Effects of Economic Growth on Aggregate Savings Rates: The Role of Poverty and Borrowing Constraints*

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Abstract

We study an overlapping generations model where ex-ante identical agents make an occupational choice under a borrowing constraint. Indivisible investment gives rise to entrepreneurial rents but does not allow all to become entrepreneurs. Competition alone without any shocks forces entrepreneurs to save more than workers. The model predicts that growth in national income has a positive effect on aggregate savings rates in poor countries but a negative effect in rich countries, and borrowing constraints increase aggregate savings rates as well as its response to growth in national income. These predictions are supported by empirical evidence based on panel data that covers more than 130 countries during 1960-2007.

Keywords: Overlapping Generations, Entrepreneurship, Occupational choice, Savings, Borrowing constraints
JEL Classification: E2, O1

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1 Introduction

What is the effect of a change in a country's national income on its domestic savings rate? Figure 1 shows a strong positive association between GDP per capita and domestic savings rates in the cross-section of countries in the year 2000.[1]

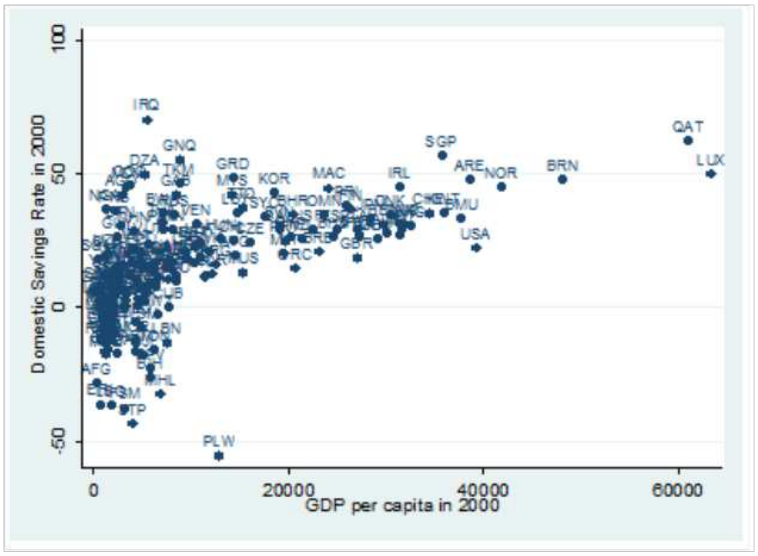


Figure 1: Cross-Country Scatter Plot (Domestic Savings Rate and GDP per capita)

The high correlations can obviously be interpreted in various ways. One interpretation is that a higher domestic savings rate is associated with a higher investment-to-output ratio and thus a higher GDP per capita.[2] Another interpretation is that the cross-sectional relationship is spurious due to omitted variables while a third interpretation is that income itself has an effect on domestic savings rates. It is the last interpretation that we will focus on in this paper, both theoretically and empirically.

The theoretical part of our paper studies an overlapping generations model with credit market imperfections. Matsuyama (2004) introduced to the Diamond model a minimum investment requirement and a borrowing constraint that arises from

[1] A similar cross-sectional relationship arises for alternative years between 1960 and 2007.

[2] This interpretation would be consistent with the well-documented Feldstein and Horioka (1980) puzzle in international macroeconomics.

limited pledgability. The borrowing constraint gives rise to a positive rent for entrepreneurial activities. However, not all agents can become entrepreneurs since they need to borrow in order to run an investment project. In Matsuyama (2004), agents consume only when old and thus save their entire wage when young. This implies that the only possible credit allocation is a random allocation and some agents are excluded from taking credit in equilibrium. Moreover, in his autarky economy, capital accumulation is independent of the borrowing constraint since agents save their entire wage inelastically.

We characterize an equilibrium where ex-ante identical agents choose to save differently. We allow for consumption when both young and old. This is not a trivial extension as saving decisions affect the allocation of credit. In our model, competition among agents for external funds alone without any shocks generates an equilibrium in which entrepreneurs save more than workers in order to obtain credit. Workers save a constant fraction of the wage independently of financial market imperfections. On the other hand, entrepreneurs increase their savings with the wage and when credit market imperfections are more severe. The fixed size of investment projects, however, causes entrepreneurial savings to increase less than proportionally with the wage. This implies that the aggregate savings rate initially rises and then falls with aggregate output. The hump-shaped aggregate saving-to-output ratio is the main theoretical finding of our model.

In contrast to the life-cycle literature which studies the precautionary demand for savings under borrowing constraints (see Modigliani, 1986, Bewley, 1986 and following studies), we focus on borrowing constraints of producers. To examine the effects of economic growth on aggregate savings rates, existing literature, to be discussed in further detail below, has mainly focused on borrowing constraints of consumers. Our producer-side borrowing constraints give rise to a novel prediction that is testable with macroeconomic data: in poor countries growth in national income leads to an increase in the aggregate savings rate while, after a threshold level of national income, the opposite is the case. Neither the standard neoclassical growth models nor the life-cycle models predict an eventual decline of saving rates with respect to national income. The prediction is important for at least two reasons. First, it is generally agreed among macroeconomists that a higher domestic savings rate has a positive effect on GDP per capita.[3] Second, as illustrated in Figure 1, there are significant differences in the domestic savings rate between rich and poor countries. A natural question that arises is thus whether these differences will be eliminated as poor countries grow richer.

In the empirical part of the paper we show how to derive the estimating equation from our theoretical model and estimate the derived econometric model based on panel data that covers more than 130 countries during 1960-2007. To correct for omitted variables bias arising from time-invariant country unobservables we control for country fixed effects. We also correct for time-varying endogeneity bias by using instrumental variables techniques. The results yield evidence in support of the predictions from the theoretical model. In particular, we find that growth in national income leads to significant within-country increases in aggregate savings rates in poor countries. However, the opposite is the case in rich countries. The estimated effects are also quantitatively large. To illustrate their size, consider a poor country with PPP GDP per capita of 1000 USD. For this low income country our estimates yield that a one percent increase in GDP per capita growth increases the savings rate by over four percent. On the other hand, for a rich country with PPP GDP per capita of 50000 USD a one percent increase in GDP per capita growth decreases the savings rate by over two percent.

Our theoretical model and empirical analysis also speak to the literature on the role of financial development. One view in this literature is that borrowing constraints inhibit growth by preventing a more efficient allocation of credit to investment.[4] Another view is that the effects of borrowing constraints on aggregate savings rates

[3] Of course, the exact size of the effect and whether an increase in the savings rate has a level or a growth effect is very much debated.

[4] See Levine (1997) for a comprehensive survey of both the theoretical and empirical literature. Other studies have identified different channels through which credit market imperfections may adversely affect economic growth. Galor and Zeira (1993), for example, show that credit market imperfections can create persistence in initial wealth inequalities by preventing children of poor families from obtaining human capital. Credit market imperfections can also reduce occupational mobility (e.g. Banerjee and Newman 1993, Aghion and Bolton 1997, Piketty 1997) and prohibit high ability workers from becoming entrepreneurs (e.g. Lloyd-Ellis and Bernhardt 2000, Matsuyama 2000).

and hence growth are positive. In particular, it is well-known from the life-cycle literature that borrowing constraints may increase aggregate savings rates (e.g. Bewley 1986, Deaton 1991, Huggett 1993, Aiyagari 1994, Levine and Zame 2002). The closest to our paper are Jappelli and Pagano (1994) and Ghatak et al. (2001) who study the positive effect of borrowing constraints on savings and thus growth in overlapping generations models.

Jappelli and Pagano (1994) examine a three period overlapping generations model in which agents work only when middle-aged but consume in all three periods. When the borrowing constraint is binding the consumption of the young is suboptimal, but it raises the savings of the middle-aged and increases the permanent income. In the presence of this trade-off the authors show the existence of an optimal level of credit market imperfections. In similar vein, Ghatak et al. (2001) analyze a two period overlapping generations model with moral hazard in the labor market and transaction costs in the credit market. They show that increases in transaction costs in the credit market may induce the young to work harder. The increase in work effort by the poor young allows them to overcome borrowing constraints and enjoy entrepreneurial rents when old.

Borrowing constraints in our model as in Jappelli and Pagano (1994) and Ghatak et al. (2001) can have a positive effect on aggregate savings rates and hence growth. We also find that there exists an optimal level of borrowing constraints when the economy under-accumulates capital. However, the mechanism leading to these features is different. In Jappelli and Pagano (1994)'s model loans for consumers are facilitated between generations, and consumers do not change their behavior even in the presence of the binding borrowing constraint. In our model, loans are facilitated within one generation, between workers and entrepreneurs, and the young have dynamic incentives to save more and become entrepreneurs. The result in Ghatak et al. (2001) is also driven by dynamic incentives for the young. Young workers supply extra effort and become self-financed entrepreneurs in their model. In our model the young become entrepreneurs through thrift.[5] The differ-

[5]Ghatak et al. (2001) refers to the dynamic incentives for the young to work hard and save in order to become self-financed entrepreneurs as the American Dream effect. In our model, the young become entrepreneurs through thrift alone.

ence in dynamics incentives generates a hump-shaped saving-to-output ratio in our model. The role of borrowing constraints in encouraging savings to set up businesses is well documented in many studies, and an excellent summary can be found in Ghatak et al. (2001). In a recent study using U.S. data, Buera (2009) documents that people who eventually become entrepreneurs have higher savings rates than people who expect to remain workers. Matsuyama (2011) discusses key results in the theoretical literature on credit market imperfections, household wealth distribution and development.

With regards to the role of financial development, our model provides two additional predictions that are testable with macroeconomic data: borrowing constraints increase the aggregate savings rate; and borrowing constraints increase the response of aggregate savings rates to growth in national income. Following the finance and development literature, we measure borrowing constraints by the GDP share of domestic credit to the private sector. We find that the measure has a significant positive within-country effect on aggregate savings rates: a one percent decrease in the GDP share of domestic credit to the private sector is associated with an increase in the aggregate savings rate by around 0.2 percent. In addition, the marginal effect of growth in national income on aggregate savings rates increases with the GDP share of domestic credit to the private sector. So much so, that in countries with a low GDP share growth in national income increases aggregate savings rates while in countries with a high share the opposite is the case.

The increasing availability of micro level data on entrepreneurship and wealth, in particular, for the U.S. economy has motivated a series of studies of dynamic models in which self-financing of entrepreneurs leads to a fat right tail of the wealth distribution (e.g. Quadrini 1998, Gentry and Hubbard 2004, Cagetti and De Nardi 2006, Buera 2009, Buera and Shin 2011, Buera and Shin 2013).[6] These models study the saving patterns of entrepreneurs under borrowing constraints when entrepreneurial ability or productivity are stochastic. Their theoretical predictions match the micro evidence showing higher saving rates for entrepreneurs than for

[6]Buera and Shin (2011) contrast the self-insurance motive of entrepreneurs a la Aiyagari (1994) with the self-finance motive under borrowing constraints to study the welfare cots of market incompleteness.

the rest of the population. The most closely related results to ours are obtained by Buera (2009) in which the probability of becoming an entrepreneur is increasing for low wealth levels but it is decreasing for higher wealth levels. Furthermore, Buera and Shin (2013) show that the investment-to-output ratios are hump-shaped, increasing in the early stages of the growth acceleration and falling in the latter phases. Their micro and macro evidence is consistent with our theoretical findings and thus supports our theoretical mechanism too. Their models however focus on microeconomic heterogeneity to yield macroeconomic implications while we abstract from the cross-sectional wealth distribution within a country. To study the saving-to-output ratios and how they are affected by borrowing constraints the young agents in our theoretical model are assumed to be ex-ante identical in all aspects. In other words, we rely neither on heterogeneity of entrepreneurs nor on any shocks to generate our results. We then test the results using macro panel data that covers more than 130 countries during 1960-2007.

The rest of the paper is organized as follows. Section 2 outlines the model. Section 3 contains main results on equilibrium properties. Section 4 tests implications of the theoretical model with panel data. Section 5 concludes. Appendix A contains all remaining proofs. Appendix B analyzes the dynamics of the model, for the autarky and the small open economy.

2 The Model

The economy is inhabited by overlapping generations, who live for two periods. Successive generations have unit mass. Every agent supplies one unit of labor inelastically when young and consumes when both young and old. At time t, production combines the current stock of capital k_t with the unit quantity of labor.[7] The resulting per-capita output is given by the Cobb-Douglas production function so that $y_t = f(k_t) = k_t^{\alpha}$ where $\alpha \in (0,1)$ is the capital share in production. Factor markets are competitive paying the wage $w_t = f(k_t) - k_t f'(k_t)$, and a gross return

[7]"Capital" may be either human or physical. It depreciates fully between periods so that the capital stock is equal to investment.

on capital $f'(k_t)$. In later sections we will exploit the property of the Cobb-Douglas function that the wage is a constant fraction of output: $w_t = (1-\alpha)y_t$. After production and distribution of factor payments, the old consume and exit the model, while the young receive the wage and make their saving decisions.

Preferences are given by $u(c_{1t}, c_{2t+1}) := \ln c_{1t} + \frac{\beta}{1-\beta} \ln c_{2t+1}$ where c_{1t} and c_{2t+1} are consumption when young and old; $\frac{\beta}{1-\beta} \in (0,1]$ is the time discount. The young face decisions of how much to save and how to invest the wage. The available option is to become either a worker or an entrepreneur. Workers lend their entire savings in the competitive credit market, which earns them a gross return equal to r_{t+1} per unit. Entrepreneurs on the other hand start an investment project. The investment project transforms one unit of the final good in period t into $R > 0$ units of capital in period $t+1$. This implies that the return for entrepreneurs measured in units of consumption goods is $Rf'(k_{t+1})$. Thus, the young are willing to become entrepreneurs whenever

$$r_{t+1} \leq Rf'(k_{t+1}). \tag{1}$$

Following Matsuyama (2004) we refer to this inequality as the profitability constraint.

Let z_t denote savings of entrepreneurs. We see later that $z_t < 1$ and, therefore, entrepreneurs must borrow $1 - z_t$ at rate r_{t+1} to start an investment project. We assume that borrowers can pledge only up to a fraction $\lambda \in (0,1)$ of the project's revenue for repayment. Thus, entrepreneurs can start the project only if

$$r_{t+1}(1 - z_t) \leq \lambda Rf'(k_{t+1}). \tag{2}$$

The parameter λ can be interpreted as a measure of credit market imperfections, with a higher value corresponding to a lower imperfection. We call the above inequality the borrowing constraint. This formulation is a parsimonious way of introducing credit market imperfections in a dynamic macroeconomic model.

3 Equilibrium

If the profitability constraint is binding, the young are indifferent between becoming a worker or an entrepreneur. Consequently, all the young save equally in equilibrium. On the other hand, if the borrowing constraint is binding, entrepreneurs would obtain a higher utility if they made the same savings as workers. The workers excluded from credit would then have an incentive to save more and offer a higher interest rate in order to become entrepreneurs. Competition alone without any shocks establishes an equilibrium where the young are indifferent between choosing a high level of savings to become an entrepreneur and a low level of savings to become a worker. In the following we will prove existence and uniqueness of the equilibrium.

Maximizing $u(c_{1t}, c_{2t+1})$ subject to $c_{1t} = w_t - x_t$ and $c_{2t+1} = r_{t+1}x_t$, the optimal saving of workers, x_t, is given by

$$x_t = \beta w_t. \tag{3}$$

What is the optimal saving of entrepreneurs z_t? We consider two cases separately. First, suppose that the saving of workers is sufficiently high so that $\beta w_t \geq 1 - \lambda$. If entrepreneurs save more than workers, $z_t > \beta w_t$, then the borrowing constraint (2) implies that the interest rate is at least as high as the rate of return from entrepreneurial activity: $r_{t+1} \geq Rf'(k_{t+1})$. As a result, entrepreneurs can no longer earn a positive rent from running an investment project. Equilibrium is established when the young are indifferent between becoming a worker and an entrepreneur, i.e., when $z_t = x_t = \beta w_t$ and $r_{t+1} = Rf'(k_{t+1})$.

Second, suppose that the saving of workers is sufficiently low so that $\beta w_t < 1 - \lambda$. If all the young save equally, i.e., $z_t = x_t = \beta w_t$, then the borrowing constraint implies that the interest rate is less than the rate of return from entrepreneurial activity. The positive entrepreneurial rent introduces competition among the young without any shocks forcing entrepreneurs to increase savings until entrepreneurs and workers obtain the same utility. In other words, homogenous agents make heterogenous decisions: entrepreneurs save more than workers.[8] Hence, $x_t < z_t$, and z_t must solve $u\left(w_t - z_t, Rf'(k_{t+1}) - (1-z_t)r_{t+1}\right) = u\left((1-\beta)w_t, \beta w_t r_{t+1}\right)$. Substituting $(1-z_t)r_{t+1} = \lambda Rf'(k_{t+1})$ into the equation we obtain

$$\ln(w_t - z_t) + \frac{\beta}{1-\beta}\ln\left(\frac{(1-\lambda)(1-z_t)}{\lambda}\right) = \ln((1-\beta)w_t) + \frac{\beta}{1-\beta}\ln(\beta w_t). \quad (4)$$

The preceding two cases imply that if $\beta w_t \geq 1-\lambda$, then entrepreneurs and workers both save the same. In contrast, if $\beta w_t < 1-\lambda$, then ex-ante identical households are effectively randomizing over strategies. Some households are saving $x_t = \beta w_t$ and others are saving $z_t > x_t$ to become entrepreneurs. Despite the differences in their saving strategies, workers and entrepreneurs achieve the same lifetime utilities, thus guaranteeing "stability" (see footnote 8) of the equilibrium allocation.

Proposition 1. *Suppose that the borrowing constraint is binding: $w < \frac{1-\lambda}{\beta}$. Then the saving of entrepreneurs is given by a function*

$$Z(w,\lambda) : \left(0, \frac{1-\lambda}{\beta}\right) \times (0,1) \to (\beta w, 1-\lambda),$$

which is strictly increasing and strictly concave in w, and strictly decreasing in λ. Moreover, $\lim_{w\downarrow 0} Z_1(w,\lambda) = 1$ and $Z_1(\frac{1-\lambda}{\beta}, \lambda) = 0$.

We can immediately see from (4) that the fixed size of investment projects implies that the lifetime utility of entrepreneurs decreases with savings. Because competition forces entrepreneurs to save more than workers entrepreneurial rents are reduced. The fixed size of investment projects and consumption smoothing cause savings to increase less than proportionally with the wage.[9] This makes entrepreneurial savings a concave function of the wage when the borrowing constraint is binding. On the other hand, we can see from (2) that credit market

[8] In equilibrium neither lenders nor borrowers can achieve a higher utility by unilaterally changing their saving decision. The equilibrium where all the agents save equally is not stable in the sense that some agents have an incentive to deviate from it.

[9] There are effects at both intensive and extensive margins. An increase in income leads to a higher fraction of entrepreneurs and a lower marginal propensity of entrepreneurial savings.

imperfections have a positive effect on entrepreneurial rents. Therefore, the entrepreneurial savings increase with the measure of credit market imperfection. In other words, entrepreneurs rely less on external funds when credit market imperfections are more severe. This captures the idea that "anybody can make it through thrift." The young, who want to become entrepreneurs, facing the borrowing constraint save more in order to earn entrepreneurial rents in the future.[10] Figure 2 illustrates these findings by displaying the equilibrium relationship between entrepreneurial savings and the wage for different values of λ.

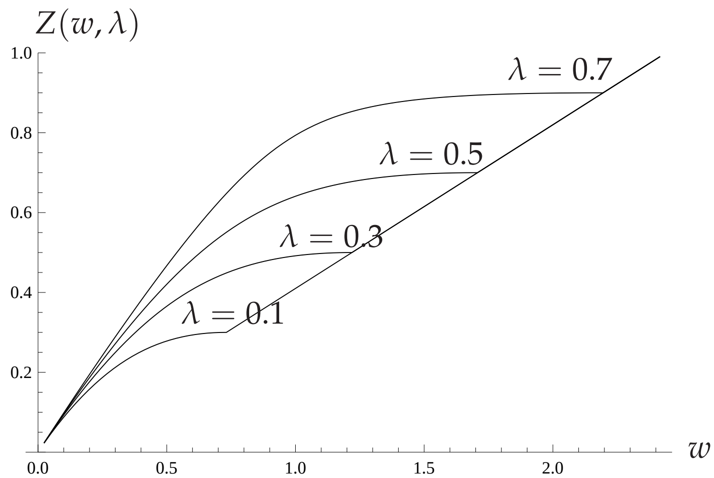


Figure 2: Entrepreneurial savings: $\beta = 0.41$

We now turn our attention to aggregate savings. Let $S_t \in (0, 1)$ denote the fraction of entrepreneurs. Equating the aggregate demand and supply of external funds we obtain $S_t(1 - z_t) = (1 - S_t)x_t$. Since the size of both young and investment projects are normalized to one, S_t also measures aggregate savings. Solving for S_t we obtain

$$S_t = S(w_t, \lambda) := \begin{cases} \frac{\beta w_t}{1 - Z(w_t, \lambda) + \beta w_t} & \text{if } w_t < \frac{1-\lambda}{\beta} \\ \beta w_t & \text{if } w_t \geq \frac{1-\lambda}{\beta}. \end{cases} \tag{5}$$

The proposition 2 in Appendix A provides properties of the aggregate savings

[10]Potential entrepreneurs may save more than potential workers: (1) to accumulate the minimal capital requirements needed to engage in entrepreneurship and to implement projects as in our paper; (2) to hedge against uninsurable entrepreneurial risks; or (3) to cover the cost of external financing as in Ghatak et al. (2001).

function. The aggregate savings rate is defined as

$$s_t = s(y_t, \lambda) := \frac{S((1-\alpha)y_t, \lambda)}{y_t} = \frac{(1-\alpha)\beta}{1 - Z((1-\alpha)y_t, \lambda) + \beta(1-\alpha)y_t} \tag{6}$$

where we used $w_t = (1-\alpha)y_t$. We observe that the equilibrium aggregate savings rate s_t, given parameters (λ, β, α), depends directly on output y_t only and is uniquely determined. The properties of the savings function of entrepreneurs lead to the next theorem which presents our main results that we will test empirically in Section 4.

Theorem 1. *The aggregate savings rate obtains its maximum when* $Z_1((1-\alpha)y, \lambda) = \beta$*. Moreover,*

1. *The aggregate saving-to-output ratio is hump-shaped.*
2. *The aggregate savings rate monotonically increases with borrowing constraints.*
3. *The effect of economic growth on the aggregate savings rate increases with borrowing constraints. In other words, borrowing constraints are a mediating factor with regards to the impact of economic growth on the aggregate savings rate.*

The first prediction follows directly from the concavity of the savings function of entrepreneurs with respect to income. It suggests that in poor countries growth in incomes per capita will lead to increases in aggregate savings rates while, after a threshold level of economic development, the opposite is the case. This prediction is not generated by previous models such as Japelli and Pagano (1994). The second prediction was also obtained and tested with macroeconomic data in Japelli and Pagano (1994). However, in our model the positive effect of borrowing constraints on aggregate savings rates arises because borrowing constraints encourage entrepreneurial savings. In Japelli and Pagano (1994) the positive effect arises because borrowing constraints reduce consumption. The third prediction simply follows from the first two properties of the aggregate savings rate. Figure 3 illustrates the three predictions of our theoretical model. The predictions are general equilibrium relationships that hold in any steady state. Hence, we delegate the analysis of dynamics to Appendix B.

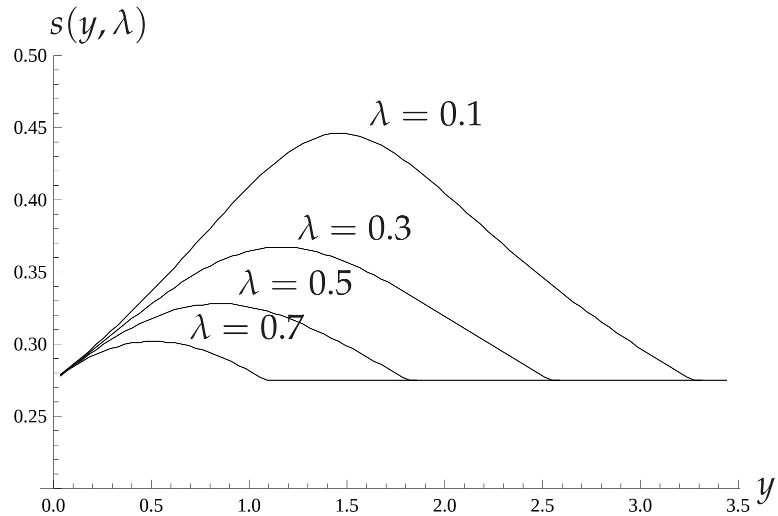


Figure 3: Hump-shaped aggregate saving-to-output ratio: $\beta = 0.41, \alpha = 0.33$

4 Empirical Analysis

This section tests the three key predictions from our theoretical model in Theorem 1: (1) changes in national income may increase or decrease the aggregate savings rate depending on the level of national income; (2) increases in borrowing constraints have a positive effect on the aggregate savings rate; (3) tighter borrowing constraints increase the effect of a change in national income on the aggregate savings rate.

In order to test the theoretical predictions we need macroeconomic data for a large sample of countries.[11] We obtain data on domestic savings rates and real GDP per capita from the Penn World Table (Heston et al., 2011). Data on the GDP share of domestic credit to the private sector are from the World Development Indicators (WDI, 2012).[12] The sample consists of 130 countries during the period 1960-2007.

[11]Note that we examine the equilibrium relationships that arise from transitions to steady states. Our theoretical model exhibits growth in endogenous variables in per capita terms in transitions to steady states even though there is no growth in steady states.

[12]Total credit is $(1 - S_t)\beta w_t$, which is the amount of funds lend to entrepreneurs. The total credit to GDP ratio is

$$\frac{\text{Total Credit}}{\text{GDP}} = \frac{(1 - S_t)\beta w_t}{y_t} = \beta(1 - \alpha)(1 - S_t).$$

Since we know from Proposition 2 that S_t is decreasing in λ, the total credit to GDP rate and the

For a list of countries in the sample see Table 5 in Appendix C.

4.1 Effects of Credit Market Imperfections and Economic Growth on Aggregate Savings

We begin the empirical analysis by estimating the average marginal effects of within-country changes in GDP per capita and borrowing constraints on within-country changes in aggregate savings. The econometric model is:

$$\triangle \ln(s_{it}) = \gamma \triangle \ln(y_{it}) + \theta \triangle \ln(\lambda_{it}) + a_i + b_t + u_{it} \tag{7}$$

where $\triangle \ln(s_{it})$ is the year $t-1$ to t change in the log of the domestic savings rate; $\triangle \ln(y_{it})$ is the year $t-1$ to t change in the log of real GDP per capita; $\triangle \ln(\lambda_{it})$ is the year $t-1$ to t change in the log of the GDP share of domestic credit to the private sector; a_i is a country fixed effect; b_t is a year fixed effect; and u_{it} is an error term that is clustered at the country level. We use the log of the savings rate, GDP per capita, and the GDP share of domestic credit to the private sector so that γ and θ capture the average elasticity response of the domestic savings rate with respect to national income and borrowing constraints, respectively.

We show how the econometric model specification in (7) can be derived from our theoretical model in the next subsection. In Section 4.1.2 we discuss identification issues pertaining to the estimation of the econometric model. We present and interpret our empirical results in Section 4.1.3.

4.1.1 Motivation of Econometric Model Specification

Taking natural logarithms of both sides of the equation (6), $\ln s(y_t, \lambda_t) = \ln(1-\alpha) + \ln\beta - \ln\left(1 - Z((1-\alpha)y_t, \lambda_t) + \beta(1-\alpha)y_t\right)$. Let $\triangle \ln s_t := \ln s_t - \ln s_{t-1}$. For

parameter λ are positively related for any fixed value of w_t.

small values of $\triangle \ln y_t$ and $\triangle \ln \lambda_t$, we then obtain[13]

$$\triangle \ln s_t \approx \gamma_{t-1} \triangle \ln y_t + \theta_{t-1} \triangle \ln \lambda_t \tag{8}$$

where

$$\gamma_{t-1} := y_{t-1} \cdot \frac{\partial \ln s(y_{t-1}, \lambda_{t-1})}{\partial y_{t-1}} = \frac{(1-\alpha) y_{t-1} (Z_1((1-\alpha) y_{t-1}, \lambda_{t-1}) - \beta)}{1 - Z((1-\alpha) y_{t-1}, \lambda_{t-1}) + \beta(1-\alpha) y_{t-1}}$$

$$\theta_{t-1} := \lambda_{t-1} \cdot \frac{\partial \ln s(y_{t-1}, \lambda_{t-1})}{\partial \lambda_{t-1}} = \frac{\lambda_{t-1} Z_2((1-\alpha) y_{t-1}, \lambda_{t-1})}{1 - Z((1-\alpha) y_{t-1}, \lambda_{t-1}) + \beta(1-\alpha) y_{t-1}}.$$

Suppose that the parameters do not vary significantly over time (we will test this hypothesis in Section 4.1.3). Then we can write (8) for a panel of $i = 1...N$ countries as

$$\triangle \ln s_{it} \approx \gamma_i \triangle \ln y_{it} + \theta_i \triangle \ln \lambda_{it}. \tag{9}$$

The above equation shows that the within-country change in the log of the savings rate should be related to the within-country changes in the logs of y and λ. In (7) γ and θ thus capture the average elasticity effect of a marginal within-country change in incomes and in borrowing constraints on the aggregate savings rate. Stated in a different way, γ and θ are sample mean elasticity effects. We will check in Section 4.1.3 whether our restricted panel data model in (7) consistently estimates these average elasticity effects using the Pesaran and Smith (1995) mean-group estimator.

For now we note that for relatively low values of y_i, $Z_1((1-\alpha)y_i, \lambda_i) > \beta$ while $Z_1((1-\alpha)y_i, \lambda_i) < \beta$ for relatively high values of y_i. It follows that γ_i is positive (negative) for low (high) values of y_i and any fixed value of λ_i. The average elasticity effect of income on the aggregate savings rate can therefore be either positive or negative. On the other hand, since $Z_2((1-\alpha)y_i, \lambda_i) < 0$, it follows that θ_i is negative for any fixed value of y_i and λ_i. Hence, our model unambiguously predicts that the elasticity effect of weaker borrowing constraints on the aggregate savings rate is negative.

[13]Observe $\ln g(x_t) \approx \ln g(x_{t-1}) + \frac{g'(x_{t-1})}{g(x_{t-1})}(x_t - x_{t-1})$. Since $\Delta \ln x_t = \ln x_t - \ln x_{t-1} \approx \frac{x_t - x_{t-1}}{x_{t-1}}$, it follows that $\ln g(x_t) \approx \ln g(x_{t-1}) + \frac{x_{t-1} g'(x_{t-1})}{g(x_{t-1})} \Delta \ln x_t$.

4.1.2 Discussion of Identification Issues

An important empirical issue in the estimation of (7) is the endogeneity of national income and borrowing constraints. Endogeneity biases could arise because within-country changes in the domestic savings rate itself affect GDP per capita growth and borrowing constraints or because of time-varying omitted variables that affect the domestic savings rate beyond GDP per capita growth and borrowing constraints. Moreover, it is well-known that classical measurement error attenuates least squares estimates towards zero (thus leading to an understatement of the true causal effect that economic growth and borrowing constraints have on aggregate savings).

In order to correct for endogeneity and measurement error bias we need plausible exogenous instruments for GDP per capita growth and borrowing constraints. Instrument validity requires that the instruments should only affect the domestic savings rate through their effects on the endogenous variables. Because the estimating equation includes country fixed effects such instruments need to be time-varying.

Following recent literature we use year-to-year variations in the international oil price weighted with countries' average net-export share of oil in GDP as an instrument for GDP per capita growth.[14] It is important to note that, because year-to-year variations in the international oil price are highly persistent (see e.g. Hamilton 2009, Brueckner et al. 2012a for evidence on international oil prices' random walk behavior), the instrumental variables estimate of γ captures the effect that a persistent shock to countries' GDP per capita has on the domestic savings rate. Because the oil price shock instrument is constructed based on countries' average net export shares (i.e. the net export shares are time-invariant), the time-series variation comes exclusively from the variation in the international oil price. By weighting the variation in the international oil price with countries' average net export shares of oil in GDP the instrument takes into account that the effects of changes in the international oil prices on GDP per capita growth differ across countries depend-

[14] See Brueckner et al. (2012, a,b). For an application of this IV strategy to US states, see Acemoglu et al. (2012).

ing on whether countries are net importers or exporters of oil. We can reasonably assume that the majority of countries are price takers on the international oil market. In order to ensure that our estimates are not driven by potentially large oil exporting or importing countries, where the exogeneity assumption may be more questionable, we will also present estimates that are based on a sample which excludes large oil exporters and importers.

The literature has, unfortunately, not come up with a plausible external instrument for borrowing constraints that varies at the within-country level. We therefore follow common practice in the panel literature and use lagged borrowing constraints as an internal instrument for current borrowing constraints. Domestic savings have a possible contemporaneous effect on countries' borrowing constraints. Using the lagged variable as an instrument should reduce concerns that our within-country estimate of θ is inconsistent. Moreover, the first difference specification (use of country fixed effects) eliminates omitted variables bias arising from time-invariant cross-country differences in historic and geographic variables that may be affecting both (changes in) aggregate savings rates and borrowing constraints.

4.1.3 Empirical Results

Table 1 presents our baseline estimates of the average marginal elasticity effect that within-country changes in national income (y) and borrowing constraints (λ) have on within-country changes in aggregate savings rates (s). In columns (1)-(4) we present instrumental variables estimates. For comparison, we show in column (5) estimates from the Pesaran and Smith (1995) mean-group (MG) estimator, and in column (6) we show estimates from the least squares (LS) fixed effects estimator. All regressions control for country and year fixed effects (which are jointly significant at the 1 percent significance level).

The main finding from the panel fixed effects regressions is that growth in national income on average increases significantly the aggregate savings rate; within-country increases in borrowing constraints also have a significant positive effect on the aggregate savings rate. Specifically, the IV estimates in column (1) show that

	$\Delta\ln(s_{it})$					
	(1)	(2)	(3)	(4)	(5)	(6)
	IV	IV	IV	IV	MG	LS
$\Delta\ln(y_{it})$	2.50***	2.43***	2.47***	2.12***	1.82***	1.52***
	(0.81)	(0.82)	(0.83)	(0.71)	(0.20)	(0.15)
$\Delta\ln(\lambda_{it})$		-0.21**	-0.22**	-1.23*	-0.98**	-0.26***
		(0.09)	(0.10)	(0.68)	(0.42)	(0.10)
$\Delta\ln(s_{it-1})$			0.19***	0.20***		
			(0.07)	(0.07)		
Kleibergen-Paap F-stat	19.60	19.40	9.96	3.70	.	.
Cragg-Donald F-stat	283.67	274.86	136.37	14.04	.	.
Endogenous Regressors	$\Delta\ln(y_{it})$	$\Delta\ln(y_{it})$	$\Delta\ln(y_{it})$, $\Delta\ln(s_{it-1})$	$\Delta\ln(y_{it})$, $\Delta\ln(\lambda_{it})$, $\Delta\ln(s_{it-1})$	.	.
Instruments	OPS_{it}	OPS_{it}	OPS_{it}, $\ln(s_{it-2})$	OPS_{it}, $\ln(\lambda_{it-1})$, $\ln(s_{it-2})$	.	.
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3781	3781	3781	3781	3781	3781

Note: The dependent variable, $\triangle\ln(s_{it})$, is the change in the log of the domestic savings rate. $\triangle\ln(y_{it})$ is the change in the log of real GDP per capita; $\triangle\ln(\lambda_{it})$ is the change in the log of the GDP share of domestic credit to the private sector. The method of estimation in columns (1)-(4) is two-stage least squares; in columns (5) mean-group estimation; column (6) least squares fixed effects. Huber robust standard errors (shown in parentheses) are clustered at the country level.

Table 1: Effects of economic growth and borrowing constraints on aggregate savings rates

unconditional on the GDP share of domestic credit to the private sector the estimated elasticity coefficient on log GDP per capita is 2.5; its standard error is 0.8. Column (2) shows that the elasticity effect of GDP per capita on the savings rate is not much different when we control for the GDP share of domestic credit to the private sector. In columns (3) and (4) we document that these IV results are robust to a dynamic panel regression and instrumenting the change in the GDP share of domestic credit to the private sector with its lag.[15]

Columns (5) and (6) show that the MG and LS estimates of θ (γ) are also negative (positive) and significantly different from zero at the conventional significance levels. Quantitatively, the IV estimates are in absolute size somewhat larger than the MG and LS estimates. One possible reason for this could be classical measurement error that attenuates the LS and MG estimates but not the IV estimates.

In Table 2 we examine the sensitivity of our IV estimates to excluding from the

[15] In the dynamic panel regression we instrument the lagged dependent variable following Bond et al. (2010).

sample large oil importing and exporting countries (column (1)); excluding the top and bottom 1st percentile of the change in the domestic savings rate (column (2)); using initial (1970) oil net-export GDP shares to construct the oil price shock instrument (column (3)); and splitting the sample into the post-1990 and pre-1990 period (columns (4) and (5)).[16] The main result from these robustness checks is that the estimated coefficient of θ (γ) is negative (positive) and significantly different from zero at the conventional significance levels.

	$\Delta \ln(s_{it})$				
	(1) Excluding large importers & exporters	(2) Excluding top/botton 1st pctl.	(3) Using initial oil net-export shares	(4) Pre-1990	(5) Post-1990
$\Delta \ln(y_{it})$	4.40***	2.31***	2.27***	2.04**	3.23***
	(1.44)	(0.57)	(0.71)	(0.98)	(0.83)
$\Delta \ln(\lambda_{it})$	-0.20*	-0.17**	-0.16**	-0.43*	-0.25**
	(0.11)	(0.09)	(0.07)	(0.22)	(0.10)
Kleibergen-Paap F-stat	13.10	16.80	17.87	9.41	169.33
Cragg-Donald F-stat	70.11	282.15	268.30	134.12	261.13
Endogenous Regressors	$\Delta \ln(y_{it})$	$\Delta \ln(y_{it})$	$\Delta \ln(y_{it})$	$\Delta \ln(y_{it})$	$\Delta \ln(y_{it})$
Instruments	OPS_{it}	OPS_{it}	OPS_{it}	OPS_{it}	OPS_{it}
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	3034	3362	3721	2075	1622

Note: The dependent variable, $\Delta \ln(s_{it})$, is the change in the log of the domestic savings rate. $\Delta \ln(y_{it})$ is the change in the log of real GDP per capita; $\Delta \ln(\lambda_{it})$ is the change in the log of the GDP share of domestic credit to the private sector. The method of estimation is two-stage least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. Column (1) excludes large oil importing countries (China, France, Italy, Japan, South Korea, Netherlands, United Kingdom, and United States) and large oil exporting countries (Algeria, Canada, Indonesia, Iran, Iraq, Kuwait, Libya, Mexico, Nigeria, Norway, Oman, Qatar, Russia, United Arab Emirates, and Venezuela). Column (2) excludes observations in the top and bottom 1st Percentile of $\Delta \ln(s_{it})$. Column (3) uses 1970 oil net-export shares to construct the oil price shock instrument. Column (4) shows estimates for the pre-1990 period; column (5) post-1990 period.

Table 2: Effects of economic growth and borrowing constraints on aggregate savings rates (robustness to excluding outliers; excluding large oil importers and exporters; using initial oil net-export GDP shares; time-period split)

Our first main empirical finding is thus that the elasticity response of the domestic savings rate to national income and borrowing constraints is positive and highly significant. This is consistent with prior empirical literature that has examined the macroeconomic relationship between savings and national income (e.g. Jappelli

[16] Table 4 in Appendix C shows first stage effects of the oil price instrument on GDP per capita growth across these robustness checks.

and Pagano (1994), Loayza et al. (2000)). The finding is consistent with the theoretical predictions (2) and (3) and suggests, in particular, that the majority of countries have a level of national income and financial development that is sufficiently low to ensure that economic growth translates into increases in the domestic savings rate.

4.2 The Role of Poverty and Borrowing Constraints

4.2.1 Estimation Framework

The theoretical model provides a number of testable predictions regarding the impact that poverty and borrowing constraints have on the marginal effect of growth in national income on aggregate savings rates. In particular, from Figure 3 the following two predictions arise:

- The marginal effect of growth in national income on the domestic savings rate is larger in poorer countries.
- The marginal effect of growth in national income on the domestic savings rate is larger in countries with more severe credit market imperfections.

Testing these predictions requires an interaction model[17]:

$$\triangle \ln(s_{it}) = \gamma' \triangle \ln(y_{it}) + \delta(\triangle \ln(y_{it}) * \lambda_i)$$

$$+\zeta(\triangle \ln(y_{it}) * y_i) + \theta' \triangle \ln(\lambda_{it}) + a_i' + b_t' + u_{it}'$$

We use countries' period average GDP shares of domestic credit to the private sector, λ_i, to construct the first interaction term. This allows us to focus on how long-run cross-country differences in borrowing constraints affect the impact of growth in national incomes on aggregate savings rates. Note that we construct the interaction term as $\triangle \ln y_{it} * \lambda_i$. Likewise we construct the second interaction that captures how the effect of growth in national incomes on aggregate savings rates differs between rich and poor countries as $\triangle \ln(y_{it}) * y_i$. The particular construction of the interaction terms implies that the coefficient γ' captures the predicted marginal effect of income growth on within-country changes in domestic savings rates when λ_i and y_i are zero.

4.2.2 Discussion of Empirical Results

Table 3 presents the estimates from the above interaction model. We begin by reporting in column (1) estimates from a more parsimonious version of the inter-

[17] Let $F(y, \lambda) \equiv y \frac{\partial \ln s(y,\lambda)}{\partial y} = \frac{(1-\alpha)y(Z_1((1-\alpha)y,\lambda)-\beta)}{1-Z((1-\alpha)y,\lambda)+\beta(1-\alpha)y}$, $\hat{y}$ be the unique solution to $Z_1((1-\alpha)y, 0) = \beta$ and $\hat{\lambda}$ be the cross-country average of λ_i. The functional form of the interaction model can be derived from our theoretical model by applying the following first-order Taylor expansion

$$\gamma_i \equiv F(y_i, \lambda_i) \approx F(\hat{y}, \hat{\lambda}) + F_1(\hat{y}, \hat{\lambda})(y_i - \hat{y}) + F_2(\hat{y}, \hat{\lambda})(\lambda_i - \hat{\lambda}).$$

Substituting the above expression in (9) yields the following relationship between the change in the log of the savings rate and the change in the log of national income and the change in the log of the borrowing constraint:

$$\triangle \ln s_{it} = \left(\gamma' + \delta\lambda_i + \zeta y_i\right) \triangle \ln y_{it} + \theta' \triangle \ln \lambda_{it}.$$

where $F(\hat{y}, \hat{\lambda}) = 0$, $\gamma' \equiv -\hat{y}F_1(\hat{y}, \hat{\lambda}) - \hat{\lambda}F_2(\hat{y}, \hat{\lambda})$, $\zeta \equiv F_1(\hat{y}, \hat{\lambda})$ and $\delta \equiv F_2(\hat{y}, \hat{\lambda})$. Note that $F_1(\hat{y}, \hat{\lambda}) = \frac{(1-\alpha)^2\hat{y}Z_{11}((1-\alpha)\hat{y},\hat{\lambda})}{1-Z((1-\alpha)\hat{y},\hat{\lambda})+\beta(1-\alpha)\hat{y}} < 0$ and $F_2(\hat{y}, \hat{\lambda}) = \frac{(1-\alpha)\hat{y}Z_{12}((1-\alpha)\hat{y},\hat{\lambda})}{1-Z((1-\alpha)\hat{y},\hat{\lambda})+\beta(1-\alpha)\hat{y}} < 0$. This implies that $\gamma' > 0$, $\delta < 0$, $\zeta < 0$ and $\theta' < 0$ as before. Hence, our theoretical model predicts that the marginal effect of growth in national income on the domestic savings rate is larger in countries with low income and more severe credit market imperfections.

	$\Delta\ln(s_{it})$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\ln(y_{it})$	6.16***	6.08***	4.82***	4.77***	6.81***	6.74***
	(1.33)	(1.33)	(1.22)	(1.22)	(1.27)	(1.25)
$\Delta\ln(y_{it})*\lambda_i$	-10.82***	-10.87***			-9.23***	-9.25***
	(3.09)	(3.05)			(3.01)	(2.94)
$\Delta\ln(y_{it})*y_i$			-0.13***	-0.13***	-0.06**	-0.06**
			(0.05)	(0.05)	(0.03)	(0.03)
$\Delta\ln(\lambda_{it})$		-0.29**		-0.20**		-0.27**
		(0.12)		(0.09)		(0.12)
Kleibergen-Paap F-stat	18.82	18.85	12.80	12.53	14.08	14.05
Endogenous Regressors	$\Delta\ln(y_{it})$, $\Delta\ln(y_{it})^*\lambda_i$,	$\Delta\ln(y_{it})$, $\Delta\ln(y_{it})^*\lambda_i$	$\Delta\ln(y_{it})$, $\Delta\ln(y_{it})^*y_i$	$\Delta\ln(y_{it})$, $\Delta\ln(y_{it})^*y_i$	$\Delta\ln(y_{it})$, $\ln(y_{it})\lambda_i$, $\Delta\ln(y_{it})^*y_i$	$\Delta\ln(y_{it})$, $\ln(y_{it})^*\lambda_i$, $\Delta\ln(y_{it})^*y_i$
Instruments	OPS_{it}, $OPS_{it}{}^*\lambda_i$	OPS_{it}, $OPS_{it}{}^*\lambda_i$	OPS_{it}, $OPS_{it}{}^*y_i$	OPS_{it}, $OPS_{it}{}^*y_i$	OPS_{it}, $OPS_{it}{}^*\lambda_i$, $OPS_{it}{}^*y_i$	OPS_{it}, $OPS_{it}{}^*\lambda_i$, $OPS_{it}{}^*y_i$
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3850	3850	3850	3850	3850	3850

Note: The method of estimation is two-stage least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable is the change in the log of the domestic savings rate. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

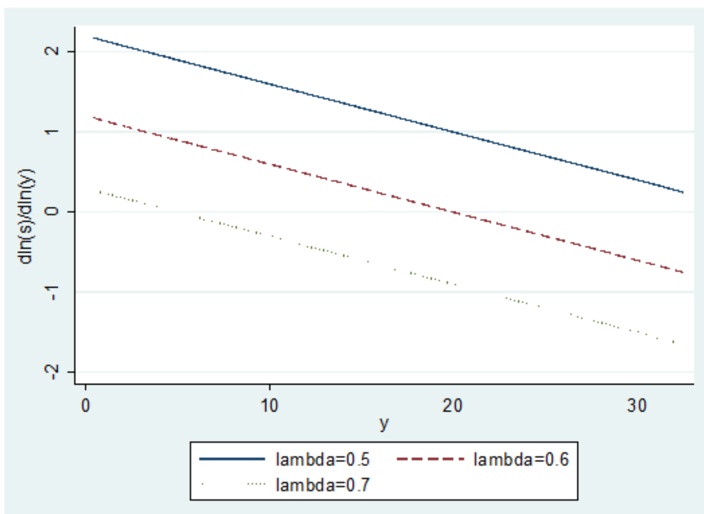
Table 3: Interactions between economic growth, poverty and borrowing constraints

action model that only has as interaction term $\triangle\ln(y_{it})*\lambda_i$. In this model specification, the estimate of γ' captures the predicted marginal effect of growth in national income on domestic savings rates when $\lambda_i = 0$. Our obtained estimate of γ' is 6.2 and its standard error is 1.3. Thus, the estimate of γ' is positive and significantly different from zero at the 1 percent level. The estimate of δ is around -10.8 (s.e. 3.1) hence negative and significantly different from zero at the 1 percent level. The significant negative δ indicates that the marginal effect of growth in national income on the domestic savings rate significantly increases across countries' borrowing constraints. So much so, that at sample minimum, $\lambda_i = 0.02$, the predicted marginal effect is 5.9 with a standard error of 1.3; at sample maximum, $\lambda_i = 1.51$, the predicted marginal effect is -10.1 with a standard error of 3.5. Column (2) shows that this result also holds when we control for the direct effect of $\triangle\ln(\lambda_{it})$ on $\triangle\ln(s_{it})$ which continues to be negative and significant at the 5 percent level.

In similar spirit as in columns (1) and (2) we present in columns (3) and (4) estimates of an interaction model that has as interaction term only $\triangle \ln(y_{it}) * y_i$. In this model specification, the estimate of γ' captures the predicted marginal effect of growth in national income on domestic savings rates when $y_i = 0$. We find that γ' is 4.8 and its standard error is 1.2. Thus, the estimate of γ' is positive and significantly different from zero at the 1 percent level. The estimate of ζ is -0.13 (s.e. 0.05) hence negative and significantly different from zero at the 5 percent level. The significant negative ζ indicates that the marginal effect of growth in national income on the within-country change in the domestic savings rate is significantly higher in poor countries. Column (4) shows that this result also holds when we control for the direct effect of $\triangle \ln(\lambda_{it})$ on $\triangle \ln(s_{it})$ which continues to be negative and significant at the 5 percent level.

In columns (5) and (6) we present estimates from the full-fledged econometric model that includes both interaction terms, $\triangle \ln(y_{it}) * y_i$ and $\triangle \ln(y_{it}) * \lambda_i$. In this model, the estimates of δ and ζ capture conditional interaction effects. That is, ζ captures how the marginal effect of growth in national income on the within-country change in the domestic savings rate varies across poor and rich countries when holding in these countries borrowing constraints, λ_i, constant. Likewise, δ captures how borrowing constraints affect the marginal effect of growth in national income on savings rates when holding income per capita, y_i, constant. Hence, any effect that being rich or poor has on the marginal effect of growth in national income on the within-country change in the domestic savings rate through borrowing constraints is shut down. And any effect that borrowing constraints may have on the marginal effect of growth in national income on the within-country change in the domestic savings rate through the level of income per capita, y_i, is also shut down.

With the above in mind, we are now ready to interpret the estimates in columns (5) and (6). The estimate of γ' that captures the predicted marginal effect of growth in national income when both $y_i = 0$ and $\lambda_i = 0$ is around 6.8; its standard error is 1.3. Note that there is no country in the sample with $y_i = 0$ and $\lambda_i = 0$. Nevertheless we can get a grasp of the quantitative implications of these estimates by considering countries with very low λ_i and y_i, say, those at the bottom 5th percentile ($y_i = 0.6$ and $\lambda_i = 0.07$).[18] For computing the predicted marginal effects we need to take into account that the estimates of δ and ζ are -9.2 and -0.06, respectively; their standard errors are 3.0 and 0.03, respectively. Hence, for a country at the bottom 5th percentile ($y_i = 0.6$ and $\lambda_i = 0.06$) a one percent increase in GDP per capita growth is predicted to increase the savings rate by around 6.1 percent (s.e. 1.1). This is a large effect. For higher values of y_i andλ_i the effect is much smaller however. For example, at the 50th percentiles ($y_i = 3.5$ and $\lambda_i = 0.27$) the predicted marginal effect is 4.1, and at the 75th percentiles ($y_i = 3.5$ and $\lambda_i = 0.27$) it is 1.4. Moreover, the marginal effect of growth in national income on savings rates can be negative for sufficiently high values of y_i (and λ_i). This is illustrated in Figure 4 where we plot for different values of λ_i the predicted marginal effect of growth in national income on savings rates over the sample range of y_i.



Note: The figure plots the predicted marginal effect of growth in national income on the within country changes in aggregate savings rates for different values in GDP per capita (y) and GDP shares of domestic credit to the private sector (λ). The figure is based on the estimates in column (6) of Table 3.

Figure 4: Predicted marginal effect of growth in national income on aggregate savings rates for different levels of GDP per capita and GDP shares of domestic credit to the private sector.

To summarize: In poor countries growth in income per capita leads to a significant increase in aggregate savings. In rich countries and countries where borrowing

[18]Note that GDP per capita, y_i, is measured in thousands; see also Appendix Table 1. Hence, $y_i = 0.6$ refers to a country with GDP per capita of 600 USD.

constraints are not severe the opposite is the case. The results provide evidence in support of theoretical predictions (1) and (3).

5 Summary and Conclusions

In the theoretical part of the paper we have studied a two-period OLG model where entrepreneurs are borrowing constrained to finance their indivisible investment projects. The borrowing constraint creates rents for entrepreneurs. However, the indivisibility of investment projects does not permit all agents to obtain credit to finance their entrepreneurial activities. This creates dynamic incentives for entrepreneurs to save more and rely less on external funds. On the other hand, the fixed size of investment projects causes entrepreneurial savings to increase less than proportionally with income. The savings behavior of entrepreneurs leads to the following, empirically testable predictions: (1) The aggregate saving-to-output ratio is hump-shaped; (2) the aggregate savings rate monotonically increases with borrowing constraints; (3) the effect of economic growth on the aggregate savings rate increases with borrowing constraints. Testing these general equilibrium predictions requires macroeconomic data and an estimation framework that can plausibly identify causal effects. We thus tested the model's predictions based on panel data covering 130 countries during the period 1960-2007. We used instrumental variables analysis to carefully address the issue of causality.

Our empirical analysis showed that, consistent with the model's first prediction, within-country changes in the logs of national incomes are significantly positively related to within-country changes in the logs of aggregate savings rates in poor countries, however, the opposite is the case in rich countries. Consistent with previous literature (i.e. Japelli and Pagano, 1994) and the model's second prediction, the empirical analysis also revealed that within-country changes in the logs of the GDP share of domestic credit to the private sector are significantly negatively related to within-country changes in the logs of the aggregate savings rates. In addition, the empirical analysis showed that the marginal effect of within-country changes in the logs of national income on within-country changes in the logs of aggregate savings rates is significantly increasing in the GDP shares of domestic credit to the private sector, thus consistent with previous literature and the model's third prediction.

We made several simplifying assumptions in order to minimize the dimension of the parameter space and to avoid unnecessary complications while analyzing the model. We assumed log-utility and a minimum scale for capital investment. The fact that the savings of workers is independent of the interest rate makes the model tractable and yields sharp predictions. This assumption could be potentially weakened. If there were (exogenous) simultaneous changes in both technology and the minimum scale of capital investment, then the saving rates would remain unaffected.

A Remaining Proofs

Proposition 2. *The aggregate savings function $S(w,\lambda) : (0,1) \times (0,1) \to (0,1)$ is strictly increasing in w and decreasing in λ. The elasticity of savings with respect to income is*

$$e(w,\lambda) \equiv \frac{wS_1(w,\lambda)}{S(w,\lambda)} = \begin{cases} \frac{1-\beta}{\beta}\frac{S(w,\lambda)(1-S(w,\lambda))}{w-S(w,\lambda)} & \text{if } w_t < \frac{1-\lambda}{\beta} \\ 1 & \text{if } w_t \geq \frac{1-\lambda}{\beta} \end{cases} \tag{10}$$

Moreover, $\lim_{w\downarrow 0} S_1(w,\lambda) = \beta$ *and* $S_1(\frac{1-\lambda}{\beta},\lambda) = \lambda\beta$.

Proof. Using $S_t(1-z_t) = (1-S_t)x_t$ to substitute out z in (4) and taking exponentials, $(\frac{\lambda}{1-\lambda})^{\frac{\beta}{1-\beta}} = (\frac{\beta}{1-\beta}\frac{1-S}{S} - \frac{1}{1-\beta}\frac{1-w}{w})(\frac{1-S}{S})^{\frac{\beta}{1-\beta}}$. Implicitly differentiating this equation we obtain the elasticity of saving with respect to income. From (5), $S_1(w,\lambda) = \frac{\beta}{1-Z(w,\lambda)+\beta w}(1+\frac{w(Z_1(w,\lambda)-\beta)}{1+Z(w,\lambda)+\beta w})$. Since $\lim_{w\downarrow 0} Z_1(w,\lambda) = 1$, it follows that $\lim_{w\downarrow 0} S_1(w,\lambda) = \beta$. Substituting $S(w,\lambda) = w\beta$ into (10), $S_1(\frac{1-\lambda}{\beta},\lambda) = \lambda\beta$. $\square$

Proof of Proposition 1. First, we show that there exists a unique $z_t \in (\beta w_t, 1-\lambda)$, which solves (4). Suppose $\beta w < 1-\lambda$. Taking exponentials of both side of (4) and rearranging, z must solve $\delta(z,\lambda) = 1$ where $\delta(z,\lambda) := \frac{w-z}{(1-\beta)w}(\frac{1-z}{\beta w})^{\frac{\beta}{1-\beta}}(\frac{1-\lambda}{\lambda})^{\frac{\beta}{1-\beta}}$. Observe that $\delta_1 < 0$ on $w \in (0, \frac{1-\lambda}{\beta})$, $\delta(\beta w, \lambda) = (\frac{1-\beta w}{\beta w}\frac{1-\lambda}{\lambda})^{\frac{\beta}{1-\beta}} > 1$ and $\delta(1-\lambda,\lambda) = \frac{1}{1-\beta}(1 - \frac{1-\lambda}{w})(\frac{1-\lambda}{\beta w})^{\frac{\beta}{1-\beta}} < 1$. The second inequality holds since the right hand side of the equation is strictly increasing in w and bounded by 1 on $w \in (0, \frac{1-\lambda}{\beta})$. This with continuity and monotonicity of δ implies the existence and uniqueness of $z \in (\beta w, 1-\lambda)$ which solves $\delta(z,\lambda) = 1$. Second, applying the implicit function theorem we obtain

$$Z_1(w,\lambda) = \frac{\frac{Z(w,\lambda)}{w} - \beta}{1 - \beta + \beta\frac{w-Z(w,\lambda)}{1-Z(w,\lambda)}}.$$

Taking limit of both sides of the equation and from $\lim_{w\downarrow 0} Z(w,\lambda) = 0$, we obtain $\lim_{w\downarrow 0} Z_1(w,\lambda) = \frac{\lim_{w\downarrow 0} Z_1(w,\lambda)-\beta}{1-\beta} = 1$. $Z_1(\frac{1-\lambda}{\beta},\lambda) = 0$ follows trivially. We can show that $Z_{11} < 0$ after some algebra. Moreover, $\delta_1 < 0$ and $\delta_2 < 0$ imply $Z_2 < 0$. $\square$

Proof of Theorem 1. From (5), $\frac{S_t}{w_t} = \frac{\beta}{1-Z(w_t,\lambda)+\beta w_t}$ if $w_t < \frac{1-\lambda}{\beta}$. Hence, $S_{11}(w,\lambda) = \frac{\beta(Z_1(w,\lambda)-\beta)}{(1-z+\beta w)^2} = 0 \Leftrightarrow Z_1(w,\lambda) = \beta$. $\square$

B Dynamics

This section describes how output (the wage) evolves over time in autarky (Section B.1) and in a small open economy (Section B.2). In contrast to Matsuyama (2004), multiple steady states arise also in autarky. This is because entrepreneurs adjust their savings in response to borrowing constraints unlike in Matsuyama (2004). The econometric models in Section 4 control for country fixed effects so that countries may be in different steady states.

B.1 The Autarky

With full depreciation of capital after one period $k_{t+1} = RS(w_t, \lambda)$, and the evolution of wage is given by

$$w_{t+1} = W(RS(w_t, \lambda)) \tag{11}$$

where $W(k) \equiv f(k) - kf'(k) = (1-\alpha)f(k)$ in case of the Cobb-Douglas production function.

Let R^+ be a solution to $W(R) = \frac{1}{\beta}$. We assume that $W(R) < \frac{1}{\beta}$. In other words, we only consider $R \in (0, R^+)$. This assumption ensures that for any $w_t \in (0, \frac{1}{\beta})$, $S(w_t, \lambda) \in (0, 1)$ and $w_{t+1} = W(RS(w_t, \lambda)) \in (0, W(R)) \subset (0, \frac{1}{\beta})$. Hence, (11) defines a dynamical system on the state space $(0, \frac{1}{\beta})$. Under (11) entrepreneurs always need to borrow in order to start an investment project.

Properties of the wage function, $S(0, \lambda) = 0$ and $S_1(0, \lambda) = \beta$ imply that zero is an unstable steady state of the economy. In addition, there exist interior steady states which satisfy

$$R = \Pi(w, \lambda) := \frac{W^{-1}(w)}{S(w, \lambda)}. \tag{12}$$

We can easily verify that $\Pi(0, \lambda) = 0$, $\Pi(\frac{1-\lambda}{\beta}, \lambda) = \frac{W^{-1}(\frac{1-\lambda}{\beta})}{1-\lambda}$ and $\Pi(\frac{1}{\beta}, \lambda) = R^+$. These conditions, with continuity of Π, imply existence of at least one interior steady state. If $R \geq \Pi(\frac{1-\lambda}{\beta}, \lambda)$, then $\Pi(\cdot, \lambda)$ is strictly increasing and there exists a unique interior steady state $W^*(R)$ which solves $w = W(\beta R w)$. In the steady state $W^*(R)$ the borrowing constraint is not binding and all agents save equally.[19] If $R < \Pi(\frac{1-\lambda}{\beta}, \lambda)$, then the borrowing constraint is binding in steady states, and thus entrepreneurs save more than workers. This condition is also necessary for non-monotonicity of $\Pi(\cdot, \lambda)$, which is a necessary condition for multiple steady states to arise. The exact conditions are derived in Appendix B.3 with a corresponding welfare analysis in Appendix B.4.

[19]Note that $R \geq \Pi((1-\lambda)/\beta) \Leftrightarrow W^*(R) > (1-\lambda)/\beta$. This implies that the borrowing constraint is less likely to bind in steady states for both high R and λ.

B.2 The Small Open Economy

In this section we extend the model to allow for international trade. We consider a small open economy that can trade the final goods intertemporally with the rest of the world. The interest rate is exogenously given in the international financial market and assumed to be constant over time: $r_{t+1} = r$.

From (1) and (2) investment is given by a function $k_{t+1} = I(w_t, \lambda, r/R)$ where

$$I\left(w_t, \lambda, \frac{r}{R}\right) := \begin{cases} (f')^{-1}\left(\frac{r}{R}\frac{1-Z(w_t,\lambda)}{\lambda}\right) & \text{if } w_t \in [0, \frac{1-\lambda}{\beta}) \\ (f')^{-1}\left(\frac{r}{R}\right) & \text{if } w_t \in [\frac{1-\lambda}{\beta}, \frac{1}{\beta}). \end{cases}$$

The evolution of the wage is then given by

$$w_{t+1} = W\left(I\left(w_t, \lambda, \frac{r}{R}\right)\right). \tag{13}$$

Suppose $r > r^- := Rf'(R^+)$. Then $w_t \in (0, 1/\beta)$ implies that $I(w_t, \lambda) \in (0, R^+)$ and thus

$$w_{t+1} = W\left(I\left(w_t, \lambda, \frac{r}{R}\right)\right) < W(R^+) = \frac{1}{\beta}.$$

Hence, (13) defines a dynamical system on the state space $(0, \frac{1}{\beta})$, and as before, entrepreneurs need to borrow in order to start an investment project. The map (13) for the small open economy is similar to the map (6) in Matsuyama (2004). Steady states must satisfy

$$\frac{R}{r} = \Psi(w, \lambda) := \begin{cases} \frac{1}{f'(W^{-1}(w))}\frac{1-Z(w,\lambda)}{\lambda} & \text{if } w_t \in \left[0, \frac{1-\lambda}{\beta}\right) \\ \frac{1}{f'(W^{-1}(w))} & \text{if } w_t \in \left[\frac{1-\lambda}{\beta}, \frac{1}{\beta}\right). \end{cases}$$

It can be easily verified that

$$\Psi(0, \lambda) = 0, \quad \Psi\left(\frac{1-\lambda}{\beta}, \lambda\right) = (1-\lambda)^{\frac{1-\alpha}{\alpha}}\frac{R}{r^-} \quad \text{and} \quad \Psi\left(\frac{1}{\beta}, \lambda\right) = \frac{R}{r^-}.$$

The above, with continuity of Ψ implies existence of at least one interior steady state. It is shown in Appendix B.5 that the small open economy, as in Matsuyama

(2004), has at least one and at most three steady states.

B.3 Multiple Steady States in Autarky

We first observe that $\Pi_w(w,\lambda) = 0$ is equivalent to $e(w,\lambda) = \frac{1}{\alpha}$. If $\alpha \leq \beta$, then $e(w,\lambda) < \frac{1}{\alpha}$ and thus $\Pi(\cdot,\lambda)$ is strictly increasing. If $\alpha > \beta$, then there exists a $\lambda^- \in (0,1)$ such that $\Pi(\cdot,\lambda)$ is monotonic for $\lambda \in (\lambda^-,1)$ and non-monotonic for $\lambda \in (0,\lambda^-)$. The condition $\alpha > \beta$ may be satisfied for empirically plausible parameter values.[20] The corresponding level of credit market imperfections necessary for multiple steady states is shown in Figure 5. For $\alpha = 0.33$, $\lambda < 0.0002$ is necessary even for a sufficiently small β. For a higher value of α the necessary value for λ declines, but even for $\alpha = 0.5$ and a sufficiently small β, $\lambda < 0.005$ is necessary. This suggests that for empirically plausible values of the capital share in production and time discount, multiple steady states arise only when the credit market imperfection is very severe, i.e., when entrepreneurs can credibly pledge only less than 0.5% of their investment project revenue.

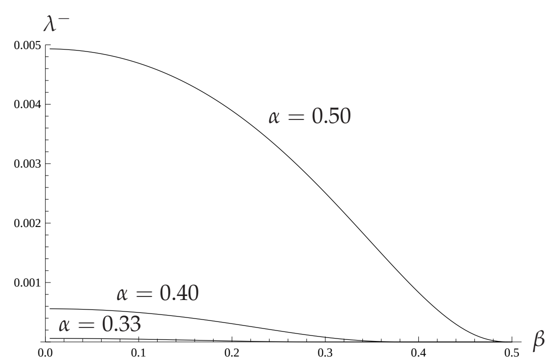


Figure 5: Necessary conditions for multiple steady states

We note that solving $e(w,\lambda) = \frac{1}{\alpha}$ is equivalent to solving $w = S(w,\lambda)(1 + \frac{\alpha(1-\beta)(1-S(w,\lambda))}{\beta})$ or $\phi^1(S(w,\lambda)) \cdot \phi^2(S(w,\lambda)) = (\frac{\lambda}{1-\lambda})^{\frac{\beta}{1-\beta}}$ where $\phi^1(S) := 1 - \frac{\beta}{S}\frac{1-\alpha(1-S)}{\beta+\alpha(1-\beta)(1-S)}$ and $\phi^2(S) := (\frac{1-S}{S})^{\frac{\beta}{1-\beta}}$.

[20] For example, if $\alpha = 0.33$ then in order to obtain multiple steady states $\beta \in (0, 0.33)$. This in turn implies that the time discount should be $\frac{\beta}{1-\beta} \in (0, 1/2)$.

Lemma 1. *$\phi^{1\prime}(S) = 0$ admits a unique solution on $(S^c, 1)$ if $\alpha > \beta$.*

Proof. By definition $1 - \phi^1(S) = \frac{\beta}{S}\frac{1-\alpha(1-S)}{\beta+\alpha(1-\beta)(1-S)}$ and thus $\frac{\phi^{1\prime}(S)}{1-\phi^1(S)} = \frac{1-\alpha}{S(1-\alpha+\alpha S)} - \frac{\alpha(1-\beta)}{\beta+\alpha(1-\beta)(1-S)}$. If $\alpha > \beta$, then for $S > S^c$, $\phi^1(S) > 0$ and $\phi^{1\prime}(S) = 0 \Leftrightarrow S(1 - \alpha + \alpha S) = \frac{1-\alpha}{\alpha(1-\beta)}(\beta + \alpha(1-\beta)(1-S))$. The left hand side of the last equation is strictly increasing in S and maps $[0, 1]$ onto $[0, 1]$. The right hand side is strictly decreasing in S. Thus there exists at most one solution. In order for a solution to exist on $(S^c, 1)$, $\frac{(1-\alpha)\beta}{\alpha(1-\beta)} < 1$ must hold which is equivalent to $\alpha > \beta$. □

Lemma 2. *Suppose $\alpha > \beta$. Then Π has two critical points $W^c_L(\lambda)$ and $W^c_H(\lambda)$ on $(0, \frac{1-\lambda}{\beta})$ for $\lambda < \lambda^-$. W^c_L is strictly increasing, W^c_H is strictly decreasing and $W^c_L(\lambda) = W^c_H(\lambda)$ at $\lambda = \lambda^-$.*

Proof. First we show that $\Pi' > 0$ if $\alpha \le \beta$. Suppose $\alpha \le \beta$. Then, $\phi^1(S) < 0$ for any $S \in (0, 1)$. This implies that $\phi^1(S) \times \phi^2(S) < 0 < (\lambda/(1-\lambda))^{\frac{\beta}{1-\beta}}$ for any $\lambda \in (0, 1)$ and $S \in (0, 1)$. Hence, $e(w, \lambda) < 1/\alpha$. Second we show that if $\alpha > \beta$, then there exists a unique $\lambda^- \in (0, 1)$ such that Π has two critical points $W^c_L(\lambda)$ and $W^c_H(\lambda)$ for $\lambda < \lambda^-$ where $0 < W^c_L(\lambda) < W^c_H(\lambda) < (1-\lambda)/\beta$, and $\Pi' > 0$ for $\lambda \ge \lambda^-$. Suppose $\alpha > \beta$. Then, there exists a unique $S^c \in (0, 1)$ such that $\phi^1(S^c) = \phi^1(1) = 0$, $\phi^1(S) < 0$ for $S \in (0, S^c)$ and $\phi^1(S) > 0$ for $S \in (S^c, 1)$. On the other hand, ϕ^2 is positive and strictly increasing. Lemma 1 with continuity of ϕ^1 and ϕ^2 implies that $\phi := \phi^1 \times \phi^2$ has a unique maximum where $\phi'(S) = 0$. Let $S^{cc} \in (S^c, 1)$ denote the maximizer and $\lambda^- := \phi(S^{cc})^{\frac{1-\beta}{\beta}}/(1 + \phi(S^{cc})^{\frac{1-\beta}{\beta}})$. If $\lambda < \lambda^-$, then $\phi(S) = (\lambda/(1-\lambda))^{\frac{\beta}{1-\beta}}$ admits exactly two solutions $S^c < S^c_L(\lambda) < S^{cc} < S^c_H(\lambda) < 1$. It is clear that S^c_L is strictly increasing while S^c_H is strictly decreasing. If $\lambda = \lambda^-$, then $S_1(\lambda)$ and $S_2(\lambda)$ meet at S^{cc} and they cease to exist for $\lambda > \lambda^-$. If $S^c_L(\lambda)$ and $S^c_H(\lambda)$ exist, then monotonicity of $w \mapsto S(w, \lambda)$ implies existence of $W^c_L(\lambda)$ and $W^c_H(\lambda)$ such that $S(W^c_L(\lambda), \lambda) \equiv S^c_L(\lambda)$ and $S(W^c_H(\lambda), \lambda) \equiv S^c_H(\lambda)$. It is clear that W^c_L is strictly increasing while W^c_H is strictly decreasing and they meet at $\lambda = \lambda^-$. □

The following proposition follows directly from Lemma 2.

Proposition 3. *Suppose $\alpha > \beta$. Then, there exist three steady states $W_L(\lambda, R) \in (0, W_L^c(\lambda))$, $W_M(\lambda, R) \in (W_L^c(\lambda), W_H^c(\lambda))$ and $W_H(\lambda, R) \in (W_H^c(\lambda), (1-\lambda)/\beta)$ if and only if $\lambda \in (0, \lambda^-)$ and $R \in (\Pi(W_L^c(\lambda), \lambda), \Pi(W_H^c(\lambda), \lambda))$.*

Figure 6 illustrates the proposition by showing a numerical plot of the function $\Pi(\cdot, \lambda)$ for $\alpha > \beta$ and $\lambda < \lambda^-$. We can see that multiple steady states would exist if $R \in (\Pi(W_L^c(\lambda), \lambda), \Pi(W_H^c(\lambda), \lambda))$.

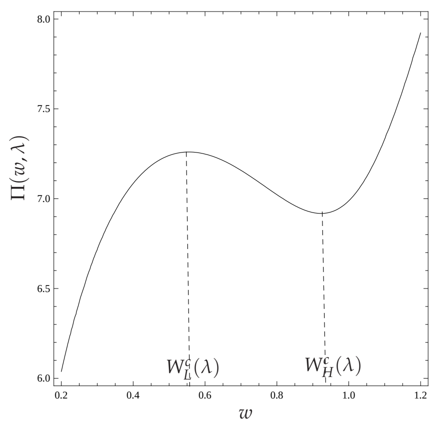


Figure 6: Emergence of multiple steady states: $\alpha = 0.7$, $\beta = 0.41$, $\lambda = 0.02$

Since W and $S(\cdot, \lambda)$ are both increasing and zero is an unstable steady state, any unique interior steady state is globally stable. If multiple steady states exist, then the entire state space $(0, \frac{1}{\beta})$ is divided into two disjoint regions $(0, W_M(\lambda, R))$ and $(W_M(\lambda, R), \frac{1}{\beta})$ which are basins of attraction for $W_L(\lambda, R)$ and $W_H(\lambda, R)$ respectively. The middle steady state $W_M(\lambda, R)$ is always unstable.

We have so far assumed that agents compete for credit by changing their savings behavior. Suppose that the allocation of credit to entrepreneurs were random. In this case agents can not influence their chance of obtaining credit by saving more. As a result, all agents would save equally and aggregate savings would be $S(w, \lambda) = \beta w$. This eliminates the possibility of multiple steady states. Hence, competition to obtain credit under borrowing constraints induces heterogenous behavior, and generates the possibility of multiple steady states.

B.4 Welfare in Autarky

Models displaying poverty traps such as Banerjee and Newman (1993) imply that improving the functioning of the credit market improves efficiency. This result is in sharp contrast with Ghatak et al. (2001) who show that at zero credit market imperfections social welfare is improved by marginally increasing credit market imperfections. This is true in this paper as well. We know from the previous section that if $R \geq \Pi(\frac{1-\lambda}{\beta}, \lambda)$, then the borrowing constraint is not binding in steady states, and thus there exists a unique interior steady state $W^*(R)$. In this case, the credit market imperfection plays no role. Therefore, in the following we will focus on the case where $R < \Pi(\frac{1-\lambda}{\beta}, \lambda)$, i.e. when the borrowing constraint is binding in steady states.

Suppose $\beta \geq \frac{\alpha}{1-\alpha}$. Then, $\beta > \alpha$ and there exists a unique steady state $W(R, \lambda)$. Moreover, the economy over-accumulates capital and thus is dynamically inefficient at the steady state since $r^* = Rf'(\beta R W^*(R)) = \frac{\alpha}{\beta(1-\alpha)} \leq 1$ and $R < \Pi(\frac{1-\lambda}{\beta}, \lambda) \Leftrightarrow W^*(R) < W(\lambda, R)$.[21] Hence, a reduction of the credit market imperfection Pareto-improves the welfare for all generations because aggregate savings decline as λ increases.

Suppose now instead $\beta < \frac{\alpha}{1-\alpha}$. Then, $r^* > 1$ and the economy under-accumulates capital at $W^*(R)$. Let us consider the case where $\beta > \alpha$, i.e., when there exists a unique steady state $W(R, \lambda)$.[22] Since $W(\lambda, R) > W^*(R)$ as before, the economy does not necessarily under-accumulate capital at $W(\lambda, R)$. However, for $W(\lambda, R)$ sufficiently close to $W^*(R)$ there will be under-accumulation of capital. In this case higher credit market imperfections might enhance the long run welfare.

Figure 7 shows how the life time utility of agents in steady states depends on the credit market imperfection. The values $V(\lambda, R)$ and $V^*(R)$ denote the welfare associated with $W(\lambda, R)$ and $W^*(R)$ respectively. The figure shows that $V(\lambda, R)$ and $V^*(R)$ meet at $R = \Pi(\frac{1-\lambda}{\beta}, \lambda)$ and reducing λ (i.e., increasing credit market imper-

[21] Reducing current investment would permit current consumption to rise at no cost of future consumption.

[22] When $\beta \leq \alpha$, multiple steady states may arise (Proposition 3). The welfare ranking and the wage ranking of the three steady states coincide.

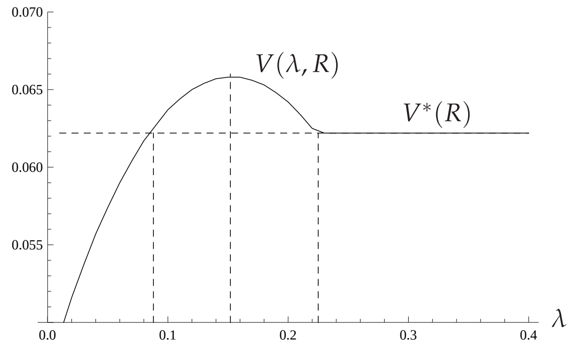


Figure 7: Life time utility in steady states: $\beta = 0.41$, $\alpha = 0.33$, $R = 30$

fections) from that point increases the welfare level. In fact, there exits an optimal level of λ that maximizes the long run welfare. Reducing λ encourages the savings of entrepreneurs and thus the aggregate savings by raising permanent income and thus welfare. However, as aggregate savings grow the marginal product of capital and therefore the return to savings is reduced. Eventually, this negative effect outweighs the positive effects leading to a decline in welfare as the figure illustrates.

B.5 Multiple Steady States in the Small Open Economy

We first observe that Ψ is strictly increasing on $w \in [\frac{1-\lambda}{\beta}, \frac{1}{\beta})$. In order to investigate non-monotonicity of Ψ on $w \in [0, \frac{1-\lambda}{\beta})$, we observe that $\Psi_1(w, \lambda) = 0$ is equivalent to

$$\frac{wZ_1(w,\lambda)}{Z(w,\lambda)} = \frac{1-\alpha}{\alpha}\frac{1-Z(w,\lambda)}{Z(w,\lambda)} \quad \Leftrightarrow \quad e(w, \lambda) = \frac{1-S(w,\lambda)}{\alpha}. \tag{14}$$

It follows from (4) that

$$\frac{wZ_1(w, \lambda)}{Z(w, \lambda)} = \frac{1 - Z(w, \lambda)}{Z(w, \lambda)} \frac{Z(w, \lambda) - \beta w}{1 - \beta - Z(w, \lambda) + \beta w}. \tag{15}$$

This with (14) implies that $\Psi_1(w, \lambda) = 0$ is equivalent to

$$Z(w, \lambda) - \beta w = (1 - \alpha)(1 - \beta). \tag{16}$$

Properties of Z implies that $w \mapsto Z(w, \lambda) - \beta w$ is an inverted U-curve on $[0, \frac{1-\lambda}{\beta}]$ and thus (16) admits either no solution or two solutions. It admits exactly one solution when

$$Z(w, \lambda) - \beta w = (1-\alpha)(1-\beta) \quad \text{and} \quad Z_1(w, \lambda) = \beta. \tag{17}$$

This with (15) implies

$$w = \tfrac{(1-\alpha)(\alpha+\beta(1-\alpha))}{\beta} \quad \text{and} \quad Z(w, \lambda) = (1-\alpha)(1+\alpha-\alpha\beta). \tag{18}$$

By substituting (18) into (4) we obtain

$$\frac{\lambda}{1-\lambda} = \frac{1-(1-\alpha)(1+\alpha-\alpha\beta)}{(1-\alpha)(\alpha+\beta-\alpha\beta)} \left(\frac{\alpha(1-\beta)}{\alpha+\beta-\alpha\beta}\right)^{\frac{1-\beta}{\beta}}. \tag{19}$$

Let $\tilde{\lambda}^-$ denote the unique λ that solves the above equation. Figure 8 shows how $\tilde{\lambda}^-$, which is the threshold value of λ below which Ψ is non-monotonic, depends on (α, β).

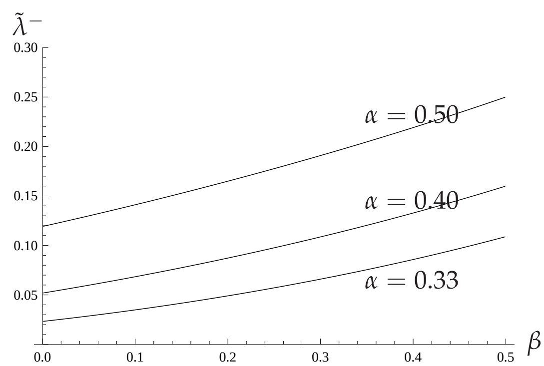


Figure 8: Necessary condition for multiple steady states

Lemma 3. *If $\lambda > \tilde{\lambda}^-$, then Ψ is strictly increasing. If $\lambda < \tilde{\lambda}^-$ then Ψ has two critical points $\tilde{W}_L^c(\lambda)$ and $\tilde{W}_H^c(\lambda)$ on $(0, \frac{1-\lambda}{\beta})$. $\tilde{W}_L^c$ is strictly increasing, $\tilde{W}_H^c$ is strictly decreasing and $\tilde{W}_L^c(\lambda) = \tilde{W}_H^c(\lambda)$ at $\lambda = \tilde{\lambda}^-$.*

Proof. If $\lambda > \tilde{\lambda}^-$, then it follows from (15), (16) and (17) that $\Psi_1 > 0$ and thus Ψ is strictly increasing. If $\lambda < \tilde{\lambda}^-$, then it follows from (15), (16) and (17) that

$\Psi_1(w,\lambda) = 0$ admits exactly 2 solutions on $(0, \frac{1-\lambda}{\beta})$. Properties of $\tilde{W}^c_L(\lambda)$ and $\tilde{W}^c_H(\lambda)$ follows from property of Ψ. $\square$

The next proposition is a direct consequence of the above lemma.

Proposition 4. *There exist three steady states* $W_L\left(\lambda, \frac{R}{r}\right) \in (0, \tilde{W}^c_L(\lambda))$, $W_M\left(\lambda, \frac{R}{r}\right) \in (\tilde{W}^c_L(\lambda), \tilde{W}^c_H(\lambda))$ *and* $W_H\left(\lambda, \frac{R}{r}\right) \in (\tilde{W}^c_H(\lambda), \frac{1}{\beta})$ *if and only if* $\lambda < \tilde{\lambda}^-$ *and* $\frac{R}{r} \in \left(\Psi(\tilde{W}^c_L(\lambda), \lambda), \Psi(\tilde{W}^c_H(\lambda), \lambda)\right)$.

C Tables

	$\Delta \ln(y_{it})$							
	(1) Full Sample	(2) Excluding Large Importers & Exporters	(3) Excluding Top/ Bottom 1st Pctl.	(4) Using Initial Oil Net-Export Shares	(5) Pre-1990 Period	(6) Post-1990 Period	(7) Rich Countries	(8) Poor Countries
OPS_{it}	1.01***	0.98***	0.98***	6.24***	0.79***	2.45***	1.01***	1.36***
	(0.23)	(0.27)	(0.23)	(1.52)	(0.26)	(0.19)	(0.25)	(0.35)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3781	3034	3721	3362	2075	1622	1890	1891

Note: The dependent variable, $\Delta \ln(y_{it})$, is the change in the log of real GDP per capita. The method of estimation is least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. Column (2) excludes large oil importing countries (China, France, Italy, Japan, South Korea, Netherlands, United Kingdom, and United States) and large oil exporting countries (Algeria, Canada, Indonesia, Iran, Iraq, Kuwait, Libya, Mexico, Nigeria, Norway, Oman, Qatar, Russia, United Arab Emirates, and Venezuela). Column (3) excludes observations in the top and bottom 1st Percentile of $\Delta \ln(s_{it})$. Column (4) uses 1970 oil net-export shares to construct the oil price shock instrument. Column (5) shows estimates for the pre-1990 period; column (6) post-1990 period. Column (7) shows estimates for countries with above sample median GDP per capita; column (8) below sample median GDP per capita.

Table 4: First stage effects

Country	GDP p.c. (y) [in Thousands]	Credit/GDP (λ)	Country	GDP p.c. (y) [in Thousands]	Credit/GDP (λ)
Albania	3.171	0.092	Indonesia	3.142	0.319
Algeria	2.912	0.333	Iran	4.22	0.227
Angola	3.053	0.049	Ireland	13.204	0.604
Argentina	6.986	0.185	Israel	10.699	0.566
Armenia	5.062	0.079	Italy	13.643	0.644
Australia	14.364	0.501	Jamaica	4.439	0.238
Austria	14.83	0.738	Japan	14.311	1.517
Azerbaijan	4.316	0.064	Mauritius	9.942	0.428
Bahrain	14.837	0.442	Mexico	5.268	0.224
Bangladesh	1.268	0.175	Mongolia	1.87	0.154
Barbados	13.165	0.496	Morocco	2.468	0.261
Belarus	13.087	0.127	Mozambique	1.299	0.131
Belize	5.672	0.363	Nepal	0.897	0.129
Benin	0.746	0.156	Netherlands	14.625	0.863
Bolivia	1.915	0.258	New Zealand	11.354	0.552
Bosnia & Herz.	4.445	0.426	Nicaragua	1.601	0.25
Brazil	4.604	0.423	Niger	0.588	0.094
Bulgaria	6.262	0.368	Nigeria	0.849	0.11
Burkina Faso	0.663	0.108	Norway	16.985	0.484
Burundi	0.506	0.097	Oman	10.919	0.249
Cambodia	1.819	0.074	Pakistan	1.499	0.245
Cameroon	1.491	0.167	Panama	3.426	0.606
Canada	15.04	0.817	Papua New Guinea	1.459	0.185
Central Afr. Rep.	0.651	0.104	Paraguay	2.791	0.198
Chad	0.874	0.079	Peru	2.984	0.168
Chile	6.164	0.442	Philippines	2.084	0.271
China	2.624	0.874	Poland	8.417	0.276
Colombia	3.42	0.283	Portugal	8.506	0.749
Congo, Rep. of	1.421	0.145	Qatar	30.938	0.299
Costa Rica	5.111	0.234	Romania	6.685	0.149
Croatia	9.394	0.401	Russia	8.37	0.187
Cyprus	12.216	1.238	Rwanda	0.794	0.063
Czech Republic	15.303	0.487	Samoa	3.888	0.243
Denmark	14.335	0.642	Senegal	1.144	0.22
Djibouti	3.651	0.354	Sierra Leone	1.326	0.048
Dom. Republic	3.527	0.231	Singapore	14.802	0.744
Ecuador	3.029	0.217	Slovenia	16.958	0.382
Egypt	2.282	0.28	South Africa	5.125	0.902
El Salvador	2.88	0.303	Spain	11.61	0.79
Eq. Guinea	5.549	0.096	Tajikistan	2.2	0.173
Estonia	11.733	0.494	Tanzania	0.626	0.087
Ethiopia	0.746	0.151	Thailand	3.498	0.657
Fiji	2.983	0.286	Togo	0.684	0.185
Finland	13.084	0.565	Trinidad &Tobago	7.552	0.336
France	13.184	0.806	Tunisia	3.919	0.514
Gabon	4.584	0.147	Turkey	3.179	0.182
Gambia, The	0.823	0.134	Turkmenistan	6.589	0.017
Georgia	4.983	0.105	Uganda	0.58	0.066
Germany	17.353	0.913	Ukraine	6.208	0.191
Ghana	0.925	0.071	United Arab Emir.	32.473	0.29
Greece	10.546	0.354	United Kingdom	13.117	0.737
Guatemala	3.043	0.167	United States	18.805	1.219
Guinea-Bissau	0.641	0.088	Uruguay	5.732	0.323
Guyana	1.562	0.333	Venezuela	5.365	0.29
Haiti	1.431	0.138	Vietnam	2.432	0.43
Honduras	1.898	0.294	Yemen	0.928	0.055
Hungary	10.36	0.399	Zambia	1.006	0.119
Iceland	15.676	0.628	Zimbabwe	2.238	0.298
India	1.307	0.213			

Table 5: List of countries

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