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Effects of Income Growth on Domestic Saving 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 and does not allow everyone to become an entrepreneur. Competition forces entrepreneurs to save more than workers. The model predicts that growth in national income has a positive effect on domestic saving rates in poor countries but a negative effect in rich countries. Borrowing constraints increase domestic saving rates as well as the response of domestic saving to growth in income. These predictions are supported by empirical evidence based on panel data that covers 130 countries during 1960-2007.

Keywords: overlapping generations; entrepreneurship; occupational choice; saving; borrowing constraints

JEL Classification: E2, O1

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1 Introduction

What is the effect of a change in a country’s income on its domestic saving rate? To answer this question we study an overlapping generations model with credit market imperfections. Our model builds on Matsuyama (2004) who introduced to the Diamond model a minimum investment requirement and a borrowing constraint that arises from limited pledgeability. The borrowing constraint gives rise to a positive rent for entrepreneurial activities. However, not all agents can become entrepreneurs. In Matsuyama (2004), agents consume only when old and thus save their entire wage. In our model, agents can consume when both young and old. This is a nontrivial extension since saving decisions affect the allocation of credit generating a non-linear relationship between income and the domestic saving rate. We show that it is optimal for entrepreneurs to save more than workers, and competition for external funds forces entrepreneurs to offer a higher interest rate. In equilibrium, workers save a constant fraction of the wage independently of financial market imperfections. On the other hand, entrepreneurs increase their saving with the wage. The fixed size of investment projects causes entrepreneurial saving to increase less than proportionally with the wage. This effect decreases the aggregate saving rate at the intensive margin. Countervailing this effect the fraction of entrepreneurs increases as the wage increases. This effect at the extensive margin increases the aggregate saving rate. We show that for low values of initial income, the effect at the extensive margin dominates the effect at the intensive margin; the opposite is true for high values of initial income. Hence, the domestic saving rate initially rises and then falls with a country’s income. The resulting hump-shaped effect of income on the domestic saving rate is the main theoretical prediction of our model.

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 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 regression results show evidence in support of the predictions from the theoretical model. In particular, we find that an increase in the change of a country’s income leads to a significant increase in the change of domestic saving rate 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 a PPP GDP per capita of 1000 USD. For this low income country our estimates show that a one percent increase in GDP per capita increases the domestic saving rate by about four percent. On the other hand,
for a rich country with a PPP GDP per capita of 50000 USD a one percent increase in GDP per capita decreases the domestic saving 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. Another view is that the effects of borrowing constraints on domestic saving rates, and hence income growth, are positive. In particular, it is well-known from the life-cycle literature that borrowing constraints may increase saving rates (e.g. Bewley 1986, Deaton 1991, Huggett 1993, Aiyagari 1994, Levine and Zame 2002). Closely related to our paper with regard to the effects that borrowing constraints have on saving are Jappelli and Pagano (1994) and Ghatak et al. (2001).

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 sub-optimal; however, a tighter borrowing constraint raises the saving of the middle-aged. In the presence of this trade-off the authors show the existence of an optimal level of credit market imperfections. In a 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 domestic saving 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 to 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 in-

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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).
centives for the young. Young workers supply extra effort and become self-financed entrepreneurs in the Ghatak et al. (2001) model. In our model, the young become entrepreneurs through thrift alone. The dynamic incentives in our model generates a hump-shaped saving rate in income.

With regards to the role of borrowing constraints, our model provides two additional predictions that are testable with macroeconomic data: borrowing constraints increase the domestic saving rate; and borrowing constraints increase the response of domestic saving rates to a change in a country’s 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 effect on domestic saving rates: a one percent decrease in the GDP share of domestic credit to the private sector is associated with an increase in the domestic saving rate by around 0.2 percent. In addition, the percent effect of a change in a country’s income on the change in the domestic saving rate increases with the GDP share of domestic credit to the private sector. So much so, that in countries with a low GDP share of domestic credit to the private sector an increase in the change of income increases the change in the domestic saving rates while in countries with a high GDP share of domestic credit to the private sector the opposite is the case.

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 contains all remaining proofs and analysis on robustness, dynamics and welfare.

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. The resulting per-

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2 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. The role of borrowing constraints for encouraging saving to set up businesses is well documented. An excellent summary can be found in Ghatak et al. (2001). In a recent study using US data, Buera (2009) documents that people who eventually become entrepreneurs have higher saving rates than people who expect to remain workers.

3 “Capital” may be either human or physical. It depreciates fully between periods so that the capital stock is equal to investment.
capita output is given by \( y_t = f(k_t) \). Factor markets are competitive paying the wage \( w_t = f(k_t) - k_t f'(k_t) \), and a gross return on capital \( f'(k_t) \). 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.

The young face decisions of how much to save and how to invest the wage. They can become either a worker or an entrepreneur. Workers lend their entire saving in the competitive credit market, which yields 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 \( R f'(k_{t+1}) \).

Let \( z_t \) denote saving of entrepreneurs. We later on restrict parameter values so that \( z_t < 1 \) for all \( t \), 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. This formulation is a parsimonious way of introducing credit market imperfections in a dynamic macroeconomic model. There are many potential micro foundation for the borrowing constraint. The simplest story would be that entrepreneurs strategically default, whenever the repayment obligation exceeds the default cost, which is proportional to the project revenue. Thus, entrepreneurs can start the project only if

\[
r_{t+1}(1 - z_t) \leq \lambda R f'(k_{t+1}). \tag{1}
\]

The parameter \( \lambda \) 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.

### 3 Equilibrium

When the borrowing constraint is not binding, the young would be 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 saving decisions as workers. The workers excluded from credit would then have an incentive to save more and offer a higher interest rate to lenders in order to become entrepreneurs. Competition alone without any shocks establishes an equilibrium where the young are indifferent between choosing a

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4 See footnote 13 in Matsuyama (2004).
high level of saving to become an entrepreneur and a low level of saving to become a worker. In the following we will prove existence and uniqueness of the equilibrium.

Workers and entrepreneurs maximize the lifetime utility

\[ u(c_{1t}, c_{2t+1}) = \ln c_{1t} + \frac{\beta}{1-\beta} \ln c_{2t+1} \]  

(2)

where \( c_{1t} \) and \( c_{2t+1} \) are consumption when young and old; \( \frac{\beta}{1-\beta} \in (0, 1] \) is the time discount. Let \( x_t \) denote saving of workers who maximize (2) subject to \( c_{1t} = w_t - x_t, \)

\( c_{2t+1} = x_tr_{t+1}, \) and \( x_t \in [0, w_t]. \) The solution gives us worker’s optimal saving

\[ x_t = \beta w_t. \]  

(3)

Entrepreneurs maximize (2) subject to \( c_{1t} = w_t - z_t, \)

\( c_{2t+1} = Rf'(k_{t+1}) - (1 - z_t)r_{t+1}, \) \( z_t \in [0, w_t], \) and (4). The solution gives us entrepreneur’s optimal saving

\[ z_t = \max \left\{ \beta w_t - (1 - \beta)Rf'(k_{t+1}) - r_{t+1}, 1 - \frac{\lambda Rf'(k_{t+1})}{r_{t+1}} \right\}. \]  

(4)

Since workers and entrepreneurs are ex-ante homogeneous, it follows that entrepreneur’s saving in a ‘stable’ equilibrium must satisfy

\[ \ln (w_t - x_t) + \frac{\beta}{1-\beta} \ln (x_tr_{t+1}) = \ln (w_t - z_t) + \frac{\beta}{1-\beta} \ln (Rf'(k_{t+1}) - (1 - z_t)r_{t+1}) \]  

(5)

so that they achieve the same level of lifetime utility and no one wants to deviate from the saving decision. We can see from (5) that the young are willing to become entrepreneurs whenever

\[ r_{t+1} \leq Rf'(k_{t+1}). \]  

(6)

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

To satisfy the optimality condition (4) and the ‘stability’ condition (5) there are two cases to be considered. First, suppose that \( \beta w_t \geq 1 - \lambda \) (That the borrowing constraint is not binding in this case is shown in the proof of Proposition 1). In this case, if entrepreneurs save more than workers, \( z_t > \beta w_t, \) then the borrowing constraint (1) implies that the interest rate is at least as high as the rate of return from entrepreneurial activity, i.e., \( r_{t+1} \geq Rf'(k_{t+1}) \). 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 $\beta w_t < 1 - \lambda$ (That the borrowing constraint is binding in this case is shown in the proof of Proposition 1). In this case, if all the young save equally as in the previous case, then the borrowing constraint (1) implies that the interest rate is less than the rate of return from entrepreneurial activity. When the borrowing constraint is binding and $(1 - z_t) r_{t+1} = \lambda R f'(k_{t+1})$, we can rewrite (5) as

$$\ln(w_t - z_t) + \frac{\beta}{1 - \beta} \ln \left( \frac{(1 - \lambda)(1 - z_t)}{\lambda} \right) = \ln((1 - \beta) w_t) + \frac{\beta}{1 - \beta} \ln(\beta w_t). \quad (7)$$

We can immediately see from (7) that the fixed size of investment projects implies that the lifetime utility of entrepreneurs decreases with saving. We show in Appendix B that the model remains essentially the same even when we allow for a flexible investment project size as long as there is a minimum investment requirement. The positive entrepreneurial rent introduces competition among the young forcing entrepreneurs to increase saving until they obtain the same utility as workers. Entrepreneurs save more than workers thereby pushing up the interest rate. In equilibrium, workers lend to entrepreneurs who run investment projects where the fraction of entrepreneurs (borrowers) is $k_{t+1}/R$ while the fraction of workers (lenders) is $1 - k_{t+1}/R$. The next proposition formalizes the equilibrium saving of entrepreneurs. The proof is delegated to the appendix.

**Proposition 1.** The saving of entrepreneurs is given by

$$z_t = \begin{cases} 
Z(w_t, \lambda) & \text{if } w_t < \frac{1 - \lambda}{\beta} \\
\beta w_t & \text{if } w_t \geq \frac{1 - \lambda}{\beta} 
\end{cases} \quad (8)$$

where $Z(w, \lambda) : (0, \frac{1 - \lambda}{\beta}) \times (0, 1) \to (\beta w, 1 - \lambda)$ is strictly increasing and strictly concave in $w$, and strictly decreasing in $\lambda$. Moreover, $\lim_{w \downarrow 0} Z_1(w, \lambda) = 1$ and $Z_1\left(\frac{1 - \lambda}{\beta}, \lambda\right) = 0$ where $Z_1$ denotes the derivative of $Z$ with respect to its first argument.

The fixed size of investment projects and consumption smoothing cause saving to increase less than proportionally with the wage. This makes entrepreneurial saving a concave function of the wage when the borrowing constraint is binding. On the other hand, we can see from (1) that credit market imperfections have a positive effect on entrepreneurial rents. Therefore, the entrepreneurial saving increases 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

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5In 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.
The young, who want to become entrepreneurs, facing the borrowing constraint save more in order to earn entrepreneurial rents in the future. Figure 1 illustrates these findings by displaying the equilibrium relationship between entrepreneurial saving and the wage for different values of \( \lambda \).

![Figure 1: Entrepreneurial saving; \( \beta = 0.41 \)](image)

We now turn our attention to aggregate saving. 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 saving. Solving for \( S_t \) we obtain

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

(9)

Proposition 2 in Appendix A provides properties of the aggregate saving function. The following definition of equilibrium reconciles market clearing and individual optimality.

**Definition 1.** Given an initial wage \( w_0 \geq 0 \), an equilibrium is a sequence \( \{w_t, x_t, z_t\}_{t=0}^{\infty} \), such that

1. the decisions \((x_t, z_t)\) are given by (3) and (8), the aggregate saving is equal to the aggregate investment, \( k_{t+1} = RS(w_t, \lambda) \), and
2. the wage evolves according to \( w_{t+1} = W(RS(w_t, \lambda)) \) where \( W(k) = f(k) - kf'(k) \).

The main reasons identified in the literature why potential entrepreneurs may save more than potential workers are: (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).
Now we are ready to make our main theoretical predictions by assuming the Cobb-Douglas production function $f(k) = k^\alpha$ where $\alpha \in (0, 1)$ is the capital share in production, and exploiting its property that the wage is a constant fraction of output $w_t = (1 - \alpha)y_t$. The aggregate saving rate is defined as

$$s_t = s(y_t, \lambda) := \frac{S((1 - \alpha)y_t, \lambda)}{y_t} = \frac{(1 - \alpha)\beta}{1 - Z((1 - \alpha)y_t, \lambda) + \beta(1 - \alpha)y_t}. \quad (10)$$

We observe that the equilibrium aggregate saving rate $s_t$, given parameters $(\lambda, \beta, \alpha)$, depends directly on output $y_t$ only and is uniquely determined. How output affects the equilibrium saving rate will be tested empirically in Section 4. The next theorem presents our main theoretical findings.

**Theorem 1.**

1. The aggregate saving rate is hump-shaped with respect to income.
2. The aggregate saving rate monotonically increases with borrowing constraints.
3. The effect of economic growth on the aggregate saving rate increases with borrowing constraints, i.e., $s_{12} > 0$ where $s_{12}$ is the cross partial-derivative of $s$ with respect to the first and the second argument.

The theorem predicts the equilibrium relationships between the aggregate saving rate, output and the borrowing constraint. In other words, we predict how the aggregate saving rate is affected by outputs and borrowing constraints when they are predetermined. Let us explain the mechanism behind the first prediction. Note that $S_t = S_t z_t + (1 - S_t) x_t$ and thus

$$s_t = (1 - \alpha) \left( S_t \cdot \left( \frac{z_t}{w_t} - \beta \right) + \beta \right).$$

There are effects at extensive and intensive margins as income rises: (1) the fraction of entrepreneurs in the population, $S_t$, rises and (2) the saving rate of entrepreneurs, $z_t / w_t$, falls. Since the saving rate of entrepreneurs exceeds that of workers, the first effect causes the aggregate saving rate to rise. However, the second effect causes it to fall. Due to concavity of the saving of entrepreneurs in income, the first effect dominates at low income levels, whereas the second effect eventually dominates. Once incomes become high

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7 In steady state the aggregate saving rate and output depend on the borrowing constraint only.

8 Proposition 2 in Appendix A shows that $S(w, \lambda)$ is strictly increasing in $w$ and Proposition 1 implies that $Z(w, \lambda)/w$ is strictly decreasing in $w$. 

9
enough so that the borrowing constraints no longer bind, the aggregate saving rate becomes constant. This prediction is not generated by previous models such as Japelli and Pagano (1994).

The second prediction was obtained and tested with macroeconomic data in Japelli and Pagano (1994) where the positive effect of borrowing constraints on aggregate saving rates arises because borrowing constraints reduce consumption. In our model, in contrast, the positive effect arises because borrowing constraints encourage entrepreneurial saving.

The third prediction simply follows from the first two properties of the aggregate saving rate. In other words, borrowing constraints are a mediating factor with regards to the impact of economic growth on the aggregate saving rate. Figure 3 illustrates the three predictions of our theoretical model.

![Figure 2: Hump-shaped aggregate saving rate w.r.t income: $\beta = 0.41, \alpha = 0.33$](image)

We delegate the analysis of dynamics to Appendix C as income is a predetermined variable in equilibrium and its evolution is not relevant for our theoretical predictions. The economy may be in different transition paths to a steady state or to different steady states. This is captured in the following econometric models by controlling for country fixed effects.

4 Empirical Analysis

This section tests the three key predictions of our theoretical model in Theorem 3: (1) a change in a country’s income may increase or decrease the change of the domestic sav-
ing rate depending on the level of the country’s initial income; (2) increases in borrowing constraints have a positive effect on the domestic saving rate; (3) tighter borrowing constraints increase the effect of a change in income on the change in the domestic saving rate. In order to test the theoretical predictions we need macroeconomic data for a large sample of countries. We obtain data on domestic saving 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). The sample consists of 130 countries during the period 1960-2007. For a list of countries in the sample see Table 5 in Appendix D.

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

We begin the empirical analysis by estimating the average marginal effect that changes in GDP per capita and borrowing constraints have on changes in domestic saving. The econometric model is:

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

(11)

where $\Delta \ln(s_{it})$ is the year $t - 1$ to $t$ change in the log of the domestic saving rate; $\Delta \ln(y_{it})$ is the year $t - 1$ to $t$ change in the log of real GDP per capita; $\Delta \ln(\lambda_{it})$ 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 saving rate, GDP per capita, and the GDP share of domestic credit to the private sector so that $\gamma$ and $\theta$ capture the average elasticity response of the domestic saving rate with respect to income and borrowing constraints, respectively.

We show how the econometric model specification in (11) 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 em-

9Total credit is $(1 - S_t)\beta w_t$, which is the amount of funds lend by workers 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 $\lambda$, the total credit to GDP rate and the parameter $\lambda$ are positively related for any fixed value of $w_t$.

10The theoretical equation (10) relates the saving rate to the level of GDP. Since the equation holds in levels it must also hold in growth rates. Due to non-stationarity of time series of incomes and saving rates we consider a difference in differences approach for our regression analysis.
4.1.1 Motivation of Econometric Model Specification

Taking natural logarithms of both sides of the equation \( \ln s(y_t, \lambda_t) = \ln(1 - \alpha) + \ln \beta - \ln (1 - Z((1 - \alpha)y_t, \lambda_t) + \beta(1 - \alpha)y_t) \). Let \( \Delta \ln s_t := \ln s_t - \ln s_{t-1} \). For small values of \( \Delta \ln y_t \) and \( \Delta \ln \lambda_t \), we then obtain\(^{11}\)

\[
\Delta \ln s_t \approx \gamma_{t-1} \Delta \ln y_t + \theta_{t-1} \Delta \ln \lambda_t
\]

where

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

\[
\theta_{t-1} := \frac{\partial \ln s(y_{t-1}, \lambda_{t-1})}{\partial \lambda_{t-1}} = \frac{\lambda_{t-1}Z_2((1-\alpha)y_{t-1}, \lambda_{t-1})}{1 - Z_1((1-\alpha)y_{t-1}, \lambda_{t-1}) + \beta(1-\alpha)y_{t-1}}.
\]

Suppose that the parameters do not vary significantly over time (we will test this hypothesis in Section 4.1.3). Then we can write (12) for a panel of \( i = 1...N \) countries as

\[
\Delta \ln s_{it} \approx \gamma_i \Delta \ln y_{it} + \theta_i \Delta \ln \lambda_{it}.
\]

The above equation shows that the within-country change in the log of the saving rate should be related to the within-country changes in the logs of \( y \) and \( \lambda \). In (11) \( \gamma \) and \( \theta \) thus capture the average elasticity effect of a marginal within-country change in incomes and in borrowing constraints on the domestic saving rate. Stated in a different way, \( \gamma \) and \( \theta \) are sample mean elasticity effects. We will check in Section 4.1.3 whether our restricted panel data model in (11) 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 \( Z_2((1 - \alpha)y_i, \lambda_i) < \beta \) for relatively high values of \( y_i \). It follows that \( \gamma_i \) is positive (negative) for low (high) values of \( y_i \) and any fixed value of \( \lambda_i \). The average elasticity effect of income on the domestic saving 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 \( \theta_i \) is negative for any fixed value of \( y_i \) and \( \lambda_i \). Hence, our model unambiguously predicts that the elasticity effect of weaker borrowing constraints on the domestic saving rate is negative.

\( ^{11} \)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 \( \Delta \ln x_t = \ln x_t - \ln x_{t-1} \approx \frac{x_t - x_{t-1}}{s_{t-1}} \), it follows that \( \ln g(x_t) \approx \ln g(x_{t-1}) + \frac{x_t - x_{t-1}}{s_{t-1}} \Delta \ln x_t \).
4.1.2 Discussion of Identification Issues

An important empirical issue in the estimation of (11) is the endogeneity of national income and borrowing constraints. Endogeneity biases could arise because within-country changes in the domestic saving rate itself affect GDP per capita growth and borrowing constraints or because of time-varying omitted variables that affect the domestic saving 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 saving).

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

Following the 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. 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 $\gamma$ captures the effect that a persistent shock to countries’ GDP per capita has on the domestic saving 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 depending 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.

12See Brueckner et al. (2012, a, b). For an application of this IV strategy to US states, see Acemoglu et al. (2012).
\[ \Delta \ln(\text{s}_{it}) \]

<table>
<thead>
<tr>
<th>IV</th>
<th>IV</th>
<th>IV</th>
<th>IV</th>
<th>MG</th>
<th>LS</th>
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<td>2.50***</td>
<td>2.43***</td>
<td>2.47***</td>
<td>2.12***</td>
<td>1.82***</td>
<td>1.52***</td>
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<td>(0.83)</td>
<td>(0.71)</td>
<td>(0.20)</td>
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<td>-0.22**</td>
<td>-1.23*</td>
<td>-0.98**</td>
<td>-0.26***</td>
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<td>(0.09)</td>
<td>(0.10)</td>
<td>(0.68)</td>
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<td>(0.07)</td>
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Kleibergen-Paap F-stat
283.67
Cragg-Donald F-stat
19.60
Endogenous Regressors
\( \Delta \ln(y_{it}) \), \( \Delta \ln(\lambda_{it}) \), \( \Delta \ln(\text{s}_{it} - 1) \)
Instruments
\( \text{OPS}_{it} \), \( \text{OPS}_{it} \), \( \text{OPS}_{it} \), \( \text{OPS}_{it} \)

Table 1: Effects of income and borrowing constraints on domestic saving rates

We use lagged borrowing constraints as an internal instrument for current borrowing constraints. Domestic saving has a possible contemporaneous effect on countries’ borrowing constraints. Using the lagged variable as an instrument should reduce concerns that our within-country estimate of \( \theta \) is inconsistent. Moreover, the first difference specification eliminates omitted variables bias arising from time-invariant cross-country differences in historic and geographic variables that may be affecting both domestic saving rates and borrowing constraints.

### 4.1.3 Empirical Results

Table 1 presents our baseline estimates of the average marginal elasticity effect that changes in income \( (y) \) and borrowing constraints \( (\lambda) \) have on changes in domestic saving 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 income on average increases significantly the change in the domestic saving rate; increases in the change of borrowing constraints also have a significant positive effect on the change in
the domestic saving rate. Specifically, the IV estimates in column (1) show that 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 saving 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.

Columns (5) and (6) show that the MG and LS estimates of $\theta (\gamma)$ 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 sample large oil importing and exporting countries (column (1)); excluding the top and bottom 1st percentile of the change in the domestic saving 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)). The main result from these robustness checks is that the estimated coefficient of $\theta (\gamma)$ is negative (positive) and significantly different from zero at the conventional significance levels.

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

\[13\] In the dynamic panel regression we instrument the lagged dependent variable following Bond et al. (2010).

\[14\] Table 4 in Appendix D shows first stage effects of the oil price instrument on GDP per capita growth across these robustness checks.
### Table 2: Effects of income and borrowing constraints on domestic saving rates (robustness to excluding outliers; excluding large oil importers and exporters; using initial oil net-export GDP shares; time-period split)

<table>
<thead>
<tr>
<th>Regressors</th>
<th>(1) Excluding large importers &amp; exporters</th>
<th>(2) Excluding top/bottom 1st percentile</th>
<th>(3) Using initial oil net-export share</th>
<th>(4) Pre-1990</th>
<th>(5) Post-1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ ln(y_it)</td>
<td>4.40***</td>
<td>2.31***</td>
<td>2.27***</td>
<td>2.04**</td>
<td>3.23***</td>
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<td></td>
<td>(1.44)</td>
<td>(0.57)</td>
<td>(0.71)</td>
<td>(0.98)</td>
<td>(0.83)</td>
</tr>
<tr>
<td>Δ ln(λ_it)</td>
<td>-0.20*</td>
<td>-0.17**</td>
<td>-0.16**</td>
<td>-0.43*</td>
<td>-0.25**</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.09)</td>
<td>(0.07)</td>
<td>(0.22)</td>
<td>(0.10)</td>
</tr>
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<td>Kleibergen-Paap F-stat</td>
<td>13.10</td>
<td>16.80</td>
<td>17.87</td>
<td>9.41</td>
<td>169.33</td>
</tr>
<tr>
<td>Cragg-Donald F-stat</td>
<td>70.11</td>
<td>282.15</td>
<td>268.30</td>
<td>134.12</td>
<td>261.13</td>
</tr>
<tr>
<td>Endogenous Regressors Δ ln(y_it) Δ ln(y_it) Δ ln(y_it) Δ ln(y_it) Δ ln(y_it)</td>
<td></td>
<td></td>
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</tr>
<tr>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>3034</td>
<td>3362</td>
<td>3721</td>
<td>2075</td>
<td>1622</td>
</tr>
</tbody>
</table>

Note: The dependent variable, Δ ln(s_it), is the change in the log of the domestic saving rate. Δ ln(y_it) is the change in the log of real GDP per capita; Δ ln(λ_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 Δ 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.

#### 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 domestic saving rates. In particular, from Figure [2](#) the following two predictions arise:

- The marginal effect of growth in national income on the domestic saving rate is larger in poorer countries.
- The marginal effect of growth in national income on the domestic saving rate is larger in countries with more severe credit market imperfections.
Testing these predictions requires an interaction model:\ref{footnote15}

\[ \Delta \ln(s_{it}) = \gamma' \Delta \ln(y_{it}) + \delta(\Delta \ln(y_{it}) \ast \lambda_i) + \zeta(\Delta \ln(y_{it}) \ast y_{it}) + \theta' \Delta \ln(\lambda_{it}) + a'_i + b'_i + u'_it \]

We use countries’ period average GDP shares of domestic credit to the private sector, \( \lambda_{it} \), 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 a change in income on the change in the domestic saving rate. Note that we construct the interaction term as \( \Delta \ln y_{it} \ast \lambda_i \). Likewise we construct the second interaction that captures the effect of a change in income on the change in the domestic saving rate differs between rich and poor countries as \( \Delta \ln(y_{it}) \ast y_i \), where \( y_i \) is a country’s average GDP per capita. The particular construction of the interaction terms implies that the coefficient \( \gamma' \) captures the predicted marginal effect of income on the domestic saving rate when \( \lambda_i \) and \( y_i \) are zero.

### 4.2.2 Discussion of Empirical Results

Table\ref{table3} presents the estimates from the above interaction model. We begin by reporting in column (1) estimates from a more parsimonious version of the interaction model that only has as interaction term \( \Delta \ln(y_{it}) \ast \lambda_i \). In this model specification, the estimate of \( \gamma' \) captures the predicted marginal effect of a change in income on the change in the domestic saving rate when \( \lambda_i = 0 \). Our obtained estimate of \( \gamma' \) is 6.2 and its standard error is 1.3. Thus, the estimate of \( \gamma' \) is positive and significantly different from zero at the 1 percent level. The estimate of \( \delta \) is around -10.8 (s.e. 3.1) hence negative and significantly different from zero at the 1 percent level. The significant negative \( \delta \) indicates that

\[ F(y, \lambda) \equiv y \frac{\partial \ln(s(y, \lambda))}{\partial y} = \frac{(1-\alpha)(y(Z(1-\alpha)y, \lambda) - \beta)}{1 - Z((1-\alpha)y, \lambda) + \beta(1-\alpha)y} \]

\( \hat{\gamma} \) be the unique solution to \( Z(1/(1-\alpha)y, \lambda) = \beta \) and \( \hat{\lambda} \) be the cross-country average of \( \lambda_i \). The functional form of the interaction model can be derived from our theoretical model by applying the following first-order Taylor expansion

\[ \gamma_i = F(y_{it}, \lambda_i) \approx F(\hat{y}, \hat{\lambda}) + F_1(\hat{y}, \hat{\lambda}) \Delta \ln(\lambda_{it}) + F_2(\hat{y}, \hat{\lambda})(\lambda_i - \hat{\lambda}). \]

Substituting the above expression in (13) yields the following relationship between the change in the log of the saving rate and the change in the log of national income and the change in the log of the borrowing constraint:

\[ \Delta \ln s_{it} = (\gamma' + \delta \lambda_i + \zeta y_{it}) \Delta \ln y_{it} + \theta' \Delta \ln \lambda_{it} \]

where \( F(\hat{y}, \hat{\lambda}) = 0, \gamma' = -\hat{\gamma}F_1(\hat{y}, \hat{\lambda}) - \hat{\lambda}F_2(\hat{y}, \hat{\lambda}), \zeta = F_1(\hat{y}, \hat{\lambda}) \) and \( \delta = F_2(\hat{y}, \hat{\lambda}) \). Note that \( F_1(\hat{y}, \hat{\lambda}) = \frac{(1-\alpha)\beta Z_{it}(1/(1-\alpha)\hat{y}, \hat{\lambda})}{1 - Z((1-\alpha)\hat{y}, \hat{\lambda}) + \beta(1-\alpha)\hat{y}} < 0 \) and \( F_2(\hat{y}, \hat{\lambda}) = \frac{(1-\alpha)\beta Z_{it}(1/(1-\alpha)\hat{y}, \hat{\lambda})}{1 - Z((1-\alpha)\hat{y}, \hat{\lambda}) + \beta(1-\alpha)\hat{y}} < 0 \). 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 saving rate is larger in countries with low income and more severe credit market imperfections.

\[ 17 \]
the marginal effect of a change in income on the change in the domestic saving 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 $\Delta \ln (\lambda_{it})$ on $\Delta \ln (s_{it})$ 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 $\Delta \ln (y_{it}) \times y_i$. In this model specification, the estimate of $\gamma'$ captures the predicted marginal effect of a change in income on the change in the domestic saving rate when $y_i = 0$. We find that $\gamma'$ is 4.8 and its standard error is 1.2. Thus, the estimate of $\gamma'$ is positive and significantly different from zero at the 1 percent level. The estimate of $\zeta$ is -0.13 (s.e. 0.05) hence negative and significantly different from zero at the 5 percent level. The significant negative $\zeta$ indicates that the percent effect of a change in income on the change in the domestic saving rate is significantly higher in poor countries. Column (4) shows that this result also holds when we control for the direct effect of $\Delta \ln (\lambda_{it})$ on $\Delta \ln (s_{it})$ which continues to be negative and significant at the 5 percent level.

Table 3: Interactions between changes in income, poverty and changes in borrowing constraints
In columns (5) and (6) we present estimates from the full-fledged econometric model that includes both interaction terms, $\Delta \ln(y_{it}) \times y_i$ and $\Delta \ln(y_{it}) \times \lambda_i$. In this model, the estimates of $\delta$ and $\zeta$ capture conditional interaction effects. That is, $\zeta$ captures how the percent effect of a change in income on the change in the domestic saving rate varies across poor and rich countries when holding borrowing constraints, $\lambda_i$, constant. Likewise, $\delta$ captures how borrowing constraints affect the percent effect of a change in income on the change in the domestic saving rate when holding average income, $y_{it}$, 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 saving rate through borrowing constraints is shut down. And any effect that borrowing constraints may have on the percent effect of a change in income on the change in the domestic saving rate through the average level of income, $y_{it}$, 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 $\gamma'$ that captures the predicted percent effect of a change in income on the change in the domestic saving rate when both $y_i = 0$ and $\lambda_i = 0$ is 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 $\lambda_i$ and $y_i$, say, those at the bottom 5th percentile ($y_i = 0.6$ and $\lambda_i = 0.07$). For computing the predicted percent effects we need to take into account that the estimates of $\delta$ and $\zeta$ 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 is predicted to increase the domestic saving rate by around 6.1 percent (s.e. 1.1). This is a large effect. For higher values of $y_i$ and $\lambda_i$ the effect is considerably smaller. 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 percent effect of a change in income on the change in the domestic saving rate can be negative for sufficiently high values of $y_i$ (and $\lambda_i$). This is illustrated in Figure 3 where we plot for different values of $\lambda_i$ the predicted percent effect of a change in income on the change in the domestic saving rate over the sample range of $y_i$.

To summarize: In poor countries a change in income leads to a significant increase in the domestic saving rate. In rich countries and countries where borrowing constraints are not severe the opposite is the case. The results provide evidence in support of theoretical

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16Note 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.
Note: The figure plots the predicted marginal effect of growth in national income on the within country changes in aggregate saving rates for different values in GDP per capita \(y\) and GDP shares of domestic credit to the private sector \(\lambda\). The figure is based on the estimates in column (6) of Table 3.

Figure 3: Predicted percent effect of a change in income on the change in the domestic saving rate for different levels of average GDP per capita and GDP shares of domestic credit to the private sector.

predictions (1) and (3).

5 Summary and Conclusions

We have studied a two-period OLG model where entrepreneurs are borrowing constrained and investment projects are indivisible. The borrowing constraint creates rents for entrepreneurs. The fixed investment size does not permit all agents to obtain credit to finance their desired 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 saving to increase less than proportionally with income. The saving behavior of entrepreneurs leads to the following, empirically testable predictions: (1) The domestic saving rate is hump-shaped in income; (2) the domestic saving rate monotonically increases with borrowing constraints; (3) the effect that a change in income has on the domestic saving 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 countries’ incomes have a significant positive effect on changes in the logs of domestic saving rates in poor countries; however, in rich countries the effect is of opposite sign (i.e. negative). Consistent with the previous literature (i.e. Japelli and Pagano, 1994) and the model’s second prediction, the empirical analysis also revealed that changes in the logs of the GDP shares of domestic credit to the private sector have a significant negative effect on changes in the logs of the domestic saving rates. In addition, the empirical analysis showed that the effect of changes in the logs of countries’ incomes on changes in the logs of domestic saving 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. For example we assumed (1) log-utility, (2) a fixed investment size and (3) an autarky. Log-utility implies that the saving rate of workers is constant while that of entrepreneurs depends only on income and the severity of the borrowing constraint. The fact that the saving rate is independent of the interest rate makes the model tractable and yields sharp predictions. This assumption could be potentially weakened. Without a minimum investment requirement the model reduces to a standard OLG model with constant saving rates. The model would remain intact if there were (exogenous) simultaneous changes in both technology and the minimum investment size. It remains as future research to investigate how robust our findings are in an open economy.

A Remaining Proofs

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

$$e(w, \lambda) = \frac{w S_1(w, \lambda)}{S(w, \lambda)} = \begin{cases} 
\frac{1 - \beta S(w, \lambda)(1 - S(w, \lambda))}{\beta w - S(w, \lambda)} & \text{if } w_t < \frac{1 - \lambda}{\beta} \\
1 & \text{if } w_t \geq \frac{1 - \lambda}{\beta}
\end{cases}$$

Moreover, $\lim_{w \to 0} S_1(w, \lambda) = \beta$ and $S_1(\frac{1 - \lambda}{\beta}, \lambda) = \lambda \beta$ where $S_1$ is the derivative of $S$ with respect to its first argument.

**Proof.** Using $S_t(1 - z_t) = (1 - S_t)x_t$ to substitute out $z_t$ in (7) and taking exponentials, $(\frac{\lambda}{1 - \lambda})^{\frac{\beta}{1 - \beta}} = (\frac{\beta}{1 - \beta} \frac{1 - S}{S} - \frac{1 - \lambda}{1 - \beta} \frac{1 - w}{w})(\frac{1 - S}{S})^{\frac{\beta}{1 - \beta}}$. Implicitly differentiating this equation we ob-
tain the elasticity of saving with respect to the wage. From (9), \( S_1(w, \lambda) = \frac{\beta}{1 - Z(w, \lambda) + \beta w} (1 + w(Z_1(w, \lambda) - \lambda)) \). Since \( \lim_{w \to 0} Z_1(w, \lambda) = 1 \), it follows that \( \lim_{w \to 0} S_1(w, \lambda) = \beta \). Substituting \( S(w, \lambda) = w\beta \) into (14), \( S_1(\frac{1-\lambda}{\beta}, \lambda) = \lambda\beta \).

The following proposition links the properties of the saving function of entrepreneurs to the aggregate saving rate.

**Proposition 3.** The aggregate saving rate obtains its maximum when \( Z_1((1 - \alpha)y, \lambda) = \beta \).

**Proof.** From (9), \( \frac{S_1}{w} = \frac{\beta}{1 - Z(w, \lambda) + \beta w} \) if \( w < \frac{1}{\beta} \). Hence, \( S_{11}(w, \lambda) = \frac{\beta(Z_1(w, \lambda) - \beta)}{(1 - z + \beta w)^2} = 0 \iff Z_1(w, \lambda) = \beta \).

**Proof of Proposition 7** We assume that \( \beta w < 1 \) and consider two cases separately. Suppose that the borrowing constraint (1) is not binding, i.e., \( z_t = \beta w_t - (1 - \beta) \frac{Rf'(k_{t+1}) - r_{t+1}}{r_{t+1}} \). Rearranging we obtain

\[
\frac{Rf'(k_{t+1})}{r_{t+1}} = 1 + \frac{\beta w_t - z_t}{1 - \beta}. \tag{15}
\]

This with (5) implies that \( z_t \) solves

\[
\beta \frac{(w_t - z_t)}{(1 - \beta) x_t} \left( \frac{w_t - z_t}{w_t - x_t} \right)^{\frac{1-\beta}{\beta}} = 1. \tag{16}
\]

One can easily verify that (16) admits a unique solution at \( z_t = x_t \). This with \( x_t = \beta w_t \) and with (15) implies that \( r_{t+1} = Rf'(k_{t+1}) \). Lastly, \( \beta w_t \geq 1 - \lambda \) must hold since

\[
\beta w_t = \beta w_t - (1 - \beta) \frac{Rf'(k_{t+1}) - r_{t+1}}{r_{t+1}} \geq 1 - \frac{\lambda Rf'(k_{t+1})}{r_{t+1}} = 1 - \lambda.
\]

Suppose that the borrowing constraint (1) is binding, i.e., \( z_t = 1 - \frac{\lambda Rf'(k_{t+1})}{r_{t+1}} \). Rearranging we obtain

\[
\frac{Rf'(k_{t+1})}{r_{t+1}} = \frac{1 - z_t}{\lambda}. \tag{17}
\]

This with (5) implies that \( z_t \) must solve

\[
1 = \frac{1 - \lambda}{\beta w} \frac{1 - z}{(1 - \beta)w} \left( \frac{w - z}{w - x} \right)^{\frac{1-\beta}{\beta}} := \Delta(z, w, \lambda).
\]

(a) If \( \beta w_t = 1 - \lambda \) then \( z_t = 1 - \lambda \), which with (17) implies that \( r_{t+1} = Rf'(k_{t+1}) \). This is consistent with (4) because \( 1 - \lambda = \max\{\beta w_t, 1 - \lambda\} \).
(b) If \( \beta w_t > 1 - \lambda \) then \( z_t < 1 - \lambda \), which with (17) implies that \( R f'(k_{t+1}) \). This contradicts (4) because if \( r_{t+1} < R f'(k_{t+1}) \) then

\[
z_t > \beta w_t - (1 - \beta) \frac{R f'(k_{t+1}) - r_{t+1}}{r_{t+1}} > \beta w_t.
\]

(c) If \( \beta w_t < 1 - \lambda \) then there exists a unique \( z_t \in (\beta w_t, 1 - \lambda) \) solving \( \Delta(z, w, \lambda) = 1 \) because

\[
\Delta(\beta w, w, \lambda) = \frac{1 - \lambda}{\lambda} \frac{1 - \beta}{\beta w} > 1 \quad \text{and} \quad \Delta(1 - \lambda, w, \lambda) < 1. \tag{18}
\]

Let \( Z(w, \lambda) \) denote the solution. One can easily establish that \( \Delta_1 < 0, \Delta_2 > 0 \) and \( \Delta_3 < 0 \) for \( 0 < \beta w < z < 1 - \lambda < 1 \). As a result, we obtain that \( Z_1 > 0 \) and \( Z_2 < 0 \). By differentiating both sides of the identity \( \Delta(Z(w, \lambda), w, \lambda) \equiv 1 \), we obtain that

\[
Z_1(w, \lambda) = \frac{1 - Z(w, \lambda)}{1 - \beta - (Z(w, \lambda) - \beta w)} \left( \frac{Z(w, \lambda) - \beta w}{w} - \beta \right). \tag{19}
\]

Since \( \lim_{w \downarrow 0} Z(w, \lambda) = 0 \) and \( \lim_{w \uparrow 1 - \lambda} Z(w, \lambda) = 1 - \lambda \), the boundary conditions follow from (19). Differentiating both sides of (19) and using (19) we can show that \( Z_{11}(w, \lambda) < 0 \).

\[\square\]

### B Flexible Investment Size

This section demonstrates that we can relax our assumption of the fixed investment size and still obtain essentially the same model. Suppose that capital is produced by the following technology

\[
F(i_t) = \begin{cases} 
0 & \text{if } i_t < I \\
R_i & \text{if } i_t \geq I
\end{cases}
\]

where \( i_t \) is the investment of the final good, \( F(i_t) \) is the produced amount of capital, and \( I \) is the minimum investment size. Entrepreneurs maximize \( 2 \) subject to \( c_{t+1} = w_t - z_t, \)

\[
c_{t+1} = F(i_t) f'(k_{t+1}) - (1 - z_t) r_{t+1}, \quad z_t \in [0, w_t], \quad \text{and} \quad r_{t+1}(i_t - z_t) \leq \lambda R f'(k_{t+1}).
\]

The solution gives us entrepreneur’s optimal saving

\[
z_t = \max \left\{ \beta w_t - (1 - \beta) \frac{R f'(k_{t+1}) - r_{t+1}}{r_{t+1}}, I - \frac{\lambda R f'(k_{t+1})}{r_{t+1}} \right\}. \tag{20}
\]

Now, we can follow the same procedure as in the proof of Proposition 1. We obtain \( z_t = x_t = \beta w_t \) when \( \beta w_t \geq I(1 - \lambda) \) (The profitability constraint is binding) and \( z_t =
\( I \times Z(w_t/I, \lambda) \) when \( \beta w_t < I(1 - \lambda) \) (The borrowing constraint is binding).

The aggregate saving \( S_t \) is

\[
S_t = \begin{cases} 
\frac{\beta w_t}{1 - I \times Z(w_t/I, \lambda) + \beta w_t} & \text{if } w_t < \frac{I(1-\lambda)}{\beta} \\
\beta w_t & \text{if } w_t \geq \frac{I(1-\lambda)}{\beta}
\end{cases}
\]

and the saving rate is \( s_t = \frac{S_t}{y_t/I, \lambda} \). We see that the properties of \( s_t \) characterized in Theorem \( \text{II} \) is preserved. With no minimum investment, i.e., \( I = 0 \), then \( \beta w_t \geq I(1 - \lambda) \) holds automatically for any \( w_t \) and therefore \( z_t = x_t = \beta w_t \).

C Dynamics

This section completely characterize the dynamics. We describe how income evolves over time and the welfare in the long run. In contrast to Matsuyama (2004), multiple steady states can arise because entrepreneurs adjust their saving in response to borrowing constraints.

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

\[
w_{t+1} = W(RS(w_t, \lambda)) \tag{21}
\]

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 \( w_t \in \left(0, \frac{1}{\beta} \right) \), \( S(w_t, \lambda) \in (0, 1) \) and \( w_{t+1} = W(RS(w_t, \lambda)) \in (0, W(R)) \subset \left(0, \frac{1}{\beta}\right) \). Hence, (21) defines a dynamical system on the state space \( (0, \frac{1}{\beta}) \). Under (21) 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

\[
R = \Pi(w, \lambda) := \frac{W^{-1}(w)}{S(w, \lambda)} \tag{22}
\]

We can easily verify that \( \Pi(0, \lambda) = 0, \Pi \left(\frac{1-\lambda}{\beta}, \lambda\right) = \frac{W^{-1}(1-\lambda)}{1-\lambda} \) and \( \Pi \left(\frac{1}{\beta}, \lambda\right) = R^+ \). These
conditions, with continuity of $\Pi$, 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 $w = W(\beta Rw)$. In the steady state $W^*(R)$ the borrowing constraint is not binding and all agents save equally.\footnote{Note that $R \geq \Pi((1-\lambda)/\beta) \iff W^*(R) > (1-\lambda)/\beta$. This implies that the borrowing constraint is less likely to bind in steady states for both high $R$ and $\lambda$.} 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 C.1 with a corresponding welfare analysis in Appendix C.2.

### C.1 Multiple Steady States

We first observe that $\Pi_1(w, \lambda) = 0$ 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.\footnote{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 $\frac{1}{1-\beta} \in (0, 1/2)$.} The corresponding level of credit market imperfections necessary for multiple steady states is shown in Figure 4. For $\alpha = 0.33, \lambda < 0.0002$ is necessary even for a sufficiently small $\beta$. For a higher value of $\alpha$ the necessary value for $\lambda$ declines, but even for $\alpha = 0.5$ and a sufficiently small $\beta, \lambda < 0.005$ 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 4](image)

**Figure 4:** 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 \( \phi^1(S(w,\lambda)) \cdot \phi^2(S(w,\lambda)) = \frac{\lambda}{1-\lambda} \). Where \( \phi^1(S) := 1 - \frac{\beta}{S + \alpha(1-\beta)(1-S)} \) and \( \phi^2(S) := \frac{1-\alpha}{S} \).

**Lemma 1.** \( \phi^1(S) = 0 \) admits a unique solution on \((S', 1)\) if \( \alpha > \beta \).

**Proof.** By definition \( 1 - \phi^1(S) = \frac{\beta}{S + \alpha(1-\beta)(1-S)} \) and thus

\[
\frac{\phi^1(S)}{1 - \phi^1(S)} = \frac{1 - \alpha}{S(1 - \alpha + \alpha S)} - \frac{\alpha(1 - \beta)}{\beta + \alpha(1 - \beta)(1-S)}.
\]

If \( \alpha > \beta \), then for \( S > S^c \), \( \phi^1(S) > 0 \) and

\[
\phi^1(S) = 0 \Leftrightarrow S(1 - \alpha + \alpha S) = \frac{1 - \alpha}{\alpha(1 - \beta)} (\beta + \alpha(1 - \beta)(1-S)).
\]

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 \((S^c, 1)\), \( \frac{1-\alpha}{\alpha(1-\beta)} < 1 \) must hold which is equivalent to \( \alpha > \beta \).

**Lemma 2.** Suppose \( \alpha > \beta \). Then \( \Pi \) 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 \( \alpha \leq \beta \). Suppose \( \alpha \leq \beta \). Then, \( \phi^1(S) < 0 \) for any \( S \in (0, 1) \). This implies that \( \phi^1(S) \times \phi^2(S) < 0 < (\lambda / (1 - \lambda))^{\frac{1-\beta}{\beta}} \) 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 \( \Pi \) 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 \( \lambda \geq \lambda^- \). 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, \( \phi^2 \) is positive and strictly increasing. Lemma 1 with continuity of \( \phi^1 \) and \( \phi^2 \) implies that \( \phi := \phi^1 \times \phi^2 \) has a unique maximum where \( \phi'(S) = 0 \). Let \( S^c \in (S^c, 1) \) denote the maximizer and \( \lambda^- := \phi(S^c)^{\frac{1-\beta}{\beta}} / (1 + \phi(S^c)^{\frac{1-\beta}{\beta}}) \). If \( \lambda < \lambda^- \), then \( \phi(S) = (\lambda / (1 - \lambda))^{\frac{1-\beta}{\beta}} \) admits exactly two solutions \( S^c < S^c \leq \lambda^- < S^c < S^c H(\lambda) < 1 \). It is clear that \( S^c \) is strictly increasing while \( S^c \) is strictly decreasing. If \( \lambda = \lambda^- \), then \( S^c(\lambda) \) and \( S^c H(\lambda) \) meet at \( S^c \) and they cease to exist for \( \lambda > \lambda^- \). If \( S^c(\lambda) \) 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 \( S(W^c_L(\lambda), \lambda) = S^c_L(\lambda) \) and \( S(W^c_H(\lambda), \lambda) = S^c_H(\lambda) \). 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 4.** Suppose $\alpha > \beta$. Then, there exist three steady states $W_L(\lambda, R) \in (0, W^c_L(\lambda))$, $W_M(\lambda, R) \in (W^c_L(\lambda), W^c_H(\lambda))$ and $W_H(\lambda, R) \in (W^c_H(\lambda), (1 - \lambda)/\beta)$ if and only if $\lambda \in (0, \lambda^-)$ and $R \in (\Pi(W^c_L(\lambda), \lambda), \Pi(W^c_H(\lambda), \lambda))$.

Figure 5 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 $R \in (\Pi(W^c_L(\lambda), \lambda), \Pi(W^c_H(\lambda), \lambda))$.

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 $(0, \beta)$ is divided into two disjoint regions $(0, W_M(\lambda, R))$ and $(W_M(\lambda, R), \beta)$ 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 saving 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 saving 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 in contrast to Matsuyama (2004).
C.2 Welfare

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 \( r^* = f'(\beta RW^*(R)) = \frac{\alpha}{\beta(1-\alpha)} \leq 1 \) and \( R < \Pi(\frac{1-\lambda}{\beta}, \lambda) \Leftrightarrow W^*(R) < W(\lambda, R) \)\(^{19}\)

Hence, a reduction of the credit market imperfection Pareto-improves the welfare for all generations because aggregate saving declines as \( \lambda \) 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 \( W(R, \lambda) \)\(^{20}\). 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 6: Life time utility in steady states: \( \beta = 0.41, \alpha = 0.33, R = 30 \)](image)

\(^{19}\)Reducing current investment would permit current consumption to rise at no cost of future consumption.

\(^{20}\)When \( \beta \leq \alpha \), multiple steady states may arise (Proposition 4). The welfare ranking and the wage ranking of the three steady states coincide.
Figure 6 shows how the lifetime 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 $R = \Pi(1 - \lambda, \lambda)$ and reducing $\lambda$ (i.e., increasing credit market imperfections) from that point increases the welfare level. In fact, there exists an optimal level of $\lambda$ that maximizes the long run welfare. Reducing $\lambda$ encourages the saving of entrepreneurs and thus the aggregate saving by raising permanent income and thus welfare. However, as aggregate saving grows the marginal product of capital and therefore the return to saving is reduced. Eventually, this negative effect outweighs the positive effects leading to a decline in welfare as the figure illustrates.

### D Tables

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<td>Poor Countries</td>
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<td>0.98***</td>
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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
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<th>Country</th>
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<th>Credit/GDP (λ)</th>
<th>Country</th>
<th>GDP p.c. ((\text{y}^{\text{in Thousands}}))</th>
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Table 5: List of countries
References


