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POLICY VARIABILITY AND ECONOMIC GROWTH*

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ABSTRACT

This paper explores the effect of policy variability (or frequency of regime switching) on economic growth and welfare. We study a one sector growth model where investment can be subsidized at either a positive rate or not subsidized at all. We find that the lack of persistence in policies per se need not be welfare reducing and that is it likely to decrease growth. Higher variability implies more frequent changes in consumption and investment. But, by creating a stronger intertemporal link across regimes, variability reduces the fluctuation in investment rates, thus reducing the amplitude of fluctuations on consumption and increasing welfare.

Keywords. Theory of Growth, Economic Dynamics, Policy regimes.

JEL Classification: C63, E13, E22, E61, O41.

1. **Introduction.**

The connection between government policies and economic growth has recently received considerable attention. For the case of developing countries, the work of Chenery et al. (1986), Easterly and Wetzel (1989) and Krueger (1978) suggests that policies that distort relative prices and resource allocation are an important source of differences in performance among countries. Examples of such policies are differential import tariffs, export and investment subsidies, allocation of foreign exchange, taxes (see Easterly (1992)).

Policies not only differ across countries, but there is also a significant variation over time within countries. Often as a consequence of political instability, regimes with different economic incentives alternate over time, with different degrees of persistence. According to Easterly, King et al. (1991) the government current expenditure variables – like consumption and education spending – are quite persistent while government investment, trade orientation, and black market premium are not very persistent[1]. Harrison (1991) also finds that over the last thirty years most developing countries have experienced large variations in commercial and exchange rate policies[2].

The purpose of this paper is to analyze the implications of such policy variability or regime switching on the level and characteristics of economic growth. Though there is a fairly widespread view that the lack of persistence could lead to slower growth and reduced welfare, to our knowledge no serious theoretical attempt has been made to consider the question in a more rigorous way. This paper explores this issue in a neoclassical growth model.

The type of policies we consider are given by the level and distribution of investment subsidies. Many policies, such as investment tax credits and regional or sectoral subsidies to investment fall into this category. The scope is even broader if one considers other policies which, indirectly, have a similar effect, such as tariffs or import quotas, quantitative allocation of credit or foreign exchange and, investment licenses or other regulatory requirements.

The growth effects of distortionary government policies was first analyzed by Easterly (1992), Jones and Manuelli (1990) and King and Rebelo (1990). By altering the rate of return to capital, these policies can either stimulate or discourage investments in different sectors of the economy, thus affecting their capital accumulation rates. In particular, any distortion that increases the price of one capital good will have a negative impact on growth. If instead the distortion decreases the price of one capital good, the result will be the reverse (i.e., there will be too much growth) [3]. This literature has not considered the effects of persistence of policy regimes -or policy variability- on growth.

Aizenman and Marion (1993) study the effects of policy uncertainty (defined as the gap between two policy regimes) and persistence in a model with two possible profit tax regimes (high or low). They find that increases in policy uncertainty can have positive or negative effects on growth depending on the degree of regime persistence and the

[1] As an example they find that the cross section correlation between 1960's and 1970's for government education spending is 0.75 while for trade orientation is 0.56.

[2] See also FIEL (1988) and (1990) for the case of Argentina.

[3] Easterly (1992) uses data for developing countries and his results suggest that distortions have a significant effect on growth.

magnitude of the policy fluctuation. They show that in the absence of persistence, policy uncertainty does not affect growth. Our paper focuses, precisely, on the implications of the *degree* of policy persistence on the level and characteristics of growth and on welfare.

We analyze a linear neoclassical growth model and, as in Aizenman and Marion (1993), identify regimes with very specific policies. We take these policies as given and do not model the political process by which they are instituted or changed. This is obviously a simplification with respect to the models of endogenous policy determination considered by the literature on intertemporal politico-economic equilibrium (for a survey see Persson and Tabellini (1990)[4]). Different degrees of policy persistence could result from voting models as a consequence of different institutional arrangements (e.g. length of appointments or majority rules for overturning decisions) or as part of the multiple equilibria that some of these models exhibit[5].

We study a one sector growth model where investment is subsidized at a uniform rate but this rate can be either positive or zero. Thus there are two possible regimes: the *subsidy* and *nonsubsidy* regimes. Subsidies are financed with lump sum taxation. The degree of policy variability of an economy is given by the arrival rate of a regime switch. The setup is similar to Aizenman and Marion (1993), but with two differences. Firstly, we allow for income effects, which by assumption are absent in their setup. Secondly, as indicated above, we focus on policies that affect the cost of investment rather than its return.[6]

The results obtained for this one sector model show that, surprisingly, higher variability leads to higher welfare and it is likely to decrease growth. The mechanism by which increased welfare results is an interesting one, where income effects play a crucial role. Since there are no externalities in capital accumulation, investment subsidies lead to an intertemporal distortion and excessive investment in periods of subsidy. This raises the value of consumption in periods of subsidy and, in anticipation, the expected return on investment in periods of no subsidy. Consequently, in periods of no subsidy investment is also above its corresponding value for a zero subsidy economy: subsidies to investment *spill over* periods of no subsidy.

Higher variability implies more frequent changes in the level of investment and consumption. But by creating a stronger intertemporal link across the two regimes, investment in periods of no subsidy increases with variability, while it decreases in periods of subsidy. This reduces the amplitude of the fluctuations in consumption, thereby increasing welfare.

We prove that average long run growth rates increase with variability when the latter

[4]An incomplete list of papers includes Alesina (1987), Alesina and Rodrik (1994), Alesina and Tabellini (1989), Persson and Tabellini (1994), Krusell and Rios-Rull (1996). Several of these papers rationalize the idea of political cycles as an important source of (policy) shocks, providing an explanation for the lack of policy persistence.

[5]To consider our question within that class of models would result, at the very least, in the need of making overly simplifying assumptions for the sake of tractability without an obvious gain in insights. An alternative, which is the one we chose, was to take a standard growth model, such as the ones used in the analysis of distortionary policies mentioned above, and as a first approximation abstract from the process of policy determination.

[6]For the one sector model, similar results are obtained with taxes on returns.

is close to zero. However, our numerical simulations suggest that this is a local result and that for more reasonable levels of variability, variability has a negative effect on growth.

An alternative definition of variability which has often been considered in the literature relates to the distance between the alternating policies; the *amplitude* of the investment subsidy process. In the paper we show that an increase in such amplitude results unequivocally in higher growth rates and lower welfare. The higher growth rates are a consequence of the convexity of the return function with respect to the subsidy rate. The effects on welfare are negative for two reasons: increases in the amplitude of the policy process result in less consumption smoothing and a larger deviation of growth rates from the undistorted value.

Increases in the amplitude of the process makes periods of high and low subsidy rates look more different, wheras increases in the frequency of changes reduces this difference. This suggests that the results obtained for increases in uncertainty as measured by the amplitude of changes which have been typically explored in the literature can be quite different to those relating increases in the frequency of policy changes. Without disregarding the importance of differences in the level of uncertainty as measured by the dispersion of policies, we think that frequency considerations are quite meaningful when considering the economic consequences of political instability.

The paper is organized as follows. The model is presented in Section 2. Section 3 describes the simulations. Section 4 discusses alternative formulations for policy uncertainty, income taxation and adjustment costs. Section 5 concludes. The Appendix contains the Welfare Analysis.

2. The Model.

We consider a simple endogenous growth model where all factors of production are reproducible and their quantity is summarized by the composite capital good k (see King and Rebelo (1990) and Rebelo (1991)).

The production technology is given by:

$$y_t = Ak_t \tag{1}$$

where $A > 0$ is a time invariant productivity parameter. Capital depreciates at rate δ and investment is irreversible:

$$\dot{k}_t = x_t - \delta k_t \tag{2}$$

where $\dot{k}_t = \partial k_t / \partial t \geq \delta$. There is a large number (constant over time) of identical agents that are endowed with an initial amount of capital. Agents maximize expected utility defined as $U = E \int_0^\infty e^{-\rho t}\, u(c_t)\, dt$, where $\rho > 0$ is the constant rate of time preference, c_t is consumption at time t and, $u(c_t)$ is the instantaneous utility. We assume that $u(c_t)$ is of the constant elasticity type so the expected utility is:

$$U = E \int_0^\infty e^{-\rho t}\, \frac{c_t^{1-\sigma}}{1-\sigma}\, dt \tag{3}$$

where $\sigma > 0$ is the reciprocal of the intertemporal elasticity of substitution.

To study the role of policy variability we analyze a very simple subsidy policy. We assume that the government grants investment subsidies that vary over time. Specifically, there are two possible regimes: one where investment is subsidized at a constant rate $0 < \tau < 1$ and another, where there is no subsidy. Let z_t be a random variable that takes values one and zero in the subsidy and no subsidy regimes respectively. Let λ represent the arrival rate of a regime change so the expected duration of a regime is then $1/\lambda$. Agents observe the realization of z_t before making their period t decisions. The investment subsidy per unit of capital at time t is then

$$\tau(z_t) = \begin{cases} \tau & \text{if } z_t = 1 \\ 0 & \text{if } z_t = 0 \end{cases} \tag{4}$$

Since investment is irreversible, aggregate investment can not be negative. Because agents are identical, we may assume without loss of generality that the representative agent is subject to this constraint. Throughout our analysis, investment is strictly positive and the growth rate constant within each regime. The price of capital is then identical to that of the consumption good, which is used as a numeraire.

Subsidies are financed by lump sum taxation. Since all agents are identical and the economy is closed, feasibility requires that the government budget be balanced in each period. Let $T_t(z_t)$ represent the lump sum taxes at t measured in units of consumption as a function of the regime, then

$$T_t(z_t) = \begin{cases} \tau x_t & \text{if } z_t = 1 \\ 0 & \text{if } z_t = 0. \end{cases} \tag{5}$$

We study the competitive equilibrium for this stochastic economy. It is important to point out that the competitive equilibrium of the model economy without taxes or subsidies is Pareto optimal so any government intervention is distortionary. The effects of government policies in the non stochastic case are well known: investment subsidies incentivate capital investment and increase growth (i.e., there will be *too much growth*), investment taxes are detrimental for growth, and lump sum taxes do not affect intertemporal decisions (and therefore growth). Since we consider stochastic investment subsidies (financed by lump sum taxes), growth rates will exceed those of the undistorted economy and welfare will be lower.

To describe the competitive equilibrium of our economy with stochastic taxes and subsidies, we will use a very simple market structure. We assume that firms do not face dynamic problems: in every period, they rent capital in the spot market. Profit maximization implies that the rental price of capital is equal to its marginal product (A). Agents own capital, rent it to the firms and make investment decisions. Agents consider lump sum taxes and investment subsidies to be independent of their behavior and choose their consumption and accumulation plans as to maximize the expected lifetime utility given by (3). Since the price of capital is one, the net price agents pay for a unit of capital is $1 - \tau(z_t)$. The representative agent's budget constraint at time t is given by:

$$c_t + (1 - \tau(z_t))x_t \leq Ak_t - T_t(z_t). \tag{6}$$

Thus, agents maximize (3) subject to (2) and (6) and taking the tax and subsidy sequences as given. Notice that we have not allowed the agent to borrow or lend and therefore capital investment is the only way to shift consumption over time. This is not restrictive in a representative agent economy since there will be no borrowing or lending in equilibrium.

For the particular preferences used and since the technology is linear, it is a well established fact that the equilibrium decision rules are linear in k_t and that along a balanced stochastic growth path the interest rate is independent of k_t (though both, decision rules and interest rate will depend on the regime, z_t). Furthermore (3) implies that the optimal growth rate of consumption $g(z_t)$ satisfies the following:

$$g(z_t) = \frac{r(z_t) - \rho}{\sigma} \tag{7}$$

where $r(z_t)$ is the real interest rate (see Rebelo (1991)). Notice that the agent's lifetime utility will be finite if the expected growth rate of the momentary utility $(1-\sigma)E(g(z_t))$ is lower than the discount rate ρ. This is also equivalent to the transversality condition of the agent's problem.

Let $c(z_t)$ represent an agent's consumption per unit of capital at time t as a function of the regime z_t. Then $c(0)$ and $c(1)$ represent time t consumption when $z_t = 0$ and $z_t = 1$, respectively, and $k = 1$. Define $\tilde{R}$ to be the relative net price of capital between subsidy and non subsidy regimes measured in consumption units of the nonsubsidized regime, i.e.:

$$\tilde{R} = (1-\tau)\,\frac{u'(c(1))}{u'(c(0))} = (1-\tau)\left(\frac{c(0)}{c(1)}\right)^{\sigma}. \tag{8}$$

The variable $\tilde{R}$ captures the change in the value of a stock of capital due to regime changes. Suppose that at time t the no subsidy regime is in place and let $c(0)$ be the numeraire. The instantaneous capital gain from a change in regime[7] is given by $(1-\tau)\,\frac{u'(c(1))}{u'(c(0))} - 1 = \tilde{R} - 1$. If instead the prevailing regime is that of subsidy and $c(1)$ the numeraire, the corresponding gain is $\frac{u'(c(0))}{u'(c(1))} - (1-\tau) = (1-\tau)(\tilde{R}^{-1} - 1)$.

Equilibrium in the capital market requires that the interest rate equals the expected return divided by the price of capital. The expected return is equal to the marginal product net of depreciation plus the expected capital gains. Since investment is always positive, capital gains are zero unless there is a regime change. Thus, the expected capital gains are $\lambda(\tilde{R} - 1)$ when z_t is equal to zero and $\lambda(1-\tau)(\tilde{R}^{-1} - 1)$ when z_t equals one.

Letting $r(0)$ and $r(1)$ represent the interest rates when $z_t = 0$ and $z_t = 1$ respectively,

$$r(0) = A - \delta + \lambda(\tilde{R} - 1) \tag{9}$$

$$r(1) = \frac{A - \delta(1-\tau) + \lambda(1-\tau)(\tilde{R}^{-1} - 1)}{(1-\tau)}. \tag{10}$$

Per capita consumption in both regimes is constrained by

$$c_t(0) = (A - g_k(0) - \delta)k_t \tag{11}$$

$$c_t(1) = (A - g_k(1) - \delta)k_t, \tag{12}$$

[7]Notice that this capital gain can be positive or negative. In fact, as we will show later, it will be positive when $z_t = 0$ and negative when $z_t = 1$.

where $g_k(0)$ and $g_k(1)$ are the growth rates of capital in the two regimes. Notice that (11) and (12) imply that if growth rates are independent of k_t and only depend on the regime in place at time t, consumption and capital will grow at the same rate (i.e., $g(0) = g_k(0)$ and $g(1) = g_k(1)$).

The equilibrium for this economy is then characterized by:

$$\sigma g(0) + \rho = A - \delta + \lambda(\tilde{R} - 1) \tag{13}$$

$$\sigma g(1) + \rho = \frac{A}{(1-\tau)} - \delta + \lambda(\tilde{R}^{-1} - 1) \tag{14}$$

$$\tilde{R} = (1-\tau)\left(\frac{A - g(0) - \delta}{A - g(1) - \delta}\right)^{\sigma}. \tag{15}$$

We now turn to the properties of the competitive equilibrium. We compare the two growth rates and analyze the effect of changes in the subsidy rate and the degree of policy variability. The first proposition shows that the growth rate (and therefore the interest rate) is higher in the subsidy regime than in the no subsidy regime.

Proposition 1. *Suppose $0 < \tau < 1$ and $\lambda > 0$, then $g(1) > g(0)$.*

Proof. Suppose, by way of contradiction, that $g(1) \leq g(0)$. Then $r(1) \leq r(0)$ and by (9) and (10):

$$\lambda(\tilde{R} - \tilde{R}^{-1}) \geq A(\frac{\tau}{1-\tau}).$$

If $\tau > 0$ the previous equation implies that $\tilde{R} > 1$. On the other hand, (15) implies that $\tilde{R} < 1$, a contradiction. ∎

The following Proposition considers the effect of changes in the level of subsidy.

Proposition 2. *For $0 \leq \tau < 1$ and $\lambda > 0$, $dg(0)/d\tau$ and $dg(1)/d\tau$ are strictly positive.*

Proof. Let $\tilde{R}_0$ and $\tilde{R}_1$ represent the partial derivatives of $\tilde{R}$ with respect to $g(0)$ and $g(1)$ respectively. Substituting (15) into (13) and (14), differentiating with respect to τ and rearranging:

$$\begin{pmatrix} \sigma - \lambda\tilde{R}_0 & -\lambda\tilde{R}_1 \\ \frac{\lambda\tilde{R}_0}{\tilde{R}^2} & \sigma + \frac{\lambda\tilde{R}_1}{\tilde{R}^2} \end{pmatrix} \begin{pmatrix} \frac{dg(0)}{d\tau} \\ \frac{dg(1)}{d\tau} \end{pmatrix} = \begin{pmatrix} -\lambda\frac{\tilde{R}}{(1-\tau)} \\ \frac{A}{(1-\tau)^2} + \frac{\lambda}{(1-\tau)\tilde{R}} \end{pmatrix}$$

Solving this system and simplifying we obtain

$$\frac{dg(0)}{d\tau} = \frac{\sigma\lambda\tilde{R}}{D(1-\tau)}\left[\frac{A}{(1-\tau)(A - g(1) - \delta)} - 1\right] > 0, \tag{16}$$

$$\frac{dg(1)}{d\tau} = \frac{\sigma A}{D(1-\tau)^2}\left[1 + \lambda\tilde{R}(A - g(0) - \delta) + \frac{\lambda(1-\tau)}{\tilde{R}A}\right] > 0, \tag{17}$$

where D, the determinant of the system, satisfies

$$D = \sigma^2 - \lambda \tilde{R}_0 \sigma + \lambda \sigma \frac{\tilde{R}_1}{\tilde{R}^2} > 0,$$

because $\tilde{R}_0 < 0$ and $\tilde{R}_1 > 0$. ∎

Proposition 2 shows that a higher subsidy results in higher growth rates in both regimes. The growth rate in the subsidy regime ($g(1)$) moves in the expected direction: increases in the subsidy rate decrease both income and the net price of capital. A higher subsidy makes investment more attractive and although higher lump sum taxes discourage investment, the first effect is stronger and $g(1)$ increases. The positive effect on $g(0)$ on the other hand is more indirect. As $g(1)$ increases, consumption in periods of subsidy decreases, raising marginal utility of consumption. Since $\lambda > 0$ this has a positive effect on the interest rate in periods of no subsidy, which leads to a higher $g(0)$. One may conjecture that this investment spillover effect will be more important the higher λ is. (In particular, when $\lambda = 0$ there is no such spillover).

Proposition 2 and equation (13) imply that $\tilde{R}_\tau = d\tilde{R}/d\tau > 0$. Since $\tilde{R} = 1$ when $\tau = 0$, $\tilde{R}$ is greater than one for $\tau > 0$. Thus taking as a numeraire the consumption good in a period of no subsidy, the net price of capital is higher in the subsidy regime than in the non subsidy regime.

We now turn to the effect of changes in the degree of policy variability on growth rates. Notice that since λ represents the arrival rate of a regime change, economies with higher λ are economies with more variability.

To study the effect of λ, a useful benchmark is the case where no regime switching occurs ($\lambda = 0$). This corresponds to the standard nonstochastic case. Let $g^\lambda(z_t)$ and $r^\lambda(z_t)$ represent the growth and interest rates for an economy with variability λ as a function of the regime z_t. Using (9) and (10) for λ equal to zero,

$$\begin{aligned} r^0(0) + \delta &= A && (18) \\ (r^0(1) + \delta)(1 - \tau) &= A. && (19) \end{aligned}$$

For $\lambda > 0$, using (9), (10), (18), (19) and rearranging,

$$\begin{aligned} r^\lambda(0) - r^0(0) &= \lambda(\tilde{R} - 1) && (20) \\ r^\lambda(1) - r^0(1) &= \lambda(\tilde{R}^{-1} - 1). && (21) \end{aligned}$$

We have previously shown that $\tilde{R} > 1$ and therefore $r^\lambda(0) > r^0(0)$ and $r^0(1) > r^\lambda(1)$. Using (7) implies that $g^\lambda(0) > g^0(0)$ and $g^0(1) > g^\lambda(1)$. By Proposition 1, $g^\lambda(1) > g^\lambda(0)$. We have thus established that:

$$g^0(1) > g^\lambda(1) > g^\lambda(0) > g^0(0).$$

The following Proposition provides a slightly stronger result.

Proposition 3. *For $0 < \tau < 1$, (1) $\frac{dg(1)}{d\lambda} < 0$ for any $\lambda > 0$, (2) $\frac{dg(0)}{d\lambda}$ is positive or negative depending on the value of λ.*

Proof. Substituting (15) into (13) and (14), differentiating with respect to λ and rearranging:

$$\begin{pmatrix} \sigma - \lambda\tilde{R}_0 & -\lambda\tilde{R}_1 \\ \frac{\lambda\tilde{R}_0}{\tilde{R}^2} & \sigma + \frac{\lambda\tilde{R}_1}{\tilde{R}^2} \end{pmatrix} \begin{pmatrix} \frac{dg(0)}{d\lambda} \\ \frac{dg(1)}{d\lambda} \end{pmatrix} = \begin{pmatrix} \tilde{R} - 1 \\ \tilde{R}^{-1} - 1 \end{pmatrix}$$

Solving the system and simplifying we obtain

$$\frac{dg(0)}{d\lambda} = \frac{\sigma}{D}\left[(\tilde{R}-1) - \frac{\lambda(\tilde{R}-1)^2}{\tilde{R}(A-g(1)-\delta)}\right] \tag{22}$$

$$\frac{dg(1)}{d\lambda} = \frac{\sigma}{D\tilde{R}}\left[-(\tilde{R}-1) - \frac{\lambda(\tilde{R}-1)^2}{(A-g(0)-\delta)}\right]. \tag{23}$$

Since $\tilde{R} > 1$, $\frac{dg(1)}{d\lambda} < 0$ for all $\lambda > 0$. The sign of $\frac{dg(0)}{d\lambda}$ depends on λ. If λ is sufficiently close to zero, $\frac{dg(0)}{d\lambda} > 0$. Since consumption is nonnegative even when λ approaches infinity, it follows from equations (13) and (14) that $\tilde{R}$ goes to one as λ goes to infinity. Therefore, $dg_0/d\lambda$ is positive for λ below a critical value, negative for larger λ's, and approaches zero as λ approaches infinity. This critical value of λ depends on the parameter values. ∎

The simulations in the next section show that for our parameter values, the critical λ value exceeds the highest λ we consider. Therefore, g_0 increases with λ for all the degrees of policy variability we study.

Proposition 3 indicates that policy variability can moderate the response of investment to a subsidy. As variability increases, subsidies (and lump sum taxes) are expected to be short lived but after they are gone they are expected to return sooner. As a response agents shift investment from the subsidy periods (where the marginal utility of consumption is higher because of higher investment) to the nonsubsidy periods.

This result arises because higher variability implies a stronger link between the two different states of the economy: subsidized and non subsidized periods. This is also reflected in the fact that $\frac{d\tilde{R}}{d\lambda} < 0$ (which can be easily established), indicating that capital gains (losses) are lower when there is more variability. Although capital gains (losses) decrease with variability, they occur more often.

Notice also that in proving the above proposition we have also used the fact that $\tilde{R} > 1$, which is a consequence of the income effects that are due to lump sum taxation. If agents could insure themselves from these policy shocks, marginal utility of consumption would be equated across states and $\tilde{R}$ would equal $1-\tau$ which is smaller than one, leading to the opposite conclusion. This also suggests the important differences in behavior that arise when interest rates are not taken as given and general equilibrium effects considered.

We have shown that higher variability will decrease the growth rate in subsidy periods for any λ and increase it in no subsidy periods when λ is close to zero. It is also of interest to evaluate what happens to the average growth rates. Since the value for λ is independent of the regime in place, the limiting probability of each regime is equal to one half. The average long run growth rate for the economy is approximately $\frac{g(0)+g(1)}{2}$, which is monotonically increasing in $r(0)+r(1)$. Using (20) and (21) :

$$\frac{r^{\lambda}(0)+r^{\lambda}(1)}{2}=\frac{r^{0}(0)+r^{0}(1)}{2}+\lambda a>\frac{r^{0}(0)+r^{0}(1)}{2},$$

since $a=\frac{(\tilde{R}-1)+(\tilde{R}^{-1}-1)}{2}$ (the average capital gain due to regime changes) is strictly positive. We have thus proved:

Proposition 4. *For $0<\tau<1$ and λ close to zero, $\frac{(g^{\lambda}(0)+g^{\lambda}(1))}{2}$ is increasing in λ.*

So asymptotic growth can be stimulated by policy variability. However, this is a local result. Since $\tilde{R}$ is decreasing in λ, $\frac{da}{d\lambda}<0$. Given that for larger values of λ this effect is likely to dominate, higher variability could lead to lower growth. The simulations presented in the following section show that this is indeed the case and that λ need not be very large for it to happen.

3. Simulations of the Model.

We simulate the model to study how changes in subsidy rates and the degree of policy variability affect growth and welfare.

Assuming that investment is positive in both regimes and given values for the parameters (A,δ,ρ,σ), equations (13)-(15) provide a nonlinear set of equations to solve for ($g(0)$ and $g(1)$). Parameter values where assigned as follows: given values for δ and σ, A and ρ can be determined to match the real interest rate (6%) and per capita growth rate (2%) of the economy, taking $\tau=0$ as a benchmark. Using parameter values that are standard in the real business cycle literature, the assignments were: $\delta=0.10$, $\sigma=2$, $\rho=0.02$ and A=0.16. As the invariant distribution puts equal weight in either regime the expected value of relevant variables were calculated as the simple average of their values in the two regimes. We consider several values for the expected duration (ED) of a regime. The most extreme case of policy variability we study is one where the expected duration of a regime is half a period (ED=0.5). At the other end, we consider the case where regimes last forever (ED= ∞). We calculate two welfare indices[8] and their long run average.

The results of the simulations for subsidies of 10% and 20% are presented in Tables 1 and 2, respectively. Since we consider distortionary investment subsidies, growth rates are higher and welfare lower than those of the undistorted economy. Notice that the undistorted economy has no subsidies, grows at 2 per cent, and achieves a welfare level of -625.

By comparing the values in Tables 1 and 2 we can analyze the effect of increases in the subsidy rate for a given degree of policy variability. As the subsidy rate increases, the subsidy and non subsidy regimes look more different and a change in policy results in a change of a larger magnitude (i.e. the amplitude of a policy change increases with the size of the subsidy). Our results show that a higher subsidy decreases expected welfare and increases growth in both regimes. It is natural to expect that an increase in the subsidy

[8] See equations (A.1) and (A.2) in the Appendix for their derivation

rate will be detrimental for welfare since it leads to a larger intertemporal distortion and to a larger gap between the two regimes. The intuition behind the growth result is as follows. A higher subsidy makes investment more attractive in the subsidy period. Although lump sum taxes increase, investment responds positively to a higher subsidy (i.e. growth rates in the subsidy period increase). This increases the value of consumption in the periods of subsidy and, in anticipation, the expected return on investment in periods of no subsidy. Therefore, investment in periods of no subsidy responds positively to subsidy increases: the effects of higher subsidies *spill over* to the periods of no subsidy.

The effects of changes in policy variability contrast sharply with the effects of changes in the subsidy rate. While a higher subsidy increases the amplitude of the changes, an increase in variability increases the frequency of regime changes.

With higher variability, the two regimes become more similar: the rate of growth of capital decreases in the subsidy regime and increases in the period of no subsidy. Consequently, growth rates become more similar across regimes. The behavior of the expected growth rate depends on the relative size of these changes. When variability is extremely low, an increase in variability increases expected growth since the positive effect on the growth rate of the non subsidy period exceeds the negative effect on the growth rate of the subsidy period. For all other levels of policy variability, the expected growth rate decreases with variability: the expected growth rate becomes closer to the optimal (undistorted) growth rate. In other words, variability attenuates the effects of distortionary policies.

We now turn to the welfare results. Tables 1 and 2 also provide three welfare indices, W_0, W_1 and $\overline{W}$. The first (second) one represent the expected discounted utility when the initial regime is one without (with) subsidy and $k_0 = 1$. $\overline{W}$ is the simple average of W_0 and W_1, providing a measure of long run average welfare.[9]

Our simulations indicate that higher variability results in higher average discounted utility. Though this may seem counterintuitive, it has a straightforward explanation. It is important to observe that here higher variability does not mean larger amplitude of oscillation but higher frequency. Moreover, the higher frequency of regime switching leads indeed to smoother consumption paths and hence lower amplitude (see Proposition 3). Because of the curvature of the utility function, average welfare is higher for these consumption paths than for those with larger but less frequent oscillations.

If the initial regime is a subsidy regime, expected discounted utility increases with variability. If instead the initial period is one without subsidy, expected discounted utility decreases with variability. Since the first effect is stronger, the net effect of variability on average welfare is positive.

The ratio of any two welfare values gives roughly the percentage by which consumption would have to change in all periods to compensate for the change in welfare. For example, let's compare an economy with $\tau = 0.20$ and where regimes are expected to last for 100 periods with the undistorted economy. A 21.1% increase in consumption per period would be needed to compensate for the lower welfare when starting in a period of subsidy $(\frac{757}{625} - 1)$, while only a 5.1% increase would be required when the initial period has no

[9]It also corresponds to the ex ante utility of an economy with probabilities $\left(\frac{1}{2}, \frac{1}{2}\right)$ of starting in either regime.

subsidy.

We can also compare expected welfare for the highest and lowest degree of variability. For instance, in order for ex-ante average utility in an economy with no variability to equate the level corresponding to that of another economy where regimes are expected to last half a period, consumption per period would have to increase by almost 9%.

4. Additional Remarks

We have defined variability as the frequency of policy reversion arrivals given by a Poisson process. An alternative measure of policy uncertainty that has been used in the literature is connected to the amplitude of changes rather than its frequency. As an example, consider the case of a brownian motion -widely used in the investment decision theoretic literature- where uncertainty is measured by the variance of its increments.[10]What effects would an increase in uncertainty as measured by the distance between the two policies have?

To analyze this question, consider a case where the investment subsidies under the two policies are given by $\tau_0 = \tau - \epsilon$ and $\tau_1 = \tau + \epsilon$ respectively, where $\tau > 0$ and $\epsilon \geq 0$. An increase in ϵ is a mean preserving increase in the variance of the process. Suppose that at a fixed arrival rate λ the policy regime switches between these two extremes. The equations defining the rates of return to investment are given by

$$r_0 = \frac{A}{1-\tau_0} - \delta + \lambda\left(\bar{R} - 1\right)$$

and

$$r_1 = \frac{A}{1-\tau_1} - \delta + \lambda\left(\bar{R}^{-1} - 1\right)$$

where

$$\bar{R} = \frac{(1-\tau_1)\, u'(c_1)}{(1-\tau_0)\, u'(c_0)}.$$

There are two effects of changes in ϵ, a direct effect on the rates of return to investment and an indirect effect through implied changes in $\bar{R}$. For low levels of λ the direct effect dominates and, as can be readily verified, the rates of return become a convex function of the subsidy rate. As a consequence, an increase in ϵ results in higher expected returns and a higher growth rate.[11]

It is worth emphasizing that in deriving this positive growth effect we ignored the effect of changes in the capital gains due to regime changes (the third term in the rates of return) by assuming small λ. In contrast, these capital gains play a crucial role in the analogous growth effect that we obtained for small values of λ.

The effect on welfare is negative for two reasons: increases in ϵ result in less consumption smoothing and a larger deviation of growth rates from the undistorted value.

[10]Since a brownian motion corresponds to the limit as the frequency of changes goes to infinity of Poisson arrivals of normally distributed increments, this process has no well defined notion of *frequency change.*

[11]This effect is similar to the positive effect of price uncertainty on investment encountered in investment decision theoretic analysis (see the surveys by Dixit (1992) and Pindyck (1991)).

This contrasts with our results. Increases in the amplitude of the process makes periods of high and low subsidy rates look more different whereas increases in the frequency of changes reduces this difference. This suggests that the results obtained for increases in uncertainty as measured by the amplitude of changes which have been typically explored in the literature are quite different to those relating increases in the frequency of policy changes. Without disregarding the importance of differences in the level of uncertainty as measured by the dispersion of policies, we think that frequency considerations are quite meaningful when considering the economic consequences of political instability.

In our model the policy changes are always reversionary. In contrast, uncertainty exhibits no mean reversion in the case of brownian motion considered by the investment literature. Since any feasible tax/subsidy policy will be characterized by bounded subsidies (and taxes), we think that policy uncertainty should be modeled by a process that allows for some mean reversion. As an example, one could consider a brownian motion for τ with two reflecting boundaries. Increases in the variance of innovations would then imply a stronger degree of mean reversion and higher renewal rates. The latter implies that the average time it takes to switch from one extreme of the policy domain to the other one decreases with the variance of this innovation, which is qualitatively similar to an increase in the frequency of Poisson arrivals in our process. It is then plausible that results analogous to ours would be obtained for that case.

We restricted our attention to the case in which the subsidy is financed with a lump sum tax. This help to isolate the effects of the subsidy policy per se from those that result from its financing. One may conjecture that if other forms of taxation such as an income tax were used, the same qualitative results would still hold though the quantitative significance would vary.[12] Since an income tax is a tax on both consumption and investment, it is likely to dampen -but not eliminate- the effects of the subsidy. As the net subsidy on investment is lower with income taxes, the subsidy and nonsubsidy periods will look more alike. Therefore, one may expect growth rates in both regimes would be lower than in the economy with lump sum taxation, but the qualitative effects of variability on growth and welfare should go in the same direction.

An assumption that we have maintained throughout is that there are no "adjustment costs" or frictions of any sort[13]. In a nonstochastic environment, the introduction of adjustment costs to investment mitigates the sensitivity of growth and welfare to economic policy[14]. We may thus conjecture that adjustment costs would dampen the response of investment to subsidies, and shrink the difference between the lowest and highest investment rates. In analogy to the nonstochastic case, one may also conjecture that there will be lower and upper boundaries to which investment rates will tend to converge in low and high subsidy periods, respectively. In this way, adjustment costs are also likely to reduce the effect of policy variability.

[12]Rebelo (1991) studies the growth effects of a proportional tax on gross income.

[13]For example adjustment costs in the investment function or frictions in labor reallocation.

[14]See King and Rebelo (1990).

5. Summary and Concluding Comments.

This paper has explored the effect of policy variability on welfare and growth using a one sector growth model with stochastic subsidies to investment.

In a neoclassical growth model, the main determinant of the growth rate of an economy is the rate of return to investment. For the representative agent economy, in absence of externalities or market failure, a competitive equilibrium results in an optimal allocation. Consequently, policies that raise the rate of return to investment lead to higher growth rates and lower welfare. This suggests that the consequences of policy variability are closely linked to the way it affects the rate of return to investment.

Policy variability, or the degree of regime switching, affects the extent to which policies that will prevail in a future regime may, in anticipation, affect investment decisions in a prior one. In the extreme, when there is no variability, regimes are completely isolated and have no impact on each other. But when a change of regime is likely to occur, future policies can play an important role in current rate of return calculations.

The anticipation of a period of high (low) consumption -and thus lower (higher) marginal utility- has a negative (positive) effect on the rate of return to investment. Periods of subsidy are periods of low consumption and while no subsidy are periods of high consumption. Thus, lower persistence tends to reduce the rate of return to investment and total investment in periods of subsidy and increase them in periods of no subsidy. This decreases investment rates in periods of subsidy and increases them in periods of no subsidy, thus reducing the amplitude of fluctuations in consumption. The previous result is driven by income effects.

Our main findings are that variability is welfare improving and that it is likely to decrease growth. The first result may perhaps seem counterintuitive given that the standard intuition suggests that uncertain consumption profiles are typically associated with lower welfare. Our analysis indicates that it is important to distinguish between the *frequency* and *amplitude* of consumption oscillations. Larger amplitude of oscillations are clearly welfare reducing. But as indicated above, the higher frequency of oscillations that results from higher variability leads to lower amplitude. This explains the welfare effect.

This paper considered a specific type of policy alternation, namely the succession of periods of high and low subsidies to all investments in the economy. An alternative type of policy with a sectoral component is considered in Hopenhayn and Muniagurria (1993). In that paper we consider a two sector model with sector specific and irreversible investment where the subsidy rate is positive and constant, but the sector being subsidized varies over time. There are two regimes in this case, depending on which type of investment is subsidized. Our results for the two sector model indicate that more frequent regime switching leads to higher average growth rates, larger intersectoral distortions and to some extent more variable consumption. As a consequence, welfare decreases with variability.

To highlight the differences between the two models, it is important to distinguish between two sources of cross-regime effects, one operating through income and the other through substitution effects. The first effect dominates when the policies that alternate differ in the degree to which investment (vis a vis consumption) is subsidized, and the type of capital that is being subsidized does not change over time. This is the case studied in the one sector model. The substitution effect predominates when it is not the level but the mix of subsidies that vary over time. This is the case studied in the two sector model.

If regimes affect the type of capital that is subsidized and not the rate of subsidy -as occurs in the two sector model- the substitution effect prevails. The anticipation of a change in the type of capital to be subsidized, increases the rate of return to investment in the currently subsidized one. Higher variability has the effect of further delaying the investment in capital goods that are not currently subsidized and concentrating most investment in those that are. As a consequence, the rate of subsidy per unit of investment increases, as the share of subsidized investment does so. This increases the average growth rate but decreases welfare.

Whether one of these two sorts of policy variability or a different type of variability is more representative of the *typical* policy variability is not an issue we attempt to resolve here. Rather, we view the two models as pointing to the key characteristics on which the consequences of policy variability may depend.

Appendix

Welfare Analysis.

Let $V(k)$ denote the expected discounted utility when capital is k and the current regime is one of subsidy. Let $W(k)$ be the corresponding value when there is no subsidy. These functions satisfy the following equations

$$\rho V(k) = \frac{c_t(1)^{1-\sigma}}{1-\sigma} + V'(k)\dot{k} + \lambda(W(k) - V(k))$$

and

$$\rho W(k) = \frac{c_t(0)^{1-\sigma}}{1-\sigma} + W'(k)\dot{k} + \lambda(V(k) - W(k)).$$

It is immediate to show that $V(k) = vk^{1-\sigma}$ and $W(k) = wk^{1-\sigma}$ for some v and w that satisfy

$$\rho v = \frac{c(1)^{1-\sigma}}{1-\sigma} + g(1)(1-\sigma)v + \lambda(w - v) \tag{A.1}$$

and

$$\rho w = \frac{c(0)^{1-\sigma}}{1-\sigma} + g(0)(1-\sigma)w + \lambda(v - w). \tag{A.2}$$

Equations (A.1) and (A.2) can be easily solved for v and w. Their values for different parameter values are presented in Tables 1 and 2: v is W_1 and w is W_0.

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Table 1: One Sector Model ($\tau = 0.10$)

ED[a]	g_0[b]	g_1	$\frac{g_0+g_1}{2}$	$E\left(\frac{T_t}{k_t}\right) \times 100$	W_0	W_1	$\overline{W}$
∞	2.00	2.89	2.44	0.644	-625	-658	-641
100	2.14	2.78	2.46	0.639	-630	-646	-638
50	2.20	2.72	2.46	0.636	-631	-642	-637
10	2.31	2.60	2.45	0.630	-633	-635	-634
5	2.33	2.57	2.45	0.629	-633	-634	-634
2	2.34	2.55	2.45	0.628	-633	-634	-633
1	2.35	2.55	2.45	0.627	-633	-633	-633
0.5	2.35	2.54	2.45	0.627	-633	-633	-633

[a] ED=$\frac{1}{\lambda}$

[b] In percentage terms. g_0 =growth rate in the no subsidy regime; g_1 =growth rate in the subsidy regime

Table 2: One Sector Model ($\tau = 0.20$)

ED[a]	g_0[b]	g_1	$\frac{g_0+g_1}{2}$	$E\left(\frac{T_t}{k_t}\right) \times 100$	W_0	W_1	$\overline{W}$
∞	2.00	4.00	3.00	1.400	-625	-833	-729
100	2.48	3.75	3.12	1.375	-657	-757	-707
50	2.62	3.62	3.12	1.362	-666	-726	-696
10	2.78	3.32	3.05	1.332	-672	-682	-677
5	2.81	3.25	3.03	1.325	-671	-675	-673
2	2.82	3.20	3.01	1.320	-670	-671	-671
1	2.83	3.19	3.01	1.319	-669	-670	-670
0.5	2.83	3.18	3.01	1.318	-669	-669	-669

[a] ED=$\frac{1}{\lambda}$

[b] In percentage terms. g_0 =growth rate in the no subsidy regime; g_1 =growth rate in the subsidy regime