process, namely effort on the part of the entrepreneur and investment on the part of someone who understands frontier technology. In technologically advanced countries, the entrepreneur and the frontier investor are likely to be the same person. But for countries further behind the frontier investor must usually be a foreign investor. Let

$$\mu_m = \mu_m(x, e)$$

denote the innovation probability as a function of frontier investment x and of local effort e. We assume:

$$\mu_m(x, e) = \begin{cases} \overline{\mu} \text{ if } x \geq \overline{x}_t \text{ and } e = 1 \\ \underline{\mu} \text{ if } x \geq \overline{x}_t \text{ and } e = 0 \\ 0 \text{ otherwise} \end{cases},$$

where

$$\overline{\mu} > \underline{\mu} > 0$$

and

$$\overline{x}_t = \phi \overline{A}_t$$

denotes the minimum cost that must be incurred by the frontier investor at date t for that sector to catch up with the technology frontier with positive probability. Finally, we take the cost of effort (that is, of $e = 1$) to be also proportional to the frontier level of productivity, with:

$$C_t(e = 1) = c\overline{A}_t,$$

where c is a random variable, independently and identically distributed across sectors according to the cumulative distribution function F, whose support is $[0, +\infty)$.

We also assume that the entrepreneur's effort cannot be observed by anyone else. This means that when the frontier investor is a foreign investor the entrepreneur may choose to shirk, setting $e = 0$, unless she has enough at stake in success of the project. As we show below, this implies that she may have to post collateral, which accrues to the foreign investor in the event the project does not result in an innovation. (Equivalently we can interpret the collateral as an equity position by the local entrepreneur in the project.)

Now we turn to the value of innovation. Let V_t denote this value at date t. Since the entrepreneur and the frontier investor are both in their last period of life, and under the simplifying assumption that in the event of no innovation next period control of the incumbent firm will fall randomly to someone of the next generation, the monopoly rents from a successful innovation will last for one period only, so we have:

$$V_t = \theta\overline{A}_t.$$

We then make the following assumptions:

1. Innovation at rate $\overline{\mu}$ is worth the innovation cost if the effort cost is low enough:

$$\overline{\mu}\theta \geq \phi, \tag{1}$$

2. No innovation project is worth the innovation cost without a local entrepreneur's effort:

$$\underline{\mu}\theta < \phi \tag{2}$$

2.3 Distance to the frontier

The first basic equation of our model determines the current average proximity to frontier (over all local intermediate sectors) as a function of the fraction of sectors λ_t that undertake an innovation project at current date t. According to (2) innovations either do not occur at all or occur with probability $\overline{\mu}$ in equilibrium. Hence productivity in any sector i that undertakes a project at date t increases randomly according to:

$$A_{it} = \begin{cases} \overline{A}_t \text{ with probability } \overline{\mu} \\ A_{it-1} \text{ with probability } 1 - \overline{\mu} \end{cases},$$

whereas sectors that do not undertake a project simply do not grow. Now, if we integrate over i to compute the average productivity, we find that aggregate productivity evolves according to:

$$A_t = \lambda_t \overline{\mu}\,\overline{A}_t + (1 - \lambda_t \overline{\mu})A_{t-1}.$$

Let

$$a_t = \frac{A_t}{\overline{A}_t}$$

denote the country's proximity to the world technology frontier at date t. Then, dividing the above difference equation through by $\overline{A}_t$, we obtain a simple dynamic equation in a_t, namely:

$$a_t = \lambda_t \overline{\mu} + \frac{1 - \lambda_t \overline{\mu}}{1 + g} a_{t-1} \tag{Dist}$$

This "distance" equation describes the current dynamic evolution of the country's distance to the world technological frontier, given the current fraction of sectors λ_t that have undertaken an investment project and hence are capable of innovating with positive probability.

2.4 Equilibrium innovation

In this subsection we derive the second basic equation of the model, namely an "innovation" equation that determines the current fraction of sectors in the domestic economy that undertake an innovation project, as a function of the country's proximity to the world technology frontier. First, suppose that in any sector the probability that the local entrepreneur is familiar with frontier technology is a function $\psi(a_{t-1})$ if how close the country was to the frontier when the entrepreneur was young. Suppose that this probability becomes unity when the country is close enough to the frontier, in which case no foreign investment is needed to undertake a project. Formally, we assume that:

$$0 < \psi(a) < 1 \text{ for } a < \widehat{a} \tag{3}$$

and

$$\psi(a) = 1 \text{ for } a \geq \widehat{a} \tag{4}$$

for some $\widehat{a}$ such that

$$0 < \widehat{a} < 1.$$

In the event that the local entrepreneur is familiar with the frontier technology, she will undertake an investment project whenever it would have a positive ex ante surplus if she made an effort; that is whenever

$$\overline{\mu}\theta - \phi \geq c \tag{5}$$

Hence the probability that an innovation will be undertaken without the aid of a foreign investor in any given sector of the country is $\psi(a_{t-1})$ times the probability that the profitability condition (5) holds:

$$\psi(a_{t-1}) F(\overline{\mu}\theta - \phi) \tag{6}$$

In the event in which the local entrepreneur is not familiar with the frontier technology, she will undertake an investment project whenever she can attract a foreign investor. This will depend on how much collateral she can put up at date t. Since by assumption her wealth is limited by her saving when young, it is equal to the saving rate σ times her wage income w_{t-1} last period. Hence the maximum amount of wealth that she can use as collateral, which accrues to the foreign investor in case the project fails, is given by:

$$k_t = \sigma\omega A_{t-1},$$

where ω is the productivity-adjusted wage rate derived above. A higher saving rate σ will facilitate innovation by reducing the share of innovation value that must be promised to the foreign investor for him to accept to invest his funds in the local project rather than on the international capital market.

We can now derive the necessary and sufficient conditions for a project to be undertaken in a sector where a foreign investor is needed. Let $x\overline{A}_t$ (resp. $(\theta - x)\,\overline{A}_t$) denote the foreign investor's (resp. the local entrepreneur's) reward in the event of a successful innovation in the corresponding sector, and let $y\overline{A}_t$ denote the collateral put up by the local entrepreneur. By (2) innovation will occur if and only if it occurs with positive effort by the local entrepreneur. Therefore, innovation will occur if and only if there exists a contract (x, y) between the entrepreneur and the foreign investor that satisfies all of the following conditions. First, the foreign investor must earn at least the required rate of return:

$$\overline{\mu}x + (1 - \overline{\mu})\,y \geq \phi \tag{RR}$$

Next, the local entrepreneur must earn enough to participate even when required to pay the cost of her input:

$$\overline{\mu}\theta - (\overline{\mu}x + (1 - \overline{\mu})\,y) \geq c. \tag{P}$$

The local entrepreneur must also have an incentive to pay the cost even though the input is unobserved:

$$\left(\overline{\mu} - \underline{\mu}\right)(\theta - x + y) \geq c \tag{IC}$$

Finally, the magnitude of the collateral is limited by the amount of accumulated savings, that is:

$$y\overline{A}_t \leq \sigma\omega A_{t-1},$$

or equivalently

$$y \leq \frac{\sigma\omega}{1+g} a_{t-1}. \tag{C}$$

Proposition 1 *When a foreign investor is needed in a sector at date t, an innovation project will be undertaken if and only if the effort cost c is low enough to satisfy not only the profitability constraint (5) above but also the collateral constraint:*

$$\frac{\sigma\omega}{1+g} a_{t-1} \geq \phi - \overline{\mu}\left(\theta - \frac{c}{\overline{\mu} - \underline{\mu}}\right) \tag{7}$$

Proof. (a) Suppose that (5) and (7) both hold. Then consider the contract (x, y) with:

$$x = \phi + (1 - \overline{\mu})\left(\theta - \frac{c}{\overline{\mu} - \underline{\mu}}\right) \quad \text{and} \quad y = \phi - \overline{\mu}\left(\theta - \frac{c}{\overline{\mu} - \underline{\mu}}\right)$$

which by construction just satisfies the foreign investor's participation constraint (RR) and the local entrepreneur's incentive-compatibility constraint (IC) with exact equality. By (7) this contract satisfies (C). By (5) and the fact that (RR) holds with equality, therefore (P) holds. Therefore an innovation project will be undertaken.

(b) Conversely, suppose that an innovation project will be undertaken. Then the four constraints (RR), (P), (IC) and (C) are satisfied by some contract (x, y). Adding the inequalities (RR) and (P) implies that (5) holds. So we just need to show that (7) holds. By (RR):

$$-x + y \leq (y - \phi)/\overline{\mu}$$

Substituting the RHS of this inequality for $-x+y$ in (IC), and rearranging, yields:

$$y \geq \phi - \overline{\mu}\left(\theta - \frac{c}{\overline{\mu}-\underline{\mu}}\right)$$

which, together with (C) implies (7). ■

The probability that c is low enough to satisfy both the profitability constraint (5) and the collateral constraint (7) is a function of the saving rate σ and the county's lagged distance to the frontier a_{t-1}, specifically:

$$\varphi(\sigma a_{t-1}) = F\left(\min\left\{\left(\frac{\overline{\mu}-\underline{\mu}}{\overline{\mu}}\right)\left(\overline{\mu}\theta - \phi + \frac{\sigma\omega}{1+g}a_{t-1}\right),\ \overline{\mu}\theta - \phi\right\}\right)$$

So the the probability that an innovation project will be undertaken with the aid of a foreign investor is equal to the probability that the local entrepreneur needs a foreign investor because she is unfamiliar with frontier technology times the probability that c is low enough to satisfy both the profitability constraint (5) and the collateral constraint (7):

$$\left(1-\psi\left(a_{t-1}\right)\right)\varphi(\sigma a_{t-1}) \tag{8}$$

By Assumption (1), the φ function satisfies:

$$\varphi(0) = F\left(\left(\frac{\overline{\mu}-\underline{\mu}}{\overline{\mu}}\right)\left(\overline{\mu}\theta - \phi\right)\right) > 0$$

Also:

$$\varphi'(x) = \frac{\overline{\mu}-\underline{\mu}}{\overline{\mu}}\frac{\omega}{1+g}a_{t-1}F'\left(\left(\frac{\overline{\mu}-\underline{\mu}}{\overline{\mu}}\right)\left(\overline{\mu}\theta - \phi + \frac{\omega}{1+g}x\right)\right) > 0 \text{ for all } x < \sigma\overline{a} \tag{9}$$

where $\overline{a}$ is defined as:

$$\overline{a} = \frac{1+g}{\sigma\omega}\frac{\underline{\mu}}{\overline{\mu}-\underline{\mu}}\left(\overline{\mu}\theta - \phi\right) > 0.$$

which is the minimal proximity to the frontier such that all countries that close or closer have enough domestic saving to satisfy the collateral requirement (7) for a project to be undertaken in every sector where it is profitable. Once a country has reached $\overline{a}$, an increase in saving will not allow any further projects to be undertaken because all profitable projects have already been undertaken even when a foreign investor is needed.

It follows that λ_t, the fraction of a country's sectors that undertake a project, is just the probability that a randomly chosen sector will undertake a project without the aid of foreign investment (6) plus the probability that it will undertake a project with a foreign investor (8):

$$\lambda_t = \psi\left(a_{t-1}\right) F\left(\overline{\mu}\theta - \phi\right) + \left(1 - \psi\left(a_{t-1}\right)\right) \varphi(\sigma a_{t-1}) \equiv \lambda\left(\sigma, a_{t-1}\right) \tag{Innov}$$

where

$$\frac{\partial \lambda\left(\sigma, a_{t-1}\right)}{\partial \sigma} = \left(1 - \psi\left(a_{t-1}\right)\right) a_{t-1} \varphi'(\sigma a_{t-1})$$

From (9) and (3) we have:

$$\frac{\partial \lambda\left(\sigma, a_{t-1}\right)}{\partial \sigma} > 0 \text{ for small enough } a_{t-1} > 0,$$

that is, when a_{t-1} is small enough that the collateral constraint is binding on some profitable projects $(a_{t-1} < \overline{a})$ we have $\varphi'(\sigma a_{t-1}) > 0$, and when a_{t-1} is also small enough that there is a positive probability that the local entrepreneur is not familiar with the frontier technology $(a_{t-1} < \widehat{a})$ we have $\left(1 - \psi\left(a_{t-1}\right)\right) > 0$, so an increase in the saving rate σ will raise the fraction of sectors that undertake a project by raising the fraction in which the necessary collateral constraint can be met. Also, from (4) we have:

$$\frac{\partial \lambda\left(\sigma, a_{t-1}\right)}{\partial \sigma} = 0 \text{ for } a_{t-1} > \widehat{a},$$

that is, when the country is close enough to the frontier it does not need foreign investors, and hence does not need collateral, so the saving rate has no further effect on the fraction of sectors that undertake a project.

Note that this effect does not depend on any limitation on an entrepreneur's ability to borrow. Her incentive to put forth effort would not be increased if she were able to borrow additional collateral, because if the project failed she would still be left with zero and if the project succeeded she would still only recover the unborrowed portion of the collateral, the rest having to be remitted to the lender. Thus her stake in the success of the project would remain unchanged by the borrowing.

2.5 Equilibrium dynamics and the theoretical predictions

Using the two basic equations (Dist) and (Innov), we can immediately express the country's proximity to the frontier at date t, a_t, as a function of its proximity to frontier in the previous period. We have:

$$a_t = \lambda(\sigma, a_{t-1})\overline{\mu} + \frac{1 - \lambda(\sigma, a_{t-1})\overline{\mu}}{1+g} a_{t-1} \text{ for all } a_{t-1} \in [0,1]. \tag{10}$$

Our primary interest is in the equilibrium growth rate g_t, defined by:

$$1 + g_t = \frac{A_t}{A_{t-1}} = (\frac{a_t}{a_{t-1}})(1+g),$$

or, using (10):

$$g_t = (\frac{1+g}{a_{t-1}} - 1)\lambda(\sigma, a_{t-1})\overline{\mu}. \tag{11}$$

Hence the effect of a higher savings rate on growth, is characterized by the derivative

$$\frac{\partial g_t}{\partial \sigma} = (1 + g - a_{t-1})\overline{\mu}\frac{\partial \lambda\left(\sigma, a_{t-1}\right)}{\partial \sigma},$$

which, according to the results of the previous section, is positive when a_{t-1} is small enough and zero when a_{t-1} is close enough to unity. Thus we have the following prediction: in a country that is not too close to the frontier, growth responds positively to an increase in the domestic saving rate, whereas in a country close enough to the frontier growth is not affected by saving. It is this prediction that we test in the next section.

3 Empirical evidence

Our test is based on cross country data over the period from 1960 to 2000, taken from the Penn World Tables 6.1. There are 91 countries in our sample, namely all the countries for which there are data on per-capita GDP in 1960 and on the saving rate, except for two countries (Lesotho and Jordan) where the average saving rate over the period was so negative (-66% and -18% respectively) that it skewed our results. The saving rate variable includes public as well as private saving, being defined as one minus the ratio of private consumption to GDP minus the ratio of government purchases to GDP. Our growth variable is the average per-capita growth rate of per-capita GDP (chain index) over the period. According to the analysis of section 2, this growth rate should also be the growth rate of productivity, and if we take the United States productivity level as a proxy for the frontier technology $\overline{A}_t$ then 1960 per-capita GDP should be proportional to the initial productivity level a_0. Thus equation (11) above implies that growth should depend on the saving rate and the output gap, the latter being defined as the log of 1960 per-capita relative to the United States.

Table 1 shows the effects of regressing growth on the saving rate and output gap. Our theoretical prediction implies that the coefficient should be positive overall but that if we restrict attention to the richest countries the effect should be much smaller. Column 1 of Table 1 shows that there is indeed a strong positive coefficient, indicating that a 10 percentage point increase in growth should lead to 1.2 extra percentage points of growth, holding initial output constant. Column 2 shows furthermore that if we include a dummy for the richest 30 countries and allow for these countries to have a different saving effect, then indeed the effect is much lower for these countries, as predicted by the theory. Specifically, the results indicate that an extra 10 percentage points of saving should lead to 1.3 extra percentage points of growth in the poorest 61 countries, but only 0.4 percentage points in the richest 30 countries. Column 3 shows that these two main results (a positive coefficient on the saving rate which is much smaller for the richest 30 countries) still hold when we include as additional regressors two of the variables known to be robust determinants of growth in cross-country regressions, namely private credit and population growth.

Column 4 of Table 1 indicates that the qualitative effect remains when we allow for separate constant and slope terms for all three country quantiles. Columns 5 and 6 indicate that the growth effect of saving in the poorest third of countries is not significantly different from the average effect, but the effect in the middle third is much larger. These results have a bearing on the comparison between East Asia and Latin America, to which we alluded in our introduction, since both of these regions consist mainly of middle-income countries. According to the estimate of column 5, the 11 percentage point difference of saving rates between the East Asian and Latin American countries in our sample would make growth higher in the former region by 1.7 percentage points over the 1960-2000 period, more than half of the actual 3 percentage point difference observed in the data.

Table 2 shows evidence that this effect is indeed consistent with not just a weaker effect of saving in the richest country but even a zero effect in the very richest. It records the results of again regressing growth on the 1960 output gap and saving with a dummy for the richest x countries and a separate coefficient of saving for those richest x countries. The last row of Table 2 shows the estimated effect of saving on growth for the richest x countries. The effect generally falls when x is reduced, and is never significantly different from zero when x is less than or equal to 30. When we consider only the five richest countries the point estimate of the effect of saving on growth is even negative.

One major qualification to these results is that we have not controlled for the possible endogeneity of saving. That is, at least some of the correlation between growth and saving may reflect a positive effect of growth on saving, perhaps working through the habit-formation effect spelled out by Carroll, Overland and Weil (2000). However, there seems no reason to believe that the habit-formation effect should cease to operate in countries closest to the technology frontier. For this reason we take the above results to be supportive of an effect of saving on growth, working through the collateral effect that we have identified in our theory, an effect which the theory predicts should indeed cease to operate in countries closest to the frontier for the simple reason that those countries do not need foreign investment, and hence do not need collateral to attract foreign investment, in order to advance technologically.

4 Conclusion

In this paper we have developed a theory according to which domestic saving affects economic growth even in a world of capital mobility. The theory is based on the idea that technological progress in relatively poor countries generally requires a mix of foreign investment and local entrepreneurial effort, which effort cannot easily be observed. The foreign investment is needed in order to transfer frontier technological knowledge to local innovating sectors. Saving provides the local entrepreneurs with collateral which may give them enough of a stake in their innovation projects to induce the effort needed to make the foreign investment profitable. The theory predicts that saving should affect growth, but not so much in relatively rich countries that are not so dependent on foreign investment for innovation because rich countries are where the frontier technologies come from. This prediction is borne out by a cross country regression that shows a positive effect of saving on growth that is much smaller for the richest countries. Our ongoing research is exploring the issue of whether this effect depends more on private or public saving, and also how it depends on the uses to which the saving is put, whether infrastructure, foreign currency reserves, or private investment.

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Table 1: Growth and Saving

Dependent variable is annual average growth of per-capita GDP 1960-2000

	1	2	3	4	5	6
1960 output gap	-0.758***	-0.957***	-1.296***	-0.756*	-0.474**	-0.796***
	(-3.96)	(-3.90)	(-5.89)	(-1.85)	(-2.03)	(-2.96)
Savingrate	0.121***	0.132***	0.113***	0.105***	0.088***	0.130***
	(7.76)	(8.61)	(7.07)	(4.31)	(4.22)	(6.64)
R30		2.475***	1.861***	2.069**		
		(3.01)	(2.89)	(2.13)		
*Savingrate*R30*		-0.092***	-0.091***	-0.072		
		(-2.62)	(-2.98)	(-1.62)		
Private credit			1.426***			
			(3.80)			
Population growth			-50.81**			
			(-2.24)			
M31				-0.716	-1.146***	
				(-1.22)	(-2.69)	
*Savingrate*M31*				0.052*	0.069***	
				(1.74)	(2.62)	
P30						0.192
						(0.39)
*Savingrate*P30*						-0.024
						(-0.79)
R-square	0.454	0.508	0.695	0.526	0.494	0.458
Sample size	91	91	78	91	91	91

Notes: R30, M31 and P30 are dummies indicating 1960 per-capita GDP among the top 30, middle 31 and bottom31 respectively of the sample. All data come from the Penn World Tables 6.1, except for Private Credit, which comes from Djankov, McLiesh and Shleifer (2005). Estimation is by ordinary least squares. The numbers in parentheses are robust t-statistics. Significance at the 1%, 5% and 10% levels is denoted by ***, ** and * respectively.

Table 2: Proximity to the frontier and the effect of saving on growth

Dependent variable is annual average growth of per-capita GDP 1960-2000

# of rich countries (x)	**5**	**10**	**20**	**30**	**40**
Savingrate	0.122***	0.124***	0.129***	0.132***	0.134***
	(7.76)	(7.81)	(8.50)	(8.61)	(8.17)
*Savingrate * Rx*	-0.130**	-0.099***	-0.114**	-0.092***	-0.044
	(-2.47)	(-3.07)	(-2.54)	(-2.62)	(-1.47)
Savingrate (1 - Rx)*	-0.008	0.025	0.015	0.040	0.090***

Notes: Rx is a dummy indicating 1960 per-capita GDP among the top x countries of the sample. The results are from a regression of growth on the 1960 output gap, the saving rate, x and x times the saving rate. All data come from the Penn World Tables 6.1. Estimation is by ordinary least squares. The numbers in parentheses are robust t-statistics. Significance at the 1%, 5% and 10% levels is denoted by ***, ** and * respectively.