Endogenous Regime Switching *

Jacek Rothert †

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Abstract

I develop a model of switching between good and bad policy regimes where transition probabilities are endogenous. A politician chooses a policy regime that affects its own and households' payoffs. Households face a sequence of politicians, observe regime with noise, and decide whether or not to change the government. The decision to switch depends on the expectation of choices of future politicians, which in turn depend on households switching decisions. I characterize equilibria and show how switching probabilities depend on fundamentals (preferences and technology). Model implications about output volatility in a cross-section of countries are supported by the data.

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†University of Minnesota. E-mail contact: rothert@umn.edu.

1 Introduction

There is a consensus in the growth and development literature that government policy matters for economic performance (see e.g. Sala-i-Martin (1994), Easterly and Levine (2001), Bergoeing et al. (2002a) and Bergoeing et al. (2002b)). "Good" policy fosters growth, "bad" policy restrains it. Understanding incentives of the governments that implement policies is important to our understanding of economic outcomes. This paper provides a simple and tractable theory of endogenous regime switching that allows us to answer the questions of why some countries experience bad policies more often than others and why bad policies are more persistent in certain countries.

I model the economy as a game in which households face a sequence of politicians and decide whether or not to overthrow the politician in power. A politician chooses a policy regime (good or bad) that affects both its own and the households' expected period payoff. Good (bad) policy regime results in high (low) expected growth. Households observe the regime type with noise and pay a cost if they decide to change the government. The strategies of households and politicians endogenously determine the transition probabilities between policy regimes. I study the effects of (i) the HH's ability to monitor the government and (ii) the cost of changing the government on equilibrium outcomes: persistence of regimes and frequency of switching.

The crucial element in the model is the politician's incentive to choose a particular regime. I assume that a "bad" politician extracts rents when he is in power but is being punished when the HH overthrows him. With poor monitoring, the only equilibrium is one in which every politician is bad. HH never overthrows the politician, because overthrowing is costly and next politician would also be bad. Hence, with poor monitoring persistence of the bad regime is 1.

As monitoring in the economy improves, HH learns faster whether it is facing a good or a bad government and there is an equilibrium where a politician is bad only with some probability less than 1. That probability further declines as the monitoring improves. As a result persistence of the low-growth regime declines and persistence of the high-growth regime increases.

The major contribution of this paper is to our understanding of the role of political institutions in economic performance and volatility (Rodrik (1999), Acemoglu and Robinson (2001), Acemoglu et al. (2001), Acemoglu et al. (2003)). Empirical studies found a positive relationship between economic performance (measured as average growth rate) and various measures of constraints imposed on the government. In my model, the better is the HH's ability to monitor the government, the larger is the persistence of a high-growth regime, and hence the larger is average growth.

What's unique to my model is its prediction about the relationship between monitoring and volatility. The least volatile countries are those with very either very good or very poor monitoring leading to a highly persistent good or bad regime, e.g. rich Western democracies or poor African countries. The most volatile are countries in the middle, experiencing switching between the high- and low-growth regimes, e.g. emerging economies (these three cases are depicted in Figure 13). This result is consistent with empirical evidence favoring a hump-shaped relationship between income and volatility (Carranza and Galdon-Sanchez (2004)). I provide additional evidence in favor of the hump-shaped relationship between macroeconomic volatility and income.

My model also predicts that adverse economic outcomes (such as low or negative growth) increases probability of the government change. This finding is consistent with empirical work estimating probabilities of government collapse conditional on recent economic performance (e.g. Alesina et al. (1996), Merlo (1998)).

This paper also contributes to the understanding of possible sources of large swings in the trend component of GDP. Aguiar and Gopinath (2007) stress the importance of shocks to the permanent component of Total Factor Productivity (TFP) in explaining features of business cycles in emerging economies. My paper adds a political economy angle to that literature[1]. The framework I develop is tractable and can be merged with the stochastic growth model to account for the volatility of the trend component of the TFP (details are provided in the Appendix[2]).

My model is a micro-foundation for regime switching models used to study income dynamics across nations e.g. in Parente (1995) or Chari et al. (1996). Parente (1995) constructs a growth model where firms face barriers to adopting more advanced technology (as in Parente and Prescott (1994)). Barriers follow a Markov chain which, calibrated to match output disparities across countries and the mobility of nations, suggests the existence of a poverty trap. Chari et al. (1996) study growth miracles and disasters in a regime switching framework embedded in a neoclassical growth model. In their model, there are two regimes for distortions to capital accumulation. In a good regime, distortions decline over time, in a bad regime they rise. The probability of a regime change is an exogenous function of the regime's duration. My paper provides a political economy theory for the source of such regime changes and explains why in some countries bad policy regimes are more persistent.

The paper is structured as follows. In Sections 2 through 5 I develop and characterize a model of switching between a good and a bad regime. In Section 6 I discuss the application of the model to study poverty traps and growth reversals in less developed countries.

[1] Dornbusch and Edwards (1990) discuss the major characteristics of populist policies in Latin American countries. Mejia and Posada (2007) develop a formal model of emergence of such policies.

[2] The Appendix is available at: http://www.econ.umn.edu/~jacek/papers/rothert_jmp_apdx.pdf

2 Model

2.1 Players, actions and payoffs

Time is infinite and discrete. There are two possible regimes - a high-output (H) regime and a low-output (L) regime. There is an infinite sequence of long-lived (potentially more than one period) politicians and an infinite sequence of one period-lived households. A politician enters the game after his predecessor exits. Politician's exit can be either exogenous (each politician faces a constant probability ϵ of death in each period) or endogenous (a politician can be removed by a household).

The game is divided into "stage" games, indexed by n[3]. Each stage game corresponds to a different politician. Upon entering the game, a new politician chooses whether to form a corrupt (bad) or an honest (good) government. Under bad (good) government country is in a low (high)-growth regime. Hence, the action set for the politician is $A^P = \{\mathtt{H}, \mathtt{L}\}$. The regime is fixed until the politician's exit. At the beginning of each period, a household decides whether to keep the current politician or replace it with a new one, i.e. the action set for the household is $A^H = \{\mathtt{keep}, \mathtt{change}\}$.

Output q is log-normally distributed with mean dependent on the government type[4]:

$$\log(q) \sim \begin{cases} N(\mu_H, 1), & \text{if government is good;} \\ N(\mu_L, 1), & \text{if government is bad.} \end{cases} \tag{2.1}$$

Household has a strictly increasing utility from consumption of output $u(q)$. Define

$$\begin{aligned} U_H &= E[u(q)| \text{ government is good}] \\ U_L &= E[u(q)| \text{ government is bad}] \end{aligned} \tag{2.2}$$

[3]Note that it is *not* a repeated game

[4]Alternatively one can specify the model where corrupt government steal a constant fraction of output. The results would remain unaltered.

to be expected payoffs under good and bad government respectively. If the household decides to change the politician it pays a utility cost $\kappa > 0$.

Politician gets payoff 0 when he formed an honest government. If he formed a corrupt government then in each period he gets a bribe $B > 0$[5]. If a bad politician gets removed by the HH, he has to pay a cost $J > \frac{B}{1-\epsilon}$ (e.g. a corrupt politician can eventually end up in jail).

2.2 Information

Household does not know whether current government is good or bad. In addition to output q, in each period a signal θ is realized, which provides additional information about the government. The signal is normally distributed:

$$\theta \sim \begin{cases} N(\bar{\theta}, 1), & \text{if government is good;} \\ N(-\bar{\theta}, 1), & \text{if government is bad.} \end{cases} \tag{2.3}$$

where $\bar{\theta}$ measures household's ability to monitor the government (e.g. $\bar{\theta}$ will be higher in countries with free press or where executives face a system of checks and balances).

2.3 Histories, beliefs and strategies

At the beginning of period t of stage game n, the history of past play is given by:

$$h^{n,t} := \left(\left((q_i, \theta_i)_{i=0}^{\tau_k} \right)_{k=1}^{n-1}, (q_i, \theta_i)_{i=0}^{t-1} \right),$$

where τ_k is the number of periods for which stage game k lasted. In each period t of a given stage game n household assigns probability $\rho_{n,t}$ to the government being bad:

$$\rho_{n,t} = \Pr\{a_n^P = \mathtt{L} | h^{n,t}\}$$

[5] Krusell and Rios-Rull (1996) develop a political economy theory where incumbent innovators' political influence allows them to prohibit the adoption of newer and better technologies. Then B can be interpreted as a cost a politician in power would have to pay to oppose the lobbying from the incumbent innovators.

Strategies for the HH and for the politicians are functions from histories to the probability distributions over their action sets:

$$\sigma^H = \sigma^H(h^{n,t}) \in \Delta(A^H)$$
$$\sigma^P = \sigma^P(h^{n,0}) \in \Delta(A^P)$$

Note that in the expressions above it has been made explicit that the politician makes his decision only upon entering the game (i.e. at $t = 0$).

2.4 Equilibrium

An equilibrium is defined in a usual way.

Definition 2.1. An equilibrium consists of strategy profiles $\hat{\sigma}_H, \hat{\sigma}_P$ and HH's beliefs $\hat{\rho}$ (all three being functions of histories) such that (i) $E_{(\hat{\rho},\hat{\sigma}_H)(h^{n,t})}[u(q)] \geq E_{(\hat{\rho},\sigma_H)(h^{n,t})}[u(q)]$ for all $h^{n,t}$ and σ_H; (ii) $\hat{\sigma}_P$ is optimal for a politician given $\hat{\sigma}_H$ and $\hat{\rho}$; (iii) $\hat{\rho}_{n,0}$ is consistent with politician's strategy $\hat{\sigma}^P$; and (iv) given HH's initial belief, $\hat{\rho}(h^{n,t})$ is induced using Bayes' rule.

3 Markov equilibria

I will restrict my attention to a special, tractable class of equilibria. I will impose two restrictions. First, I require that $\sigma^P(h^{n,0}) = (1 - \rho_0, \rho_0)$ for any history $h^{n,0}$. This restriction implies that after each stage, the game resets: each new politician forms a corrupt government with the same probability ρ_0. Second, for any two histories h and $\tilde{h}$, if $\rho(h) = \rho(\tilde{h})$ then $\sigma^H(h) = \sigma^H(\tilde{h})$, i.e. each HH conditions its decision only on the value of the belief ρ that the current government is bad.

I will first characterize the problem of the HH and of the politician assuming the restrictions above hold. This will lead to definitions of best response correspondences for the players. Then I will define a stationary Markov equilibrium for the game.

HH's problem In each period the HH decides whether to keep or to change the government. HH's state variable is belief ρ that government is bad. Given the belief ρ, the value of keeping the government is:

$$V^k(\rho) = \rho U_L + (1-\rho)U_H \tag{3.1}$$

while the value of changing is:

$$V^c = \rho_0 U_L + (1-\rho_0)U_H - \kappa \tag{3.2}$$

where ρ_0 is HH's belief that the next government is bad (ρ_0 is a number). It is straightforward to show that HH's decision has the threshold property, described in the following lemma.

Lemma 3.1. *There is a unique threshold belief $\rho^*(\rho_0)$ s.t. the household will change the government iff $\rho > \rho^*(\rho_0)$ and*

$$\rho^*(\rho_0) = \rho_0 + \frac{\kappa}{U_H - U_L} \tag{3.3}$$

Proof. Comparing (3.1) with (3.2) yields the result. □

We can define a best response correspondence for a HH to be:

$$BR^H(\rho_0) := \left\{\rho^* : \rho^* = \rho_0 + \frac{\kappa}{U_H - U_L}\right\}$$

Politician's problem Upon entering the game, the politician chooses the government type. The politician takes as given the HH's initial belief ρ_0 and the implied threshold belief $\rho^* = \rho_0 + \frac{\kappa}{U_H - U_L}$. Being corrupt means the politician gets a bribe $B > 0$ per period, so the expected net revenue from being corrupt is:

$$E(\tau | a^P = \mathtt{L}; \rho_0) \cdot B$$

where $E(\tau|a^P = \mathtt{L}; \rho_0)$ denotes the expected time in power of a corrupt politician if HH's initial belief is ρ_0. If a HH removes a corrupt politician, then the politician has to pay a cost J, so the expected cost of being corrupt is:

$$\Pr\{\tau^1 \leq \tau^0 | a^P = \mathtt{L}\} \cdot J$$

where τ^0 is the time of the politician's exogenous exit and τ^1 is the first time that HH's belief exceeds the threshold belief ρ^*. Note that $\Pr\{\tau^1 \leq \tau^0 | a^P = \mathtt{L}\}$ is simply the probability that a corrupt politician will eventually be removed by the HH. Then, the expected payoff from being corrupt is:

$$W(\rho_0) = E\left(\tau \middle| a^P = \mathtt{L}; \rho_0\right) \cdot B - \Pr\left\{\tau^1 \leq \tau^0 \middle| a^P = \mathtt{L}; \rho_0\right\} \cdot J \tag{3.4}$$

Payoff from being honest is normalized to 0. The politician's problem is then:

$$\max_{s \in [0,1]} s \cdot W(\rho_0)$$

A best response for the politician can be defined as:

$$BR^P(\rho_0) := \arg\max_{s \in [0,1]} s \cdot W(\rho_0)$$

A definition of a stationary Markov equilibrium now follows.

Definition 3.2. A stationary Markov equilibrium is a triple (ρ_0, ρ^*, s^*) such that (i) $\rho_0 = s^*$, (ii) $\rho^* \in BR^H(\rho_0)$ and (iii) $s^* \in BR^P(\rho_0)$.

A stationary equilibrium is a collection of three objects: (i) HH's initial belief ρ_0, (ii) HH's threshold belief ρ^* and (iii) politician's strategy s^* that satisfy the usual conditions of optimality and consistency.

4 Characterization

The triple $(1, 1 + \frac{\kappa}{U_H - U_L}, 1)$ is always an equilibrium (government is always corrupt, HH's initial belief is 1 and HH never changes the government). The existence of an equilibrium with $\rho_0 = s^* \in (0,1)$ will require finding ρ_0 such that the politician is indifferent between being honest and corrupt.

4.1 Payoff from choosing low regime

The key endogenous variable in the model is the expected payoff from being corrupt. A new politician who enters the game, takes as given HH's initial belief ρ_0 - the probability the HH assigns to him being corrupt and to the politician after him being corrupt. The payoff from being corrupt is denoted by $W(\rho_0)$. The following two lemmas summarize major characteristics of the function $W(\cdot)$.

Lemma 4.1. *$W(\rho_0)$ is strictly decreasing in ρ_0 if and only if $\rho_0 < \frac{1}{2} - \frac{\kappa}{2(U_H - U_L)}$ and strictly increasing in ρ_0 iff $\rho_0 \in (\frac{1}{2} - \frac{\kappa}{2(U_H - U_L)}, 1 - \frac{\kappa}{U_H - U_L})$.*

Proof. See Section A.2.1 in the Appendix. □

Lemma 4.2. *$W(\rho_0)$ is continuous.*

Proof. See Section A.2.2 in the Appendix. □

A typical graph of $W(\rho_0)$ is presented in Figure 1. Recall that the payoff from being corrupt increases with expected time in power (of a corrupt politician) and declines with the probability of being removed. It means the payoff is larger when the HH doesn't change its belief about the government type too quickly, i.e. when the HH's belief is not very responsive to new information. This is the case when the HH is either almost sure any new government is good (ρ_0 close to zero) or almost sure any new government is bad (ρ_0 close to one). When the HH believes that both government types are ex-ante quite likely, the arriving information (output q and signal θ) will have relatively large impact on the HH's belief. Then, forming a corrupt government implies that HH's belief is likely to increase rapidly, which makes being corrupt less profitable.

FIGURE 1 here

Politician chooses to be corrupt if $W(\rho_0) > 0$. The incentive to do so is the highest when ρ_0 is either very low or very high. For low values of the initial belief, HH keeps the government, because it actually thinks that the government is good. For high values of ρ_0, HH keeps the government, even though it thinks that the government is bad. However, the probability of next politician being corrupt is also large so the expected gain from changing the government is small. Note that even though the mechanics in each case are the same - low/high values of initial belief imply that HH's update is slow - the economic intuition in both cases is different.

4.2 Effect of monitoring

One of the parameters of interest in the model is $\bar{\theta}$ - a measure of the precision of the signal θ. The value of $\bar{\theta}$ will affect the expected in power of a corrupt politician and the probability of being removed by the HH. Higher value of $\bar{\theta}$ makes the HH learn the government type more quickly. Then, for a given initial belief ρ_0, the HH will change the government earlier, so the expected payoff from being bad declines. This effect is depicted in Figure 2.

Lemma 4.3. *Let $W(\cdot;\bar{\theta})$ denote the payoff function $W(\cdot)$ from being corrupt for a given value of signal precision $\bar{\theta}$. Then, for all $\rho_0 \in (0, 1 - \frac{\kappa}{U_H - U_L})$, $W(\rho_0, \bar{\theta}_1) \leq W(\rho_0, \bar{\theta}_2) \iff \bar{\theta}_1 \geq \bar{\theta}_2$.*

Proof. See Section A.2.3 in the Appendix. $\square$

Figure 2 here.

4.3 Effect of switching cost

The switching cost κ is another parameter that can be interesting from a policy perspective. In the political economy setting of this paper, κ can measure the costs of changing a government - in democracies these costs are relatively low comparing to autocratic regimes. In the model reduction in the cost of changing the government will reduce the threshold belief ρ^*. Given the HH's initial prior ρ_0, the HH is now more eager to change the government, which means that expected payoff from being corrupt. The graph of the payoff function $W(\rho_0)$ shifts downwards. This effect is depicted in Figure 3.

Lemma 4.4. *Let $W(\cdot;\kappa)$ denote the payoff function $W(\cdot)$ from being corrupt for a given switching cost κ. Fix $\kappa = \kappa_1$. Then, for all $\rho_0 \in (0, 1 - \frac{\kappa_1}{U_H - U_L})$, if $0 < \kappa_2 < \kappa_1$ then $W(\rho_0, \kappa_2) < W(\rho_0, \kappa_1)$.*

Proof. See Section A.2.4 in the Appendix. □

Figure 3 here.

4.4 Multiplicity of stationary equilibria

The triple $(1, 1 + \frac{\kappa}{U_H - U_L}, 1)$ is always an equilibrium. However, depending on parameter values, there can also be mixed strategy equilibria. This situation is depicted in Figure 4. The three circles mark three stationary Markov equilibria - one with $\rho_0 = \rho_0^3 = 1$ and two equilibria in which politician is indifferent and chooses to be corrupt with probability consistent with the HH's initial belief. In one equilibrium that belief is low - $\rho_0 = \rho_0^1$, in the other one it is high - $\rho_0 = \rho_0^2$. In general, the values of ρ_0^1 and ρ_0^2 depend on specific parameters of the model, in particular on the precision of the signal $\bar{\theta}$ and on the switching cost κ, i.e. $\rho_0^1 = \rho_0^1(\bar{\theta}, \kappa)$ and $\rho_0^2 = \rho_0^2(\bar{\theta}, \kappa)$.

Figure 4 here.

Whether the game has one, two or three equilibria depends on the values of $\bar{\theta}$ and κ. The intuition behind the effect of $\bar{\theta}$ on the number of equilibria can be read from Figure 2. When monitoring is very poor (low value of $\bar{\theta}$), corrupt politician doesn't get detected too quickly and it pays off to be corrupt. This corresponds to the dashed green line in the Figure. Note that the line is always above 0 (i.e. $W(\rho_0) > 0$ for every ρ_0). This means that a politician always chooses to be corrupt no matter what the HH's initial belief is. Hence the only stationary equilibrium is one with $\rho_0 = 1$. With better monitoring (higher $\bar{\theta}$) the graph of $W(\cdot)$ is shifted down. This corresponds to the solid blue line and the dotted-dashed black line in Figure 2. Note that both lines cross 0 at two values of ρ_0 which indicates the existence of additional two stationary equilibria - with $\rho_0 = \rho_0^1(\bar{\theta})$ and $\rho_0 = \rho_0^2(\bar{\theta})$.

Theorem 4.5. *There is a unique threshold precision of the signal $\hat{\theta} \geq 0$ s.t:*

1. $\bar{\theta} < \hat{\theta} \Rightarrow$ *there is only one stationary equilibrium and* $\rho_0 = 1$.
2. $\bar{\theta} > \hat{\theta} \Rightarrow$ *there are exactly three stationary equilibria: one with* $\rho_0 = 1$ *and two with distinct values of* $\rho_0 \in (0, 1)$.

Proof. Step 1. Consider arbitrary $\bar{\theta}$. Lemma 4.1 implies that $W(\rho_0)$ has its minimum at $\rho_0 = \frac{1}{2} - \frac{\kappa}{2(U_H - U_L)}$ and since $\bar{\theta}$ was arbitrary the arg min is independent of it.

Step 2. Define $h(\bar{\theta}) := W(\frac{1}{2} - \frac{\kappa}{2(U_H-U_L)}; \bar{\theta})$. From Lemma 4.3 it follows that $h(\bar{\theta}_1) \leq h(\bar{\theta}_2) \iff \bar{\theta}_1 \leq \bar{\theta}_2$ and from Lemmas 4.2 and 4.1 it follows that if $h(\bar{\theta}) < 0$ then $\exists! \rho_0^1 \in (0, \frac{1}{2} - \frac{\kappa}{2(U_H-U_L)})$ and $\exists! \rho_0^2 \in (\frac{1}{2} - \frac{\kappa}{2(U_H-U_L)}, 1 - \frac{\kappa}{(U_H-U_L)})$ such that $W(\rho_0^1; \bar{\theta}) = W(\rho_0^2; \bar{\theta}) = 0$.

Step 3. Define $\hat{\theta} := \inf\{\bar{\theta} \geq 0 : h(\bar{\theta}) < 0\}$. Existence and uniqueness of such $\hat{\theta}$ is assured by the completeness axiom for the real line. This finishes the proof. $\square$

Reduction in the switching cost κ has effects similar to an increase in the precision of the signal $\bar{\theta}$. When switching costs are prohibitively high the payoff from being corrupt is $\frac{B}{\epsilon}$, regardless of the value of the HH's initial belief. When the switching cost declines the HH becomes more willing to change the government and so the time in power of a corrupt politician (and probability of being removed) begin to depend on HH's initial belief ρ_0. The effect of a reduction in the switching cost is depicted in Figure 3. A result similar to the one in Theorem 4.5 can be stated, stressing the effect of the switching cost κ on existing equilibria.

Theorem 4.6. *There is a unique threshold switching cost $\hat{\kappa} \geq 0$ s.t:*

1. $\kappa > \hat{\kappa} \Rightarrow$ *there is only one stationary equilibrium and* $\rho_0 = 1$.
2. $\kappa < \hat{\kappa} \Rightarrow$ *there are exactly three stationary equilibria: one with* $\rho_0 = 1$ *and two with distinct values of* $\rho_0 \in (0, 1)$.

Proof. Step 1. Define $h(\kappa) := W(\frac{1}{2} - \frac{\kappa}{2(U_H - U_L)})$. From Lemma 4.4 it follows that $h(\kappa_1) \leq h(\kappa_2) \iff \kappa_1 \leq \bar{\kappa}_2$ and from Lemmas 4.2 and 4.1 it follows that if $h(\kappa) < 0$ then $\exists! \rho_0^1 \in (0, \frac{1}{2} - \frac{\kappa}{2(U_H - U_L)})$ and $\exists! \rho_0^2 \in (\frac{1}{2} - \frac{\kappa}{2(U_H - U_L)}, 1 - \frac{\kappa}{(U_H - U_L)})$ such that $W(\rho_0^1; \kappa) = W(\rho_0^2; \kappa) = 0$.

Step 2. Define $\hat{\kappa} := \sup\{0 \leq \kappa \leq U_H - U_L : h(\kappa) < 0\}$. □

The equilibrium correspondences are pictured in Figures 5 and 6. Figure 5 plots the set of equilibrium initial beliefs against the precision of the signal $\bar{\theta}$ and Figure 6 does the same against the switching cost κ. Equilibrium selection will be discussed in the next section.

FIGURE 5 here

FIGURE 6 here

4.5 Equilibrium selection

Section B in the Appendix discusses the equilibrium selection in detail. The selection requires the equilibrium to be a limit of equilibria of a modified game. The modification is based on the concept of fictitious play (Brown (1951), Fudenberg and Levine (1998)). The major idea used in the selection mechanism is that the HH's initial belief is likely to depend on the fraction of past government that were corrupt.

Such modification of the model selects a unique equilibrium among the stationary Markov equilibria. The selected equilibrium is either the one with $\rho_0 = 1$ or with $\rho_0 = \rho_0^1(\bar{\theta}, \kappa)$. The equilibrium with $\rho_0 = \rho_0^2(\bar{\theta}, \kappa)$ is never selected. The intuition is based on local (in)stability. Suppose that HH's initial belief is $\rho_0^2 - \epsilon$. Since $W(\rho_0^2 - \epsilon) < 0$, a new politician will will be honest. In the modified game this will push the initial belief further down. If HH's initial belief is $\rho_0^2 + \epsilon$, then new politician will be corrupt. In the modified game this will push the initial belief further up. A similar argument shows that the equilibrium with $\rho_0 = \rho_0^1$ is locally stable.

Whether the equilibrium with $\rho_0 = 1$ or with $\rho_0 = \rho_0^1(\bar{\theta}, \kappa)$ is selected depends on (i) values of parameters $(\bar{\theta}, \kappa)$ and on (ii) initial conditions of the modified game. However, it can be shown (see Section B for details) that if for some parameters $(\bar{\theta}_1, \kappa_1)$ the selected equilibrium is the one with $\rho_0 = \rho_0^1(\bar{\theta}_1, \kappa_1)$, then for parameters $(\bar{\theta}_1, \kappa_2)$ and $(\bar{\theta}_2, \kappa_1)$ satisfying $\bar{\theta}_2 > \bar{\theta}_1$ and $\kappa_2 < \kappa_1$ the selected equilibrium will be the one with $\rho_0 = \rho_0^1(\bar{\theta}_2, \kappa_1)$ and $\rho_0 = \rho_0^1(\bar{\theta}_1, \kappa_2)$ respectively. Hence, for simplicity, we can focus on the equilibrium with the lowest possible initial belief ρ_0. In particular, we can define

$$\rho_0(\bar{\theta}, \kappa) = \begin{cases} \rho_0^1(\bar{\theta}, \kappa), & \text{if } \min_{\rho_0} W(\rho_0) < 0; \\ 1, & \text{otherwise.} \end{cases} \tag{4.1}$$

The expression above states that whenever a mixed strategy equilibrium exists we will set $\rho_0(\bar{\theta}, \kappa) = \rho_0^1(\bar{\theta}, \kappa)$. Otherwise the only Markov equilibrium is the one with $\rho_0(\bar{\theta}, \kappa) = 1$. Equilibrium selection is depicted in Figures 7 and 8.

FIGURE 7 here

FIGURE 8 here

5 Transition Matrix

Let $s \in \{H, L\}$ denote current policy regime type. Let Π denote the transition matrix between the two regimes:

$$\Pi = \begin{pmatrix} \pi_{HH} & 1 - \pi_{HH} \\ 1 - \pi_{LL} & \pi_{LL} \end{pmatrix}$$

where $\pi_{HH} = \Pr\{s' = H | s = H\}$ and $\pi_{LL} = \Pr\{s' = L | s = L\}$ with s' denoting the state next period. In the paper I am focusing on the effects of two parameters of the model - the precision of the signal $\bar{\theta}$ and the switching cost κ. The value of both parameters will affect persistence of each policy regime.

5.1 Effect of monitoring

In this section I will keep the cost of switching κ fixed and will look at the effects of changes in the HH's ability to monitor the government, measured by the precision of the signal - $\bar{\theta}$. Suppose that HH's belief that current government is bad (i.e. that the country is in a low-output regime) is ρ. Then:

$$\begin{aligned}
\pi_{HH}(\rho; \bar{\theta}) = {} & \epsilon \cdot (1 - \rho_0(\bar{\theta})) + \\
& (1 - \epsilon) \cdot \Big[\Pr\{\rho' \leq \rho^* | \rho; s = H\} + \Pr\{\rho' > \rho^* | \rho; s = H\} \cdot (1 - \rho_0(\bar{\theta})) \Big] \\
\pi_{LL}(\rho; \bar{\theta}) = {} & \epsilon \cdot \rho_0(\bar{\theta}) + \\
& (1 - \epsilon) \cdot \Big[\Pr\{\rho' \leq \rho^* | \rho; s = L\} + \Pr\{\rho' > \rho^* | \rho; s = L\} \cdot \rho_0(\bar{\theta}) \Big]
\end{aligned}$$

where ϵ is the probability of politician's exogenous death, $\rho_0(\bar{\theta})$ is the probability that any new government is bad in a stationary Markov equilibrium (given by (4.1)) and $\Pr\{\rho' \leq \rho^* | \rho; s\}$ is the probability that next period belief is above the threshold conditional on today's belief ρ and on current policy regime.

Note that $\rho_0(\bar{\theta})$ is decreasing in $\bar{\theta}$. Note also that for a fixed current belief $\rho < \rho^*$, the probability next period's belief will exceed the threshold is declining in $\bar{\theta}$ if government is bad and increasing in $\bar{\theta}$ if government is good. These two facts imply the persistence of high-output regime increases with $\bar{\theta}$, while persistence of low-output regime declines with $\bar{\theta}$. Figure 9 graphs the persistence of both regimes against the value of $\bar{\theta}$ (HH's ability to monitor the government).

Frequency of regime switching, on the other hand, changes non-monotonically with $\bar{\theta}$. For low values of $\bar{\theta}$, $\rho_0(\bar{\theta}) = \rho_0^3 = 1$, every government is bad and HH never changes the government. Once $\bar{\theta}$ crosses the threshold defined in Theorem 4.5 we have $\rho_0(\bar{\theta}) = \rho_0^1(\bar{\theta}) \in (0,1)$ with ρ_0 decreasing in $\bar{\theta}$. The frequency of regime switching jumps to its highest value and then declines with $\bar{\theta}$ as $\rho_0(\bar{\theta}) \searrow 0$. Figure 10 graphs equilibrium initial belief and frequency of regime switching as functions of HH's ability to monitor the government.

FIGURE 9 here.

FIGURE 10 here.

5.2 Effect of switching cost

In this section I will keep the precision of the signal $\bar{\theta}$ fixed and will look at the effects of changes in the switching cost κ. Suppose that the HH's belief that the current government is bad is ρ. Then:

$$\begin{aligned}
\pi_{HH}(\rho;\kappa) = {} & \epsilon \cdot (1-\rho_0(\kappa)) + \\
& (1-\epsilon) \cdot \left[\Pr\{\rho' \le \rho^*(\kappa) | \rho; s = H\} + \Pr\{\rho' > \rho^*(\kappa) | \rho; s = H\} \cdot (1-\rho_0(\kappa)) \right] \\
\pi_{LL}(\rho;\kappa) = {} & \epsilon \cdot \rho_0(\kappa) + \\
& (1-\epsilon) \cdot \left[\Pr\{\rho' \le \rho^*(\kappa) | \rho; s = L\} + \Pr\{\rho' > \rho^*(\kappa) | \rho; s = L\} \cdot \rho_0(\kappa) \right]
\end{aligned}$$

Recall that $\rho_0(\kappa)$ is increasing in κ. Note also that, holding the initial belief fixed, the threshold belief increases with κ. For a fixed current belief $\rho < \rho^*$, the probability next period's belief exceeds the threshold decreases with κ. Hence, the persistence of low-output regime increases with κ, but the effect on the persistence of high-output regime seems ambiguous. We can however determine unambiguously the effect of switching cost on the persistence of high-output regime at two values of belief ρ, namely at $\rho = \rho_0(\kappa)$ and $\rho = \rho^*(\kappa)$. At these values of ρ the persistence of high-output regime decreases with the switching cost. Figure 11 graphs persistence of high- and low-output regime against the switching cost when HH's belief is at the threshold value (which also varies with the switching cost).

FIGURE 11 here.

FIGURE 12 here.

Note that for low values of κ frequency of regime switching increases with the switching cost. This effect is result of general equilibrium effect outweighing partial equilibrium effect. Keeping ρ_0 fixed, lower κ reduces the threshold belief ρ^*. This would increase the probability of a government being removed by the HH. This is the partial equilibrium effect. However, in a mixed strategy equilibrium, the politician must be indifferent between being honest and corrupt. Increasing the switching cost, would increase the probability a new politician is corrupt. Since it is the corrupt politician that gets removed more often by the HH, we observe more switching. Figure 12 graphs equilibrium initial belief and frequency of regime switching as functions of the switching cost κ. As was the case with the precision of the signal, frequency of switching changes non-monotonically with κ. Initially it is increasing (higher κ implies low-output regime is more probable). Once κ crosses the threshold defined in Theorem 4.6, the country is always in a low-output regime and the HH never changes the government.

Determination of transition probabilities An important feature of the model is that the probability of a policy regime change is determined endogenously through the optimizing behavior of both politicians and households. The effect of the politician's behavior is captured by the term $\rho_0(\bar{\theta}, \kappa)$, while the effect of household's decision is embedded in the probability of next period belief crossing the threshold - $\Pr\{\rho' > \rho^* | \rho; s\}$.

6 Monitoring the Government and Output Volatility

During the post-war period most developed economies have experienced small fluctuations (business cycles) around a stable trend of positive output growth. Many of the less developed economies have been very volatile with large fluctuations at lower than business cycle frequency, switching between relatively long periods of growth and stagnation. Finally, some underdeveloped economies have experienced little volatility with a stable trend of output growth that was either zero or negative. Those three different scenarios are depicted in Figure 13.

FIGURE 13 here.

Note that while in the top and bottom two panels there seems to be no regime change (USA and Norway are in a high growth regime throughout the entire period, while Benin and Central African Republic are in the low growth regime), there are clear breaks in the two panels in the middle. Greece experienced high growth until the early 1980s and then entered a long period of stagnation that lasted until the mid 1990s. Trinidad and Tobago had a similar experience. The model developed in this paper can help explain the differences between these three groups.

6.1 Regime switching in growth rates

Consider an exchange economy with aggregate output in time t given by:

$$Y_t = e^{g_t} \cdot Y_{t-1}$$

The growth rates is stochastic and its distribution depends on the current government. Assume the distribution of growth rate is normal with lower mean if the government is corrupt:

$$g \sim \begin{cases} N(\mu_H, 1), & \text{if govt honest (high regime);} \\ N(\mu_L, 1), & \text{if govt corrupt (low regime).} \end{cases} \tag{6.1}$$

Assume that a household has a logarithmic utility from consumption. Household's expected utility in period t is:

$$E(\log(Y_t)) = \log(Y_{t-1}) + E(g_t)$$

Then, HH's expected period payoffs defined in (2.2) become:

$$U_H(Y_{t-1}) = \log(Y_{t-1}) + \mu_H$$
$$U_L(Y_{t-1}) = \log(Y_{t-1}) + \mu_L$$

The key aspect of the model I will focus on in this application is HH's ability to monitor the the government. This is captured by the precision of the signal θ about the government type - $\bar{\theta}$.

Recall that a stationary Markov equilibrium was defined as a triple (ρ_0, ρ^*, s^*) consisting of (i) HH's initial belief ρ_0, (ii) HH's threshold belief ρ^* and (iii) politician's strategy s^*.

From Section 3 we know that HH's threshold belief is given by $\rho^* = \rho_0 + \frac{\kappa}{U_H - U_L}$. Note that $U_H(Y_{t-1}) - U_L(Y_{t-1}) = \mu_H - \mu_L$, i.e. the difference between expected period payoffs is independent of current level of output. That means that the threshold belief is also independent of the level of output and all the results from Section 4 remain unaltered.

6.2 Model results

Let $var(g)$ denote the unconditional variance of the growth rate in a stationary equilibrium, let $var(g|a^P)$ be the variance of the growth rate conditional on the politician having made the decision a^P. By the law of total variance, $var(g)$ is given by:

$$var(g) = E[var(g|a^P)] + var[E(g|a^P)]$$

which can be written as:

$$\begin{aligned} var(g) = & \Pr\{a^P = \mathtt{L}\} \cdot var(g|a^P = \mathtt{L}) + \\ & \Pr\{a^P = \mathtt{H}\} \cdot var(g|a^P = \mathtt{H}) + \\ & + var[E(g|a^P)] \end{aligned}$$

where $\Pr\{a^P = \mathtt{H}\}$ is the unconditional probability that the country is in a high-growth regime. Given our assumptions about the process governing the growth rate in (6.1) the expression above becomes:

$$var(g) = 1 + var[E(g|a^P)]$$

It is clear from the above that in the model all the cross-country variation in volatility comes from the variance of the expectation of the growth rate, i.e. from regime switching. Given that we have only two possible regimes (high and low) it is straightforward to show that:

$$var(g) = 1 + \Pr\{a^P = \mathtt{L}\} \cdot (1 - \Pr\{a^P = \mathtt{L}\}) \cdot [\mu_H - \mu_L]^2 \tag{6.2}$$

It follows from (6.2) that the variance of growth rate is minimized when $\Pr\{a^P = \mathtt{L}\} = 0$ or when $\Pr\{a^P = \mathtt{L}\} = 1$, i.e. either when every politician chooses high-growth regime or every politician always chooses low-growth regime. The unconditional variance of the growth rate increases in $\Pr\{a^P = \mathtt{L}\}$ when $\Pr\{a^P = \mathtt{L}\} < 0.5$ and is maximized when $\Pr\{a^P = \mathtt{L}\} = 0.5$.

Note that the unconditional probability of the regime being low - $\Pr\{a^P = \mathtt{L}\}$ - is proportional to HH's initial belief ρ_0 (i.e. to the politician's strategy):

$$\frac{\Delta \Pr\{a^P = \mathtt{L}\}}{\Delta \rho_0} > 0.$$

How does HH's ability to monitor the government affect the volatility of growth in the model? Consider some arbitrary, large value of signal precision $\bar{\theta}_1$ so that $\rho_0(\bar{\theta}_1) = \rho_0^1(\bar{\theta}_1)$ is close to 0 (from Theorem 4.5 we know that it is possible to find such $\bar{\theta}$). Such equilibrium would correspond to a country with transparent public sector, press freedom, good institutions. Since in that equilibrium $\Pr\{a^P = \mathtt{L}\}$ is very small, the variance of the growth rate is close to its smallest value at 1. Next consider an infinitesimal decrease in $\bar{\theta}$ to some value $\bar{\theta}_2 = \bar{\theta}_1 - \epsilon$. Note that $0.5 > \rho_0^1(\bar{\theta}_2) > \rho_0^1(\bar{\theta}_1)$ and hence $0.5 > \Pr\{a^P = \mathtt{L}\}(\bar{\theta}_2) > \Pr\{a^P = \mathtt{L}\}(\bar{\theta}_1)$. Then equation (6.2) implies that the variance of the growth rate increases as precision of the signal declines.

Assume that the parameters of the model are such that when $\bar{\theta} = 0$, then in equilibrium $\rho_0 = 1$ (i.e. mixed strategy equilibria do not exist). Then from Theorem 4.5 we know there is a threshold precision of the signal $\hat{\theta} > 0$ such that $\rho_0(\bar{\theta}) = 1$ for all $\bar{\theta} < \hat{\theta}$. Then $\Pr\{a^P = \mathtt{L}\} = 1$ and the variance of the growth rate is 1 (i.e. at its lowest value).

The analysis above shows that in the model there is a hump-shaped relationship between HH's ability to monitor the government and volatility of the growth rate. When monitoring is very good, probability of being in a low regime is very small volatility is small. When monitoring is very bad, probability of being in a low regime is 1 (every politician chooses to be corrupt), country is in a poverty trap and volatility is again small. In between we observe switching between high- and low-growth regimes, instability and large volatility of growth. The results of this section can be summarized in the following proposition.

Proposition 6.1. *Let $var(g)$ denote the unconditional variance of the growth rate in a* *stationary Markov equilibrium with $\rho_0(\bar{\theta})$ given by (4.1). Then, there exists a unique threshold precision of the signal $\hat{\theta} \geq 0$ such that*

1. *If $\bar{\theta} < \hat{\theta}$, then $var(g) = 1$*

2. *If $\bar{\theta} > \hat{\theta}$, then $var(g) > 1$ and $var(g)$ decreases with $\bar{\theta}$.*

Proof. Let $\hat{\theta}$ be the one defined in Theorem 4.5.

1. If $\bar{\theta} < \hat{\theta}$ then the unique equilibrium is the one with $\rho_0 = \rho_0^3 = 1$. Then $\Pr\{a^P = \mathtt{L}\} = 1$ and $\Pr\{a^P = \mathtt{H}\} = 0$. Then (6.2) implies that $var(g) = 1$.

2. Consider arbitrary $\bar{\theta} > \hat{\theta}$. In a stationary Markov equilibrium we have $\rho_0(\bar{\theta}) = \rho_0^1(\bar{\theta}) < 0.5$. Since the expected duration of a bad government is shorter than that of a good government we have that $\Pr\{a^P = \mathtt{L}\} \leq \rho_0(\bar{\theta}) < 0.5$. Since $\rho_0(\bar{\theta})$ decreases with $\bar{\theta}$ and $\Delta \Pr\{a^P = \mathtt{L}\}/\Delta\rho_0$ we get that $\Pr\{a^P = \mathtt{L}\}$ decreases with $\bar{\theta}$. Then, since $\Pr\{a^P = \mathtt{L}\} \in (0, 1)$, (6.2) implies that $var(g) > 1$ and is decreasing in $\bar{\theta}$.

□

Figure 14 plots results from a simulation of the model for different values of the parameter $\bar{\theta}$. The top panel plots equilibrium initial belief ρ_0 defined in (4.1). The bottom panel plots standard deviation of the growth rate of real GDP for a particular parametrization of the model. The parameters were chosen so that for low values of $\bar{\theta}$ there is only one stationary Markov equilibrium with $\rho_0 = 1$ (in the context of Theorem 4.5 and Proposition 6.1 this means that $\hat{\theta} > 0$).

FIGURE 14 here.

6.3 Evidence (very preliminary)

The theory developed in this paper provides a number of testable predictions. This section will evaluate the one prediction that is unique to this paper - a hump-shaped relationship between precision of the information that HHs have about their government and volatility. The goal of this section is to establish a particular correlation pattern in the data without making any claims about the direction of causality.

Since measuring the precision of the information that the HHs have about their government is very difficult, at this stage I will focus on the correlation between low-frequency volatility and income. In general, poor countries are less developed also in terms of quality of institutions, transparency of their public sector, press freedom etc., all of which would influence the information people have about the politicians in power.

Figure 15 shows a scatter-plot of the volatility over the period 1970-2005 against log of real income per capita in 1970. Volatility is measured as the log of a standard deviation of 5-year moving averages of the growth rate of real GDP. Taking 5-year moving average of growth rates smoothes the high frequency variation so that the standard deviation reflects volatility of medium- and long-run economic performance. Income per capita is measured in constant 2000 US dollars. All the data is from the World Bank World Development Indicators. Least volatile countries are the poorest and the richest ones, while most volatile are those in the middle. Major commodity exporters have been omitted, because their volatility is largely due to (partly) exogenous fluctuations in commodity prices.

Figure 15 here.

Part of the low-frequency volatility may come from convergence - country that starts poor will be catching up (and have high growth). When its income converges, the growth will slow down. This would show up in the data as relatively large volatility at low frequency. To remove the convergence effect I run a growth regression with lagged income relative to the US as an explanatory variable, time and country effects, on a panel of 91 countries[6] over

[6] The sample of countries is based on the following criteria: (i) full data availability and (ii) average fraction of oil exports in GDP does not exceed 30%.

the period 1970-2005:

$$\Delta y_{i,t} = \beta_1 \Delta y_{i,t-1} + \beta_3 y_{i,t-1} + \mu_i + \eta_t + \epsilon_{i,t} \tag{6.3}$$

where $\Delta y_{i,t}$ is country i's growth rate between year $t-1$ and t, $y_{i,t-1}$ is country i's income relative to the US in year $t-1$, μ_i are fixed effects and η_t denote year dummy variables[7].

Next, for each country, I calculate the standard deviation of the 5-year moving average of residuals from (6.3). The scatter plot of that residual volatility against income in 1970 is presented in Figure 16. Although the correlation is now much weaker (because we removed the convergence effect), there is still a (statistically) significant hump-shaped relationship between initial income and low-frequency volatility (with $R^2 = 0.29$).

Figure 16 here.

While very preliminary and incomplete, this section indicates that least volatile countries are those that have been either very rich or very poor in 1970. The model developed in this paper formalizes one mechanism that can explain such pattern. The mechanism relies on the assumption that poor countries cannot monitor their governments very well and are thus more vulnerable to experience bad government policies.

6.4 Discussion

6.4.1 Government's effect on the economy

Does government policy have an impact on economic performance? A number of studies indicate that this is indeed the case. Bergoeing et al. (2002b) compare the experience of Chile and Mexico in the 1980's and 1990's. They argue that reforms in banking and bankruptcy

[7]This specification is similar to Islam (1995).

laws in Chile (and lack thereof in Mexico) are important in accounting for Chile's fast growth (and prolonged depression in Mexico) between 1985 and 2000.

Cole et al. (2005) study the role of national policies that foster (or restrain) competition. They argue that accounting for income disparities between Latin America and Western countries requires significant disparities in TFP. They document that Latin America has more competitive barriers than Western economies and provide a number of micro case studies where removal of such barriers was followed by an increase in productivity to Western levels.

Jones and Olken (2005) provide statistical evidence that country leaders have an impact on a country's growth. First, they point out that most of the less developed countries have at some point experienced long periods of growth followed by long periods of stagnation. Second, they argue that such reversals cannot be explained by the institutional variables used in cross-country growth regressions. They compare average growth rates 5 years before and 5 years after the death of a country's leader and find that an exogenous leader change is associated with a statistically significant change in average growth rate.

7 Conclusions

In this paper I developed a model of endogenous regime switching. In the model, a politician chooses policy regime that affects its own and household's payoffs. Household decides whether to change the politician in power. Transition probabilities between policy regimes are determined endogenously through optimizing behaviors of both politicians and households.

Motivated by existing growth and development literature stressing importance of government policies for medium- and long-run economic performance I applied my framework to study the persistence of bad government policies. The model I developed sheds light on problems such as African poverty trap and growth reversals in emerging economies.

While the model presented in this paper is very stylized, it can be used to enrich other standard models by introducing micro-founded regime changes. Section C in the Appendix discusses how my framework can be merged with the model of Aguiar and Gopinath (2007) to generate volatility of the trend component of GDP. This can potentially serve as a regime switching framework for the study of business cycles in emerging economies with particular focus on the emergence of populist policies (see e.g. Dornbusch and Edwards (1990)). This is a promising and exciting path for further research.

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A Proofs

A.1 Preliminaries

Note that the condition (3.3) in Lemma 3.1 can be written as:

$$\frac{\rho_0}{\rho_0 + (1-\rho_0)R^*} = \rho_0 + \frac{\kappa}{U_H - U_L} \tag{A.1}$$

where R^* is the threshold likelihood ratio such that if the likelihood ratio of the history of current stage game falls below R^* household will change the politician. The following preliminary result will be very useful.

Lemma A.1. *Let R^* satisfy (A.1). Then $\frac{\partial R^*}{\partial \rho_0} \geq 0 \iff \rho_0 \leq \frac{1}{2} - \frac{\kappa}{2(U_H - U_L)}$.*

Proof. Equation (A.1) can be rewritten as:

$$\rho_0 = [\rho_0 + (1-\rho_0)R^*] \cdot \left(\rho_0 + \frac{\kappa}{U_H - U_L}\right)$$

Dividing both sides by $\rho_0 + \frac{\kappa}{U_H - U_L}$ and then rearranging the denominator on the LHS we get:

$$\frac{\rho_0}{\frac{\rho_0(U_H - U_L) + \kappa}{U_H - U_L}} = \rho_0 + (1-\rho_0)R^*$$

Next we take ρ_0 to the LHS, divide both sides by $(1-\rho_0)$ to get:

$$\frac{\rho_0(U_H - U_L)}{(1-\rho_0)[\rho_0(U_H - U_L) + \kappa]} - \frac{\rho_0[\rho_0(U_H - U_L) + \kappa]}{(1-\rho_0)[\rho_0(U_H - U_L) + \kappa]} = R^*$$

We can rewrite the above as:

$$\frac{(1-\rho_0)\rho_0(U_H - U_L) - \kappa\rho_0 + \kappa - \kappa}{(1-\rho_0)\rho_0(U_H - U_L) + (1-\rho_0)\kappa} = R^*$$

which simplifies to:

$$R^* = 1 - \frac{\kappa}{(1-\rho_0)\rho_0(U_H - U_L) + (1-\rho_0)\kappa}$$

The above defines R^* as a function of ρ_0:

$$R^*(\rho_0) = 1 - \frac{\kappa}{f(\rho_0)}$$

where $f(\rho_0) := (1-\rho_0)\rho_0(U_H - U_L) + (1-\rho_0)\kappa$. Note that $f(\rho_0) > 0$ for all $\rho_0 \in [0,1)$. Chain rule implies that:

$$\frac{\partial R^*}{\partial \rho_0} \geq 0 \iff \frac{\kappa}{f(\rho_0)^2} \cdot f'(\rho_0) \geq 0 \iff f'(\rho_0) \geq 0$$

Basic algebra yields:

$$f'(\rho_0) = (U_H - U_L) - 2\rho_0(U_H - U_L) - \kappa$$

which yields that $f'(\rho_0) \geq 0 \iff \rho_0 \leq \frac{1}{2} - \frac{\kappa}{2(U_H - U_L)}$. □

A.1.1 Duration of the stage game

Let $\delta_t = 1$ if a politician exogenously died in period t and 0 otherwise. Define

$$\tau^0 := \inf\{t \in \mathbb{N} : \delta_t = 1\}$$

The random variable τ^0 is the time of politician's exogenous death. Let $G^0 : \mathbb{N} \to [0,1]$ be the CDF of the random variable τ^0:

$$G^0(t) = 1 - (1-\epsilon)^t$$

Next, define:

$$\tau^1 := \inf\left\{t \in \mathbb{N} : \prod_{i=0}^{t}\left[\frac{pdf(q_i, \theta_i | a^P = \mathtt{H})}{pdf(q_i, \theta_i | a^P = \mathtt{L})}\right] < R^*\right\}$$

The random variable τ^1 is the first time when the likelihood ratio of the history of the stage game crosses the threshold R^*. Let $G^1(\cdot; R^*) : \mathbb{N} \to [0,1]$ denote the CDF of the random variable τ^1 for a given threshold likelihood ratio R^*. Finally, the duration of the stage game is defined as:

$$\tau = \min\{\tau^0, \tau^1\}$$

The random variable τ is the minimum of τ^0 - the time of exogenous death - and τ^1 - the first time the likelihood ratio of the history of the stage game crosses the threshold R^*. Let

$F(\cdot; R^*) : \mathbb{N} \to [0,1]$ denote the CDF of the random variable τ for a given threshold likelihood ratio R^*. The remainder of this section will describe in greater detail the distribution functions $G^1(\cdot; R^*)$ and $F(\cdot; R^*)$.

Define:

$$\begin{aligned} A_t &= \{(\delta_i, q_i, \theta_i)_{i=1}^t \in \{0,1\}^t \times \mathbb{R}^t \times \mathbb{R}^t \text{ s.t. } \delta_i = 1 \text{ for some } i \leq t\} \\ B_t(R^*) &= \left\{ (\delta_i, q_i, \theta_i)_{i=1}^t \in \{0,1\}^t \times \mathbb{R}^t \times \mathbb{R}^t \text{ s.t. } \prod_{i=1}^k \left[\frac{pdf(q_i, \theta_i | a^P = \mathtt{H})}{pdf(q_i, \theta_i | a^P = \mathtt{L})} \right] \geq R^* \text{ for all } k \leq t \right\} \end{aligned}$$

Then:

$$\begin{aligned} F(t; R^*) &= \Pr\{\tau \leq t; R^*\} = \Pr\{A_t \cup B_t(R^*)^c\} = \\ &= \Pr\{A_t\} + \Pr\{B_t(R^*)^c\} - \Pr\{A_t\} \cdot \Pr\{B_t(R^*)^c\} = \\ &= \Pr\{A_t\} + (1 - \Pr\{A_t\}) \Pr\{B_t(R^*)^c\} \end{aligned}$$

where the second equality follows from the fact that A_t and $B_t(R^*)$ are independent. Since $\Pr\{A_t\} = (1-\epsilon)^t$, the above can be written as:

$$F(t; R^*) = (1-\epsilon)^t \Pr\{B_t(R^*)^c\} + 1 - (1-\epsilon)^t \tag{A.2}$$

The distribution function of τ^1 is simply

$$G^1(t; R^*) = \Pr\{B_t(R^*)^c\} \tag{A.3}$$

The distribution function G^0, G^1 and F can be used to describe the two important endogenous variables in the model: (i) the expected duration of the stage game when politician chose a low regime and (ii) the probability that politician who chose low regime gets removed by the HH.

The following four Lemmas will be helpful in proving the main results from the paper.

Lemma A.2. *For all* t, $F(t; R_1^*) \leq F(t; R_2^*) \iff R_1^* \leq R_2^*$.

Proof. From (A.2) it follows that

$$F(t;R_1^*) \leq F(t;R_2^*) \iff \Pr\{B_t(R_1^*)^c\} \leq \Pr\{B_t(R_2^*)^c\} \iff$$

$$\iff \Pr\{B_t(R_1^*)\} \geq \Pr\{B_t(R_2^*)\} \iff B_t(R_1^*) \supseteq B_t(R_2^*) \iff R_1^* \leq R_2^*$$

□

Lemma A.3. *For all t, $G^1(t;R_1^*) \leq G^1(t;R_2^*) \iff R_1^* \leq R_2^*$.*

Proof. Since $G^1(t;R^*) = \Pr\{B_t(R^*)^c\}$ the result is obvious. □

Lemma A.4. *For all t, $F(t;R^*)$ is continuous in R^*.*

Proof. It is enough to show that $\Pr\{B_t(R^*)\}$ is continuous in R^* for every t. Proof is by induction.

Step 1. Set $t = 1$. Then $\Pr\{B_1(R^*)\} = \Pr\{X_0 \geq r^* := \log(R^*)\}$ where

$$X_0 := g_H(q_0) - g_L(q_0) + f_H(\theta_0) - f_L(\theta_0)$$

$g_{H(L)}$ is the log of the density of q when regime is high (low) and $f_{H(L)}$ is the log of the density of θ when regime is high (low). Since q was log-normally distrbuted and θ was normally distributed, the logs of their densities are:

$$\begin{aligned}
g_H(y) &= -\frac{(\log(q) - \mu_H)^2}{2} - \log(q) - \log(\sqrt{2\pi}) \\
g_L(y) &= -\frac{(\log(q) - \mu_L)^2}{2} - \log(q) - \log(\sqrt{2\pi}) \\
f_H(\theta) &= -\frac{(\theta - \bar{\theta})^2}{2} - \log(\sqrt{2\pi}) \\
f_L(\theta) &= -\frac{(\theta + \bar{\theta})^2}{2} - \log(\sqrt{2\pi})
\end{aligned}$$

Then:

$$\begin{aligned}
g_H(y) - g_L(y) &= (\mu_c^2 - \mu_h^2) + \log(q) \cdot (\mu_H - \mu_L) \\
f_H(\theta) - f_L(\theta) &= -2\bar{\theta}\theta
\end{aligned}$$

Hence, if the politician chooses low regime we will have:

$$g_H(y) - g_L(y) \sim N\left(-\frac{(\mu_H - \mu_L)^2}{2}, (\mu_H - \mu_L)\right)$$
$$f_H(\theta) - f_L(\theta) \sim N\left(-2\bar{\theta}^2, 2\bar{\theta}\right)$$

Then

$$g_H(y_0) - g_L(y_0) + f_H(\theta_0) - f_L(\theta_0) \sim N(\nu_L, \lambda)$$

where $\nu_L = -\frac{(\mu_H-\mu_L)^2}{2} - 2\bar{\theta}^2$ and $\lambda = \sqrt{(\mu_H - \mu_L)^2 + 4\bar{\theta}^2}$. Then $\Pr\{X_0 \geq r^* = \int_{\frac{r^*-\nu_L}{\lambda}}^{\infty} d\Phi(x) = 1 - \Phi(\frac{r^*-\nu_L}{\lambda})$ which is continuous in r^*.

Step 2. Suppose $\Pr\{B_{t-1}(R^*)\}$ is continuous in R^*. WTS: $\Pr\{B_t(R^*)\}$ is continuous in R^*. Note that

$$\begin{aligned}
\Pr\{B_t(R^*)\} &= \Pr\left\{\forall k \leq t \sum_{i=0}^{k} X_i \geq r^*\right\} \\
&= \Pr\left\{\sum_{i=0}^{t} X_i \geq r^* \middle| \sum_{i=0}^{t-1} X_i \geq r^*\right\} \cdot \Pr\left\{\forall k \leq t-1 \sum_{i=0}^{k} X_i \geq r^*\right\} \\
&= \Pr\left\{X_t + \sum_{i=0}^{t-1} X_i \geq r^* \middle| \sum_{i=0}^{t-1} X_i \geq r^*\right\} \cdot \Pr\{B_{t-1}(R^*)\}
\end{aligned}$$

Note that $\sum_{i=0}^{t} X_i \sim N(t\nu_L, \sqrt{t}\lambda)$, because $X_i \sim N(\nu_L, \lambda)$. Since for any two independent random variables y, z such that $y \sim N(\mu_y, \sigma_y), z \sim N(\mu_z, \sigma_z)$ we have

$$\Pr\{y + z \geq r^* | z \geq r^*\} = \frac{\int_{\frac{r^*-\mu_z}{\sigma_z}}^{\infty} \left[\int_{\frac{r^*-z-\mu_y}{\sigma_y}}^{\infty} d\Phi(y)\right] d\Phi(z)}{1 - \Phi(\frac{r^*-\mu_z}{\sigma_z})}$$

is continuous in r^*, so is $\Pr\left\{X_t + \sum_{i=0}^{t-1} X_i \geq r^* \middle| \sum_{i=0}^{t-1} X_i \geq r^*\right\}$. Therefore $\Pr\{B_t(R^*)\}$ is continuous in R^*. This implies that $F(t; R^*)$ is continuous in R^* for every t. □

Lemma A.5. *For all t, $G^1(t; R^*)$ is continuous in R^*.*

Proof. It is enough to show that $\Pr\{B_t(R^*)\}$ is continuous in R^* for every t. See the proof of the previous Lemma. □

Expected duration of the low regime Define $E(\tau; R^*) : (0,1) \to \mathbb{R}_+$

$$E(\tau; R^*) := \sum_{t=0}^{\infty} t \cdot \Pr\{\tau = t; R^*\},$$

to be the expected duration of the stage game when politician chose low regime, given the threshold likelihood ratio R^*. Note that

$$E(\tau; R^*) := \sum_{t=0}^{\infty} t \cdot [F(t; R^*) - F(t-1; R^*)] \tag{A.4}$$

where I substitute $\Pr\{\tau = t; R^*\} = F(t; R^*) - F(t-1; R^*)$. Recall that R^* is implicitly defined in (A.1).

Probability of being removed $\psi : (0,1) \to [0,1]$:

$$\psi(R^*) := \Pr\{\tau^1 \leq \tau^0; R^*\}$$

to be the probability that a politician who chose low regime gets removed by the HH, given the threshold likelihood ratio R^* defined in (A.1). That probability can be written as:

$$\begin{aligned}
\psi(R^*) &= \sum_{t=1}^{\infty} \left[\sum_{k=1}^{\infty} \mathbf{1}_{t \leq k} [G^0(t) - G^0(t-1)] \right] [G^1(t; R^*) - G^1(t-1; R^*)] \\
&= \sum_{t=1}^{\infty} \eta(t) [G^1(t; R^*) - G^1(t-1; R^*)] \qquad \text{(A.5)} \\
& \qquad \text{(A.6)}
\end{aligned}$$

where $\eta(t) := \sum_{k=1}^{\infty} \mathbf{1}_{t \leq k} [G^0(t) - G^0(t-1)]$ is a strictly decreasing function of t.

A.2 Proofs from the main text

A.2.1 Proof of Lemma 4.1

Note that $W(\rho_0) = E(\tau; R^*(\rho_0)) \cdot B - \psi(R^*(\rho_0)) \cdot J$. To prove the result it is enough to show that (i) $E(\tau; R^*)$ is strictly decreasing R^* and (ii) $\psi(R^*)$ is strictly increasing R^*. The result will then follow from the chain rule and Lemma A.1.

Recall that from (A.4) and (A.5) we have:

$$E(\tau; R^*) = \sum_{t=0}^{\infty} t \cdot [F(t; R^*) - F(t-1; R^*)]$$

$$\psi(R^*) = \sum_{t=1}^{\infty} \eta(t)[G^1(t; R^*) - G^1(t-1; R^*)]$$

where $\eta(t) := \sum_{k=1}^{\infty} \mathbf{1}_{t \leq k}[G^0(t) - G^0(t-1)]$ is a strictly decreasing function of t. From Lemmas A.2 and A.3 we know that $F(\cdot; R_1^*)$ first order stochastically dominates $F(\cdot; R_2^*)$ if and only if $R^*1 \leq R_2^*$ and that $G^1(\cdot; R_1^*)$ first order stochastically dominates $G^1(\cdot; R_2^*)$ if and only if $R^*1 \leq R_2^*$. Therefore (i) $E(\tau; R^*)$ is strictly decreasing R^* and (ii) $\psi(R^*)$ is strictly increasing R^*. The result then follows from the chain rule and Lemma A.1.

Q.E.D.

A.2.2 Proof of Lemma 4.2

Note that $W(\rho_0) = E(\tau; R^*(\rho_0)) \cdot B - \psi(R^*(\rho_0)) \cdot J$. To prove the result it is enough to show that both (i) $E(\tau; R^*)$ and (ii) $\psi(R^*)$ are continuous in R^*.

Recall that from (A.4) and (A.5) we have:

$$E(\tau; R^*) = \sum_{t=0}^{\infty} t \cdot [F(t; R^*) - F(t-1; R^*)]$$

$$\psi(R^*) = \sum_{t=1}^{\infty} \eta(t)[G^1(t; R^*) - G^1(t-1; R^*)]$$

where $\eta(t) := \sum_{k=1}^{\infty} \mathbf{1}_{t \leq k}[G^0(t) - G^0(t-1)] = \sum_{k=1}^{\infty} \mathbf{1}_{t \leq k} \cdot \epsilon \cdot (1 - \epsilon^{k-1})$

$E(\tau)$ continuous in R^* Note that $F(t; R^*) = (1-\epsilon)^t \Pr\{B_t(R^*)^c\} + 1 - (1-\epsilon)^t$. Then $[F(t; R^*) - F(t-1; R^*)] \leq (1-\epsilon)^{t-1}$ for every t. Therefore, $\forall \delta > 0$, $\exists T(\delta) \in \mathbb{N}$ such that

$$\sum_{t=T(\delta)+1}^{\infty} t \cdot [F(t; R^*) - F(t-1; R^*)] \leq \sum_{t=T(\delta)+1}^{\infty} t \cdot (1-\epsilon)^{t-1} < \delta$$

Hence

$$\left| E(\tau; R^*) - \sum_{t=T(\delta)+1}^{\infty} t \cdot [F(t; R^*) - F(t-1; R^*)] \right| < \delta$$

Since $T(\delta)$ is independent of R^* it suffices to show that $F(t; R^*)$ is continuous in R^* for every $t \leq T(\delta)$. This was established in Lemma A.4 which means that $E(\tau; R^*)$ is continuous in R^*.

$\psi(R^*)$ continuous in R^* Recall that $\eta(t) = \sum_{k=1}^{\infty} \mathbf{1}_{t\leq k}[G^0(k) - G^0(k-1)] = \sum_{k=1}^{\infty} \mathbf{1}_{t\leq k} \cdot \epsilon \cdot (1-\epsilon)^{k-1}$. Therefore, $\forall \delta > 0$, there is $T(\delta)$ such that $\eta(t) < \delta$ for all $t > T(\delta)$.

Then, it suffices to show that $G^1(t; R^*)$ is continuous in R^* for all $t < T(\delta)$. This was established in Lemma A.5 which means that $\psi(R^*)$ is continuous in R^*.

Q.E.D.

A.2.3 Proof of Lemma 4.3

Fix $\rho_0 \in (0, 1 - \frac{\kappa}{U_H - U_L})$. This fixes $R^* \in (0,1)$. Since $W(\rho_0; \bar{\theta}) = E(\tau; R^*(\rho_0); \bar{\theta}) \cdot B - \psi(R^*(\rho_0); \bar{\theta}) \cdot J$ it suffices to show that (i) $E(\tau; R^*, \bar{\theta})$ is strictly decreasing in $\bar{\theta}$ whenever $R^* \in (0,1)$ and that (ii) $\psi(R^*(\rho_0); \bar{\theta})$ is strictly increasing in $\bar{\theta}$ whenever $R^* \in (0,1)$.

Lemma A.6. *$E(\tau; R^*, \bar{\theta})$ is strictly decreasing in $\bar{\theta}$.*

Proof. Fix $R^* \in (0,1)$. The expected duration of low regime (as a function of $\bar{\theta}$) is given by:

$$E(\tau; \bar{\theta}) = \sum_{t=0}^{\infty} t \cdot [F(t; \bar{\theta}) - F(t-1; \bar{\theta})]$$

where

$$F(t; \bar{\theta}) = (1-\epsilon)^t \Pr\{B_t \bar{\theta})^c\} + 1 - (1-\epsilon)^t$$

and

$$B_t(\bar{\theta}) := \left\{ (q_i, \theta_i)_{i=0}^t \text{ s.t. } \prod_{i=0}^{k} \left[\frac{pdf(q_i, \theta_i | a^P = \mathtt{H}; \bar{\theta})}{pdf(q_i, \theta_i | a^P = \mathtt{L}; \bar{\theta})} \right] \geq R^* \text{ for all } k \leq t \right\}.$$

To prove the result we need to show that $F(t;\bar{\theta}_1) \leq F(t;\bar{\theta}_2) \iff \bar{\theta}_1 \leq \bar{\theta}_2$. It suffices to show that $\Pr\{B_t(\bar{\theta}_1)\} \geq \Pr\{B_t(\bar{\theta}_2)\} \iff \bar{\theta}_1 \leq \bar{\theta}_2$, all t. Note that:

$$B_t(\bar{\theta}) = \left\{(X_i)_{i=0}^k \text{ s.t. } \sum_{i=0}^k X_i \geq r^* := \log(R^*) \text{ for all } k \leq t\right\}$$

where $X_i \sim N(\nu_L, \lambda)$, with $\nu_L(\bar{\theta}) = -\frac{(\mu_H-\mu_L)^2}{2} - 2\bar{\theta}^2$ and $\lambda(\bar{\theta}) = \sqrt{(\mu_H-\mu_L)^2 + 4\bar{\theta}^2}$. The proof is by induction.

Step 1. Set $t = 1$. Then $\Pr\{B_1(\bar{\theta})\} = \Pr\{X_0 \geq R^*\}$, i.e.

$$\Pr\{B_1(\bar{\theta})\} = \int_{\frac{r^*-\nu_L(\bar{\theta})}{\lambda(\bar{\theta})}}^{\infty} d\Phi(x) = 1 - \Phi\left(\frac{r^*-\nu_L(\bar{\theta})}{\lambda(\bar{\theta})}\right)$$

It suffices to show that $x(\bar{\theta}) := \frac{r^*-\nu_L(\bar{\theta})}{\lambda(\bar{\theta})}$ is increasing in $\bar{\theta}$. Note that

$$h'(\bar{\theta}) = \frac{-\nu_L'(\bar{\theta})\lambda(\bar{\theta}) - \lambda'(\bar{\theta})[r^*-\nu_L(\bar{\theta})]}{\lambda(\bar{\theta})^2} > 0 \iff -\nu_L'(\bar{\theta})\lambda(\bar{\theta}) - \lambda'(\bar{\theta})\left[r^*-\nu_L(\bar{\theta})\right] > 0$$

Taking the derivatives we get $\nu_L'(\bar{\theta}) = -4\bar{\theta}$ and $\lambda'(\bar{\theta}) = \frac{4\bar{\theta}}{\sqrt{(\mu_H-\mu_L)^2+4\bar{\theta}^2}}$. Then

$$h'(\bar{\theta}) = 4\bar{\theta}\sqrt{(\mu_H-\mu_L)^2 + 4\bar{\theta}^2} - \frac{4\bar{\theta}}{\sqrt{(\mu_H-\mu_L)^2 + 4\bar{\theta}^2}} \cdot \left[r^* + \frac{(\mu_H-\mu_L)^2}{2} + 2\bar{\theta}^2\right]$$

Assume $\bar{\theta} > 0$, multiply both sides by $\sqrt{(\mu_H-\mu_L)^2 + 4\bar{\theta}^2}$, then $h'(\bar{\theta}) > 0$ iff

$$\frac{(\mu_H-\mu_L)^2}{2} + 2\bar{\theta}^2 > r^*$$

which is always satisfied, because $r^* < 0$. Hence $\Pr\{B_1(\bar{\theta}_1)\} \geq \Pr\{B_1(\bar{\theta}_2)\} \iff \bar{\theta}_1 \leq \bar{\theta}_2$.

Step 2. Suppose $\Pr\{B_{t-1}(\bar{\theta}_1)\} \geq \Pr\{B_{t-1}(\bar{\theta}_2)\} \iff \bar{\theta}_1 \leq \bar{\theta}_2$. We need to show that the same holds for t. Note that

$$\begin{aligned}
\Pr\{B_t(\bar{\theta})\} &= \Pr\left\{\forall k \leq t \sum_{i=0}^k X_i \geq r^*\right\} \\
&= \Pr\left\{\sum_{i=0}^t X_i \geq r^* \middle| \sum_{i=0}^{t-1} X_i \geq r^*\right\} \cdot \Pr\left\{\forall k \leq t-1 \sum_{i=0}^k X_i \geq r^*\right\} \\
&= \Pr\left\{X_t + \sum_{i=0}^{t-1} X_i \geq r^* \middle| \sum_{i=0}^{t-1} X_i \geq r^*\right\} \cdot \Pr\{B_{t-1}(\bar{\theta})\}
\end{aligned}$$

Similar argument to the one in Step 1 shows that $\Pr\left\{X_t + \sum_{i=0}^{t-1} X_i \geq r^* \middle| \sum_{i=0}^{t-1} X_i \geq r^*\right\}$ is decreasing in $\bar{\theta}$, because

$$\Pr\left\{X_t + \sum_{i=0}^{t-1} X_i \geq r^* \middle| \sum_{i=0}^{t-1} X_i \geq r^*\right\} = \Pr\left\{X_t \geq r^* - \sum_{i=0}^{t-1} X_i \middle| \sum_{i=0}^{t-1} X_i \geq r^*\right\}$$

where $X_t \sim N(\nu_L, \lambda)$ and $\sum_{i=0}^{t-1} X_i \sim N(t\nu_L, \sqrt{t}\lambda)$. Since $\Pr\{B_{t-1}(\bar{\theta})\}$ is strictly decreasing in $\bar{\theta}$ so is $\Pr\{B_t(\bar{\theta})\}$. This completes the proof. □

Lemma A.7. *$\psi(R^*, \bar{\theta})$ is strictly increasing in $\bar{\theta}$.*

Proof. Since

$$\psi(R^*, \bar{\theta}) = \sum_{t=1}^{\infty} \eta(t)[G^1(t; \bar{\theta}) - G^1(t-1; \bar{\theta})]$$

and $\eta(t)$ is strictly decreasing in t it is enough to show that $G^1(t; \bar{\theta}_1) \leq G^1(t; \bar{\theta}_2) \iff \bar{\theta}_1 \leq \bar{\theta}_2$. Since $G^1(t; \bar{\theta}) = \Pr\{B_t(\bar{\theta})^c\}$ the result follows from the proof of the previous lemma. □

The main result now follows from Lemmas A.6 and A.7.

Q.E.D.

A.2.4 Proof of Lemma 4.4

Fix $\rho_0 \in (0, 1 - \frac{\kappa_1}{U_H - U_L})$. Since

$$W(\rho_0; \kappa) = E(\tau; R^*(\rho_0; \kappa))B - \psi(R^*(\rho_0; \kappa))J$$

it is enough to show that (i) $E(\tau; R^*(\rho_0; \kappa_2)) \leq E(\tau; R^*(\rho_0; \kappa_1)) \iff \kappa_2 \leq \kappa_1$ and (ii) $\psi(R^*(\rho_0; \kappa_2)) \geq \psi(R^*(\rho_0; \kappa_1)) \iff \kappa_2 \leq \kappa_1$.

First note that for a given ρ_0, $R^*(\rho_0; \kappa_1) \geq R^*(\rho_0; \kappa_2) \iff \kappa_2 \leq \kappa_1$ (from (A.1)). Then (i) follows from Lemma A.2 and (ii) follows from Lemma A.3.

Q.E.D.

B Equilibrium selection

Idea The equilibrium selection is based on the idea that HH's initial belief is likely to be proportional to the fraction of low regimes the economy has experienced. People living in a country that has a long history of corrupt governments will assign high probability to a new government being corrupt. A customer who has had 10 bad experiences in 10 different restaurants in town X is likely to believe that all restaurants in town X have poor service.

The rest of this section formalizes this idea. Formalization is based on the concept of fictitious play (Brown (1951), Shapley (1964), Fudenberg and Levine (1998)).

HH's fictitious play Suppose that HH thinks every new regime is low with a fixed probability s but the value of s is unknown (because for example HH doesn't internalize provider's problem). Instead, it has some initial prior over s. Suppose regime type is revealed after the stage game ends, i.e. the history for the HH in stage game n, at time t is:

$$h^{n,t} = \left(\left(a_k^P, (q_i, \theta_i)_{i=0}^{\tau_k}, \delta_k \right)_{k=1}^{n-1}, (q_i, \theta_i)_{i=0}^{t-1} \right)$$

The only difference between the above expression and history defined in Section 2.3 is that HHs know decisions made by past providers. This is captured by the term a_k^P. After $n-1$ stage games, HH has observed $n-1$ regime types. Each regime was either `low` or `high`. Under the assumption that each time `low` happens with constant probability s, the observed sequence of regimes is a realization of a binomially distributed random variable with parameter s, the value of which HHs learn over time. Since the conjugate prior to a binomial distribution is Beta distribution I will assume that HH's initial prior over s has a Beta distribution with some parameters $\alpha_1, \beta_1 \in \mathbb{N}$. The posterior after having observed $n-1$ regimes will have a Beta distribution with parameters (α_n, β_n) where $\alpha_n = \alpha_1 + \sum_{i=1}^{n-1} 1_{a_i^P = \mathtt{L}}$ and $\beta_n = \beta + \sum_{i=1}^{n-1} 1_{a_i^P = \mathtt{H}}$, where $1_{a_i^P = \mathtt{L(H)}}$ denotes an indicator function of the event that i^{th}

provider chose low (high) regime.

HH's initial belief that provider n chose low regime is $\rho_{n,0} = E(s|h^{n,0})$. When posterior over s has Beta distribution with parameters (α_n, β_n) this simplifies to:

$$\rho_{n,0} = \frac{\alpha_n}{\alpha_n + \beta_n} \tag{B.1}$$

Given history $h^{n,t} = \left(\left(a_k^P, (q_i, \theta_i)_{i=0}^{\tau_k}, \delta_k\right)_{k=1}^{n-1}, (q_i, \theta_i)_{i=0}^{t-1}\right)$, the value of keeping current provider is:

$$V^k(h^{n,t}) = \rho_{n,t}(h^{n,t})U_L + (1 - \rho_{n,t}(h^{n,t}))U_H$$

while the value of changing is:

$$V^o(h^{n,t}) = E(\rho_{n+1,0}|h^{n,t})U_L + (1 - E(\rho_{n+1,0}|h^{n,t}))U_H - \kappa$$

where

$$E(\rho_{n+1,0}|h^{n,t}) = \rho_{n,t}\frac{\alpha_1 + \sum_{i=1}^{n-1} 1_{a_i^P = \mathtt{L}} + 1}{\alpha_1 + \beta_1 + n + 1} + (1 - \rho_{n,t})\frac{\alpha_1 + \sum_{i=1}^{n-1} 1_{a_i^P = \mathtt{L}}}{\alpha_1 + \beta_1 + n + 1}$$

HH will change the provider if and only if $V^o(h^{n,t}) > V^k(h^{n,t})$ which turns out to be equivalent to $\rho_{n,t} > \left(\rho_{n,0} + \frac{\kappa}{U_H - U_L}\right) \cdot \left(1 + \frac{1}{\alpha_n + \beta_n}\right)$. Define a best response correspondence for a HH to be:

$$BR^H(\rho^{n,0}) = \left\{\rho^* : \rho^* = \left(\rho_{n,0} + \frac{\kappa}{U_H - U_L}\right) \cdot \left(1 + \frac{1}{\alpha_n + \beta_n}\right)\right\}$$

Note that as $\alpha, \beta \to \infty$ the expression above collapses to HH's best response in a stationary equilibrium.

Provider's problem Provider's problem is essentially the same as before - again, he takes as given HH's initial belief and threshold belief, which determine the expected duration of the low regime. In particular, best response correspondence for the provider is:

$$BR^P(\rho^{n,0}) = \arg\max_{s \in [0,1]} \left[sW(\rho_{n,0}, \rho_n^*)\right]$$

Equilibrium The definition of a fictitious-play equilibrium now follows.

Definition B.1. Given the parameters (α_1, β_1) of HH's initial prior over s, a fictitious-play equilibrium consists of: (i) sequence of HH's initial beliefs $(\rho_{n,0})_{n=1}^{\infty}$, (ii) sequence of HH's threshold beliefs $(\rho_n^*)_{n=1}^{\infty}$, (iii) sequence of providers' strategies $(s_n)_{n=1}^{\infty}$ and (iv) sequence of parameters $(\alpha_n, \beta_n)_{n=1}^{\infty}$ of HH's posteriors over s such that: (i) $\rho_{n,0} = \frac{\alpha_n}{\alpha_n+\beta_n}$, (ii) $\rho_n^* \in BR^H(\rho^{n,0})$, (iii) $s_n \in BR^P(\rho_{n,0})$ and (iv) (α_n, β_n) are induced from (α_1, β_1) using Bayes' rule.

B.1 Learning and convergence

Introducing this type of irrationality on the side of the HH yields a unique fictitious-play equilibrium path (for a given initial prior over s). In this section I will define a globally stable Markov equilibrium and describe conditions under which fictitious-play equilibrium path converges to a stable stationary Markov equilibrium.

Definition B.2. Given parameters (α_1, β_1) of HH's initial prior over s^*, a globally stable Markov equilibrium is a triple (ρ_0, ρ^*, s^*) such that (i) (ρ_0, ρ^*, s^*) is a stationary Markov equilibrium as defined in Section 3 and (ii) $\rho_0 = \lim_{n\to\infty} \rho_{n,0}$, $s^* = \lim_{n\to\infty} \frac{\alpha_n}{\alpha_n+\beta_n}$ where $(\rho_{n,0})_{n=1}^{\infty}$ and $(\alpha_n, \beta_n)_{n=1}^{\infty}$ are sequences in a fictitious-play equilibrium.

Theorem B.3. *Given parameters (α_1, β_1) there exists a unique globally stable Markov equilibrium.*

Which stationary Markov equilibrium is globally stable depends on the parameters of the model. Of course, initial prior over s^* matters - the more pessimistic the HH is to start with, the more likely is that the globally stable is the triple $(1, 1+\frac{\kappa}{U_H-U_L}, 1)$. Given the parameters (α_1, β_1) of the initial prior, two parameters that were the focus of this paper - precision of the signal $\bar{\theta}$ and switching cost κ - will also determine globally stable equilibrium.

Theorem B.4. *Suppose that HH's initial prior over s is Beta with parameters $\alpha_1, \beta_1 \in \mathbb{N}$. Then $\exists!\hat{\theta} \geq 0$ s.t:*

1. *If $\bar{\theta} < \hat{\theta}$ then: (i) $\rho_{n,0} \to 1$ and (ii) $a_n^P = \mathtt{L}$ for all n.*

2. *If $\bar{\theta} > \hat{\theta}$ then: (i) $\rho_{n,0} \to \rho_0^1(\bar{\theta})$ and (ii) $\frac{\sum_{i=1}^n 1_{a_i^P = L}}{n} \to s^* = \rho_0^1(\bar{\theta})$.*

Proof. Fix $\bar{\theta}$ so that there are three stationary equilibria. After n stage games the parameters of the posterior are $\alpha_{n+1} = \alpha_1 + k_n$ and $\beta_{n+1} + n - k_n$ where k_n is the number of providers that chose low regime in the n stage games. Note that

$$\lim_{n\to\infty} \frac{\alpha_n}{\alpha_n + \beta_n} = \lim_{n\to\infty} \frac{\alpha_1 + k_n}{\alpha_1 + k_n + \beta_1 + n - k_n} = \lim_{n\to\infty} \frac{k_n}{n}$$

Lemma B.5. $\frac{k_n}{n} \to 1$ *or* $\frac{k_n}{n} \to \rho_0^1$

Proof. Fix $\epsilon > 0$ and let n be large enough so that $|\frac{k_{n+1}}{n+1} - \frac{k_n}{n}| < \frac{\epsilon}{2}$

1. $\frac{k_n}{n} \in N_\epsilon(\rho_0^1) \Rightarrow \frac{k_{n+1}}{n+1} \in N_\epsilon(\rho_0^1)$.

   (a) $\frac{k_n}{n} < \rho_0^1 - \frac{\epsilon}{2}$. Then $a_n^P = \mathtt{L}, k_{n+1} = k_n + 1, \frac{k_{n+1}}{n+1} > \frac{k_n}{n}$ but $\frac{k_{n+1}}{n+1} < \rho_0^1 + \epsilon$.

   (b) $\frac{k_n}{n} > \rho_0^1 + \frac{\epsilon}{2}$. Then, using the result established before this lemma, $a_n^P = \mathtt{H}, k_{n+1} = k_n, \frac{k_{n+1}}{n+1} < \frac{k_n}{n}$ but $\frac{k_{n+1}}{n+1} > \rho_0^1 - \epsilon$.

2. $\frac{k_n}{n} \notin N_\epsilon(\rho_0^1)$

   (a) $\frac{k_n}{n} < \rho_0^1 - \epsilon$. Then $a_n^P = \mathtt{L}$, hence $\frac{k_{n+1}}{n+1} > \frac{k_n}{n}$. Then $\exists m > n$ s.t. $\frac{k_m}{m} \in N_\epsilon(\rho_0^1)$.

   (b) $\frac{k_n}{n} > \rho_0^1 + \epsilon$ and $W(\rho_0(h^{n,0}), \rho^*(h^{n,0})) < 0$. Then $a_n^P = \mathtt{H}$ and $\exists m > n$ s.t. $\frac{k_m}{m} \in N_\epsilon(\rho_0^1)$.

   (c) $\frac{k_n}{n} > \rho_0^1 + \epsilon$ and $W(\rho_0(h^{n,0}), \rho^*(h^{n,0})) > 0$. Then either (i) $\exists m > n$ such that $W(\rho_0(h^{m,0}), \rho^*(h^{m,0})) < 0$ and the argument from (b) applies or (ii) $\frac{k_n}{n} \to 1$.

Lemma B.6. *Let $k_n(\bar{\theta})$ denote the number of corrupt governments observed in n games when the precision of the signal is $\bar{\theta}$. Then $\bar{\theta}_1 \leq \bar{\theta}_2 \Rightarrow k_n(\bar{\theta}_1) \geq k_n(\bar{\theta}_2)$, all n.*

Proof. By induction. Set $n = 0$. Then $k_n = 0$, regardless of $\bar{\theta}$. Suppose $k_n(\bar{\theta}_1) \geq k_n(\bar{\theta}_2)$. If $k_n(\bar{\theta}_1) > k_n(\bar{\theta}_2)$ we are done, because $k_{n+1} \in \{k_n, k_n + 1\}$. Suppose $k_n(\bar{\theta}_1) = k_n(\bar{\theta}_2)$. Then α_n and β_n are the same for $\bar{\theta} = \bar{\theta}_1$ and $\bar{\theta} = \bar{\theta}_2$ and hence both $\rho_{0,n}$ and ρ_n^* are the same for $\bar{\theta} = \bar{\theta}_1$ and $\bar{\theta} = \bar{\theta}_2$. Then, payoff from being corrupt is weakly lower when $\bar{\theta} = \bar{\theta}_2$. Hence, if $n + 1^{st}$ politician chooses to be honest when $\bar{\theta} = \bar{\theta}_1$ he will also choose to be honest when $\bar{\theta} = \bar{\theta}_2 \geq \bar{\theta}_1$. Hence $k_{n+1}(\bar{\theta}_1) \geq k_{n+1}(\bar{\theta}_2)$. □

Define $D(\bar{\theta}) := \left\{(\alpha_1, \beta_1) \in \mathbb{N} \times \mathbb{N} : \frac{\alpha_n}{\alpha_n+\beta_n} \to \rho_0^1(\bar{\theta})\right\}$. Lemma B.6 implies that $\lim_{n\to\infty} \frac{k_n}{n}(\bar{\theta}_1) \geq \lim_{n\to\infty} \frac{k_n}{n}(\bar{\theta}_2)$ if $\bar{\theta}_1 \leq \bar{\theta}_2$. Then $\lim_{n\to\infty} \frac{\alpha_n}{\alpha_n+\beta_n}(\bar{\theta}_1) \geq \lim_{n\to\infty} \frac{\alpha_n}{\alpha_n+\beta_n}(\bar{\theta}_2)$ if $\bar{\theta}_1 \leq \bar{\theta}_2$. But $\lim_{n\to\infty} \frac{\alpha_n}{\alpha_n+\beta_n}(\bar{\theta}) \in \{\rho_0^1(\bar{\theta}), 1\}$. Hence $\bar{\theta}_1 \leq \bar{\theta}_2 \Rightarrow D(\bar{\theta}_1) \subseteq D(\bar{\theta}_2)$. □

Setting $\hat{\theta} := \inf\{\bar{\theta} \in \bar{R}_+ : (\alpha_1, \beta_1) \in D(\bar{\theta})\}$ finishes the proof of the Theorem. □

Theorem B.4 states that when monitoring in the economy is poor (low value of $\bar{\theta}$) then the economy will converge to a stationary equilibrium in which $\rho_0 = 1$ - every regime is low. On the equilibrium path each provider will choose low regime and HH's belief over provider's strategy s will converge to a degenerate distribution with all mass at 1.

If on the other hand $\bar{\theta}$ exceeds certain threshold $\hat{\theta}$, the economy will converge to a stationary equilibrium in which $\rho_0 < 1$ and (most importantly) it is the stationary equilibrium with the lowest possible ρ_0. On the equilibrium path providers will almost always play a pure strategy (with s_n being either 0 or 1) but the fraction of observed low regimes will converge to s^* - provider's strategy in a stationary equilibrium with the lowest ρ_0. Similarly, HH's belief over s^* will converge to a degenerate distribution with all the mass at $s^* = \rho_0$. A result similar to the one in Theorem B.4 can be stated in terms of the switching cost κ.

Theorem B.7. *Suppose that HH's initial prior over s is Beta with parameters $\alpha_1, \beta_1 \in \mathbb{N}$. Then $\exists! \hat{\kappa} > 0$ s.t:*

1. *If $\kappa > \hat{\kappa}$ then: (i) $\rho_{n,0} \to 1$ and (ii) $a_n^P = \mathtt{L}$ for all n.*
2. *If $0 < \kappa < \hat{\kappa}$ then: (i) $\rho_{n,0} \to \rho_0^1(\kappa)$ and (ii) $\frac{\sum_{i=1}^n 1_{a_i^P = L}}{n} \to s^* = \rho_0^1(\kappa)$.*

Proof. The proof mimics the proof of Theorem B.4. □

C Extensions

In this section I will discuss one extension of the model which will allow to merge my framework with a stochastic growth model.

C.1 Endogenous Volatility of the Trend in a Stochastic Growth Model

Consider the following modification of the version of a stochastic growth model in Aguiar and Gopinath (2007) (henceforth AG). There is a representative household with log utility over consumption (for simplicity I abstract for a while from labor/leisure choice):

$$\sum_{t=0}^{\infty} \beta^t \log(C_t)$$

Resource constraint in the closed economy is:

$$Y_t = e^{z_t} K_t^{\alpha} (\Gamma_t L_t)^{1-\alpha}$$

where

$$\begin{aligned}
\Gamma_t &= e^{g_t} \Gamma_{t-1} \\
g_t &= (1-\rho_g)\bar{g}_t + \rho_g g_{t-1} + \epsilon_t^g \\
z_t &= \rho_z z_{t-1} + \epsilon_t^z \\
\epsilon_t^g &\sim N(0, \sigma_g) \\
\epsilon_t^z &\sim N(0, \sigma_z)
\end{aligned}$$

and

$$\bar{g}_t = \begin{cases} \bar{g}_H, & \text{if government is honest;} \\ \bar{g}_L, & \text{if government is corrupt.} \end{cases}$$

and $\bar{g}_H > \bar{g}_L$. In each period household only observes g_t (but cannot observe neither $\bar{g}_H$ nor ϵ_t^g). It has initial prior ρ_0 that any new government is corrupt. At the beginning of each period, with probability κ household has an opportunity to overthrow the government at no cost. This would correspond to elections happening every $\frac{1}{\kappa}$ periods on average.

Recursive formulation of the HH problem Following AG I define detrended (whenever applicable) variables as:

$$\hat{x}_t := \frac{X_t}{\Gamma_{t-1}}$$

The resource constraint is now:

$$\hat{c}_t + e^{g_t}\hat{k}_{t+1} \leq e^{z_t}\hat{k}_t^{\alpha}(e^{g_t}L_t)^{1-\alpha}$$

Household makes two decisions. One is a 0-1 choice of keeping / changing the government. The other is a standard intertemporal consumption / saving decision. The state variables are $(\hat{k}, z, g, \rho)$ where $\rho = \Pr\{\bar{g} = \bar{g}_L\}$. Let $s := (k, z, g, \rho)$. Let V denote the value function when HH decides whether to keep the government or overthrow it and let W denote the value function when HH chooses c and k'. The value functions V and W satisfy:

$$V(k,z,g,\rho) = \max\{W(k,z,g,\rho), W(k,z,g,\rho_0)\} \tag{C.1}$$

$$W(k,z,g,\rho) = \max_{c,k'}\{u(c) + \beta \cdot [\kappa E_\rho V(k',z',g',\rho') + (1-\kappa)E_\rho W(k',z',g',\rho')]\} \tag{C.2}$$

subject to:

$$c + e^g k' \leq e^z k^\alpha (e^g L)^{1-\alpha} \tag{C.3}$$

$$z' = \rho_z z + \epsilon_z \tag{C.4}$$

$$g' = (1-\rho_g)\bar{g} + \rho_g g + \epsilon_g \tag{C.5}$$

$$\epsilon_g \sim N(0,\sigma_g) \tag{C.6}$$

$$\epsilon_z \sim N(0,\sigma_z) \tag{C.7}$$

Politician's problem There is an infinite sequence of politicians. When a politician in power dies, next politician enters the game and forms the government. Upon entering, politician draws his type $i \sim U[0,1]$. Type is private information. After learning his type, politician decides whether to be corrupt or honest, i.e. $A^P = \{\texttt{c},\texttt{h}\}$. If corrupt, politician receives a bribe B in each period in power. The one-time payoff from being honest is $J(i) := i$ (note that this payoff is now specific to a politician)[8]. A politician can exit the game in two ways. It can be removed from the office by the HH or it can simply exogenously die which happens at the end of a period with a constant probability $\epsilon < \kappa$. A politician compares the expected payoff from being corrupt, which is equal to $E(\tau | a(i) = \texttt{c}) \cdot B$, with a payoff from being honest which is $J(i)$ for the politician i.

Equilibrium I will focus on stationary Markov equilibria. An equilibrium is defined as follows.

Definition C.1. An equilibrium consists of (i) HH's initial belief ρ_0, (ii) value functions V and W, (iii) policy functions $c(s), k'(s)$ and (iv) politician's i strategy p_i^* such that (i) ρ_0 is the fraction of politicians that choose to be corrupt, (ii) V and W solve (C.1)-(C.2), (iii) policy functions attain maximum in (C.1)-(C.2) and (iv) $p_i^* \leq 0 \iff E(\tau | a(i) = \texttt{c}) \cdot B \leq J(i)$.

Characterization - preview Note that now HH doesn't pay a cost of overthrowing, but the chance of remove the government arrives stochastically. Clearly, the HH will now choose to change the government if and only if $\rho > \rho_0$. Determination of the equilibrium value of ρ_0 is very straightforward. A politician i will be indifferent between being corrupt and honest iff $E(\tau | a(i) = \texttt{c}) \cdot B = J(i)$. Note that LHS of that equation is constant while the RHS is strictly increasing in i, so there will be a threshold value i^* such that $E(\tau | a(i^*) = \texttt{c}) \cdot B = J(i^*)$, i.e. such that politician i^* is indifferent between being corrupt and honest. Then $\rho_0 = i^*$. Note that the equilibrium is now unique.

[8]Introducing a one time payoff from being honest does not change the main results (comparing to the benchmark specification) but makes the analysis much simpler.

D Figures

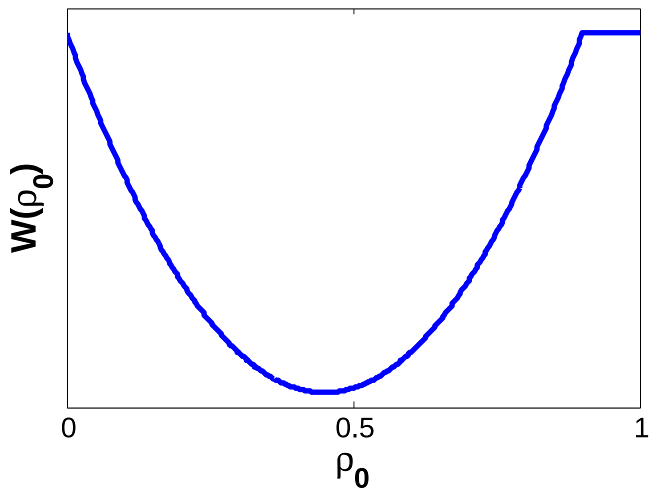

Figure 1: Net payoff from choosing low regime

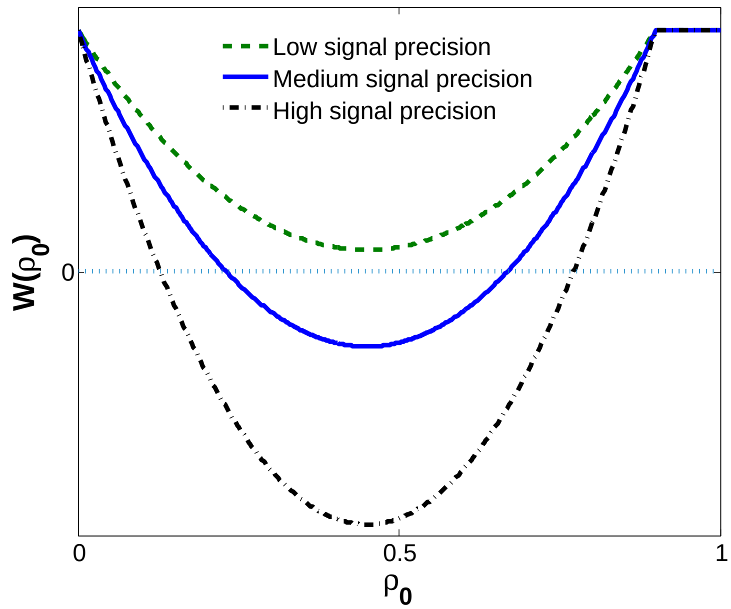

Figure 2: Monitoring and payoff from choosing low regime

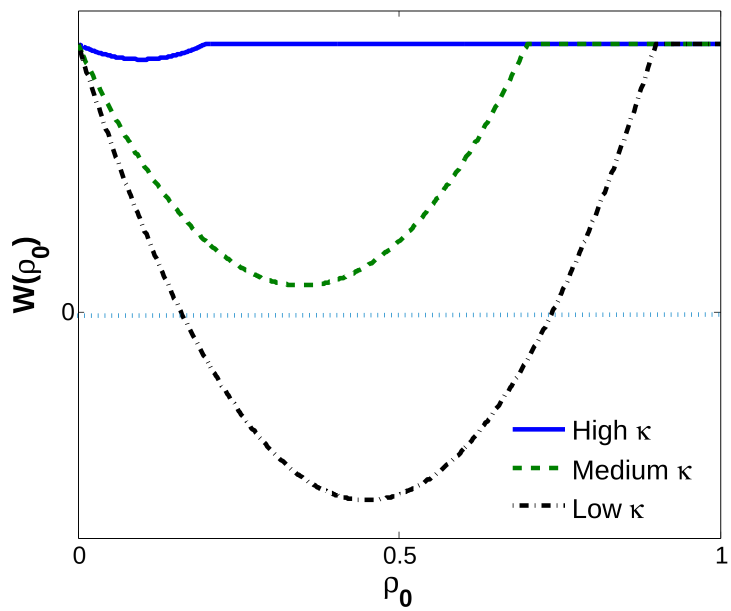

Figure 3: Switching cost and payoff from choosing low regime

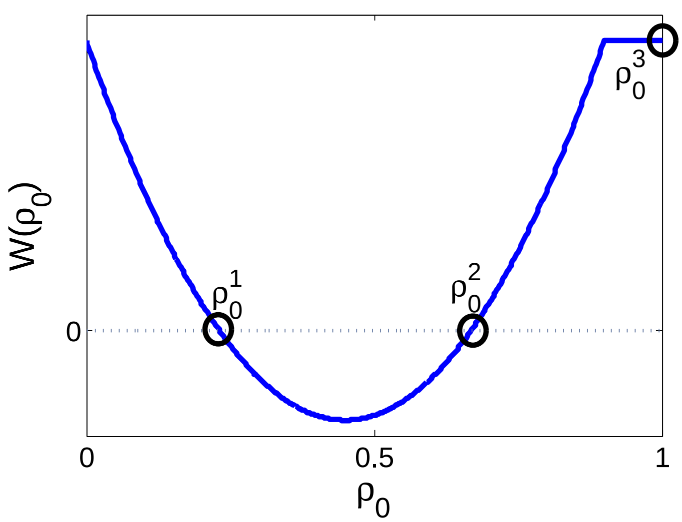

Figure 4: Stationary Markov Equilibria

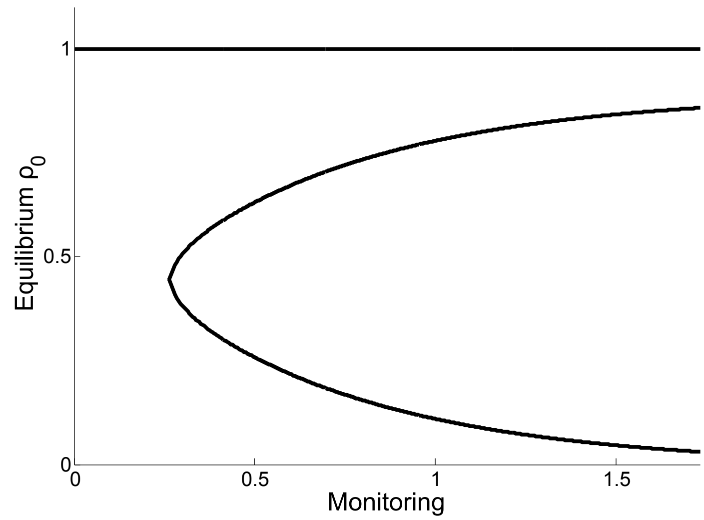

Figure 5: Initial belief in a stationary equilibrium

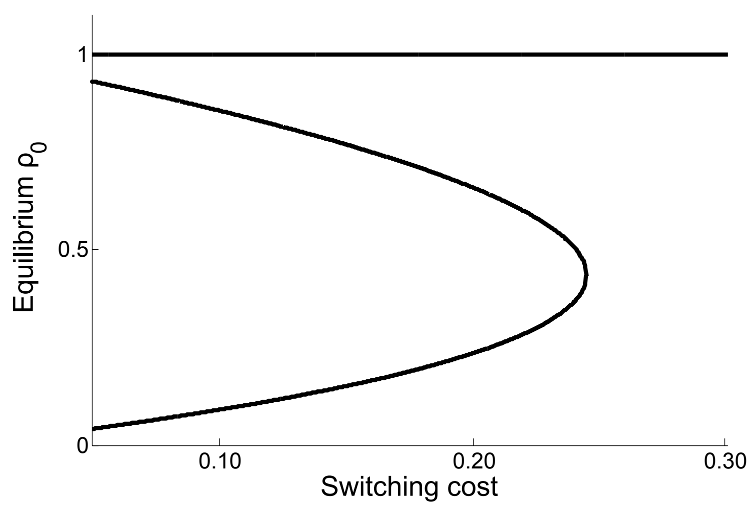

Figure 6: Initial belief in a stationary equilibrium

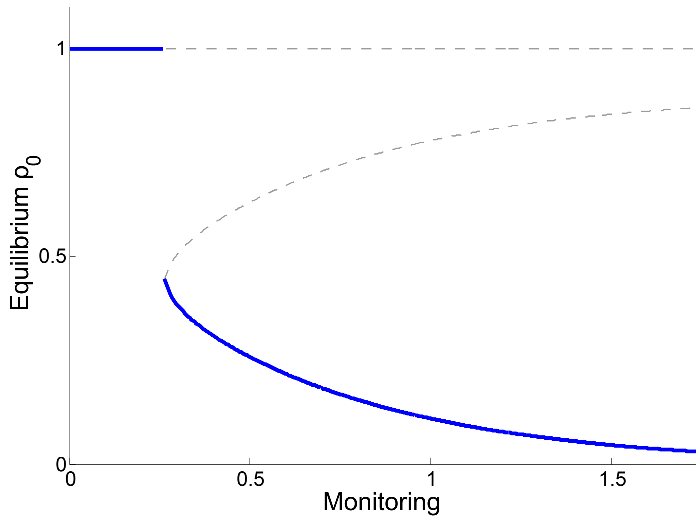

Figure 7: Equilibrium selection - monitoring

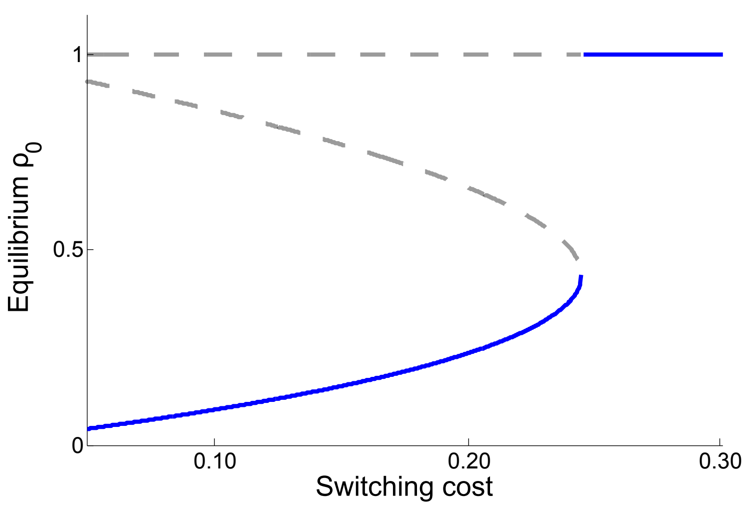

Figure 8: Equilibrium selection - switching cost

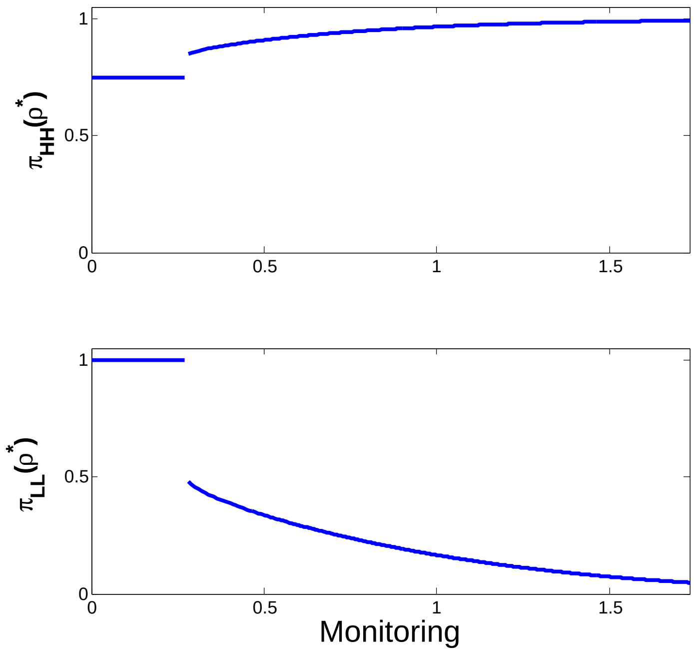

Figure 9: Persistence of regimes - effect of monitoring

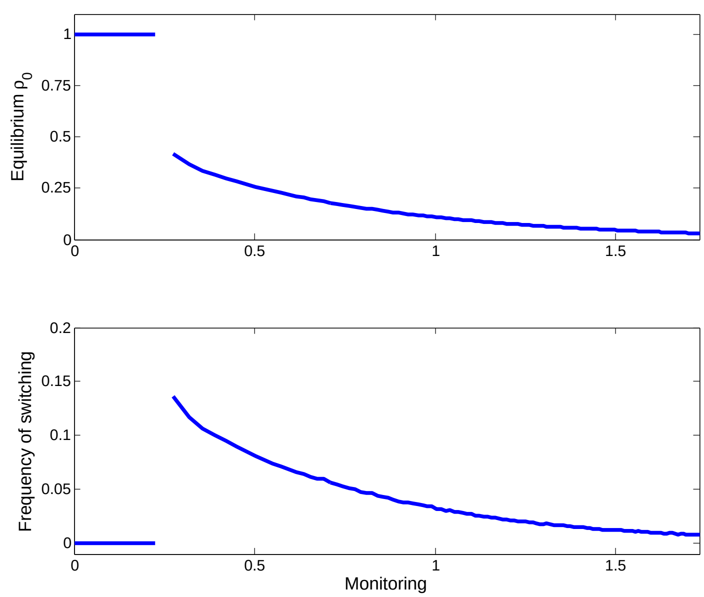

Figure 10: Frequency of regime switching in a stationary equilibrium

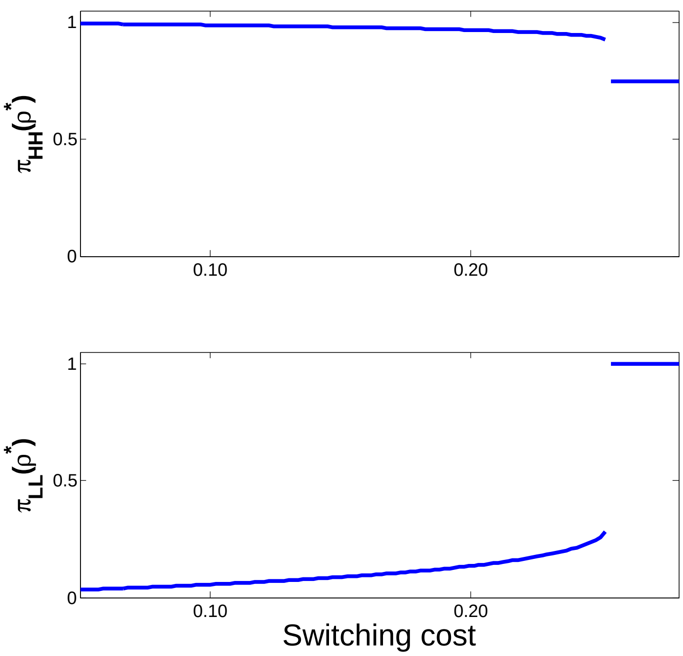

Figure 11: Persistence of regimes - effect of switching cost

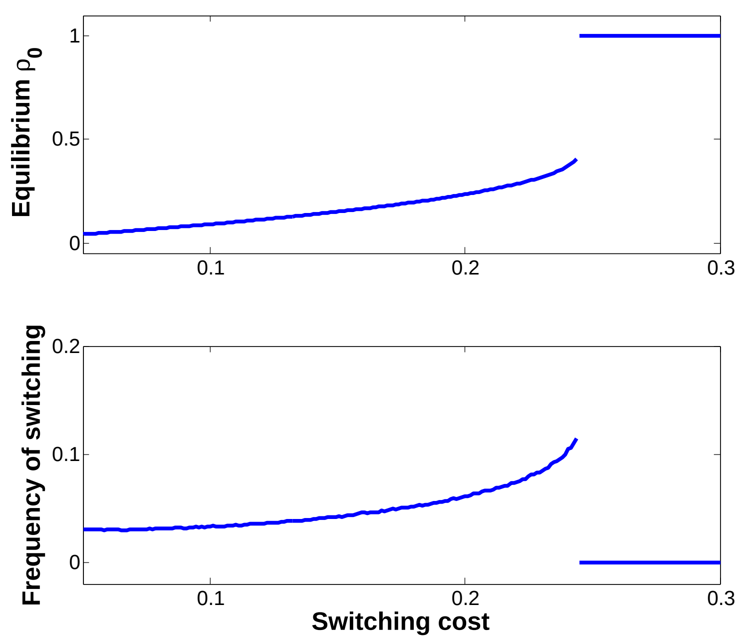

Figure 12: Switching frequency - switching cost

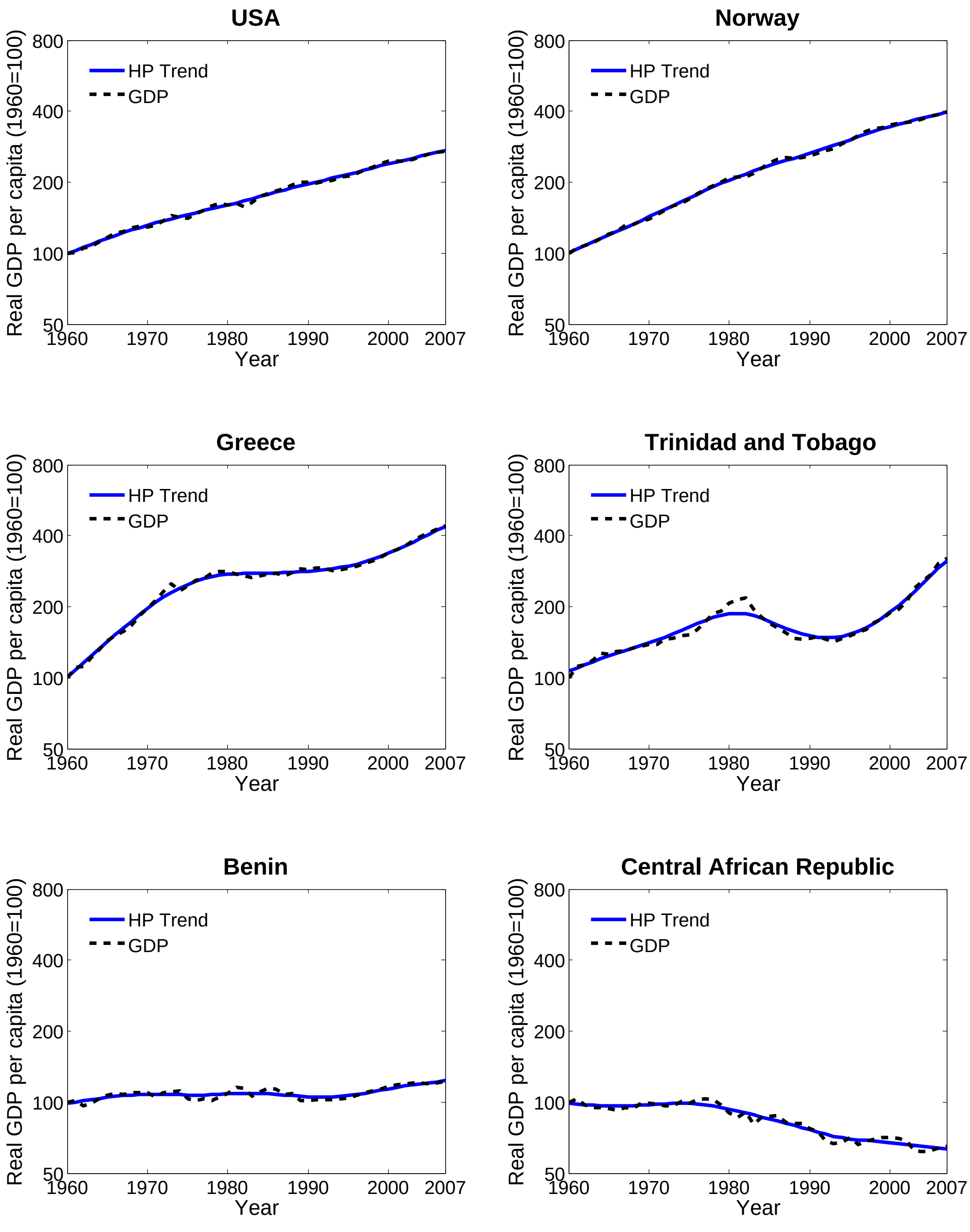

Figure 13: Volatility in developed, developing and undeveloped countries (Source: WDI)

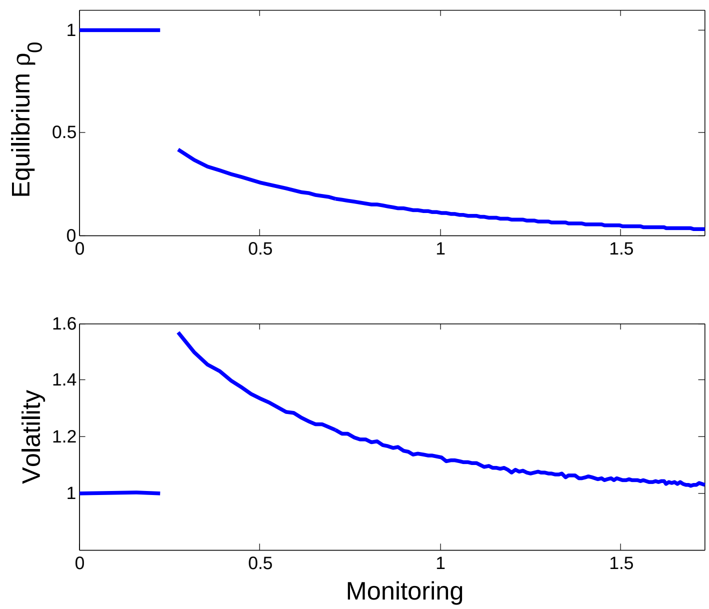

Figure 14: Volatility in a stationary equilibrium

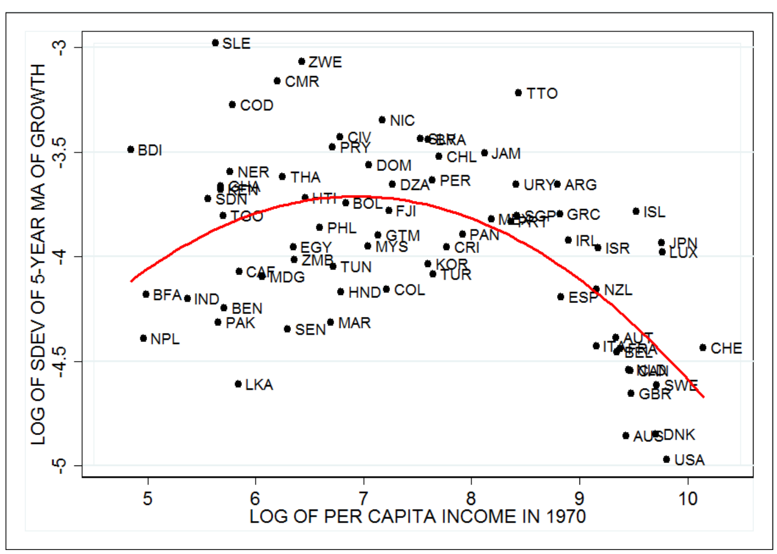

Figure 15: Income and low-frequency volatility of growth rates

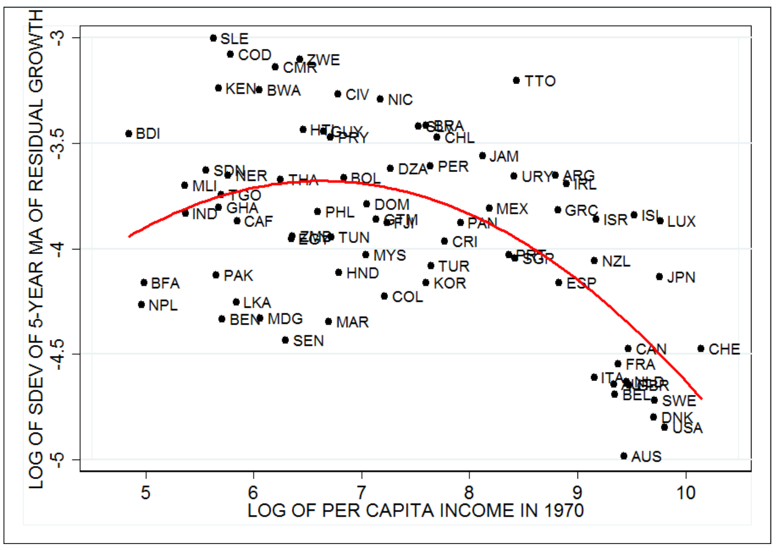

Figure 16: Income and low-frequency volatility of residuals from regression (6.3)