

Endogenous Borrowing Constraints and Stagnation in Latin America

Paulina Restrepo-Echavarria*

University of California Los Angeles

February 12, 2010

Abstract

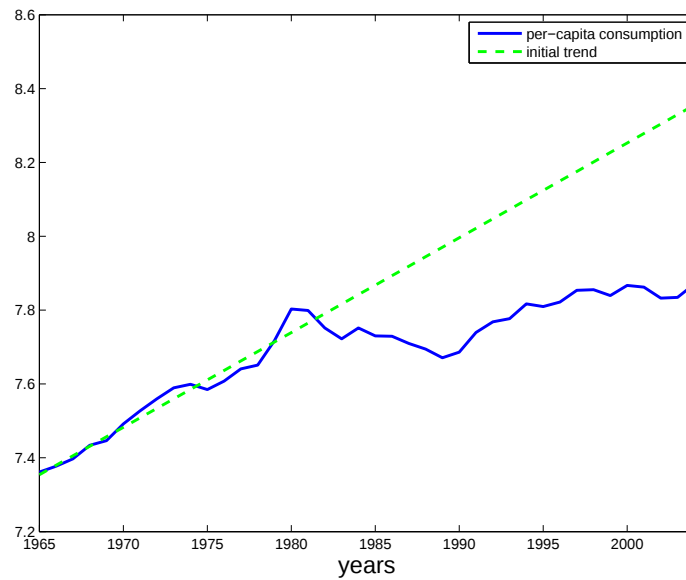
Latin America has had striking changes in economic performance over time. None more striking than consumption. Consumption per-capita in the year 2004 was roughly the same as it was in 1980. Latin America is also an open economic region, with several international debt crises. This paper studies the time path of consumption using a small open economy real business cycle model with limited commitment. I compare the distortions to the planner's pareto weights and investment that are generated endogenously by the model, to those that can be recovered from an international extension of a business cycle accounting exercise in the spirit of Chari, Kehoe and McGrattan (2007). I find that the limited commitment model does a good job at explaining the behavior of Latin American consumption and that the endogenous distortions to the planner's pareto weights are very similar to those recovered from the accounting exercise.

*I thank Cristina Arellano, Yan Bai, Francisco Buera, Ariel Burstein, Roger Farmer, Jonathan Heathcote, Hanno Lustig, Fabrizio Perri, Andrea Raffo and Pierre-Olivier Weill for helpful conversations. As well as attendants of the Macro Rookie Conference at the Federal Reserve Bank of Chicago and the Macro Economics Proseminar at UCLA. I am especially grateful with Andrew Atkeson, Christian Hellwig, Ellen McGrattan, and Mark Wright for their invaluable time and comments. Finally, I am specially indebted to Lee Ohanian for all his time, comments and support. All errors are my own. Contact: paur@ucla.edu

1 Introduction

Consumption per-capita in the year 2004 was roughly the same as it was in 1980. Specifically, per-capita consumption grew at a rate of 2.8% from 1950 to 1980, it then suffered a decline from 1980 to 1990 where it had a negative growth rate of -0.02% , and after 1990 it picked up again with a growth rate of 1.4%.

Figure 1: Logarithm of per-capita consumption in Latin America 1950-2004



This behavior is puzzling. The blue line in Figure 1 shows the logarithm of per-capita consumption in Latin America from 1950 to 2004. Extrapolating the trend for the first thirty years of the sample (the dashed green line) we see that per-capita consumption in 2004 should have been around 50% higher than it actually was.

When we think about what happened in the Latin American economy that might help explain this puzzling behavior of consumption, the main event that comes up is the Latin American debt crisis of the 1980's and the events that led to it.

External debt in Latin America went from \$75 billion in 1975 to more than \$314 billion in 1983, furthermore, debt service reached \$66 billion in 1982, compared to \$12 billion in 1975. At the same time in 1979, when the second oil shock occurred, the United States and other OECD nations reacted by increasing interest rates and tightening monetary policy. This hike in interest rates generated a widespread capital flight from Latin America. In 1982, Mexico announced that they would no longer be able to service their debt and as a result of this announcement most commercial banks reduced or halted new lending to Latin America, and creditors began demanding payment. Shut off from international credit, and having to transfer great amounts of resources abroad, Latin American countries slowly stopped honoring their debt.¹

This paper studies the time path of consumption using a small open economy real business cycle model with limited commitment. In the model the access to international capital markets depends on domestic productivity shocks and international interest rate shocks.

More specifically, the model is a standard one-sided limited commitment model. The rest of the world acts as a lender and is fully committed, and there is a small open economy country that has limited commitment. The rest of the world has linear utility on the transfers that it receives from the small country, and faces an exogenously given stochastic discount factor. The business cycle fluctuations are driven by shocks to productivity of the small open economy, and shocks to the stochastic discount factor of the big country (the international interest rate). I study the planning problem that maximizes the weighted sum of the expected discounted utilities of the big and small country, subject to a participation constraint for the small country—which requires that in each period and state, allocations can be enforced only if their value is greater than it would be if they were relegated to autarky.

In the model, productivity shocks have two effects. In the short run, high productivity shocks make the participation constraint more binding because they make the value of autarky more attractive. In the long-run, a long sequence of low productivity shocks run consumption down until the participation constraint binds. Shocks to the stochastic discount factor have the same effect in the long and in the short-run. High shocks make the constraint more likely to bind because they increase the relative impatience of the small country.

¹Institute of Latin American Studies “The Debt Crisis in Latin America”.

Latin America has been experiencing a sequence of low productivity shocks since the 1980's, which explain the negative consumption growth until the 1990's through a looser participation constraint. From 1990 on, there is a tighter participation constraint due to moderate international interest rate shocks, which explains the slow but positive growth.

Although the model is able to generate the behavior of aggregate consumption, it misses in a number of other aspects. When the participation constraint is introduced into the model, it endogenously generates two distortions. It distorts the relative wealth of the small country—the planner weight is time varying—, and it distorts the marginal product of capital—it generates an investment tax—. Implicitly, this time varying planner weight and the investment tax are driving the behavior of consumption, investment and net-exports. When the model fails to explain the data, it means that the planner weight and the investment tax generated by the model are not the correct ones.

Motivated by this, in the last section of the paper I take a more agnostic view at the problem. Instead of letting these distortions arise endogenously, I introduce into the first-order conditions of the model, an exogenous time varying planner weight, an exogenous investment tax and an exogenous labor income tax. The first two distortions are directly comparable to the ones that are endogenously generated by the limited commitment model. The distortion to labor income is not present in the limited commitment model, but it is important to identify the relevance of labor market frictions for explaining Latin American data.

To identify these distortions I use a methodology that takes the business cycle accounting idea used by Chari, Kehoe and McGrattan (2007, [7]) and extend it using recent Bayesian techniques for DSGE models.

I find that the planner weight generated by the limited commitment model behaves in a very similar way to that identified in the data. This result reinforces the idea that models with endogenous borrowing constraints are important for understanding the performance of the Latin American economy. The tax to investment that arises from the limited commitment model does not coincide with the investment tax identified from the data. This result was expected given that the limited commitment model does not do a good job at matching investment data. Finally, I find that the labor wedge plays an important role in Latin America, specially before 1970. The limited commitment model does not

generate any distortion on this margin so its not surprising that it is not able to fully capture the behavior of hours worked.

I follow the literature on international debt that relies on the willingness to pay as well as the literature on debt-constrained asset markets. On the international debt literature I follow, among others, Eaton and Gersovitz (1981, [11]) where a debtor who defaults faces permanent exclusion from international capital markets, and Atkeson (1991, [4]) who considers an environment where the participation constraint interacts with a moral hazard problem. The literature on debt-constrained asset markets has studied the theoretical implications of limited commitment constraints, but mostly in pure exchange, closed economy setups. This literature includes Kehoe and Levine (1993, [14]), Kocherlakota (1996, [15]) and Alvarez and Jermann (1996, [2]).

Kehoe and Perri (2002, [13]) go a step further and extend the work of Kehoe and Levine (1993, [14]) and Kocherlakota (1996, [15]), to a full-blown international business cycle model with production. They study business cycle co-movements across industrial countries. This paper is one of the few quantitative applications of these types of models.

This paper follows Kehoe and Perri (2002, [13]), I consider a two country production economy where market incompleteness arises endogenously. It is also closely related to Aguiar et al (Forthcoming, [1]). They consider a small open economy, where the government cannot commit to policy and seeks to insure a risk averse domestic constituency. The setup coincides in that the limited commitment is one-sided in the context of a small open economy. My paper differs in that the small open economy is subject to international interest rate shocks, which are represented by the stochastic discount factor, and labor supply is elastic.

The rest of the paper proceeds as follows: Section 2 summarizes the limited commitment model, Section 3 describes the methodology, Section 4 explains the model dynamics, Section 5 explains the calibration, Section 6 shows the results, Section 7 shows the business cycle accounting exercise, Section 8 compares the results of the limited commitment model with those of the business cycle accounting and the last section summarizes my findings.

2 The Limited Commitment Model

The economy is composed of a small open economy country, and a big country. The small country produces a good using domestic labor and capital, and production is subject to a country-specific productivity shock. Output is used for domestic consumption, domestic investment and to make a transfer of resources to the big country. This transfer can be positive or negative and can be interpreted as net-exports.

The big country has linear utility on the transfers received from the small country, and faces a stochastic discount factor which reflects the world interest rate. The business cycle fluctuations are driven by the country-specific productivity shock and by the stochastic discount factor for the big country.

Time is discrete and runs to infinity. In each period t , the state of the world, determined by the productivity and the stochastic discount factor shocks, s_t is realized. I denote by $s^t = (s_0, \dots, s_t)$ the history of events up to and including period t . The probability of any particular history s^t as of period 0, is given by $\pi(s^t)$, and the initial realization s_0 is such that $\pi(s_0) = 1$. In period t , a good is produced in the small country using inputs of capital $k(s^{t-1})$ and domestic labor $h(s^t)$. Production is also affected by a productivity shock $A(s^t)$ which follows an exogenous process. Output at history s^t in the small country is given by

$$A(s^t) F(k(s^{t-1}), h(s^t)) \quad (1)$$

where F is a standard constant returns to scale production function. Consumers in the small country have preferences given by

$$\sum_{t=0}^{\infty} \sum_{s^t} \tilde{\beta}^t \pi(s^t) u(c(s^t), h(s^t)) \quad (2)$$

where $c(s^t)$ denotes consumption at s^t and $\tilde{\beta}$ denotes the discount factor. The budget constraint of the small country is given by

$$c(s^t) + T(s^t) + x(s^t) \leq A(s^t) F(k(s^{t-1}), h(s^t)), \quad (3)$$

where $T(s^t)$ denotes the transfers made by the small country to the big country at s^t and $x(s^t)$ denotes

investment at s^t . Investment is determined by the capital-accumulation equation as follows

$$x(s^t) = k(s^t) - (1 - \delta)k(s^{t-1}). \quad (4)$$

The big country on the other hand faces the following utility function

$$\sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) Q(s^t) T(s^t), \quad (5)$$

where $\beta^t Q(s^t)$ denotes the stochastic discount factor, $Q(s^t) = q(s^0)q(s^1)\dots q(s^t)$, and $q(s^t)$ denotes the realization of the stochastic discount factor shock at s^t . Note that the discount factor β^t of the big country, differs from the discount factor $\tilde{\beta}^t$ of the small country. This means that even when $q(s^t)$ is at its unconditional mean, the big and the small country have different levels of impatience. This assumption will become important when the limited commitment is introduced.

In the absence of limited commitment the planner would maximize a weighted sum of the expected discounted utilities of the big and small country

$$\max_{\{k(s^t), h(s^t), c(s^t)\}} \left[\sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) Q(s^t) T(s^t) + \mu \sum_{t=0}^{\infty} \sum_{s^t} \tilde{\beta}^t \pi(s^t) u(c(s^t), h(s^t)) \right] \quad (6)$$

subject to the budget constraint (3) and the capital accumulation constraint (4) of the small country.

Now consider an economy where there is limited commitment on the side of the small country. In this case, apart from the budget and capital accumulation constraints, the small country faces a participation constraint. The participation constraint requires that at every point in time, the country prefers the allocation it receives by being in the contract and shipping $T(s^t)$ units of output to the big country, to the allocation it could attain if it were in autarky from then on. The participation constraint is of the form

$$E_t \sum_{r=t}^{\infty} \sum_{s^t} \tilde{\beta}^{r-t} \pi(s^r | s^t) u(c(s^r), h(s^r)) \geq V^A(k(s^{t-1}), s^t) \quad \forall r, s^r \quad (7)$$

where $\pi(s^r | s^t)$ denotes the conditional probability of s^r given s^t , $\pi(s^t | s^t) = 1$, and $V^A(k(s^{t-1}), s^t)$

denotes the value of autarky from s^t onward. The value of autarky corresponds to the utility delivered by the following problem:

$$V^A(k(s^{t-1}), s^t) = \max_{\{k(s^r), h(s^r), c(s^r)\}} \sum_{r=t}^{\infty} \sum_{s^r} \tilde{\beta}^{r-t} \pi(s^r | s^t) u(c(s^r), h(s^r))$$

subject to

$$c(s^r) + k(s^r) \leq A(s^r) F(k(s^{r-1}), h(s^r)) + (1 - \delta) k(s^{r-1}) \quad \forall r, s^r$$

where $r \geq t$, and $k(s^{r-1})$ is given.

In the context of limited commitment, the planner would maximize the weighted sum of the expected discounted utilities of the big and small country (6), subject to the participation constraint (7), the budget constraint (3) and the capital accumulation constraint (4) of the small country

$$\max_{\{k(s^t), h(s^t), c(s^t)\}} \left[\sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) Q(s^t) T(s^t) + \mu \sum_{t=0}^{\infty} \sum_{s^t} \tilde{\beta}^t \pi(s^t) u(c(s^t), h(s^t)) \right] \quad (8)$$

subject to

$$E_t \sum_{r=t}^{\infty} \sum_{s^r} \tilde{\beta}^{r-t} \pi(s^r | s^t) u(c(s^r), h(s^r)) \geq V^A(k(s^{t-1}), s^t) \quad \forall r, s^r,$$

$$c(s^t) + T(s^t) + x(s^t) \leq A(s^t) F(k(s^{t-1}), h(s^t)),$$

and

$$x(s^t) = k(s^t) - (1 - \delta) k(s^{t-1}).$$

Notice that the model with limited commitment has incomplete markets in the sense that there is a limit to the amount of contingent claims of a particular type that can be sold. The limit is determined by the amount the small country is willing to repay according to the participation constraint.

3 Methodology

Solving problem (8) can be complicated because it has an infinite number of enforcement constraints, which can have complicated binding patterns. Furthermore, given that consumption and leisure enter

the current enforcement constraint, the standard dynamic programming approach cannot be used.

Kydland and Prescott (1980, [16]) show that when this feature is present, the state space can be expanded to include an extra state variable, in this way the problem has a solution that is stationary in the new expanded state space. Marcet and Marimon (1999, [17]) follow Kydland and Prescott (1980, [16]) and extend their approach to different applications.

To solve the limited commitment model, I extend the recursive contract approach of Marcet and Marimon (1999, [17]) in a similar way to Kehoe and Perri (2002, [13]). The added state variable is the current relative weight of the small country in the planning problem. Adding this state variable, and assuming that the shocks to productivity and the stochastic discount factor are Markovian, allows me to write a recursive problem.

I can write the Lagrangian for problem (8) as follows

$$\begin{aligned} \max_{\{k(s^t), h(s^t), c(s^t)\}} & \sum_{t=0}^{\infty} \sum_{s^t} \beta^t Q(s^t) \pi(s^t) \{A(s^t) F(k(s^{t-1}), h(s^t)) - c(s^t) - k(s^t) + (1 - \delta) k(s^{t-1})\} \\ & + \mu \sum_{t=0}^{\infty} \sum_{s^t} \tilde{\beta}^t \pi(s^t) u(c(s^t), h(s^t)) \\ & + \sum_{t=0}^{\infty} \sum_{s^t} \tilde{\beta}^t \pi(s^t) \lambda(s^t) \left\{ \sum_{r=t}^{\infty} \sum_{s^r} \tilde{\beta}^{r-t} \pi(s^r | s^t) u(c(s^r), h(s^r)) - V^A(k(s^{t-1}), s^t) \right\}, \end{aligned}$$

where $\tilde{\beta}^t \pi(s^t) \lambda(s^t)$ denote the multipliers on the participation constraint.

Marcet and Marimon (1999, [17]) point out that given that we know that $\pi(s^r) = \pi(s^r | s^t) \pi(s^t)$ then we can define $\sum_{t=0}^{\infty} \tilde{\beta}^t \lambda_t \sum_{r=t}^{\infty} \tilde{\beta}^{r-t} u(c_r) = \sum_{t=0}^{\infty} \tilde{\beta}^t M_t u(c_t)$, where $M_t = M_{t-1} + \lambda_t$, $M_{-1} = 0$ and $\lambda(s^t)$ is the Lagrange multiplier associated with the participation constraint.

Given this, the participation constraint can be written as

$$\sum_{t=0}^{\infty} \sum_{s^t} \tilde{\beta}^t \pi(s^t) \{M(s^t) u(c(s^t), h(s^t)) - \lambda(s^t) V^A(k(s^{t-1}), s^t)\}$$

where $M_t = M_{t-1} + \lambda(s^t)$ and $M(s^{-1}) = \mu$. Hence, the Lagrangian can be re-written as

$$\begin{aligned} & \max_{\{k(s^t), h(s^t), c(s^t)\}} \sum_{t=0}^{\infty} \sum_{s^t} \beta^t Q(s^t) \pi(s^t) \{A(s^t) F(k(s^{t-1}), h(s^t)) - c(s^t) - k(s^t) + (1 - \delta) k(s^{t-1})\} \\ & + \sum_{t=0}^{\infty} \sum_{s^t} \tilde{\beta}^t \pi(s^t) \{M(s^{t-1}) u(c(s^t), h(s^t)) + \lambda(s^t) (u(c(s^t), h(s^t)) - V^A(k(s^{t-1}), s^t))\} \end{aligned} \quad (9)$$

where $M(s^t)$ is defined as the original planner weight for the small country μ , plus the sum of the past multipliers on the enforcement constraint along history s^t .

The optimality conditions of the model are summarized by

$$u_{c(s^t)} = \frac{\beta^t Q(s^t)}{\tilde{\beta}^t (M(s^{t-1}) + \lambda(s^t))}, \quad (10)$$

$$-u_{h(s^t)} = u_{c(s^t)} A(s^t) F_{h(s^t)}, \quad (11)$$

$$u_{c(s^t)} = \tilde{\beta} \sum_{s^{t+1}} \pi(s^{t+1}|s^t) \left[u_{c(s^{t+1})} \frac{M(s^{t+1})}{M(s^t)} (A(s^{t+1}) F_{k(s^t)} + 1 - \delta) - \frac{\lambda(s^{t+1})}{M(s^t)} V_{k(s^t)}^A \right] \quad (12)$$

and the complementary slackness condition. For computational convenience and following Kehoe and Perri (2002, [13]), I normalize the multiplier and define $v(s^t) = \frac{\lambda(s^t)}{M(s^t)}$. I also denote the right-hand side of equation (10) as

$$\frac{\beta^t Q(s^t)}{\tilde{\beta}^t (M(s^{t-1}) + \lambda(s^t))} = \frac{\beta^t Q(s^t)}{\tilde{\beta}^t M(s^t)} = \hat{M}(s^t). \quad (13)$$

By doing this transformation I don't have to keep track of all past realizations of q . I just need a transition law for $\hat{M}(s^t)$ which determines its evolution. This transition equation is given by

$$\hat{M}(s^t) = \frac{\beta^t}{\tilde{\beta}^t} q(s^t) (1 - v(s^t)) \hat{M}(s^{t-1}). \quad (14)$$

Using the normalization for the multiplier and (13), the first-order conditions can be re-written and summarized by (11),

$$\hat{M}(s^t) = u_{c(s^t)} \quad (15)$$

instead of (10),

$$u_{c(s^t)} = \tilde{\beta} \sum_{s^{t+1}} \pi(s^{t+1}|s^t) \left[\frac{u_{c(s^{t+1})}}{1 - v(s^{t+1})} (A(s^{t+1}) F_{k(s^t)} + 1 - \delta) - \frac{v(s^{t+1})}{1 - v(s^{t+1})} V_{k(s^t)}^A \right] \quad (16)$$

instead of (12), the transition law for $\hat{M}(s^t)$ and the complementary slackness conditions.

Note that (14) can be written in terms of consumption by using (15)

$$u_{c(s^t)} = \frac{\beta^t}{\tilde{\beta}^t} q(s^t) (1 - v(s^t)) u_{c(s^{t-1})}. \quad (17)$$

This substitution changes the nature of consumption within the model and transforms it from a control variable to a state variable. Hence the state is given by $x_t = (c(s^{t-1}), k(s^{t-1}), s_t)$, where $s = (A(s^t), q(s^t))$

I assume that the underlying shocks for productivity $A(s^t)$ and the stochastic discount factor $q(s^t)$ are Markov. This assumption implies that the conditional probability $\pi(s^t|s^{t-1})$ can be written as $\pi(s_t|s_{t-1})$, and the solution to the programming problem in (6) can be characterized recursively by policy rules for $k(s^t)$, $c(s^t)$, $h(s^t)$ and $v(s^t)$, where the state is x_t .

The policy rules satisfy the first-order conditions (11), (16), (17), the participation constraint (7) and the complementary slackness condition on the multiplier.

To calculate the policy functions I use a version of policy function iteration, and modify it to handle enforcement constraints in a similar way to Kehoe and Perri (2002, [13]). Specifically, I define a grid X on the state space. I restrict the search to functions that take arbitrary values for every $x \in X$ and are completely characterized over the state space when their value for every $x \in X$ is identified.

I define a value function for each country. $W(x)$ for the small country, and $P(x)$ for the big country. These value functions satisfy the first-order conditions (11), (16), (17), the participation constraint (7) and the complementary slackness condition on the multiplier, and are of the form

$$W(x) = u(c(x), h(x)) + \tilde{\beta} \sum_{s'} \pi(s'|s) W(x'), \quad (18)$$

$$P(x) = T(x) + \beta \sum_{s'} \pi(s'|s) q(x') W(x'). \quad (19)$$

I start with the solution to the planner's problem when there is no limited commitment (6). This guarantees that the initial value functions $W^0(x)$ and $P^0(x)$ are uniformly greater than or equal to the value of the true solution. This condition is needed for the algorithm to converge to the right solution.

Given the first-order conditions and the initial guess for labor, the normalized multiplier and the value functions $(h^0(x), v^0(x), W^0(x), P^0(x))$ I find a new set of policy functions

$$(k^1(x), c^1(x), h^1(x), v^1(x), W^1(x), P^1(x)).$$

To do so, I first assume that the participation constraint doesn't bind and find a set of allocations (h, c', k') . When the participation constraint doesn't bind $v = 0$, and the the set of allocations has to satisfy (11),

$$u_{c(s^t)} = \frac{\beta^t}{\tilde{\beta}^t} q(s^t) u_{c(s^{t-1})}, \quad (20)$$

and

$$u_{c(s^t)} = \tilde{\beta} \sum_{s^{t+1}} \pi(s^{t+1}|s^t) u_{c(s^{t+1})} (A(s^{t+1}) F_{k(s^t)} + 1 - \delta). \quad (21)$$

After finding this set of allocations, I check if they satisfy the participation constraint

$$u(c, h) + \tilde{\beta} \sum_{s'} \pi(s'|s) W^0(x') \geq V^A(k, s), \quad (22)$$

if they do then I define them to be the new set of allocations for x , and $v^1(x) = 0$. If they don't satisfy the participation constraint (22) then I solve for a set of allocations (h, v, c', k') , that satisfy (11), (16), (17) and the participation constraint (22). This new set of allocations then becomes $(k^1(x), c^1(x), h^1(x), v^1(x), W^1(x), P^1(x))$.

4 Model dynamics

The dynamics of the model are driven by the effect that the productivity and stochastic discount factor shocks have on the participation constraint. Furthermore the dynamics of the model are different when

the participation constraint is binding and when its not.

First assume that the constraint is not binding. This would imply that $v = 0$, and from (17) and (27) we know

$$c(s^t) = \frac{\tilde{\beta}}{\beta q(\tilde{\beta})} c(s^{t-1}). \quad (23)$$

As $\frac{\tilde{\beta}^t}{\beta^t q(s^t)} < 1$, the relative impatience of the small country leads to declining consumption. There is full insurance $c(s^t) = c_t$. At the same time from (21), (27) and (23) we know

$$1 = \tilde{\beta} \sum_{s^{t+1}} \pi(s^{t+1}|s^t) \frac{\beta q(s^{t+1})}{\tilde{\beta}} (A(s^{t+1}) F_{k(s^{t+1})} + 1 - \delta), \quad (24)$$

and if s^t is *i.i.d.* then $k(s^t)$ is constant.

If the participation constraint is binding $v \neq 0$. From (17) and (27) we know

$$c(s^t) = \underbrace{\frac{\tilde{\beta}}{\beta q(s^t)}}_A \underbrace{\frac{1}{1 - v(s^t)}}_B c(s^{t-1}). \quad (25)$$

Equation (25) states that there are two competing forces leading the long-run properties of consumption. Part *A*, represents the relative impatience of the small country and leads to declining consumption. Part *B* drives consumption up whenever the participation constraint binds.

The first order condition with respect to capital (16) includes the marginal product of capital tomorrow, and the expected impact of capital on next periods participation constraint. The expected impact of capital on next periods participation constraint, depends on the marginal value of tomorrows capital in autarky. Whenever the marginal value increases, autarky becomes more attractive and the participation constraint is more likely to bind. This term is analogous to an investment “wedge”, see Chari, Kehoe and McGrattan (2007, [7]), which is isomorphic to a tax on investment.

Summarizing, consumption shrinks if the participation constraint does not bind; there is debt accumulation. If the participation constraint binds, the dynamics of consumption depend on the tightness of the constraint. History matters through $c(s^t)$ and $k(s^t)$.² Consumption (debt) dynamics drives capital dynamics. When consumption is low (high debt), the participation constraint is more

²Unlike the endowment economy where history doesn't matter.

likely to bind and generate a higher investment tax. When consumption is high (low debt), the participation constraint is less likely to bind and the investment tax is lower.

In general the productivity shocks have two effects. In the short run, high productivity shocks make the constraint more binding because they make the value of autarky more attractive. In the long-run, a long sequence of low productivity shocks run consumption down until the participation constraint binds.

Shocks to the stochastic discount factor have the same effect in the long and in the short-run. High shocks make the constraint more likely to bind because they increase the relative impatience of the small country.

Finally, hours worked are determined by (11), (27) and (28)

$$h(s^t) = \left(\frac{1}{\psi c(s^t)} A(s^t) (1 - \alpha) k(s^t)^\alpha \right)^{\frac{1}{\gamma + \alpha}}, \quad (26)$$

independent of whether the constraint is binding or not.

5 Calibration and functional forms

The model has six structural parameters and six parameters describing the shocks. The structural parameters define the preferences, the production function and the capital accumulation equation.

I assume that the preferences of the small country are given by

$$U(c, h) = \log c_t - \left(\frac{\psi}{1 + \gamma} (h_t)^{1 + \gamma} \right), \quad (27)$$

and output is determined by a standard constant returns to scale, Cobb-Douglas production function

$$F(k, h) = k^\alpha h^{1 - \alpha}. \quad (28)$$

Table (1) summarizes the parameter values. I set $\alpha = 0.36$, as is standard in the literature. ψ is set such that the level of hours worked in the model matches the data, and γ is set to one which is common in the literature.

Table 1: Structural Parameters

β	$\tilde{\beta}$	δ	α	γ	ψ
0.99	0.85	0.10	0.36	1	1.5

δ is set by the depreciation value generated by the first order condition with respect to capital in the the no limited commitment problem, when it is evaluated at the sample means of the data. I use aggregate annual data for consumption, investment, output and hours worked for all the main Latin American countries and generate a regional aggregate.³

The discount factor of the small country ($\tilde{\beta}$) is set to 0.90. The level of this parameter on its own is not that important. What really matters for the dynamics of the model is the relative impatience of the small country to the big country, the difference between $\tilde{\beta}$ and βq .

For the participation constraint to bind I need $\tilde{\beta} < \beta q$. As the spread between the two discount factors increases, the participation constraint becomes tighter. I set $\beta = 0.99$, so that given an unconditional mean for q of 0.97 the expected value for βq becomes 0.96. An average discount factor of 0.96 implies an annual international interest rate of 4% which is close to the average rate of return on capital over the past hundred years.

In an unconstrained economy, the Euler equation is given by

$$u_{c(s^t)} = \beta \sum_{s^{t+1}} \pi(s^{t+1}|s^t) u_{c(s^{t+1})} (A(s^{t+1}) F_{k(s^t)} + 1 - \delta),$$

and the interest rate (marginal product of capital) is equal to $\frac{c(s^{t+1})}{\beta c(s^t)}$. The discount factor is the inverse of this object. For the calibration, I define the big country as an aggregate of the developed world. Mainly the United States, Canada, Western Europe, Australia and New Zealand. I collect consumption data for each country from OECD sources and generate an aggregate to calculate the inverse of consumption growth, which stands for the discount factor q .

I assume that the logarithm of the stochastic discount factor follows a standard autorregressive

³The data for Latin America is obtained from the World Bank *Global Development Indicators* and supplemented by Mitchell (2001) and other country specific sources.

process of order one

$$\log(q_{t+1}) = (1 - \rho_q) \log(q_{ss}) + \rho_q \log(q_t) + \sigma_q \varepsilon_{qt}. \quad (29)$$

To estimate ρ_q and σ_q I use OLS, and find $\rho_q = 0.27$ and $\sigma_q = 0.0134$.

I recover the productivity shock by using the aggregate data on output, hours worked and investment for Latin America. I use the perpetual inventory method according to (4) to recover capital.

I assume that the logarithm of productivity follows a standard autoregressive process of order one

$$\log(A_{t+1}) = (1 - \rho_A) \log(A_{ss}) + \rho_A \log(A_t) + \sigma_A \varepsilon_{At}. \quad (30)$$

To estimate ρ_A and σ_A I use OLS, and find $\rho_A = 0.99$ and $\sigma_A = 0.025$.

In order to solve the model, I have to discretize the stochastic discount factor and productivity shocks. To do so, I follow the methodology suggested by Tauchen and Hussey (1991). I discretize A to 5 states and q to 3 states, for a total of 15 states.

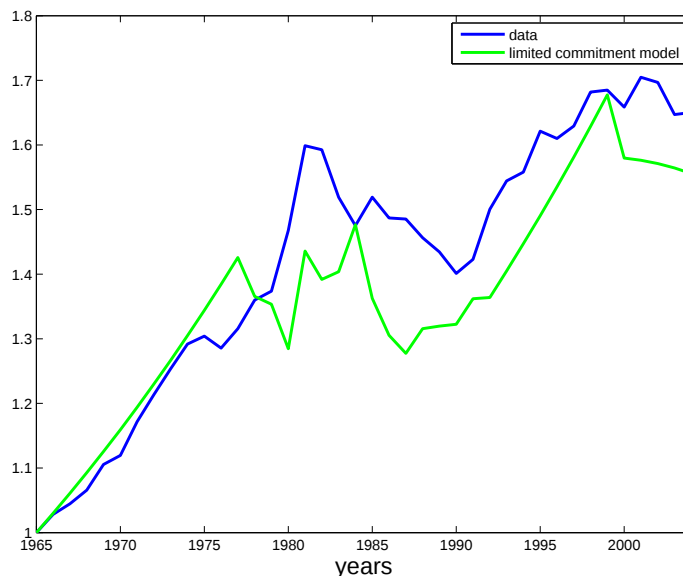
6 Results

This section, compares the model generated data with observed data for Latin America. The observed data is constructed as was mentioned in the calibration section, and corresponds to aggregate variables. The model generated data is stationary by definition. To compare it with the observed data I add a 2% trend.

Figure 2, shows aggregate consumption from the data (the solid blue line) versus the consumption generated by the model (the dashed green line). The limited commitment model generates the lost decade of the 80's, and is also able to explain the slower recovery observed from the 90's onward.

Figure 3 shows observed versus model generated data for per-capital hours worked, output, net-exports and investment over output. Once more, the solid blue lines represent the observed data and the dashed green lines represent the model generated data. We observe that even though the model is able to explain consumption to a great extent, it misses in a number of other fronts. Per-capita hours

Figure 2: Per-capita consumption: data versus model

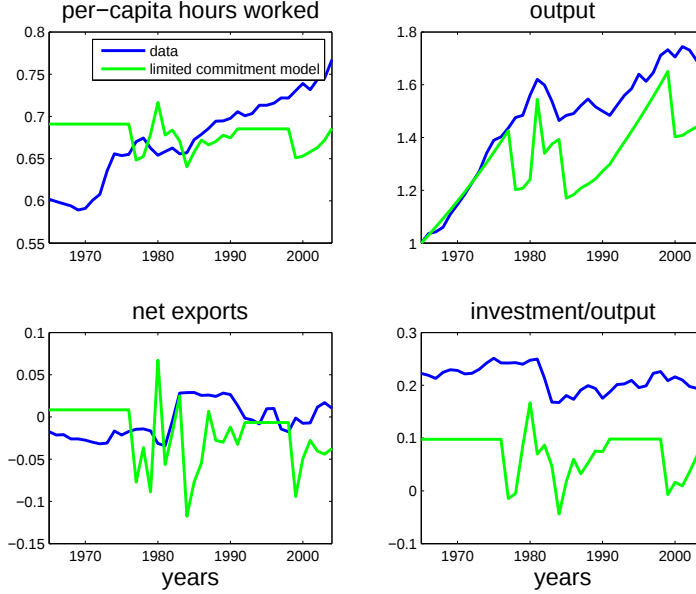


worked in the model are initially higher than the observed ones due to low initial consumption. The model's investment is lower than in the observed data. The model produces such low investment rates given the investment “tax” that is generated by the tightness of the constraint and the marginal utility of capital in autarky.

The fact that the model overestimates per-capita hours worked during the first half of the period, offsets the low capital generated by the model during this same time. Hence, the model does a decent job at explaining output during the first half of the sample. After the mid 1970's, the model underestimates output. This is due to the low investment, given that during this period the model matches the level of per-capita hours worked pretty well.

The third panel of Figure 3 shows the comparison for net-exports. At a first glance it might seem like the model misses in this dimension. But there are several things to take into account. There is no reason to think that the model should do a good job at matching net exports before 1970. We know that Latin American economies had inward looking policies during this time. The model is able to generate the sharp reversal of capital flows around 1980—although it comes a little sooner than it does

Figure 3: Other variables: data versus model

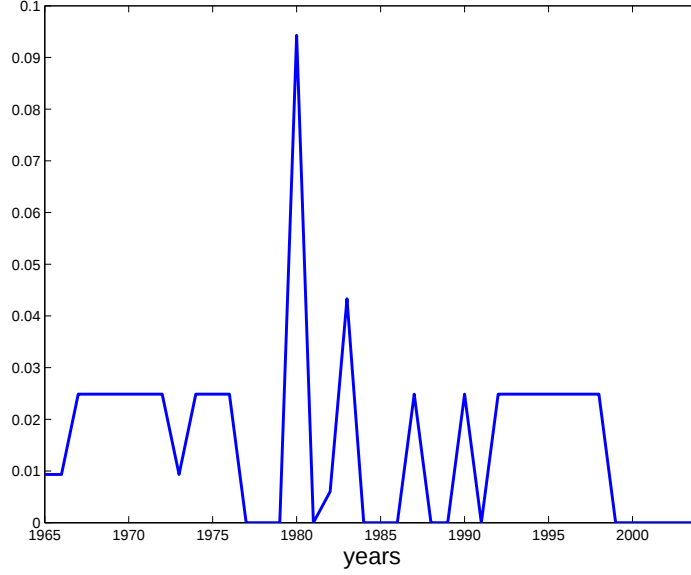


in the data—but the model is not able to capture the prolongation of the debt crisis. This is expected because in the model the intent to default is corrected immediately, while in reality we know that the debt crisis took around a decade to overcome.

To further understand the behavior of net-exports in the model, it is important to understand the behavior of the participation constraint. Figure 4 shows the behavior of the normalized multiplier v , given the behavior of the stochastic discount factor and productivity shocks which are shown in Figure 5. A positive v means that the constraint is binding and a $v = 0$ means that the constraint is not binding. Oscillations in between show how the constraint tightens or relaxes.

The constraint is binding until 1977, due to both high productivity shocks and moderate stochastic discount factor shocks. We know that in this types of models, there are capital inflows only when the constraint is not binding and debt is being accumulated, hence before 1977 the model generates positive net-exports, and only until 1977 that the constraint relaxes there are capital inflows (negative net-exports). Immediately after this, in 1980 a high productivity shock hits together with a high stochastic discount factor shock making the constraint bind and net-exports become positive. This situation changes after 1984 because the stochastic discount factor shock goes back to around its

Figure 4: Normalized multiplier v



unconditional mean and productivity starts going down making autarky less attractive. The model only generates negative net-exports in the periods where the constraint is not binding.

Figures 6 and 7 show two counterfactual exercises. They show what happens to the model generated data when only one of the two shocks is feeded in and the other shock is set to its unconditional mean. This exercise will show us the importance of each of the shocks for the model dynamics.

Figure 6 shows what happens when the productivity shock is set to its unconditional mean and only the stochastic discount factor shocks are feeded into the model. The first sub-plot shows aggregate consumption in the data (blue solid line) and aggregate consumption generated by the model (dashed green line). The second sub-plot shows the behavior of the normalized multiplier v . Notice that the stochastic discount factor is not the shock that is generating the drop in consumption observed in the 80's.

Figure 5: Productivity and stochastic discount factor shocks

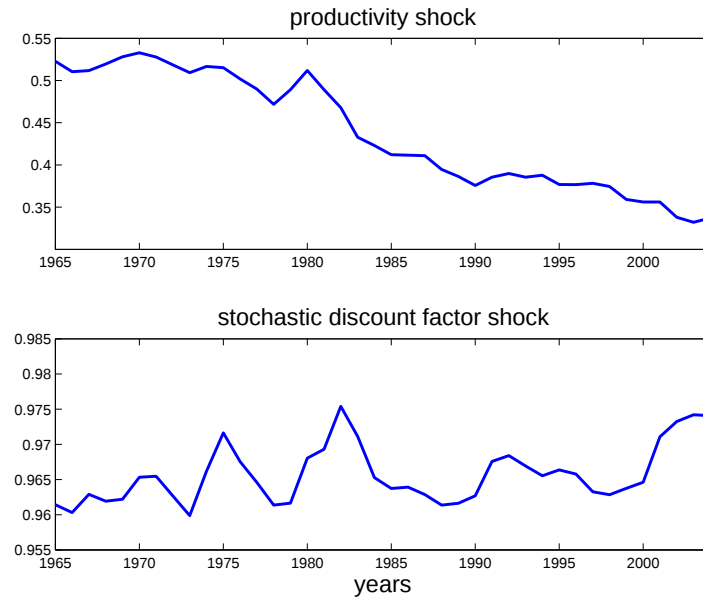


Figure 6: Effect of the stochastic discount factor over the participation constraint

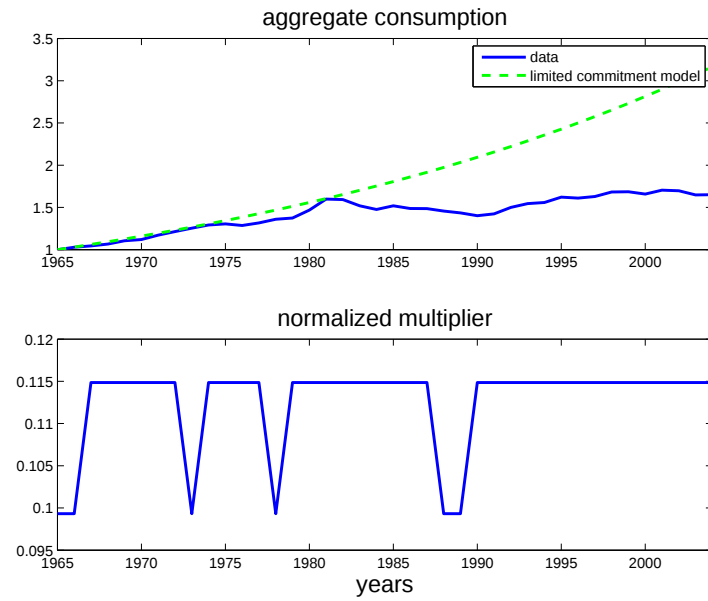


Figure 7: Effect of productivity over the participation constraint

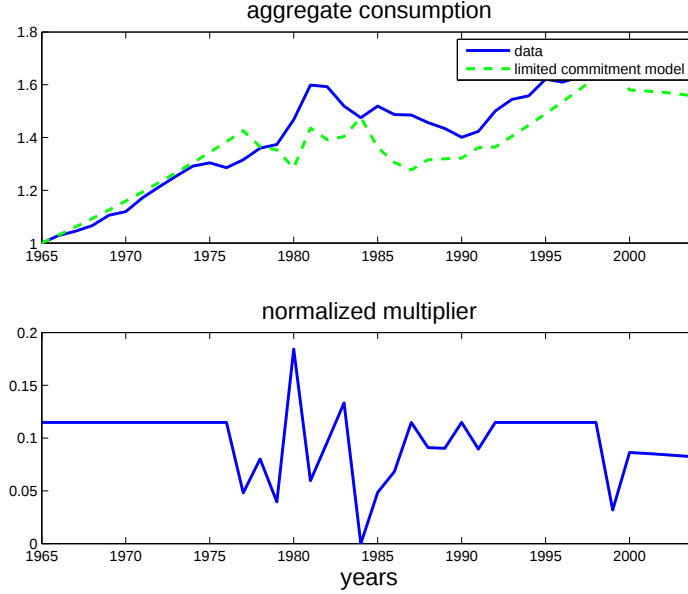


Figure 7 shows what happens when the stochastic discount factor shock is set to its unconditional mean and only the productivity shocks are fed into the model. The first sub-plot shows aggregate consumption in the data (blue solid line) and aggregate consumption generated by the model (dashed green line). The second sub-plot shows the behavior of the normalized multiplier v . Productivity shocks explain the consumption drop of the 80's. They do so because the stream of low shocks loosens the constraint and consumption is runned down. Nevertheless, productivity by itself overestimates the drop in consumption by generating very loose constraints from the 90's onward.

This results show that productivity is crucial for explaining the behavior of consumption in Latin America.

Overall, we learn several things from this exercise. We learn that a limited commitment model like the one presented above is able to generate the observed behavior of Latin American consumption after 1980. We learn that the model over estimates per-capita hours worked during the first twenty

years of the sample and that it under estimates investment for most of the period. Given that it misses on capital it also misses on output after the 1970's. We know that the model misses on capital because it endogenously generates an investment tax which is presumably too high.

Finally the model misses in net-exports because it can't account for the fact that Latin America was a fairly closed economy until the 70's, and it can't account for the actual duration of the debt crisis.

Given that the model misses in these dimensions, I am going to take a more agnostic view of the problem and in the next section I'm going to propose a methodology that will help me figure out what other frictions that are absent in this model are important for explaining the Latin American data.

7 A diagnostic tool

In this section I present a model and a methodology that will help me understand what are the underlying frictions in the Latin American economy and what is it that the limited commitment model presented above is missing.

I enrich the Backus, Kehoe and Kydland (1992, [5]) model by adding "wedges" in the spirit of Cole and Ohanian (2002, [10]) and Chari, Kehoe and McGrattan (2007, [7]). In the close economy dimension, apart from the stochastic productivity, I introduce stochastic population, government spending and two distortions to household's efficiency conditions. One distortion is isomorphic to a labor income tax in the labor/leisure choice, the other distortion is isomorphic to a capital income tax in the Euler equation. This last distortion can be mapped into the investment "tax" that arises in the limited commitment model when the participation constraint tightens.

In the open economy dimension I introduce shocks to the planner Pareto weights in the spirit of Ohanian et al (2009, [19]). The planner weight in this model is equivalent to the planner weight that arises endogenously in the limited commitment mode and that I denote by $M(s^t)$.

To solve the model and recover the wedges I use a methodology that takes the business cycle accounting idea used by Chari, Kehoe and McGrattan (2007, [7]) and extend it using recent Bayesian techniques for DSGE models. There are three main differences between their approach and mine. First, there are some parameters in the model that I can't calibrate and hence I estimate using the Kalman

filter and what is becoming standard — Markov Chain Monte-Carlo (MCMC) methods. Second, estimation results can depend significantly (see Cogley and Nason (1995, [9])) on the way the data is pre-filtered. In order to avoid certain filtering biases I minimize the extent to which I alter the data and embed the trends into the model as in Fernandez-Villaverde and Rubio-Ramirez (2006, [12]). Third, because many of the parameters of the model are estimated using MCMC methods, I use the same approach to recover the wedges. I apply the Kalman filter to the linearized version of the model to compute the stochastic innovations of the wedges as in Cheremukhin and Restrepo-Echavarria (2009, [8]).

7.1 The model economy

The model is the one presented in Backus, Kehoe and Kydland (1992, [5]) augmented by “wedges” in the spirit of Cole and Ohanian (2002, [10]) and Chari, Kehoe and McGrattan (2007, [7]).

Apart from stochastic productivity, the model has stochastic population, government spending and two distortions to household’s efficiency conditions. The first distortion is between the marginal rate of substitution and the marginal product of labor. This distortion is isomorphic to a labor income tax and from now on I will refer to it as the labor wedge. The second distortion to the household’s efficiency conditions distorts the Euler equation and is isomorphic to a tax on investment, from now on I will refer to this distortion as the investment wedge.

In the open economy dimension of the model I introduce a distortion to the relative consumption between countries. I do so by introducing time varying Pareto weights in the spirit of Ohanian et al (2009, [19]).

Consider a world populated by two countries, “Latin America” and the “Rest of the World”. They are indexed by j . The planner maximizes the sum of the weighted expected discounted utility of the two regions, subject to the aggregate resource constraint and capital accumulation constraint:

$$\max_{\{c_{jt}, h_{jt}, K_{jt+1}\}} E \sum_{t=0}^{\infty} \beta^t \left\{ \sum_j \chi_{jt} \left(\log c_{jt} - \frac{1}{\tau_{l_{jt}}} \left(\frac{\psi}{1+\gamma} (h_{jt})^{1+\gamma} \right) \right) N_{jt} \right\}$$

subject to

$$\sum_j (C_{jt} + I_{jt} + G_{jt}) = \sum_j A_{jt} K_{jt}^{\alpha} (N_{jt} h_{jt})^{1-\alpha}$$

$$I_{jt} = \tau_{kjt} \left(K_{jt+1} - (1 - \delta) K_{jt} - \left(\frac{\nu}{2} \left(\frac{I_{jt}}{K_{jt}} - b_j \right)^2 K_{jt} \right) \right)$$

where C_{jt} , I_{jt} , K_{jt} denote consumption, investment and capital for country j . h_{jt} denotes labor and N_{jt} denotes population. A_{jt} denotes productivity or the efficiency wedge, G_{jt} represents the government wedge, τ_{ljt} is the labor wedge, τ_{kjt} is the capital wedge and χ_{jt} is the planner's Pareto weight for country j . The last term of the capital accumulation constraint is an investment adjustment cost. Introducing adjustment costs to investment is a common practice to decrease investment volatility which is known to be very high in this type of model.

I assume that population and productivity in the “Rest of the World” are non-stationary and follow a random walk:

$$\log(A_{Rt}) = \log(a_{Rss}) + \log(A_{Rt-1}) + \sigma_{AR} \varepsilon_{ARt} \quad (31)$$

$$\log(N_{Rt}) = \log(n_{Rss}) + \log(N_{Rt-1}) + \sigma_{NR} \varepsilon_{NRt} \quad (32)$$

where a_{Rss} and n_{Rss} are the mean growth rates of productivity and population in the “Rest of the World”. All the other shocks are assumed to be stationary and follow first-order autoregressive processes.

$$\log(g_{jt}) = (1 - \rho_{gj}) \log(g_{jss}) + \rho_{gj} \log(g_{jt-1}) + \sigma_{gj} \varepsilon_{gjt}$$

$$\log(\tau_{ljt}) = (1 - \rho_{\tau_{lj}}) \log(\tau_{ljss}) + \rho_{\tau_{lj}} \log(\tau_{ljt-1}) + \sigma_{\tau_{lj}} \varepsilon_{\tau_{lj}t}$$

$$\log(\tau_{kjt}) = (1 - \rho_{\tau_{kj}}) \log(\tau_{kjss}) + \rho_{\tau_{kj}} \log(\tau_{kjt-1}) + \sigma_{\tau_{kj}} \varepsilon_{\tau_{kj}t}$$

$$\log(\chi_{jt}) = (1 - \rho_{\chi j}) \log(\chi_{jss}) + \rho_{\chi j} \log(\chi_{jt-1}) + \sigma_{\chi j} \varepsilon_{\chi jt}$$

where g_{jt} is the fraction of GDP consumed by the government in region j .

The reason for assuming random walks for the productivity and population of the “Rest of the World” is the following. In the data real output, consumption and investment are non-stationary. To make the data comparable to the model, the business cycle literature commonly uses the Hodrick-Prescott (HP) filter. However, Cogley and Nason (1995, [9]) and Canova (1998, [6]) show that the use

of the filter introduces significant biases into the data by amplifying business-cycle frequencies even if it does not have any. To avoid using any kind of filter I follow the approach presented in Fernandez-Villaverde and Rubio-Ramirez (2006, [12]). I assume random walks for productivity and population which are commonly thought to be extremely persistent, and detrend the model with respect to a pair of nonstationary trends.

From equations (31), (32) and the optimality conditions of the model we can see that all variables grow at a factor $a_{ss}^{\frac{1}{1-\alpha}} n_{ss}$. If we take the first differences of the productivity and population by defining $a_{Rt} = \frac{A_{Rt}}{A_{Rt-1}} = a_{Rss}^{1-\rho_a} a_{Rt-1}^{\rho_a} \exp(\sigma_{aR} \varepsilon_{aRt})$ and $n_{Rt} = \frac{N_{Rt}}{N_{Rt-1}} = n_{Rss}^{1-\rho_n} n_{Rt-1}^{\rho_n} \exp(\sigma_{nR} \varepsilon_{nRt})$ we can derive an aggregate trend $Z_t = (A_{Rt})^{\frac{1}{1-\alpha}} N_{Rt}$, which will be common to all the variables except capital. I define detrended variables as $x_t = \frac{X_t}{Z_{t-1}}$.

In terms of the productivity and population processes of “Latin America”, I assume that there is a common trend for the two regions, and define:

$$A_{Lt} = a_{Lt} A_{Rt}$$

$$N_{Lt} = n_{Lt} N_{Rt}$$

where a_L and n_L are stationary and represent the domestic component of productivity and population in Latin America. They follow first-order autoregressive processes.

$$\log(a_{Lt}) = (1 - \rho_{aL}) \log(a_{Lss}) + \rho_{aL} \log(a_{Lt-1}) + \sigma_{aL} \varepsilon_{aLt}$$

$$\log(n_{Lt}) = (1 - \rho_{nL}) \log(n_{Lss}) + \rho_{nL} \log(n_{Lt-1}) + \sigma_{nL} \varepsilon_{nLt}$$

The residuals for all the shocks are distributed normal with zero mean and variance equal to one. Given that $\frac{A_{Rt}}{A_{Rt-1}} = a_{Rt}$, when the model is detrended $A_{Lt} = a_{Lt} a_{Rt}$, which is stationary.

7.2 Methodology: calibration and estimation

The model has 9 structural parameters and 33 parameters that characterize the wedges. I calibrate the structural parameters and the steady state levels of the wedges. Table 2 summarizes most of the

calibrated structural parameters.

Table 2: Calibrated structural parameters

α	β	γ	δ_D	δ_L	ν	ψ
0.36	0.96	1	0.06	0.10	4	1.57

α , β and γ are standard in the literature. ν determines the curvature of the investment adjustment costs and is fixed according to what Neumeyer and Perri (2005, [18]) find is a sensible parameter value for Argentina. The depreciation rate for each region is set such that the steady state of investment and capital equal the sample mean. The parameter b_j of the investment adjustment costs is such that the cost is zero in the steady state.

Table 4 in the Appendix summarizes the steady states values for the wedges as well as the mean reversion for productivity and population. The steady state of the labor wedge for the rest of the world (τ_{LDss}) is set to 1, and ψ and τ_{Lss} are set such that the steady state of hours worked is equal to the sample mean in each of the regions. The steady state of the investment wedge guarantees that the steady state of capital equals the sample mean.

The steady state for the productivities, population and government spending processes is set to their sample means.

Notice that the planner weight of Latin America relative to that of the rest of the world can be pinned down directly from the data, and in equilibrium it is equal to the ratio of consumptions between regions. I normalize the planner weight of Latin America with respect to the rest of the world such that there is only one planner weight for Latin America. χ_{Lss} is set equal to its sample mean.

The autoregressive processes for productivity and population are estimated using Ordinary Least Squares.

To estimate the rest of the parameters that characterize the wedges, I log-linearize the model around the steady state and use a standard decomposition technique to obtain the state space representation. I apply the Kalman-Filter to calculate the likelihood and recover the wedges. I use Bayesian methods to find the unknown parameters (see An and Schorfheide (2007, [3])).

For these procedure I use yearly data on output, consumption, hours, investment, population and net-exports for the period 1950 to 2004, for each of the two regions of the world.

Latin America includes all the main countries, and the rest of the World is the rest of the world except for Africa and those countries that were or are not market economies. The data for the rest of the World and Latin America comes from OECD sources, the World Bank *Global Development Indicators* and other country specific sources.

To be able to estimate the model I need to add a measurement equation for every variable that we observe. This means that I need to add five measurement equations per region, corresponding to output, consumption, hours, investment and population, and one more for Latin America that corresponds to net-exports. Notice that I do not use data on government spending, this means that G_{jt} acts as a residual and wont necessarily look as in the data.

Alternatively, I could throw the measurement error into net-exports by using data on government spending. I choose to use data on net-exports and not government spending because I'm interested in the behavior of capital markets. By using net-export data, I guarantee that the model will reproduce the observed capital flows of these two regions⁴.

I have eleven stochastic processes⁵ and seventeen data series⁶ for a system that is perfectly identified.

The linearized optimality conditions of the model combined with the linearized measurement equations form a state-space representation of the model. I apply the Kalman filter to compute the likelihood of the data given the model and to obtain smoothed estimates of the innovations to the wedges. I combine the likelihood function $L(Y^{Data}|p)$, where p is the parameter vector, with the priors $\pi_0(p)$ to obtain the posterior distribution of the parameters $\pi(p|Y^{Data}) = L(Y^{Data}|p) \pi_0(p)$. Draws from the posterior distribution are generated using the Markov-Chain Monte-Carlo (MCMC) algorithm. I use the Random-Walk Metropolis-Hastings implementation. See Table 3 in the Appendix for a summary of the estimated parameters.

⁴I use net-exports instead of the current account data because there is no good data on factor payments. If one looks at net-exports plus factor payments, the world is in deficit with itself. Furthermore net-exports are not subject to decentralizations.

⁵ $a_{jt}, n_{jt}, g_{jt}, \tau_{l,jt}, \tau_{k,jt}$ for each region and χ_{jt} for Asia and Latin America.

⁶Output, consumption, hours, investment and population for the three regions, and net-exports for Asia and Latin America.

Note that the efficiency wedge, the labor wedge and the relative planner weight can be calculated directly from the data by using the production function, the labor/leisure condition and the optimality conditions for consumption. But it is not possible to recover the investment wedge directly from the data because the Euler condition is a forward-looking equation. This is why I use the Kalman filter to recover the smoothed estimates of the innovations to the wedges. Instead of using the Kalman filter, I could iterate over the solution of the model until I find a fixed point. I do not use this alternative because it is more complicated than just using the filter, and by construction, the wedges obtained through the Kalman filter, are the same as the ones obtained by using the static optimality conditions of the model and iterating over the solution to recover the investment wedge.

7.3 Recovered wedges

In this section, I show the recovered wedges that are relevant for understanding the dimensions in which the limited commitment model is missing. Figure 8 shows the behavior of productivity, labor wedge, investment wedge and relative planner weight.

The productivity or efficiency wedge recovered with this methodology is equal to the solow residual calculated using the production function. The productivity that is feeded into the limited commitment model and that is showed in Figure 5, is just the detrended version of the series shown in Figure 8.

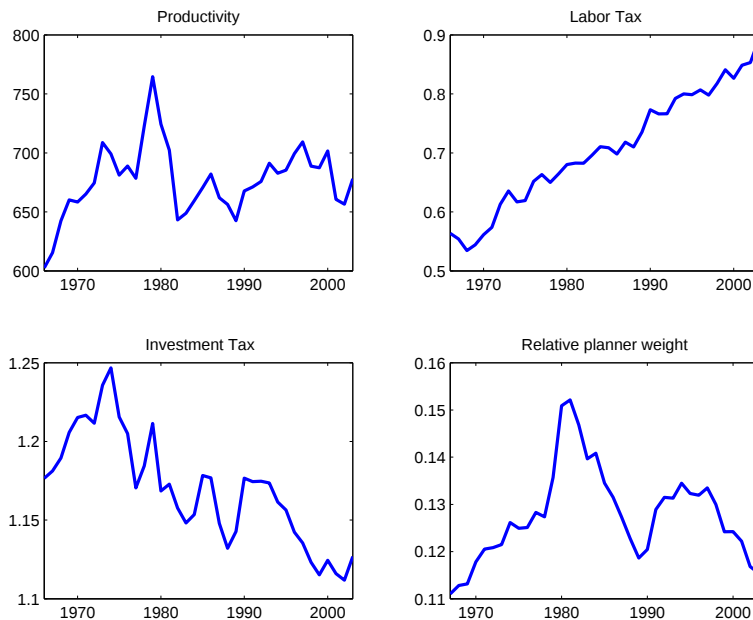
The last panel in Figure 8 shows the behavior of the relative planner weight. The diagnostic model says that Latin America was gaining importance for the planner until the 1980's. It was becoming richer with respect to the rest of the world, but after 1980 it started losing ground until 2004 when the situation wasn't very different from what it was in 1950.

The third panel of Figure 8 shows the investment wedge. An investment wedge that is greater than one represents a tax. The diagnostic model says that Latin America's tax on investment increased until the mid 70's and then decreased.

Finally, the second panel in Figure 8 shows the behavior of the labor wedge. When the wedge is less than one it can be interpreted as a tax on labor income. The labor wedge states that Latin America had an increasing labor tax until 1970 and that after that period it started declining. The period from 1950 to 1970, is exactly where the limited commitment model misses the sharp decrease in per-capita

hours worked that is observed in the data. Hence introducing a distortion to the labor/leisure condition should improve the ability to the limited commitment model to match the data on hours worked.

Figure 8: Recovered Wedges



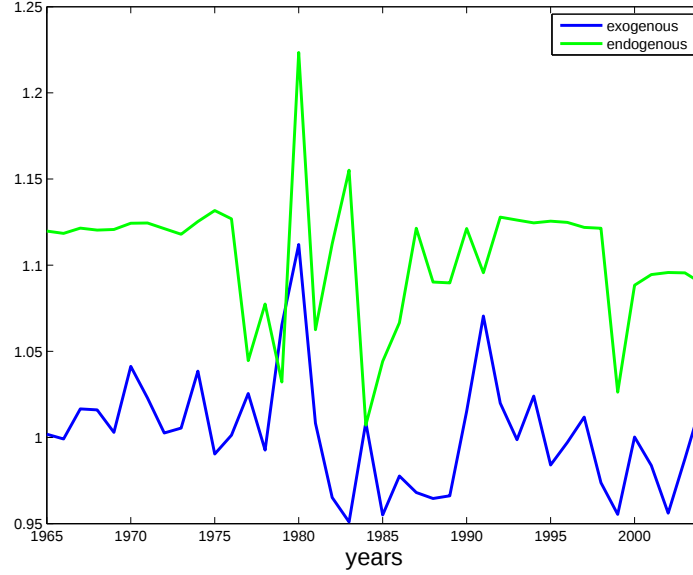
8 Endogenous versus exogenous distortions

In this section I compare the results from the limited commitment model with those of the business cycle accounting exercise.

Figure 9 shows the comparison of the growth rates of the planner weights. Note that the planner weight that is generated endogenously by the limited commitment model is fairly similar to the one recovered using the business cycle accounting exercise.

Figure 10 shows the comparison of the investment tax generated by the limited commitment model with that recovered from the business cycle accounting exercise. The one generated by the limited

Figure 9: Endogenous versus exogenous planner weights



commitment model is much higher than that recovered from the data.

9 Conclusion

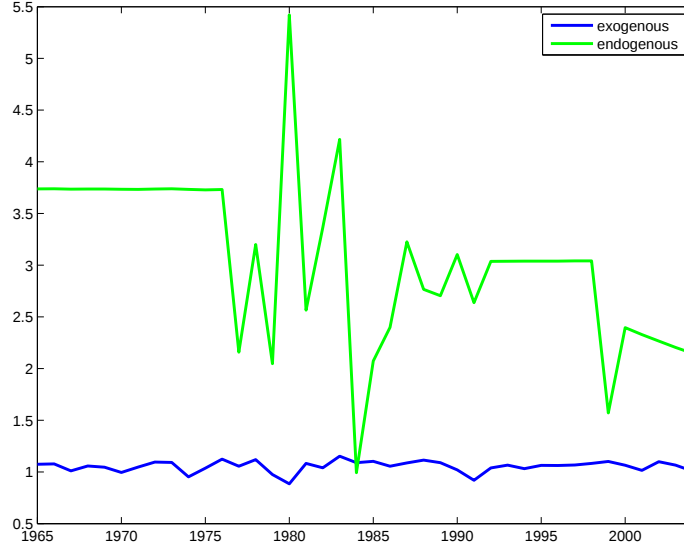
This paper points out that consumption per-capita in Latin America was roughly the same in 2004 as it was in 1980. Furthermore, not only did consumption not grow during this period, but from 1980 to 1990 there was negative per-capita consumption growth.

Motivated by the fact that this decline in consumption coincides with the start of the Latin American debt crisis, this paper examines a limited commitment model where the access to international capital markets depends on domestic productivity shocks and international interest rate shocks.

I find that the model does a good job at matching the behavior of aggregate consumption in Latin America for the 1950 to 2004 period.

Although the model is able to generate the behavior of aggregate consumption, it misses in a number of other aspects. Given that the model misses in these dimensions, I propose a methodology

Figure 10: Endogenous versus exogenous investment tax



that identifies if the distortions generated endogenously by a limited commitment model are the relevant ones for understanding the behavior of the Latin American economy, and which other distortions that are not present in the model are important.

I enrich the Backus, Kehoe and Kydland (1992, [5]) model by adding "wedges" in the spirit of Cole and Ohanian (2002, [10]) and Chari, Kehoe and McGrattan (2007, [7]). In the close economy dimension, apart from the stochastic productivity, I introduce two distortions to household's efficiency conditions. One distortion is isomorphic to a labor income tax in the labor/leisure choice and the other distortion is isomorphic to a capital income tax in the Euler equation. This last distortion can be mapped into an "investment tax" that arises in the limited commitment model when the participation constraint tightens. In the open economy dimension I introduce shocks to the planner Pareto weights in the spirit of Ohanian et al (2009, [19]). The planner weight in this model is equivalent to the planner weight that arises endogenously in the limited commitment model.

To solve the model and recover the wedges I use a methodology that takes the business cycle accounting idea used by Chari, Kehoe and McGrattan (2007, [7]) and extend it using recent Bayesian techniques for DSGE models.

I find that the planner weight generated by the limited commitment model behaves in a very similar

way to that in the diagnostic model. This result reinforces the idea that models with endogenous borrowing constraints are important for understanding the performance of the Latin American economy. The tax to investment that arises from the limited commitment model is different from the investment tax that arises from the diagnostic model. This result was expected given that the limited commitment model does not do a good job at matching investment data. Finally, I find that the labor wedge plays an important role in Latin America. The limited commitment model does not generate any distortion in this margin so its not surprising that it is not able to fully capture the behavior of hours worked.

To summarize, this paper shows that a limited commitment model with domestic productivity shocks and international interest rate shocks is able to explain the behavior of Latin American consumption for the past 30 years. For the model to be able to explain the whole pattern of net exports, output, capital and hours worked for the same period, it would have to generate a different investment tax and have a distortion to the labor/leisure margin.

References

- [1] Mark Aguiar, Manuel Amador, and Gita Gopinath. Investment cycles and sovereign debt overhang. Technical report, NBER, 2007.
- [2] F. Alvarez and U. J. Jermann. Asset pricing when risk sharing is limited by default. Manuscript, University of Pennsylvania.
- [3] Sungbae An and Frank Schorfheide. Bayesian analysis of dsge models. *Econometric Reviews*, 26(2-4):113–172, 2007.
- [4] Andrew Atkeson. International lending with moral hazard and risk repudiation. *Econometrica*, 59:1069–1089, 1991.
- [5] David K. Backus, Patrick J. Kehoe, and Finn E. Kydland. International real business cycles. *Journal of Political Economy*, 100(4):745–775, August 1992.
- [6] Fabio Canova. Detrending and business cycle facts. *Journal of Monetary Economics*, 41(3):475–512, May 1998.

- [7] V. V. Chari, Patrick J. Kehoe, and Ellen R. McGrattan. Business cycle accounting. *Econometrica*, 75(3):781–836, 05 2007.
- [8] Anton Cheremukhin and Paulina Restrepo-Echavarria. The labor wedge as a matching friction. University of California Los Angeles.
- [9] Timothy Cogley and James M. Nason. Effects of the Hodrick-Prescott filter on trend and difference stationary time series: Implications for business cycle research. *Journal of Economic Dynamics and Control*, 19:253–278, 1995.
- [10] Harold L. Cole and Lee E. Ohanian. The u.s. and u.k. great depressions through the lens of neoclassical growth theory. *American Economic Review*, 2002.
- [11] Jonathan Eaton and Mark Gersovitz. Debt with potential repudiation: Theoretical and empirical analysis. *Review of Economic Studies*, 48:289–309, 1981.
- [12] Jesus Fernandez-Villaverde and Juan F. Rubio-Ramirez. Estimating macroeconomic models: A likelihood approach. *NBER Technical Working Papers*, WP(0321), February 2006.
- [13] Patrick J. Kehoe and Fabrizio Perri. International business cycles with endogenous incomplete markets. *Econometrica*, 70(3):907–928, May 2002.
- [14] T. J. Kehoe and D. K. Levine. Debt-constrained asset markets. *Review of Economic Studies*, 60:865–888, 1993.
- [15] N. R. Kocherlakota. Implications of efficient risk sharing without commitment. *Review of Economic Studies*, 63:595–609, 1996.
- [16] Finn E. Kydland and Edward C. Prescott. A competitive theory of fluctuations and the feasibility and desirability of stabilization policy. In Stanley Fischer, editor, *Rational Expectations and Economic Policy*, pages 169–198. 1980.
- [17] A. Marcet and R. Marimon. Recursive contracts. Manuscript, Universitat Pompeu Fabra.
- [18] Pablo A. Neumeyer and Fabrizio Perri. Business cycles in emerging economies: The role of interest rates. *Journal of Monetary Economics*, 52:345–380, 2005.

- [19] Lee E. Ohanian, Paulina Restrepo-Echavarria, and Mark L. J. Wright. Bad investments and missed opportunities? capital flows to asia and latin america, 1950-2004. University of California Los Angeles.

Appendix

Table 3: Prior and posterior distributions of shock parameters

Parameter	Prior			Posterior				
	Distribution	Mean	SD	Mode	SD	Mean	5%	95%
$\rho_{\tau_{lR}}$	Beta	0.8	0.1	0.94	0.04	0.93	0.88	0.97
$\rho_{\tau_{lL}}$	Beta	0.8	0.1	0.97	0.02	0.97	0.95	0.99
$\rho_{\tau_{kR}}$	Beta	0.8	0.1	0.96	0.04	0.94	0.88	0.99
$\rho_{\tau_{kL}}$	Beta	0.8	0.1	0.91	0.05	0.92	0.86	0.97
ρ_{gR}	Beta	0.97	0.02	0.98	0.02	0.98	0.95	0.99
ρ_{gL}	Beta	0.85	0.1	0.89	0.06	0.89	0.82	0.96
$\sigma_{\tau_{lR}}$	IGamma	0.04	0.02	0.02	0.002	0.03	0.02	0.03
$\sigma_{\tau_{lL}}$	IGamma	0.04	0.02	0.02	0.003	0.03	0.02	0.03
$\sigma_{\tau_{kR}}$	IGamma	0.02	0.01	0.01	0.002	0.01	0.01	0.01
$\sigma_{\tau_{kL}}$	IGamma	0.02	0.01	0.01	0.002	0.02	0.01	0.02
σ_{χ_L}	IGamma	0.027	0.01	0.04	0.003	0.04	0.03	0.04
σ_{gR}	IGamma	0.1	0.5	0.03	0.003	0.03	0.03	0.04
σ_{gL}	IGamma	0.1	0.5	0.05	0.005	0.05	0.05	0.06

Table 4: The other shock parameters

a_{ss}	a_{Lss}	n_{ss}	n_{Lss}	τ_{lRss}	τ_{lLss}
1.02	0.22	1.01	1.39	1	0.70
τ_{kRss}	τ_{kLss}	χ_{Lss}	g_{Rss}	g_{Lss}	
1.36	1.16	0.12	0.19	0.15	
ρ_a	ρ_{aL}	ρ_n	ρ_{nL}	ρ_{χ_L}	
0.19	0.99	0.82	0.99	0.91	