Fiscal Policy Amplified Cycles

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Abstract

Emerging markets are characterized by high levels of income volatility. These cycles are accompanied by procyclical fiscal policies: governments tend to increase spending and reduce taxes during expansions; and the reverse during contractions. What generates this procyclicality and does it exacerbate the cycle in emerging markets? This paper addresses this question.

We model a developing economy as one with limited access to financial markets and where the government plays a redistributive role - favoring the workers over the capitalists. It does this through the use of linear taxes/subsidies, however it lacks commitment. The absence of state contingent financial assets generates counter-cyclical taxes. However, when the government can fully commit, it is able to use counter-cyclical taxes to provide insurance without distorting capital investment. On the other hand, when it has limited commitment, the government finds itself forced to distort investment in order to provide insurance. More importantly, this distortion is more likely to take place when the economy is in a recession as compared to when it is booming. Consequently, fiscal policy amplifies the cycle by distorting capital accumulation and exacerbating downturns. This is consistent with empirical evidence on rising expropriation risk and worsening economic freedom indicators during downturns in emerging markets.

1 Introduction

Emerging markets are characterized by high levels of income volatility, with business cycles that are two to three times as volatile as in developed economies (Aguiar and Gopinath (2004)). Several authors (Kaminsky, Reinhart and Vegh (2004), Gavin and Perotti (1997)) have documented that these cycles are accompanied by procyclical fiscal policies: governments in emerging market economies tend to increase spending and reduce taxes during expansions; and the reverse during contractions. A striking example is the recent experience of Argentina. During its most recent crisis in 2002, the Argentine government introduced new taxes on exports and imposed price controls on foreign utility companies. As Table 1 shows, expropriation risk and wage and price regulation in Argentina increased during its recent crisis. What, then, generates procyclical fiscal policy and does this exacerbate the cycle in emerging markets? This paper addresses this question. We present a model of endogenously procyclical fiscal policy that creates distortions and amplifies the cycle in emerging markets.

We model a developing economy as one where capital markets are segmented and a government without commitment plays a redistributive role. In our model, a significant fraction of the population (workers) is risk averse and has no access to financial markets while another fraction (capitalists) invests in physical capital. A government regulates the economy through linear taxes/subsidies on income sources, maximizes the welfare of workers but cannot commit to future policy. The economy is subject to productivity shocks. In our benchmark specification, the government runs a balanced budget. Before the productivity shock is realized, capital is invested. After the shock, workers supply labor inelastically and collect a wage. By affecting the equilibrium wage, the productivity shock generates a risk that the workers cannot insure. The government could use a combination of taxes on capital income and labor income to mitigate the effects of the income shocks the workers are receiving.

Under commitment, it is optimal for the government not to distort the capital margin in this economy (an application of Judd (1985), Chamley (1986), Atkeson et al (1999).). The government could insure the workers against the intra-period uncertainty by taxing capital and subsidizing labor in bad times; while subsidizing capital and taxing labor in good times. Investment depends on the expected capital tax payments next period (ex ante capital tax rates), while insurance depends on ex post capital tax rates. In an optimal plan, insurance through taxation is done in such a way that the expected capital tax payments are zero (Zhu (1992)). The government through its tax policy can provide period-by-period insurance[1] without distorting the investment margin (since investment takes place before the shock is realized). The realized (ex-post) capital tax rates would be countercyclical, that is, would be higher in bad times[2] but there would be no amplification of the business cycle. We shall refer to these are first-best taxes.

However, absent perfect commitment, the government is limited to sustainable tax programs. Given that the capital stock is fixed for one period, the government is thus tempted to tax capital at the highest possible rate (which we model as exogenous) and redistribute the proceeds to the workers. We characterize the best subgame perfect equilibria of such a game by first showing that the worst possible equilibrium is Markov: the government taxes capital at the highest rate possible for all histories and redistributes the proceeds to the workers. Deviations from sustainable plans would trigger this Markov equilibrium. We compute the best sustainable plans as competitive allocations where the government has no incentive to deviate from the promised tax rates if it faces as a punishment continuation value equal to the one generated by the worst equilibrium.

The government's ability to commit to first best taxes will depend on the gains from deviating and this will vary with the state of the economy. When the shocks are i.i.d. the temptation to deviate will be greater when the state is high, as opposed to low. This is because consumption in autarky, will always be higher in the high state as compared to the low state, and continuation values are independent of the current state. Consequently, in any incentive compatible plan, consumption must be increasing in the state. If the incentive constraint only binds in the low state then it will always be possible to reallocate consumption by a small amount from the high to the low state, maintaining incentive compatibility, keeping expected consumption unchanged and strictly raising the welfare of the workers.

[1] This refers to static intra-period insurance. Inter-temporal insurance is not obtained.

[2] This, in the terminology of Kaminsky, Reinhart and Vegh (2004) refers to procyclical fiscal policy.

The result that in an i.i.d. world incentive constraints are binding in high states is fairly standard. These are the states where the government is called to subsidize capital and what it really desires to do is to increase the transfer to workers. However, as will be explained below, this intuition is incomplete when analyzing the model in an economy with persistent shocks. In an i.i.d. world the future capital tax promises are independent of the current states and hence the current state should not affect next period taxes nor current period investment. However, in a world with persistent shocks, the current state does affect the future promises of taxation, and will affect the level of investment.

A main result of the paper relates to this more realistic case when shocks have persistence. We show that, when productivity shocks are positively correlated, the incentive constraint in any state today is more likely to bind (relative to the first best) if the previous state was low as opposed to if it was high. Consequently, distortions on the capital margin start appearing in the low states. Put differently, if in an optimal equilibrium the government distorts ex ante the capital margin in the high states of the world (where productivity is high), then it distorts the capital margin in the low states as well. We prove that the proposition holds under fairly general conditions for the utility and production functions. Since a government in a recession will more likely distort ex-ante incentives to invest, while being better able to preserve ex ante incentives when the economy is booming, fiscal policy will exacerbate downturns, prolong recessions and therefore amplify the cycle.

The intuition as to why governments respond this way to a recession is based on the persistence of the underlying shock process and can be understood by considering deviations from the first best. In the first best, average consumption promised to workers is higher following a boom compared to a recession. Consequently, the gains to deviating from the first best taxes, in terms of the value of the additional consumption will be greater following a recession as compared to a boom. On the other hand, the size of the capital stock will be higher following a boom than a recession which will make it more tempting to deviate following a recession since there is more to expropriate. We show that as long as the underlying shock is sufficiently persistent, relative to the curvature of the production function, the proposition described in the previous paragraph will hold. A specific instance when this condition holds is in the case of log utility and a Cobb Douglas production function, as long as the expected value of the shock is increasing in the shock.

In our model, the absence of state contingent financial assets generates counter-cyclical taxes. However, counter-cyclical taxes on capital income alone do not generate distortions and raise volatility. Capital responds only to the ex ante expected tax on profits. Full commitment allows the government to obtain insurance without distortions. Absent commitment, however, the government finds itself forced to distort investment in order to provide insurance. We show that this distortion remains even when the government has access to static insurance (i.e. it cannot borrow or save, but can insure across states period-by-period), as long as financial contracts face the same commitment problems as tax policy. This highlights the importance of limited commitment in generating procyclical fiscal policy that amplifies the cycle.

While data on government transfers is limited for emerging markets, the recent experience of Argentina supports our premise. Table 2 presents evidence for Argentina that transfers to the private sector as a ratio of all government expenditures (excluding interest payments) increased during the most recent crisis. It rose from 4.7% in 1993 to a high of 16% in 2002 and 2003. In 1995 when Argentina experienced a recession, while other forms of government expenditure fell by 3.7%, transfers rose by 48%. Similarly when the crisis hit in 2002, transfers rose by 14% at the same time when other government expenditure fell by 24%. This supports the models predictions that transfers to workers are higher in bad times. In March 2002, immediately following the crisis, the Argentinean government introduced 10% taxes on primary product exports and a 5% tax on processed agricultural and industrial products. They also stipulated that privately owned gas, electric and telephone utilities should freeze prices at pre-devaluation levels. The introduction of export taxes was justified as "necessary to generate hard currency for funding social programs".[3]

The view that fiscal policy plays an important role in explaining the low growth and high volatility of developing countries is often expressed. However, the formal literature on this is quite limited. Calvo (2003) discusses a reduced form model where growth is a negative function of fiscal burden. Telvi and Vegh (2000) describe a perfect foresight model of optimal taxation where running budget surpluses is assumed to be costly, owing to which taxes are kept low in good times. We provide a formal model where under the assumption

[3] news report http:/www.fas.usda.gov/pecad2/highlights/2002/03/ardeval/

of market segmentation, and a redistributive government with lack of commitment, fiscal policy amplifies the cycle. In our model, recessions are periods where the government cannot commit not to tax capital in the future and hence, capital withdraws from the economy. This fits nicely the fact that indexes of expropriation and economic freedom worsen consistently during bad shocks in developing economies.

2 Model

Time is discrete and runs to infinity. The economy produces consumption goods out of capital and labor according to the neoclassical form:

$$y = zF(k, l)$$

where z represents a productivity shock. The production function F is constant returns to scale with $F_{kl} \geq 0$.

We let $z \in Z$, and let $z^t = \{z_1, ...z_t\}$ be a history of productivity shocks up to time t. Denote by $q(z^t)$ the probability that z^t occurs. At the begining of every period, before the productivity shock is realized, capital is invested and cannot be reallocated until the end of period.

The economy is composed of two types of agents : workers and capitalists. Workers are identical, supply (inelastically) a unit of labor every period and collect a wage. Their expected lifetime utility is given by

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c\left(z^t\right)\right)$$

where $c(z^t)$ is their consumption in history z^t.

Assumption (Segmented Capital Markets). *Workers have no access to financial markets. Their consumption is given by*

$$c\left(z^t\right) = w\left(z^t\right) l + T\left(z^t\right)$$

where $T(z^t)$ are transfers received at history z^t.

There is a mass of capitalists that has no labor, are risk neutral and in equilibrium expect a rate of return r^* on their invested capital. Capitalists own competitive domestic firms that produce by hiring labor in the domestic labor market and using capital. After production, the capital used depreciates by a rate δ.

There is a government that taxes firms profits at a linear rate $\tau\left(z^t\right)$ and transfers the proceeds to the workers $T\left(z^t\right)$. The government runs a balanced budget at every state

$$\tau\left(z^t\right)\pi\left(z^t\right) = T\left(z^t\right)$$

where $\pi\left(z^t\right)$ are the aggregates profits generated by the firms.

The following assumption defines the government objective.

Assumption (Redistributive Government). *The governments objective function is to maximize the lifetime utility of the workers.*

The profits of the firms are

$$\pi\left(z^t\right) = z_t F\left(k\left(z^{t-1}\right), l\right) - w\left(z^t\right) l$$

where $w\left(z^t\right)$ is the competitive wage at history z^t.

Given a tax rate plan $\tau\left(z^t\right)$, domestic firms, owned by capitalists, maximize profits taking as given the the tax rate,

$$E_0 \sum \left(\frac{1}{1+r^*}\right)^t \left(1-\tau\left(z^t\right)\right)\pi\left(z^t\right)$$

Profit maximization by firms and capitalists investment decision imply the following two conditions:

$$z_t F_l\left(k\left(z^{t-1}\right), l\right) = w\left(z^t\right) \tag{1}$$

$$\delta + r^* = E\left[z_t\left(1-\tau\left(z^t\right)\right)|z^{t-1}\right] F_k\left(k\left(z^{t-1}\right), l\right) \tag{2}$$

We now proceed to characterize the optimal fiscal policy under commitment.

2.1 Optimal Taxation under Commitment

Under commitment, the government can commit at time 0 to a tax policy $\tau(z^t)$ for every possible history of shocks z^t.

From the budget we have

$$c\left(z^t\right) = w\left(z^t\right) l + \tau\left(z^t\right)\left(z_t F\left(k\left(z^{t-1}\right), l\right) - w\left(z^t\right) l\right)$$

or

$$z_t F\left(k\left(z^{t-1}\right), l\right) - c\left(z^t\right) = \left(1 - \tau\left(z^t\right)\right) z_t \left(F\left(k\left(z^{t-1}\right), l\right) - F_l\left(k\left(z^{t-1}\right), l\right) l\right) \qquad (3)$$

where we used (1).

From the capital decision we have that

$$(\delta + r^*) k\left(z^{t-1}\right) = E\left[z_t\left(1 - \tau\left(z^t\right)\right)\left(F\left(k\left(z^{t-1}\right), l\right) - F_l\left(k\left(z^{t-1}\right), l\right) l\right) | z^{t-1}\right] \qquad (4)$$

where we used that $F(k, l) = F_k k + F_l l$. Combining (3) and (4) we get a new aggregate constraint in expectation:

$$E\left[z_t | z^{t-1}\right] F\left(k\left(z^{t-1}\right), l\right) - E\left[c\left(z^t\right) | z^{t-1}\right] - (\delta + r^*) k(z^{t-1}) = 0 \qquad (5)$$

The following lemma helps in simplifying the constraint set.

Lemma 1 *For any $c\left(z^t\right)$ and $k\left(z^{t-1}\right)$ that satisfy (5), there exists a function $\tau\left(z^t\right)$ such that (3) and (4) are satisfied.*

Proof. Just define $\tau\left(z^t\right)$ as the solution to (3) for given $c\left(z^t\right)$ and $k\left(z^{t-1}\right)$. The fact that (4) holds follows. ■

The problem of the government under commitment is then

$$\max_{c(z^t), k(z^t)} E_0 \sum_{t=0}^{\infty} \beta^t u\left(c\left(z^t\right)\right)$$

subject to (5).

Proposition 2 *Under commitment, the optimal fiscal policy provides full intra-period insurance to the workers:*

$$c\left(\left\{z_t, z^{t-1}\right\}\right) = c\left(\left\{z_t', z^{t-1}\right\}\right) \text{ for all } \left(z_t, z_t'\right) \in Z_t \times Z_t \text{ and } z^{t-1} \in Z^{t-1}$$

and at the begining of every period, the expected capital tax payments are zero:

$$E\left[z_t \tau\left(z^t\right) | z^{t-1}\right] = 0$$

Proof. The Lagrangian of the problem is

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c\left(z^t\right)\right) + \sum_{z^{t-1}} \beta^t \lambda\left(z^{t-1}\right) \left\{ \begin{array}{c} E\left[z_t | z^{t-1}\right] F\left(k\left(z^{t-1}\right), l\right) \\ -E\left[c\left(z^t\right) | z^{t-1}\right] - \left(\delta + r^*\right) k(z^{t-1}) \end{array} \right\}$$

Notice that if $\lambda\left(z^{t-1}\right)$ is non-negative the Lagrangian is concave on c, k. The first order conditions for the maximization of the Lagrangian are

$$\begin{aligned} u'\left(c\left(z^t\right)\right) &= \frac{\lambda\left(z^{t-1}\right)}{q\left(z^{t-1}\right)} \\ E\left[z_t | z^{t-1}\right] F_k\left(k\left(z^{t-1}\right), l\right) &= \delta + r^* \end{aligned}$$

where the first condition implies that $c\left(\left\{z_t, z^{t-1}\right\}\right) = c\left(\left\{z_t', z^{t-1}\right\}\right)$ for all $(z_t, z_t') \in Z_t \times Z_t$ and the second one implies that $E\left[z_t \tau\left(z^t\right) | z^{t-1}\right] = 0$ ■

Proposition 2 shows that the government can insure all the intra-period risk the workers are facing without distorting the investment margin,

$$E\left[z_t | z^{t-1}\right] F_k\left(k\left(z^{t-1}\right), l\right) = \delta + r^*$$

In this purely redistributive model it is efficient to set expected tax payments on capital equal to zero, a result well known in the Ramsey taxation literature (Judd (1985), Chamley (1986) and the stochastic version in Zhu (1992)).

A quick corollary follows,

Corollary 3 *Under commitment, realized capital taxes are countercyclical:*

$$\tau\left(z_t, z^{t-1}\right) > \tau\left(z_t', z^{t-1}\right) \quad \text{for } z_t < z_t'$$

Proof. From (3) it is possible to solve for the tax rate

$$\tau\left(z^t\right) = \frac{c\left(z^t\right)/z_t - F_l\left(k\left(z^{t-1}\right), l\right) l}{F_k\left(k\left(z^{t-1}\right), l\right) k}$$

given that $c\left(z^t\right)$ is independent of z_t, the result follows. ■

The results in this section tell us that a government with commitment would not amplify the cycle through its tax policy. Even when it taxes capital countercyclically, at the beginning of every period the expected tax burden on capital is zero. However, what if the government has no ability to commit to future policy? Would the tax policy of such a government amplify the cycle? This important question is the one we turn our attention to next.

3 Optimal Taxation with Limited Commitment

Once the investment decision by the capitalists has been made at the beginning of a period, for any possible realization of the productivity shock, the government would like to tax capital as much as possible and redistribute the proceeds to the workers. Thus, the optimal tax policy under commitment might not be dynamically consistent. As is standard in the literature, we model the economy as a game between the capitalists and the government and use sustainability (Chari and Kehoe (1990) as our solution concept. We are interested in characterizing the efficient sustainable equilibria of the game.

We assume the following

Assumption (A Maximum Tax Rate). *At any state z , the tax rate on capital cannot be higher than $\bar{\tau}(z)$*

Let h_{t-1} be the history of tax policies and productivity shocks up to the beginning of period t: $h_{t-1} = \{(\tau_s, z_s) | s = 0, ..., t-1\}$ (we do not need to incoporate the capitalists previous investment decisions, see Chari and Kehoe (1990)). A government's policy rule at time t is a function $\tau_t(h_{t-1}, z_t)$ that maps previous history into a corresponding tax rate smaller than $\bar{\tau}(z)$. A capitalist's investment rule at time t is a function $k(h_{t-1})$ that maps previous history into a corresponding capital level.

A government policy plan is a sequence of policy rules $\sigma = \{\tau_1, \tau_2, ...\}$. A capitalist's investment plan $\kappa = \{k_1, k_2, ...\}$ is a sequence of investments rules. For any (σ, κ) we can compute the associated consumption level of the workers after any history, called the consumption allocation by $c(\sigma, \kappa)$.

Definition. A *sustainable equilibrium* is a pair (σ, κ) such that:

(i) Given a policy plan σ and any history h_{t-1}, the associated investment rule under κ, $k_t(h_{t-1})$, is the value of k that solves

$$\delta + r^* = E\left[z_t\left(1 - \tau(h_{t-1}, z_t)\right) F_k\left(k, l\right) | z^{t-1}\right] \tag{6}$$

(ii) Given κ, for any history (h_{t-1}, z_t), the continuation of the policy plan σ maximizes the expected lifetime utility of the workers from t onwards.

We will focus attention now on a particular sustainable equilibrium.

3.1 The Autarkic (Markov) Equilibrium

Suppose that the government after any history sets tax rates equal to $\bar{\tau}(z_t)$. Let σ_M be respective policy plan. Let $\kappa_M = \{k_1, k_2, ...\}$ where $k_t(h_{t-1}, z_t)$ is given by (6). Note that the only relevant history is the history of the productivity shocks. The following holds

Proposition 4 (Worst Equilibrium) *The pair (σ_M, κ_M) is a sustainable equilibrium. In particular, of all sustainable equilibria, after any history h_{t-1}, (σ_M, κ_M) generates the **lowest** utility to the government.*

Proof. To be completed. ■

In the Markov equilibrium, clearly, the government will always set the capital tax rate at the maximum possible level. This will generate distortions in capital investment in all states of the world.

Let $V_M(z^{t-1})$ be the payoff to the government at the beginning of period t after a history of shocks z^{t-1} under the equilibrium (σ_M, κ_M). We can use this function V_M to generate efficient equilibria in a recursive fashion by following Abreu, Pearce and Stachetti (1990). We turn to the characterization of the equilibria in the next subsection.

3.2 The Best Sustainable Equilibria

We can characterize the best equilibrium recursively as follows:

$$W(z_{t-1}) = \max_{k,c(\cdot)} E_{z_t|z_{t-1}} \left[u(c(z_t)) + \beta W(z_t)\right] \tag{7}$$

subject to

$$E\left[z_t|z_{t-1}\right] F\left(k,l\right) - E\left[c\left(z_t\right)|z_{t-1}\right] - \left(\delta + r^*\right) k = 0 \tag{8}$$

$$u(c(z_t)) + \beta W(z_t) \geq u(\bar{c}(z_t, k)) + \beta V^M(z_t) \tag{9}$$

for

$$\bar{c}(z_t, k) = z_t[(1 - \bar{\tau}(z_t))F_l(k, l)l + \bar{\tau}(z_t)F(k, l)]$$

and where V^M is the value function of the government in the worst equilibrium as previously described.

Equation (8) is the aggregate resource constraint of the government and inequality (9) is the participation constraint. One problem when trying to characterize the best equilibrium is that the constraint set in the maximization above is not convex. The presence of k, a choice variable, in what could be the *wrong* side of an inequality, constraint (9), implies that we need to be extra careful in taking first order conditions for instance.

However, since the Bellman operator in (7) is monotone, for a numerical implementation we could iterate down to the best equilibrium with the initial guess for the value function being the full commitment value. The section **XX** describes the results of the simulations. However, before entering into the simulation, it is still possible to provide more information about the optimal equilibrium analytically. We start by proving a Folk theorem.

Proposition 5 *There exists a $\beta^* \in (0, 1)$ such that for all $\beta \geq \beta^*$ the* ***Ramsey solution*** *is* ***sustainable*** *and it is* ***not sustainable*** *for $\beta \in [0, \beta^*)$*

Proof. First we show that if for β_0 the Ramsey allocation is sustainable, then it is sustainable for all $\beta \in [\beta_0, 1]$. Note that the Ramsey allocation is independent of the value of β. Note also that the Markov allocation is independent of the value of β as well. Let $\Delta(z_{t-1})$ be the Ramsey value minus the Markov value and define by c^R and c^M the consumption allocations under the Ramsey and the Markov plan respectively. Then we can represent $\Delta(z_{t-1})$ as

$$\begin{aligned}\Delta(z_{t-1},\beta) &= W(z_{t-1}) - V(z_{t-1}) \\ &= \{u(c^R(z_{t-1})) - E[u(c^M(z_t)|z_{t-1}]\} + \beta E[\Delta(z_t,\beta)|z_{t-1}]\end{aligned}$$

Taking derivatives with respect to β we get

$$\Delta_\beta(z_{t-1},\beta) = \beta E[\Delta_\beta(z_t,\beta)|z_{t-1}] + \beta E[\Delta(z_t,\beta)|z_{t-1}]$$

which solves for

$$\Delta_\beta(z_{t-1},\beta) = \sum_{z\in Z} a(z|z_{t-1})E[\Delta(z_t,\beta)|z]$$

for some $a(z|z_{t-1}) \geq 0$. Given that $u(c^R(z_{t-1})) \geq E[u(c^M(z_t)|z_{t-1}]$[4] this implies $\Delta(z_t,\beta) \geq 0$; and this that $\Delta(z_t,\beta)$ is increasing in β. So the participation constraint at the Ramsey allocation

$$u(c^R(z_{t-1})) - u(\bar{c}(z_t, k^R(z_{t-1}))) \geq -\beta\Delta(z_t,\beta)$$

is monotonically relaxed as β increases. When $\beta = 0$, it is clearly not satisfied for some z. When $\beta = 1$, it is clearly satisfied with slackness (the right hand side is minus infinity). So there exists a $\beta \in (0,1)$ for which above that β the Ramsey solution is sustainable and below it isn't. ■

When the government is patient enough, the Ramsey solution is sustainable. As before, this will imply a fiscal policy that does not affect the business cycle. The interesting question is however, what happens when the government is not patient enough to sustain the Ramsey solution, nor impatient enough that the punishment equilibrium is the unique sustainable one.

Definition 6 *Let $k(z)$ and $c(z'|z)$ be the respective policy rules that solve the Bellman problem at state z.*

The following propositions helps towards an answer.

[4] Note, that this is after k has adjusted to the Markov level.

Lemma 7 *For any given state z_{t-1} if the participation constraints (9) are not binding for a subset $Z_o \subset Z$ then $c(z|z_{t-1}) = c(z'|z_{t-1})$ for all $(z, z') \in Z_o \times Z_o$.*

Proof. Sketch. For given k the problem is convex on c. Optimality over c will yield the result. ■

So, if the participation constraints do not bind tomorrow for two states, the planner will equalize consumption in those states. If consumption is not equalized across two states tomorrow, is because a participation constraint is binding. We have the following result.

Lemma 8 (Distorting Down) *For any given state z_{t-1},*

$$E[z_t|z_{t-1}]F_k(k(z_{t-1}), l) \geq (\delta + r^*)$$

If for some $z, z' \in Z \times Z$ we have that $c(z|z_{t-1}) \neq c(z'|z_{t-1})$ then

$$E[z_t|z_{t-1}]F_k(k(z_{t-1}), l) > (\delta + r^*)$$

Proof. A necessary condition for an optimum is that there exists a $\lambda(z) \geq 0$ and γ such that

$$\gamma\{E[z_t|z_{t-1}]F_k(k, l) - (\delta + r^*)\} - \sum_{z_t} \lambda(z_t) u'(\bar{c}(z_t, k))\bar{c}_k(z_t, k) = 0$$

Another necessary condition for an optimum is that

$$\begin{gathered} q(z_t)u'(c(z_t)) - \gamma q(z_t|z_{t-1}) + \lambda(z_t)u'(c(z_t)) = 0 \\ \Leftrightarrow (1 + \lambda(z_t)/q(z_t))u'(c(z_t)) = \gamma/q(z_{t-1}) \end{gathered}$$

This implies that $\gamma \geq 0$. Using that $F_{kl} > 0$ we have that $\bar{c}_k > 0$. The first necessary condition then implies the first part of the lemma.
For the second part note that if $c(z_t)$ is not constant for all $z_t \in Z$ at an optimum (by the hypothesis of the second part of the lemma) then $\lambda(z) > 0$ for some z. Given then that $\lambda(z) \geq 0$ with strict inequality for at least one $z \in Z$ we have the proof of the second part of the lemma. ■

Benhabid and Rusticini (1997) have shown that in a deterministic closed economy model of capital taxation without commitment, there are situations where capital is subsidized in the long run, and the steady state level of capital is higher than the first best level. In our case, with an open economy, such a situation never happens. The previous lemma tells us that capital is always distorted downwards (taxed). It also says that if consumption is not equalized across states then, in an efficient allocation, capital will be distorted. Now the question is if this distortion is more likely to happen in a downturn? Before trying to answer it, let us first analyze a simpler case, where fiscal policy does not affect the cycle.

3.3 The Case of i.i.d. Shocks

It is easy to see that if the productivity shocks follow an i.i.d. process, then the value functions V^M and W are constants. Then the following result follows

Proposition 9 (IC binds in high states) *Let the productivity shock follow an i.i.d. process. In an optimal allocation, if an incentive constraint binds for any $z \in Z$, then it also binds for any $z' \in Z$ such that $z' > z$*

Proof. Suppose that an IC constraint is slack for some z_2 but it is binding for some z_1 where $z_2 > z_1$.

$$u(c(z_1)) = u(\bar{c}(z_1, k)) + \beta(V^M - W)$$
$$u(c(z_2)) > u(\bar{c}(z_2, k)) + \beta(V^M - W)$$

Given that $\bar{c}(z, k)$ increases in z, this implies that $c(z_2) > c(z_1)$. Now, create a new allocation by increasing $c(z_1)$ and reduce $c(z_2)$ such that the expected consumption does not change. For small enough change, this is incentive compatible. However, the new allocation attains strictly higher utility than the previous one, which is a contradiction. ■

This is a fairly standard result. In an i.i.d. world, incentive constraints are binding in high states. These are the states where the government is called to subsidize capital and what it really desires to do is to increase the transfer to workers. However, as will be explained below, this intuition is incomplete when analyzing the model in an economy with persistent shocks. In an i.i.d. world the future capital tax promises are independent of the current states and hence the current state should not affect next period taxes nor current period investment. However, in a world with persistent shocks, the current state does affect the future promises of taxation, and will affect the level of investment. This is where our attention turns next.

3.4 Persistent Shocks and Amplification

With i.i.d. shocks, the current state of the economy did not affect next period promises of taxation, nor next period expected productivity shocks, and investment was independent of the current state.

In a world where the current productivity shocks are signals about the distribution of productivity shocks tomorrow, the promises of taxation will be functions of the current state. Whether the economy is in a boom or recession, this will affect the expected future state of the economy and affect the tax promises the government will have to make to achieve full static insurance and maintain an efficient level of investment. How do these promises change over the cycles? Is it harder for a government to make promises of not taxing capital in good times or in bad times? How would this affect the business cycle?

We make the following assumption

Assumption (Persistent Shocks). *The productivity shocks are such that $E(z|z_{-1})$ is strictly increasing in z_{-1}.*

Our main result will state that for any z_t, the incentive constraint is more likely to bind at time t if the state of the economy was low at $(t-1)$. A low state today thus signals tighter incentive constraints tomorrow and will imply distortions on the investment margin during bad times.

Consider the commitment solution. Consumption under full commitment can be written as:

$$c^*(z_{t+1}|z_t) = E(z_{t+1}|z_t)F(k^*(z_t), l) - (r+\delta)\,k^*(z_t)$$

where $k^*(z)$ is such that $E(z'|z)F_k(k^*(z), l) = r + \delta$.

As stated before, consumption at time t under commitment is independent of the realization of the productivity shock at time $(t+1)$, z_{t+1}.

On the other hand, autarkic consumption similarly can be written as

$$\bar{c}\left(z_{t+1}, k^*(z_t)\right) = z_{t+1}F(k^*(z_t), l) - \frac{z_{t+1}(1-\bar{\tau}(z_{t+1}))}{E(z_{t+1}|z_t)}(r+\delta)k^*(z_t)$$

Define

$$\Delta\left(z_t, z_{t+1}\right) = u(c(z_{t+1}|z_t)) - u(\bar{c}\left(z_{t+1}, k^*(z_t)\right))$$

Under the assumption that the first best is implementable, the incentive constraints can be written as

$$\Delta\left(z_t, z_{t+1}\right) \geq \beta(V(z_{t+1}) - W(z_{t+1}))$$

If $\Delta\left(z_t, z_{t+1}\right)$ is increasing in z_t then as β decreases, incentive constraints are binding first in states where the previous productivity shock was low. This is formalized below.

Proposition 10 (Distortion at the Bottom) *Suppose that $\Delta\left(z_t, z_{t+1}\right)$ is increasing in z_t for all z_{t+1}. Then the following holds:*

In an optimal allocation if $k(z) = k^*(z)$ for some $z \in Z$ then $k(z') = k^*(z')$ for all $z' > z$.

Proof. The fact that $k(z) = k^*(z)$ implies that the first best capital level is attained immediately after a z shock. We know from lemma XX that consumption the period after a z shock will be constant and equal to c^*. So, it is the case then that

$$\Delta\left(z, \hat{z}\right) \geq \beta(V(\hat{z}) - W(\hat{z}))$$

for all $\hat{z} \in Z$. Given the monotonicity condition this implies that

$$\Delta\left(z', \hat{z}\right) \geq \beta(V(\hat{z}) - W(\hat{z}))$$

for all $z' > z$. So, first best capital is attained also after a z' shock and $k(z') = k^*(z')$. ■

When is $\Delta\left(z_t, z_{t+1}\right)$ increasing in z?

Proposition 11 *If the production function is Cobb Douglas, i.e. $y = zk^{\alpha}l^{1-\alpha}$, then $\Delta\left(z, z'\right)$ will increase in z if the following necessary condition holds, $\frac{u'(c^*)c^*}{u'(\bar{c})\bar{c}} \geq \alpha$. A sufficient condition requires that $\frac{z'}{E(z'|z)} \leq \frac{(1-\alpha)}{\alpha}$.*

Corollary 12 *If the utility function is log utility, the production function is Cobb-Douglas and $E(z'|z)$ is increasing in z, then $\Delta\left(z', z\right)$ will be increasing in z.*

When the state of the economy is low it is not incentive compatible to promise first best tax rates as compared to if the state of the economy is high. Consequently, an economy in a low state will accumulate lesser capital. This will cause the downturn to last longer.

The intuition as to why governments respond this way to a recession is based on the persistence of the underlying shock process and can be understood by considering deviations from the first best. In the first best, average consumption promised to workers is higher following a boom compared to a recession. Consequently, the gains to deviating from the first best taxes, in terms of the value of the additional consumption will be greater following a recession as compared to a boom. On the other hand, the size of the capital stock will be higher following a boom than a recession which will make it more tempting to deviate following a recession since there is more to expropriate. We show that as long as the underlying shock is sufficiently persistent, relative to the curvature of the production function, the proposition described in the previous paragraph will hold. A specific instance when this condition holds is in the case of log utility and a Cobb Douglas production function, as long as the expected value of the shock is increasing in the shock.

4 Simulations

To solve the problem numerically, we iterate on (7). We consider two discrete values for z - z_H and z_L. Given how the problem is written, the only state variable is z. Our initial guess for the value function $W^0(z)$, is the value function for the case with full commitment. Since the value in the case with full commitment will necessarily be at least as great as the value with limited commitment, and since the bellman operator is monotone, starting with $W^0(z)$ we should converge monotonically down to the maximized value with limited commitment. Given the continuation value $W^0(z)$,the government chooses $t_H(z'_H|z)$ and $t_L(z'_L|z)$, for each z that maximizes (7) subject to (8), (**??**) and (9). This gives a new value $W^1(z)$. We repeat this procedure until $|W^{i+1} - W^i| < \varepsilon$, where ε is a very small number. Figure 1 depicts the distortion in capital stock in the low states (z_L). The dashed line represents the capital stock when there are no tax distortions, which is the case with perfect commitment. The strong line represents the capital stock in the case of limited commitment. As argued earlier, capital accumulation is not distorted in the high states, however it is distorted in the low states. This in turn exacerbates the downturn in output during recessions and prolongs recessions.

5 Empirical Evidence

Fiscal policy in developing countries are increasingly documented as displaying pro-cyclicality. That is government expenditures tend to be high when the economy is booming as compared to recession. Similarly, tax rates tend to be countercyclical. That is, tax rates tend to be raised in low states and kept low in high states. Such a policy will amplify the cycle of a country as opposed to stabilizing it as a countercyclical policy will do. Evidence on tax policy is presented in Kaminsky, Reinhart and Vegh (2004). As they argue, to check for policy stance one should use measures of tax rates as opposed to ratios of tax revenues to GDP. The latter is at best an ambiguous measure of policy stance. In general obtaining a series on tax rate is not easy for most developing countries. Kaminsky et al (2004) present evidence on inflation tax. They find that while developing countries are more likely to display procyclicality, this is not true for the OECD countries. Ideally, one would need other measures of tax policy. Also, it would be useful to have a detailed break-up of expenditure to examine where the cuts in spending take place in recessions. Here we present evidence for Argentina starting from 1993. This data was obtained from (Carta Economica, Estudio Broda, several issues), a private think tank in Argentina.

Firstly, Table X documents new taxes introduced by Argentina on certain export items that previously were subject to 0 tax rates. Table 2 indicates evidence of the rising share of export tax revenue and profit tax revenue. The profit tax as a ratio of GDP increased during the crisis. Interestingly, while government expenditures declined dramatically during the crisis "transfers to the private sector" did not decline. During the 1995 recession when other forms of government expenditure declined, transfers rose by 48%. Similarly when the crisis hit in 2002, transfers rose by 14% at the same time when other government expenditure fell by 24%.

Table 1 shows that expropriation risk and wage and price regulation in Argentina increased during its recent crisis. This is data from the Heritage Foundation and the Fraser Index.

6 Conclusion

(To be completed)

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TABLE 1

ARGENTINA: ECONOMIC FREEDOM MEASURES

	Heritage Foundation*			Fraser Institute**		
	Index of Economic Freedom	Property Rights	Regulation of Wages and Prices	Index of Economic Freedom	Legal Freedom and Property Rights	Regulation of Labor,Credit and Business
1995	2.85	2.0	2.0	6.7	5.5	6.6
1996	2.63	2.0	2.0	na	na	na
1997	2.75	2.0	2.0	na	na	na
1998	2.53	2.0	2.0	na	na	na
1999	2.28	2.0	2.0	na	na	na
2000	2.23	2.0	2.0	7.2	5.4	6.7
2001	2.29	2.0	2.0	6.5	3.6	5.4
2002	2.58	3.0	1.0	5.8	3.2	5.1
2003	3.04	3.0	2.0	na	na	na
2004	3.48	3.0	3.0	na	na	na
2005	3.49	3.0	3.0	na	na	na

Note: *Increase implies a worsening. **Increase implies an improvement. The property rights index of the heritage foundation measures the legal protection of property and the risk of government expropriation of property. The wages and prices index calculated the extent to which a government allows the market to set wages and prices.

TABLE 2

ARGENTINA: TAX AND TRANSFER DATA

Year	GDP growth	Ratio of Transfers to Government Expenditure (excluding interest payment)	Government Expenditure (excluding interest payments and transfers to private sector)	Real Government Transfers to the Private Sector	Ratio of Export Tax to Government Revenue (excluding privatizations)	Ratio of Profit Tax to Government Revenue (excluding privatizations)
1993		0.047			0.015	0.096
1994	0.056	0.062	0.002	0.345	0.026	0.122
1995	-0.029	0.101	-0.037	0.488	0.005	0.129
1996	0.053	0.094	0.026	-0.050	0.008	0.147
1997	0.078	0.107	0.103	0.254	0.007	0.153
1998	0.038	0.109	0.030	0.054	0.002	0.168
1999	-0.0345	0.118	0.008	0.099	0.001	0.168
2000	-0.007	0.116	-0.030	-0.051	0.002	0.188
2001	-0.045	0.118	-0.065	-0.045	0.092	0.200
2002	-0.111	0.165	-0.241	0.139	0.118	0.162
2003	0.081	0.163	0.158	0.143	0.098	0.191
2004		0.134				0.212

Source: Carta Economica, Estudio Broda, several issues.

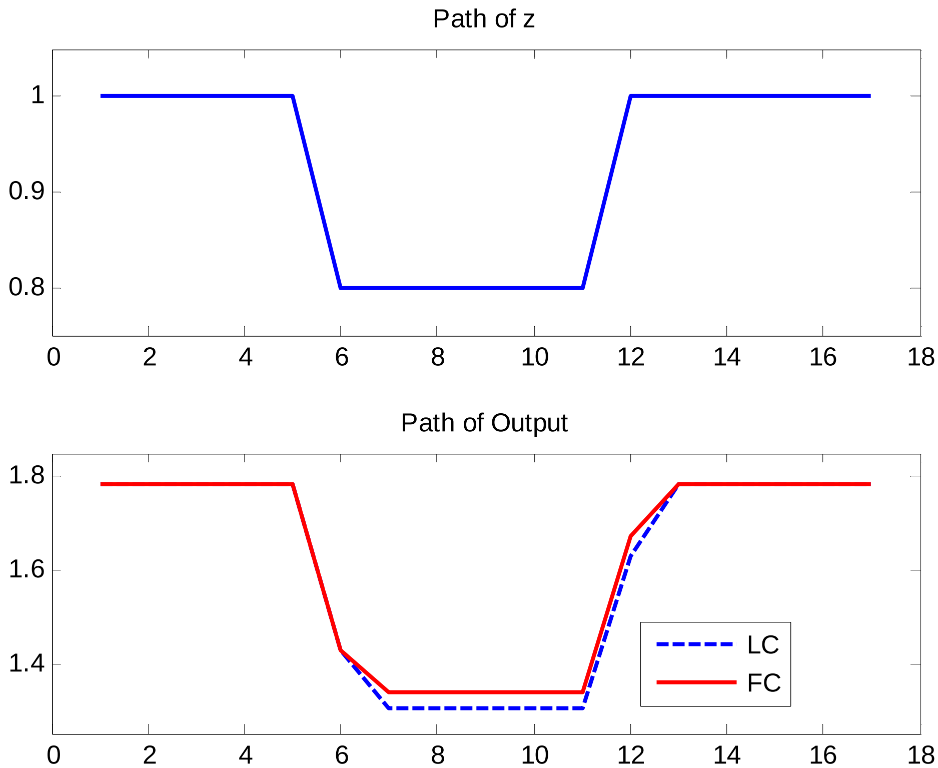
Simulation Parameters

World interest rate	0.05
Depreciation rate	0.05
Time preference rate	0.67
Risk Aversion	2
Punishment Tax	0.5
Capital Share	0.33
zH	1
zL	0.8
pHH	0.9
pLL	0.7

CAPITAL TAX RATES

	Full Commitment	**Limited Commitment**
$\tau(H \mid H)$	-0.04	-0.04
$\tau(L \mid H)$	0.45	0.45
$\tau(H \mid L)$	-0.28	-0.04
$\tau(L \mid L)$	0.15	0.12
$E(z\tau \mid H)$	0	0
$E(z\tau \mid L)$	0	0.04

	Full Commitment	Limited Commitment
$\sigma(z)$	0.089	0.089
$\rho(z)$	0.622	0.622
$\sigma(Y)$	0.119	0.128
$\rho(Y)$	0.747	0.773
$\rho(\tau, Y)$	-0.653	-0.666
${K_H}^{LC} / {K_H}^{FC}$		1
${K_L}^{LC} / {K_L}^{FC}$		0.93


Path of z
1
0.9
0.8
0
2
4
6
8
10
12
14
16
18
Path of Output
1.8
1.6
1.4
LC
FC