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Dedication

This thesis is dedicated to the three most important people in my life. They will know...

Abstract

In the first chapter of the thesis 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.

The second chapter of the thesis is co-authored with Jacob Short. We address the puzzle that the developing countries experiencing rapid TFP growth tend to run current account surpluses. This finding is puzzling in the context of the neoclassical growth model, which predicts that these countries should be net borrowers (Gourinchas and Jeanne, 2009). We account for this puzzle by introducing a non-tradable sector to an otherwise standard growth model. We propose that complementarity between tradable and non-tradable goods is key. With an initially underdeveloped non-tradable sector, a representative household is willing to trade a portion of current tradable output in exchange for tradable goods in the future when its production of non-tradable goods increases. A drawback of the simplest version of the model is that faster growing countries experience a reduction in the relative price of non-tradable goods.

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Chapter 1

Introduction

This thesis consists of two essays. In the first essay I study the role of political institutions in influencing output volatility in less developed economies. Motivated by the existing growth and development literature that stresses the importance of government policies for medium- and long-run economic performance (e.g. [1] or [2]), I develop a model of switching between “good” and “bad” policy regimes. The model addresses 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 to overthrow the politician in power. A politician chooses a policy regime that affects both its own and the households’ payoff. The two regimes I consider are a high-growth and a low-growth regime. Households observe the regime type with noise and pay a cost if they decide to change the government. The strategies of the households and the 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.

In the model, there is a positive (negative) relationship between the persistence of a high-growth (low-growth) regime and HH’s ability to monitor the government. An implication of the above is a hump-shaped relationship between monitoring and output volatility. The least volatile countries are those with 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 good and bad regimes, e.g. emerging economies. While my framework is very stylized, it can be used to enrich other standard models by introducing micro-founded regime changes. One extension is discussed in my paper. My job market paper also contributes to the literature on business cycles in emerging economies ([3]), the empirical studies of relationship between quality of institutions and volatility ([4]), theories of political turnover ([5]) and studies of cross-country income dynamics ([6]).

The second essay - "Saving for Sunny Days" - attempts to account for the "Allocation Puzzle" of [7]: the fact that developing countries experiencing rapid TFP growth tend to run current account surpluses. This finding is puzzling in the context of the neoclassical growth model, which predicts that these countries should be net borrowers.

We account for this puzzle by introducing a non-tradable sector to a standard growth model. Our intuition rests on the complementarity between tradable and non-tradable goods: e.g. household appliances (tradable) tend to work best when consumed with houses (non-tradable). Then, if rapidly growing countries initially have a relatively underdeveloped non-tradable sector, they may be willing to forgo a portion of their current tradable output in exchange for tradable goods in the future, when they are able to combine them with output from a more productive non-tradable sector.

The paper joins a large literature studying the increase in Chinese net foreign asset position. Most papers focus on financial market imperfections ([**?**]) or build an endogenous growth model where higher savings lead to higher growth ([**?**]). We ask a different question: how much does the complementarity between tradable and non-tradable goods matter in accounting for the observed positive correlation between growth rate of TFP and change in net foreign asset position.

Our hypothesis relies on the observation that as countries develop the share of services produced in the economy tends to increase relative to the manufacturing sector. Such a change has a clear implication for the productivity of capital in the two sectors. A decrease in employment in manufacturing sector - ceteris paribus - decreases the marginal product of capital in that sector. Similarly, an increase in the employment in the service sector increases the marginal product of capital in the service sector. If a large portion of investment in the non-tradable sector has to be financed domestically, this would induce a higher saving rate in the non-tradable sector. Furthermore, if tradable and non-tradable goods are complements in consumption, it may also increase the savings rate in the tradable sector, leading to a current account surplus. This is the driving mechanism of our model.

Chapter 2

Monitoring the Government and Output Volatility: Theory and Evidence

2.1 Introduction

There is a consensus in the growth and development literature that government policy matters for economic performance (see e.g. [1], [8], [9] and [2]). "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 ([10], [11], [12], [4]). 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 A.13). This result is consistent with empirical evidence favoring a hump-shaped relationship between income and volatility ([13]). 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. [14], [15]).

This paper also contributes to the understanding of possible sources of large swings in the trend component of GDP. [3] 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.

My model is a micro-foundation for regime switching models used to study income dynamics across nations e.g. in [18] or [6]. [18] constructs a growth model where firms face barriers to adopting more advanced technology (as in [19]). 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. [6] 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 Chapter is structured as follows. In Sections 2.2 through 2.5 I develop and characterize a model of switching between a good and a bad regime. In Section 2.6 I discuss the application of the model to study poverty traps and growth reversals in less developed countries.

2.2 Model

2.2.1 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

[1] [16] discuss the major characteristics of populist policies in Latin American countries. [17] develop a formal model of emergence of such policies.

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[2] . 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[3] :

$$\log(q) \sim \begin{cases} N(\mu_H, 1), & \text{if government is good;} \\ N(\mu_L, 1), & \text{if government is bad.} \end{cases} \tag{2.2.1}$$

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

$$\begin{aligned} U_H = & \quad E[u(q)| \text{ government is good}] \\ U_L = & \quad E[u(q)| \text{ government is bad}] \end{aligned} \tag{2.2.2}$$

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 $B > 0$[4] . 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).

2.2.2 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

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

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

[4] [20] 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.

about the government. The signal is normally distributed:

$$\theta \sim \begin{cases} N(\bar{\theta}, 1), & \text{if government is good;} \\ N(-\bar{\theta}, 1), & \text{if government is bad.} \end{cases} \tag{2.2.3}$$

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).

2.2.3 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:

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

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

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

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 $t = 0$).

2.2.4 Equilibrium

An equilibrium is defined in a usual way.

Definition 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.*

2.3 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:

$$V^k(\rho) = \rho U_L + (1-\rho)U_H \tag{2.3.1}$$

while the value of changing is:

$$V^c = \rho_0 U_L + (1-\rho_0)U_H - \kappa \tag{2.3.2}$$

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

$$\rho^*(\rho_0) = \rho_0 + \frac{\kappa}{U_H - U_L} \tag{2.3.3}$$

Proof. Comparing (2.3.1) with (2.3.2) 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:

$$W(\rho_0) = E\left(\tau \middle| a^P = \mathtt{L}; \rho_0\right) \cdot B - \Pr\left\{\tau^1 \leq \tau^0 \middle| a^P = \mathtt{L}; \rho_0\right\} \cdot J \tag{2.3.4}$$

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 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.

2.4 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.

2.4.1 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 2.4.1. *$W(\rho_0)$ 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.1.2 in the Appendix. □

Lemma 2.4.2. *$W(\rho_0)$ is continuous.*

Proof. See Section A.1.2 in the Appendix. □

A typical graph of $W(\rho_0)$ is presented in Figure A.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 A.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.

2.4.2 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 A.2.

Lemma 2.4.3. *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.1.2 in the Appendix. □

Figure A.2 here.

2.4.3 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 A.3.

Lemma 2.4.4. *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.1.2 in the Appendix. □

Figure A.3 here.

2.4.4 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 A.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 A.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 A.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 A.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 2.4.5. *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 2.4.1 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 2.4.3 it follows that $h(\bar{\theta}_1) \leq h(\bar{\theta}_2) \iff \bar{\theta}_1 \leq \bar{\theta}_2$ and from Lemmas 2.4.2 and 2.4.1 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. □

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 A.3. A result similar to the one in Theorem 2.4.5 can be stated, stressing the effect of the switching cost κ on existing equilibria.

Theorem 2.4.6. *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 2.4.4 it follows that $h(\kappa_1) \leq h(\kappa_2) \iff \kappa_1 \leq \bar{\kappa}_2$ and from Lemmas 2.4.2 and 2.4.1 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 A.5 and A.6. Figure A.5 plots the set of equilibrium initial beliefs against the precision of the signal $\bar{\theta}$ and Figure

A.6 does the same against the switching cost κ. Equilibrium selection will be discussed in the next section.

FIGURE A.5 here

FIGURE A.6 here

2.4.5 Equilibrium selection

Section A.2 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 ([21], [22]). 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 A.2 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

$$\rho_0(\bar{\theta}, \kappa) = \begin{cases} \rho_0^1(\bar{\theta}, \kappa), & \text{if } \min_{\rho_0} W(\rho_0) < 0; \\ 1, & \text{otherwise.} \end{cases} \tag{2.4.1}$$

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 A.7 and A.8.

FIGURE A.7 here

FIGURE A.8 here

2.5 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.

2.5.1 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:

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

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 (2.4.1)) and $\Pr\{\rho' \le \rho^*|\rho; s\}$ 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 A.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 2.4.5 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 A.10 graphs equilibrium initial belief and frequency of regime switching as functions of HH's ability to monitor the government.

FIGURE A.9 here.

FIGURE A.10 here.

2.5.2 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:

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

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 A.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 A.11 here.

FIGURE A.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 A.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 2.4.6, 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 - $\Pr\{\rho' > \rho^*|\rho; s\}$.

2.6 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 A.13.

FIGURE A.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.

2.6.1 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:

$$g \sim \begin{cases} N(\mu_H, 1), & \text{if govt honest (high regime);} \\ N(\mu_L, 1), & \text{if govt corrupt (low regime).} \end{cases} \tag{2.6.1}$$

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 (2.2.2) become:

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

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 2.3 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 2.4 remain unaltered.

2.6.2 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:

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

where $\Pr\{a^P = \texttt{H}\}$ is the unconditional probability that the country is in a high-growth regime. Given our assumptions about the process governing the growth rate in (2.6.1) 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:

$$var(g) = 1 + \Pr\{a^P = \mathtt{L}\} \cdot (1 - \Pr\{a^P = \mathtt{L}\}) \cdot [\mu_H - \mu_L]^2 \tag{2.6.2}$$

It follows from (2.6.2) 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 2.4.5 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 (2.6.2) 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 2.4.5 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 2.6.1. *Let $var(g)$ denote the unconditional variance of the growth rate in a stationary Markov equilibrium with $\rho_0(\bar{\theta})$ given by (2.4.1). 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 2.4.5.

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 (2.6.2) 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 $\Pr\{a^P = \mathtt{L}\} \in (0, 1)$, (2.6.2) implies that $var(g) > 1$ and is decreasing in $\bar{\theta}$.

□

Figure A.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 (2.4.1). 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 2.4.5 and Proposition 2.6.1 this means that $\hat{\theta} > 0$).

FIGURE A.14 here.

2.6.3 Evidence

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 A.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 A.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[5] over the period 1970-2005:

$$\Delta y_{i,t} = \beta_1 \Delta y_{i,t-1} + \beta_3 y_{i,t-1} + \mu_i + \eta_t + \epsilon_{i,t} \tag{2.6.3}$$

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[6] .

[5] 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%.

[6] This specification is similar to [?].

Next, for each country, I calculate the standard deviation of the 5-year moving average of residuals from (2.6.3). The scatter plot of that residual volatility against income in 1970 is presented in Figure A.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 A.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.

2.6.4 Discussion

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. [2] compare the experience of Chile and Mexico in the 1980's and 1990's. They argue that reforms in banking and bankruptcy 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.

[23] 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.

[24] 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.

2.7 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 A.3 in the Appendix discusses how my framework can be merged with the model of [3] 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. [16]). This is a promising and exciting path for further research.

Chapter 3

Saving for Sunny Days

3.1 Introduction

Developing countries experiencing rapid growth tend to run current account surpluses ([7]). This finding is inconsistent with the predictions of the standard deterministic neoclassical growth model, where countries whose Total Factor Productivity (TFP) grows relatively faster than that of the world, imports capital from abroad to (i) finance higher investment and (ii) smooth consumption over time. Gourinchas and Jeanne (henceforth GJ) study a sample of 69 developing countries and find that the allocation of capital flows among these countries suggests positive correlation between capital outflows and the growth rate of the TFP. They refer to their finding as "the allocation puzzle" - the allocation of capital flows among the developing countries is at odds with the predictions of the standard growth model.

Our goal in this paper is to suggest a possible explanation for this puzzle. We use a two sector growth model with a tradable and a non-tradable good, along with frictions restricting the mobility of factors of production between the two sectors. The basis for our intuition is the complementarity between tradable and non-tradable goods (which we will assume in the model), e.g. household appliances tend to work best when consumed with houses. Therefore, if rapidly growing countries initially have a relatively underdeveloped non-tradable sector, then they may be willing to trade a portion of their current tradable output in exchange for tradable goods in the future when they are able to combine them with the higher output from the non-tradable sector.

Our hypothesis relies on the observation that as countries develop the share of services produced in the economy tends to increase relative to the manufacturing sector. This relates our paper to the literature on structural change which has documented a substantial rise in the percentage of US labor force employed in the service sector (e.g. [25], [26], [27] or [28]). Such a change has a clear implication for the productivity of capital in the two sectors. A decrease in employment in manufacturing sector – ceteris paribus – decreases marginal product of capital in that sector. Similarly, an increase in the employment in the service sector increases marginal product of capital in the service sector. If a large portion of the investment in the non-tradable sector has to be financed domestically this would induce higher saving rate in the non-tradable sector. Furthermore, if tradable and non-tradable goods are complements in consumption, it may also increase the savings rate in the tradable sector, leading to current account surplus. This mechanism will be the driving force in our model.

We are not the first that try to explain positive correlation between savings and growth in the developing countries. [29] build an endogenous growth model in which a less developed country needs to attract foreign investors in order to catch up with the world frontier. In order to attract foreign investors the country must accumulate its own assets to co-finance investment projects. Thus, higher savings rate is essential for a country to catch-up with the rest of the world. In that sense, [29] reverse the causality - countries need to save in order to increase their TFP growth.

In contrast, we treat the path of TFP as exogenous and ask whether we can rationalize positive cross-country correlation between productivity growth and national savings. In addition, we do not introduce any uncertainty or incomplete markets, which may add additional motives for savings. For example, one could set up a model with uncertainty about the persistence of the observed productivity changes. If increases in productivity are temporary, then the individuals may save today in order to consume more in the future when productivity falls. Uncertainty about the persistence of shocks could exploit this motive. We abstract from these possible motives and ask whether the complementarity between tradable and non-tradable goods can account for positive correlation between savings and growth.

Since we model a two-good open economy, our paper is also related to the literature on the evolution of real exchange rates. The general finding within this literature is that most of the growth takes place in the manufacturing sector and as countries grow relative to the world's frontier their real exchange rate appreciates (precisely because it is the tradable sector that grows fast). Some studies argue that the size of the Balassa-Samuelson effect is low among the fast growing Asian countries. For example, [30] argues that in some of the ASEAN countries (Hong-Kong and Singapore) productivity in the non-tradable sector was growing fast along with the productivity in the tradable sector. He uses this finding as an explanation for the lower then expected appreciation of the real exchange rate in Hong-Kong and Singapore. While the behavior of the real exchange rate is not at the center of our interest, our model does have implications for it. Unfortunately, the model implies that faster growing countries experience depreciation of the real exchange rate, which is counterfactual; this is driven by the structural change imposed in our model.

The rest of the paper is structured as follows: Section 3.2 explains the allocation puzzle of GJ, and presents evidence on the structural change that rapidly growing countries undergo. In Section 3.3 we will illustrate our basic intuition with a simple 2-period 2-good economy. Section 3.4 describes the model that we use for our quantitative analysis. In Section 3.5 we will present numerical results from our model. In Section 3.6 we summarize our main findings and suggest paths for further research.

3.2 Data

In this section we will describe the allocation puzzle of GJ. We will also provide the motivation for the approach that we take in explaining the puzzle.

3.2.1 The Allocation Puzzle

Differences in productivity levels is a widely accepted explanation for differences in real incomes per capita across countries (see [31] and [32]). GJ point out that this view has an implication for the direction of international capital flows; countries with high (relative to the world) productivity growth should experience inflows of capital from abroad, while countries with slow productivity growth (relative to the world) should experience capital outflows. In contrast, the data suggests the opposite relationship between growth and capital flows. Figure B.1 presents the essence of the GJ allocation puzzle: a positive cross-country correlation between average TFP growth and capital outflows among the developing countries (all figures are presented in Appendix A). GJ calibrate a one good model and compute the implied cumulated capital outflows and compare the model predictions against the data. Figure B.2 displays the results of this comparison for the countries within our reduced sample[1] .

It is important to note that the allocation puzzle, as presented by GJ, differs from other puzzles in international economics such as the "Lucas puzzle" ([33]) or the "Feldstein-Horioka puzzle" ([34])

The "Lucas puzzle" is about the size of capital flows to developing countries. Gourinchas and Jeanne argue that given the size of capital flows between developed and developing countries, their allocation among the developing countries is contrary to the predictions of the standard growth model. The "Feldstein-Horioka puzzle" states that among the developed economies there is a positive correlation between country's savings and investment: $corr(s, i) > 0$. If capital was mobile between countries, this correlation should be zero. By contrast the allocation puzzle is about the positive correlation between the difference in national savings and investment, and the productivity growth, i.e. $corr(s - i, g) > 0$.

[1] GJ use a sample of 69 developing countries. Our sample is reduced to 38 due to the availability of data on the shares of labor across sectors. For a list of the countries in our sample, see the table in appendix C

3.2.2 The Rise of the Service Sector

The literature on structural change has documented and attempted to explain the large increase in the fraction of labor force employed in the service sector in developed economies. Between 1950 and 2000 this fraction has increased from 57 to 75 percent in the United States ([27]). Comparing the level of GDP per capita to the fraction of labor employed in the non-tradable[2] sector for a sample of OECD countries, we find a positive relationship between the two variables (figure B.3).

Data from our sample of developing countries suggests that these patterns hold among developing economies as well. Figure B.4 presents the same comparison as figure B.3 for our sample in 2000. We also find a positive correlation between the level of GDP per capita and the output of services as a share of GDP in 2000 (figure B.5). This evidence suggest that as countries develop, the relative size of their service sector increases. If we examine the correlation between the change in the fraction of labor employed in the tradable sector and average productivity growth between 1980 and 2000, we find a correlation of -0.11 (see table 3.1). Furthermore, comparing the 10 fastest growing countries in our sample to the 10 slowest, we see that the fraction of labor in the trade-able sector fell nearly twice as much over the period 1980 to 2000 in the fastest growing countries. The top 10 countries grew at an average rate of 3.70 percent and the fraction of labor in the tradable sector over that time dropped by 20 percent. The 10 slowest growing countries experienced the reduction in the fraction of labor employed in the tradable sector of only 11 percent (table 3.1). Table 3.1 indicates that countries with faster growth experienced a larger increase in the fraction of labor employed in the non-tradable sector.

Table 3.1: TFP growth and labor reallocation in developing countries

	$g-1$	$\ell^T_{2000}/\ell^T_{1980}-1$
Bottom 10	-0.017	-0.11
Top 10	0.037	-0.20
$\rho(\Delta\ell^T, g)$	-0.11	

[2] We use output of services as our measure of the non-tradable sector, and assume all other sectors to be tradable.

What implication can these findings have for international capital flows to countries experiencing rapid growth? Suppose that agents in a fast growing country expect that the fraction of labor in the tradable sector will fall and will rise in the non-tradable sector. A shift of labor towards the non-tradable sector increases the marginal product of capital in the non-tradable sector relative to its marginal product in the tradable sector. Suppose that capital in the non-tradable sector needs to be domestically financed[3] (while there is international mobility of capital in the tradable sector). If faster growth implies a larger shift of labor towards the non-tradable sector, then a larger portion of investment must be financed domestically. This increases savings in the non-tradable sector, and if tradable and non-tradable good are complements then it may imply an increase in the savings within the tradable sector.

In the next section we will illustrate our basic idea using a simple 2-period 2-good economy. We will show that an increase in the future output of the non-tradable good may induce a country to increase its exports today. Since the results differ in the two environments, we will present separate analysis for the exchange and production economies.

3.3 Simple 2 Period Model

In this section we will try to explain the basic intuition behind our idea using a simple 2-period model. We will first present the result for the exchange economy, then discuss possible problems that may arise in the production economy.

3.3.1 Exchange Economy

Consider a 2-period, small, open exchange economy. There are two goods: one tradable (T) and one non-tradable (N). Period $t = 1, 2$ consumption is a CES composite of both

[3] [35] argue that among the OECD countries about 51% of aggregate investment comes from the construction sector. They also estimate that at most 32% of intermediate goods that the construction sector uses are tradable goods.

goods:

$$c_t = [a{c_t^N}^b + (1-a){c_t^T}^b]^{1/b} \tag{3.3.1}$$

where c^T is the consumption of the tradable good and c^N is the consumption of the non-tradable good, $a \in (0,1)$ and $\theta := \frac{1}{1-b}$ is the intra-temporal elasticity of substitution between the two goods. A representative household has the following utility over consumption of the aggregate good in the two periods:

$$U(c_1, c_2) = \frac{c_1^{1-\sigma}}{1-\sigma} + \frac{c_2^{1-\sigma}}{1-\sigma} \tag{3.3.2}$$

where $\frac{1}{\sigma} > 0$ is the inter-temporal elasticity of substitution between consumption of the aggregate good in periods 1 and 2. In each period, the household receives endowments ω_t^T and ω_t^N of the tradable good and non-tradable good, respectively. The Arrow-Debreu budget constraint for the household is:

$$\sum_{t=1}^{2}(p_t^N c_t^N + p_t^T c_t^T) = \sum_{t=1}^{2}(p_t^N \omega_t^N + p_t^T \omega_t^T) \tag{3.3.3}$$

The household can trade the tradable good with the rest of the world at the fixed world prices p_t^T, where we assume $p_1^T = p_2^T = 1$. We assume balanced trade, therefore, the net exports in both periods must add up to zero:

$$\sum_{t=1}^{2}(\omega_t^T - c_t^T)p_t^T = 0 \tag{3.3.4}$$

Lastly, the market clearing conditions for the non-tradable goods are:

$$c_t^N = \omega_t^N, \quad t = 1, 2 \tag{3.3.5}$$

Definition 3. *An equilibrium is defined as* $\{c_t^T, c_t^N, c_t, p_t^N\}_{t=1,2}$ *such that (i) given* $\{p_t^N\}_{t=1,2}$ *HH maximizes (3.3.2) subject to (3.3.1), (3.3.3), and (ii) (3.3.4) and (3.3.5) hold.*

We are interested in how the net exports in period 1, $nx_1 := \omega_1^T - c_1^T$ behaves in response to an increase in the endowment of the non-tradable good in period 2 (i.e. an increase in ω_2^N). A standard result in one-good inter-temporal models is that a country will run a current account deficit when it expects its future output to be higher. This result is driven by the strict concavity of the households utility function, which induces the household to smooth consumption over time.

In a two-good world, the desire to smooth consumption can be diminished by the complementarity between tradable and non-tradable goods. If tradable and non-tradable goods are complements and an increase in future output is due to higher output of the non-tradable good, then the household may be willing to export the tradable good today so that it may import it tomorrow and combine it with larger amount of the non-tradable good. Proposition 3.3.1 captures the above intuition more precisely:

Proposition 3.3.1. *In a two good exchange economy* $nx_1 := \omega_1^T - c_1^T$ *is increasing in* ω_2^N *if and only if* $\theta < \frac{1}{\sigma}$*.*
Proof: See Appendix B.

If $\theta < \frac{1}{\sigma}$, then there is greater complementarity within a period than between periods - keeping the ratio of consumption of the tradable and non-tradable good fixed is more important than smoothing aggregate consumption over time. Therefore, an increase in the endowment of the non-tradable good in the second period makes the consumer want to reduce consumption of the tradable good today so that she will have more units of the tradable good available for tomorrow.

Proposition 3.3.1 explains the basic intuition for our paper. Developing countries with high growth and an underdeveloped non-tradable sector are countries which expect the size of the non-tradable sector to increase in the future. Therefore, they want to export the tradable goods they produce today in exchange for future tradable goods, when they will have a more abundant supply of non-tradable goods.

In contrast, within a production economy there is more flexibility in adjusting output in the first period in response to increase in productivity in the second period. Thus, the result that we have just obtained in the exchange economy may not hold in the production economy. We discuss this in the next section.

3.3.2 Production Economy

Consider a 2-period production economy with 2 sectors: tradable (T) and non-tradable (N). Preferences are as before, and outputs of both goods are produced using a Cobb-Douglas production function:

$$y^i = A^i {k^i}^\alpha {\ell^i}^{1-\alpha}, \quad i \in \{T, N\} \tag{3.3.6}$$

Total labor is normalized to 1 in both periods, and the initial capital in period 1 is given by k_1. Market clearing conditions for the factor markets are:

$$k_t^T + k_t^N = k_t, \quad \ell_t^T + \ell_t^N = 1 \tag{3.3.7}$$

For simplicity, assume capital fully depreciates. The output of the tradable good in the first period, y_1^T, is divided between consumption of the tradable good c_1^T, capital stock for the next period k_2 and net export of that good nx_1; thus, the resource constraint in the tradable sector is:

$$c_1^T + k_2 + nx_1 = y_1^T \tag{3.3.8}$$

In the second period, no investment is made:

$$c_2^T + nx_2 = y_2^T \tag{3.3.9}$$

Output in the non-tradable sector is used for consumption only:

$$c_t^N = y_t^N, \quad t = 1, 2 \tag{3.3.10}$$

The capital in the economy is held by the household who rent it to perfectly competitive firms. The Arrow-Debreu budget constraint of the household is:

$$\sum_{t=1}^{2} \left[p_t^N c_t^N + (c_t^T + k_{t+1})\right] = \sum_{t=1}^{2} (r_t k_t + w_t). \tag{3.3.11}$$

Again, we set $p_t^T = 1$ in both periods. The utility maximization problem for the household is now:

$$\max \frac{c_1^{1-\sigma}}{1-\sigma} + \frac{c_2^{1-\sigma}}{1-\sigma} \tag{HH}$$

subject to (3.3.1) and (3.3.11).

Rental rates and wages are determined from the profit maximization of firms in the two sectors. The problem of a firm in sector $i = T, N$ is:

$$\max p_t^i A_t^i {k_t^i}^{\alpha} {\ell_t^i}^{1-\alpha} - r_t k_t^i - w_t \ell_t^i \tag{FF}$$

Lastly, the country cannot "die" with debt, i.e.:

$$nx_1 + nx_2 = 0 \tag{3.3.12}$$

Definition 4. *An equilibrium consists of allocations* $(c_t^T, c_t^N, c_t, \ell_t^T, \ell_t^N, k_t^T, k_t^N, nx_t)_{t=1,2}$ *and* k_2 *and prices* $(p_t^N, r_t, w_t)_{t=1,2}$ *such that given prices* $(p_t^N, r_t, w_t)_{t=1,2}$*,* $(c_t^T, c_t^N, c_t)_{t=1,2}$ *and* k_2 *solve the household utility maximization problem (HH),* $(\ell_t^T, \ell_t^N, k_t^T, k_t^N)_{t=1,2}$ *solve firms' profit maximization problem (FF), market clearing conditions (3.3.6)-(3.3.10) hold and the trade balance (3.3.12) is satisfied.*

Growth of the Non-tradable Sector

Our analysis of the production economy is similar to the exchange economy, except that now we study the effects of the growth in TFP in the non-tradable sector in period 2. We can prove the following proposition.

Proposition 3.3.2. *In the economy described in Section 3.3.2,* nx_1 *is increasing in* A_2^N *if and only if* $0 < \sigma < 1$*. Proof:* See Appendix B.

The intuition for the above proposition is straightforward. We can rewrite the budget constraint of the household as:

$$P_1 c_1 + P_2 c_2 \leq \text{Income} \tag{3.3.13}$$

where c_t is the consumption of aggregate good in period t and P_t is the price of the aggregate good in period t. The numeraire is $p_1^T = p_2^T = 1$. It can be shown that the RHS of (3.3.13) remains unchanged as a result of increase in A_2^N. The aggregate price P_1 remains unchanged as well; however, the aggregate price P_2 falls, because p_2^N decreases. The intuition follows from the relative size of income and substitution effects. A drop in P_2 increases the real income, which induces the household to consume more of both c_1 and c_2. However, a substitution effect occurs as a result of the decrease in P_2 makes consumption tomorrow cheaper relative to today. If the substitution effect is greater than the income effect, we will observe a decrease in c_1 and hence an increase in net exports in period 1. For the CRRA utility function, the substitution effect will outweigh the income effect if $\sigma < 1$.

The main message from Proposition 3.3.2 is that the behavior of net exports in the production economy is independent of the value of θ - the intra-temporal elasticity of substitution between tradable and non-tradable goods. This result is substantially different from the one in exchange economy. In the exchange economy it was the relative magnitude of intra- and inter-temporal elasticity of substitution which mattered.

3.4 The Model

In the frictionless production economy there is a large flexibility in adjusting the output of both goods in the first period by shifting capital and/or labor between the two sectors. Thus, the analogue of Proposition 3.3.1 for the frictionless production economy does not hold. For the quantitative analysis we will consider an infinite horizon version of the production economy but we will introduce frictions in the factor markets. We make the following (rather stark) assumptions:

- Capital is sector specific and must be financed within each sector.
- The share of labor in each sector is exogenous.

In other words we assume that factors of production cannot move between sectors. The literature seems to suggest that, in case of labor market, the costs of inter-sectoral reallocation may be quite large (see e.g. [36], [37] or [27]).

3.4.1 Model Description

We consider an infinitely lived small open economy. The representative household owns the capital in each sector, k_t^i and inelastically supplies sector specific labor endowments, $\bar{\ell}_t^i$ for $i \in \{T, N\}$, where $\bar{\ell}_t^T + \bar{\ell}_t^N = 1$. The household can borrow from and lend to the rest of the world at a fixed gross real (in units of the tradable good) interest rate R^*.

The household's sequential budget constraint is

$$\begin{aligned} p_t^N(c_t^N + k_{t+1}^N) + c_t^T + k_{t+1}^T + R^* d_t &\leq \\ w_t^T \bar{\ell}_t^T + w_t^N \bar{\ell}_t^N + d_{t+1} &+ (r_t^T + 1 - \delta)k_t^T + (r_t^N + p_t^N(1-\delta))k_t^N \end{aligned} \quad (3.4.1)$$

where all prices are in terms of the tradable good, and d_t is international debt in period t. Since factors of production are not mobile across sectors, factor prices may differ between sectors. Given prices and endowments for labor and capital, the household's problem is

$$\max_{\{c_t, c_t^T, c_t^N, k_{t+1}^T, k_{t+1}^N\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma}$$

subject to (3.3.1) and (3.4.1) and a no-Ponzi condition:

$$\lim_{t \to \infty} R^{*-t} d_t \leq 0. \quad (3.4.2)$$

Given current period TFP, A_t^i, the firm in sector $i \in \{T, N\}$ solves:

$$\max \ p_t^i A_t^i {k_t^i}^{\alpha} {\ell_t^i}^{1-\alpha} - r_t^i k_t^i - w_t^i \ell_t^i$$

The market clearing conditions are:

$$\begin{aligned} c_t^T + k_{t+1}^T + nx_t &= A_t^T {k_t^T}^{\alpha} {\ell_t^T}^{1-\alpha} + (1-\delta)k_t^T \\ c_t^N + k_{t+1}^N &= A_t^N {k_t^N}^{\alpha} {\ell_t^N}^{1-\alpha} + (1-\delta)k_t^N \\ \ell_t^i &= \bar{\ell}_t^i \text{ for } i \in \{T, N\} \end{aligned}$$

A country is characterized by its initial capital stock in each sector k_0^i for $i \in \{T, N\}$, initial debt d_0, a sequence of TFP for each sector $\{A_t^i\}_{t=0}^{\infty}$ for $i \in \{T, N\}$, and a sequence of labor endowments $\{\bar{\ell}_t^i\}_{t=0}^{\infty}$ for $i \in \{T, N\}$.

3.4.2 Empirical Analysis

We solve our model over a finite time horizon, $[0, T]$, with a sample of 38 developing economies for which we were able to collect consistent data on sectoral employment. Following Gourinchas and Jeanne (2008), we focus on the period 1980 to 2000. Unfortunately, the model parameters are not yet fully calibrated. We solve the model under a particular parametrization, and briefly discuss how the predictions change with the parameter values.

We define net exports for period t in the model as

$$nx_t = R^* d_t - d_{t+1}. \tag{3.4.3}$$

When computing the model we restrict the debt of a country by imposing balanced trade, i.e.

$$\sum_{t=0}^{T} p_t^T nx_t = 0 \tag{3.4.4}$$

We assume initial debt, d_0, is zero for all countries. In order to allow for positive/negative debt at the end of the period we are interested in (21 years), we solve the model for 31 periods. We only require that debt be 0 at the end of the last period.

We assume a period to be a year, and set the discount factor $\beta = 0.96$. We choose the depreciation rate, $\delta = 0.1$, the capital share of output in each sector, $\alpha = 0.33$, and the share of non-tradables in aggregate consumption, $a = 0.5$. The parameters that we want to focus on are σ and b. We choose $b = -5$ so that the tradable and non-tradable goods are complements (the implied intra-temporal elasticity of substitution is 0.18). Finally, we set $\sigma = 0.5$ which implies inter-temporal elasticity of substitution of 2.

We do not have disaggregate data on capital stocks in each sector, so we cannot measure the TFP in each sector. Therefore, we assume that TFP is the same across sectors: $A_t^T = A_t^N = A_t$. We obtain the productivity level for each year by computing the measured TFP from the data, that is

$$A_t = \left(\frac{\hat{y}_t}{\hat{k}_t}\right)^{1/(1-\alpha)} \tag{3.4.5}$$

where $\hat{y}$ and $\hat{k}$ are output per worker and capital per worker, respectively. An important caveat is that the sequence for productivity, $\{A_t\}$, that we obtain from (3.4.5) is a theoretical sequence of TFP pertaining to a one-sector model. Ideally, we would have a mapping between our model and a one-good model, in which we can infer the productivity for each sector, $\{A_t^N, A_t^T\}$, from the aggregate TFP, $\{A_t\}$, and labor shares; then, the implied TFP in each sector together with the allocations should produce an aggregate TFP $\{\tilde{A}_t\}$ that is consistent with the initial aggregate TFP series in (3.4.5). We have not derived this mapping yet, therefore, we will use the sequence of TFP from (3.4.5). Of course, if we obtain sectoral data on capital stocks, then this point is mute.

We set the initial level of TFP, A_0, to 1 for each country. The growth rate of TFP in each period for the first 21 periods is set equal to the growth rate of measured TFP in the data divided by the world growth rate of TFP g^*. Then, positive growth is interpreted as the country catching-up with the rest of the world, while negative growth is interpreted as the country falling behind. The world gross real interest rate is $R^* = 1/\beta$. Following GJ we assume that in the last 10 periods the economy grows at the same rate as does the world frontier. In our computation this implies constant TFP over that period.

Using data from the Penn World Table from 1960 to 2000 ([38]), we compute capital stock series for each country using the standard perpetual inventory method. Ideally we would like to compute the capital stock for each sector separately; however, we do not have investment data at the sectoral level, therefore, we compute the aggregate capital stock. The initial capital stock in each sector is then chosen such that the capital per worker is equal across sectors, that is

$$k_0^i = \tilde{k}_{1980} \cdot \bar{\ell}_{1980}^i \text{ for } i \in \{T, N\} \tag{3.4.6}$$

where $\tilde{k}_{1980} = \frac{\hat{k}_{1980}}{A_{1980}}$ is the effective capital per worker in 1980 and $\bar{\ell}_{1980}^i$ is the share of labor in the tradable sector in 1980.

Lastly, for the path of labor endowments we use data from the World Development Indicators on the share of labor in services, industry, and agriculture. We define the share of labor in non-tradables to be the share of labor in services, and the share of labor in tradables to be the share in agriculture and industry. Unfortunately, the share of labor in industry includes labor in the energy and construction sectors; however, we do not feel this is a considerable drawback. Examining OECD data on Korea, we find that over the period 1985 to 1998 the average growth of labor in energy and construction was

2.7%. In addition, it is plausible that as a country develops and expands production capacity, these sectors would necessarily become larger. Since the movement of labor into the service sector is an important mechanism driving the results of the model, removing the share of labor in these sectors from industry would only strengthen our results.

3.5 Results

In this section, we compare the predictions of our model with the data. We will look at the covariance of the cumulative net exports and average growth rate. We will also compare the predictions of our model for the cumulative net exports with those observed in the data. Table 3.2 summarizes the main result of our model. The current ad-hoc parametrization does not match the data, it does seem to be an improvement from the one-good model.

Table 3.2: Correlation between net exports and growth

Data	Standard model	Our model
0.30	-0.77	0.016

Figures B.6 and B.7 present preliminary results from our model. Figure B.6 plots the cumulated capital outflows predicted by the model and compares them with the actual capital outflows from the data. Figure B.7 plots cumulated net exports predicted by our model as a fraction of initial tradable output against the average TFP growth over the period 1980-2000. The correlation between these two variables is positive, albeit quite small.

3.5.1 Discussion

Two parameters are important for the correlation between net exports and growth: σ and b. The lower the value of b the lower the intra-temporal elasticity of substitution between tradable and non-tradable goods $\frac{1}{1-b}$. The lower the value of σ the higher the inter-temporal elasticity of substitution between aggregate goods in two different periods. For our calculations we used the values $\sigma = 0.5$ and $b = -5$. Lowering either one of them will increase the correlation between net exports and growth.

The correlation between actual and predicted capital flows in a standard one-good growth model is -0.32 (see Table 3.3). In our model the correlation between actual and predicted capital flows is 0.08. It is no longer negative although it is still quite small. Our ad-hoc specification does not allow for cross-country differences in factor markets frictions. We also abstract from differences in initial debt holdings. We do not have data on sectoral investment and capital stocks for the countries in our sample so we assumed the same level of TFP in both sectors.

Table 3.3: Correlation of actual and predicted capital flows

Standard model	Our model
-0.32	0.08

Our result is driven by the presence of structural change in faster growing countries. We want to stress that currently we do not attempt to explain structural change - we simply take as given the reallocation of workers across sectors. The literature on structural change provides a number of explanation for the rise of the service sector. These usually include non-linearity of the Engel curve ([39], [26]) and differential sectoral growth rates combined with different labor intensities across sectors ([25]). We would like to make this change endogenous in the future versions of our paper.

Finally, one cannot write a two-good international paper without at least mentioning what happens to the real exchange rate. Unfortunately, our model delivers counterfactual prediction about the behavior of the real exchange rate. In the data, countries whose TFP grows rapidly tend to experience real exchange rate appreciation. In our model the correlation between the growth rate and the change in the relative price of non-tradable goods is negative. This result is not surprising. The exogenous movement of labor into the non-tradable sector increases the productivity of capital in that sector, which drive the price of non-tradable goods downward. Figure B.8 depicts the relation between RER changes and TFP growth in the model.

3.6 Conclusion

In this paper, we study the behavior of net exports in a sample of developing economies. We attempt to rationalize the empirical observation that countries with high productivity growth tend to run current account surpluses.

We present a two-good small open economy model with immobility of factors of production across the two sectors. We show that with enough complementarity between tradable and non-tradable goods we may observe positive correlation between growth rate of the TFP and net exports.

The major shortcoming of the model is the behavior of relative prices - faster growing countries experience reduction in the price of non-tradable goods. In the 2-sector model that we presented it implies the depreciation of real exchange rate among fast-growing countries. The Balassa-Samuelson effect therefore doesn't hold. One has to note however that Balassa-Samuelson is an aggregate effect. It would require a more thorough investigation what actually happens to relative prices of non-tradable goods that are complementary to the tradable goods, such as housing, education etc.

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Appendix A

Appendix to Chapter 2

A.1 Proofs

A.1.1 Preliminaries

Note that the condition (2.3.3) in Lemma 2.3.1 can be written as:

$$\frac{\rho_0}{\rho_0 + (1-\rho_0)R^*} = \rho_0 + \frac{\kappa}{U_H - U_L} \tag{A.1.1}$$

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.1.1. *Let R^* satisfy (A.1.1). 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.1.1) 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 $f'(\rho_0) \geq 0 \iff \rho_0 \leq \frac{1}{2} - \frac{\kappa}{2(U_H - U_L)}$. □

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:

$$F(t; R^*) = (1-\epsilon)^t \Pr\{B_t(R^*)^c\} + 1 - (1-\epsilon)^t \qquad \text{(A.1.2)}$$

The distribution function of τ^1 is simply

$$G^1(t; R^*) = \Pr\{B_t(R^*)^c\} \qquad \text{(A.1.3)}$$

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

Proof. From (A.1.2) 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.1.3. *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.1.4. *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:

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

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.1.5. *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

$$E(\tau; R^*) := \sum_{t=0}^{\infty} t \cdot [F(t; R^*) - F(t-1; R^*)] \tag{A.1.4}$$

where I substitute $\Pr\{\tau = t; R^*\} = F(t; R^*) - F(t-1; R^*)$. Recall that R^* is implicitly defined in (A.1.1).

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.1.1). That probability can be written as:

$$\begin{aligned}
\psi(R^*) &= \sum_{t=1}^{\infty} \left[\sum_{k=1}^{\infty} \mathbf{1}_{t \leq k} [G^0(t) - G^0(t-1)] \right] [G^1(t; R^*) - G^1(t-1; R^*)] \\
&= \sum_{t=1}^{\infty} \eta(t) [G^1(t; R^*) - G^1(t-1; R^*)] && \text{(A.1.5)} \\
& && \text{(A.1.6)}
\end{aligned}$$

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.1.2 Proofs from the main text

Proof of Lemma 2.4.1

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.1.1.

Recall that from (A.1.4) and (A.1.5) we have:

$$\begin{aligned} E(\tau;R^*) &= \sum_{t=0}^{\infty} t\cdot[F(t;R^*)-F(t-1;R^*)] \\ \psi(R^*) &= \sum_{t=1}^{\infty} \eta(t)[G^1(t;R^*)-G^1(t-1;R^*)] \end{aligned}$$

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. From Lemmas A.1.2 and A.1.3 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.1.1.

Q.E.D.

Proof of Lemma 2.4.2

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.1.4) and (A.1.5) we have:

$$\begin{aligned} E(\tau;R^*) &= \sum_{t=0}^{\infty} t\cdot[F(t;R^*)-F(t-1;R^*)] \\ \psi(R^*) &= \sum_{t=1}^{\infty} \eta(t)[G^1(t;R^*)-G^1(t-1;R^*)] \end{aligned}$$

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.1.4 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.1.5 which means that $\psi(R^*)$ is continuous in R^*.

Q.E.D.

Proof of Lemma 2.4.3

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.1.6. *$E(\tau;R^*,\bar{\theta})$ 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.1.7. *$\psi(R^*, \bar{\theta})$ 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.1.6 and A.1.7.

Q.E.D.

Proof of Lemma 2.4.4

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.1.1)). Then (i) follows from Lemma A.1.2 and (ii) follows from Lemma A.1.3.

Q.E.D.

A.2 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 ([21], [40], [22]).

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 2.2.3 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:

$$\rho_{n,0} = \frac{\alpha_n}{\alpha_n + \beta_n} \tag{A.2.1}$$

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 5. *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.*

A.2.1 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 6. *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 2.3 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 A.2.1. *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 A.2.2. *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 A.2.3. $\frac{k_n}{n} \to 1$ *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 A.2.4. *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 $\bar\theta_1 \le \bar\theta_2 \Rightarrow k_n(\bar\theta_1) \ge k_n(\bar\theta_2)$, all n.*

Proof. By induction. Set $n = 0$. Then $k_n = 0$, regardless of $\bar\theta$. Suppose $k_n(\bar\theta_1) \ge k_n(\bar\theta_2)$. 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 $\bar\theta = \bar\theta_2 \ge \bar\theta_1$. Hence $k_{n+1}(\bar\theta_1) \ge k_{n+1}(\bar\theta_2)$. $\square$

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 A.2.4 implies that $\lim_{n\to\infty} \frac{k_n}{n}(\bar\theta_1) \ge \lim_{n\to\infty} \frac{k_n}{n}(\bar\theta_2)$ if $\bar\theta_1 \le \bar\theta_2$. Then $\lim_{n\to\infty} \frac{\alpha_n}{\alpha_n+\beta_n}(\bar\theta_1) \ge \lim_{n\to\infty} \frac{\alpha_n}{\alpha_n+\beta_n}(\bar\theta_2)$ if $\bar\theta_1 \le \bar\theta_2$. But $\lim_{n\to\infty} \frac{\alpha_n}{\alpha_n+\beta_n}(\bar\theta) \in \{\rho_0^1(\bar\theta), 1\}$. Hence $\bar\theta_1 \le \bar\theta_2 \Rightarrow D(\bar\theta_1) \subseteq D(\bar\theta_2)$. $\square$

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

Theorem A.2.2 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 A.2.2 can be stated in terms of the switching cost κ.

Theorem A.2.5. *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 A.2.2. □

A.3 Extensions

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

A.3.1 Endogenous Volatility of the Trend in a Stochastic Growth Model

Consider the following modification of the version of a stochastic growth model in [3] (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:

$$V(k,z,g,\rho) = \max\{W(k,z,g,\rho), W(k,z,g,\rho_0)\} \tag{A.3.1}$$

$$W(k,z,g,\rho) = \max_{c,k'} \left\{u(c) + \beta \cdot [\kappa E_\rho V(k',z',g',\rho') + (1-\kappa)E_\rho W(k',z',g',\rho')]\right\} \tag{A.3.2}$$

subject to:

$$c + e^g k' \leq e^z k^\alpha (e^g L)^{1-\alpha} \tag{A.3.3}$$

$$z' = \rho_z z + \epsilon_z \tag{A.3.4}$$

$$g' = (1-\rho_g)\bar{g} + \rho_g g + \epsilon_g \tag{A.3.5}$$

$$\epsilon_g \sim N(0, \sigma_g) \tag{A.3.6}$$

$$\epsilon_z \sim N(0, \sigma_z) \tag{A.3.7}$$

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. $A^P = \{\texttt{c,h}\}$. 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)[1] . 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 7. *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 (A.3.1)-(A.3.2), (iii) policy functions attain maximum in (A.3.1)-(A.3.2) 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.

A.4 Figures

[1] 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.

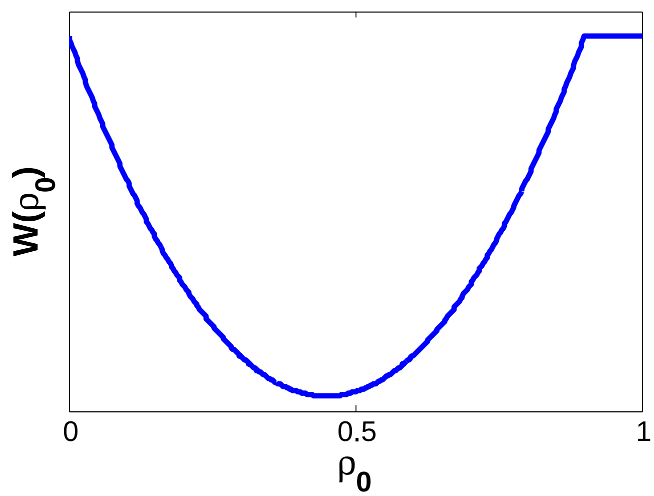

Figure A.1: Net payoff from choosing low regime

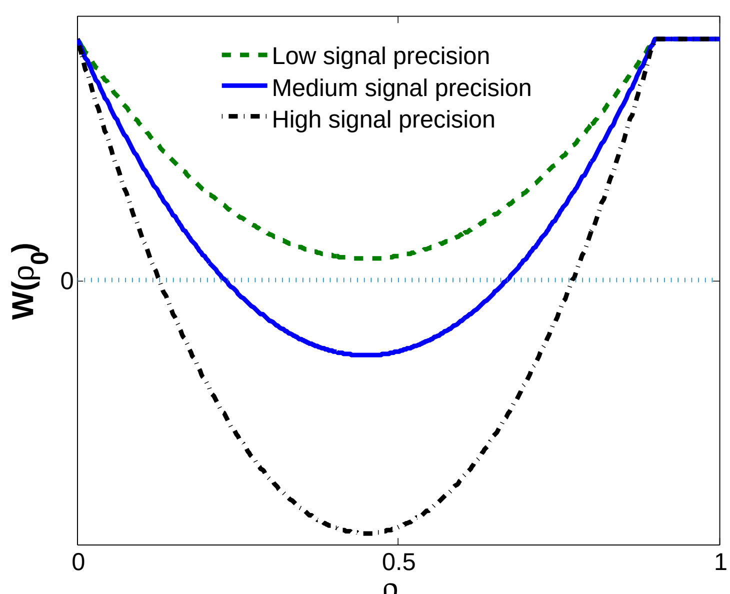

Figure A.2: Monitoring and payoff from choosing low regime

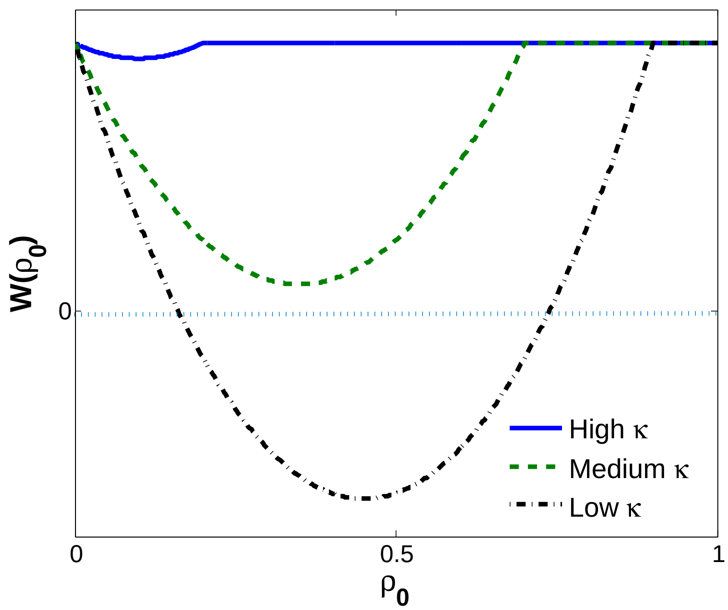

Figure A.3: Switching cost and payoff from choosing low regime

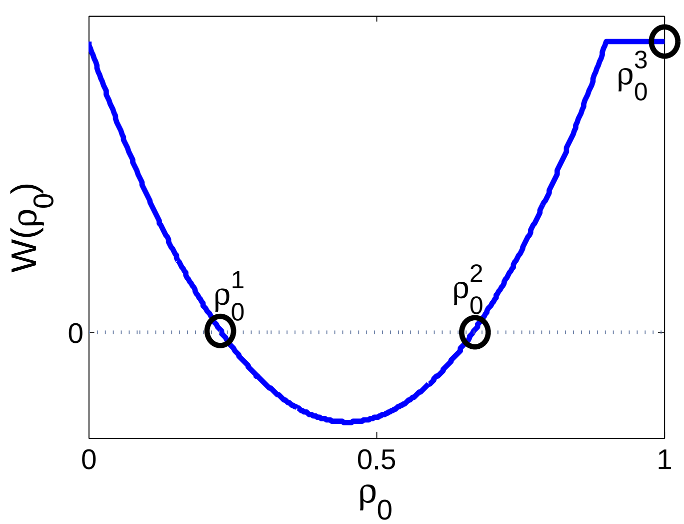

Figure A.4: Stationary Markov Equilibria

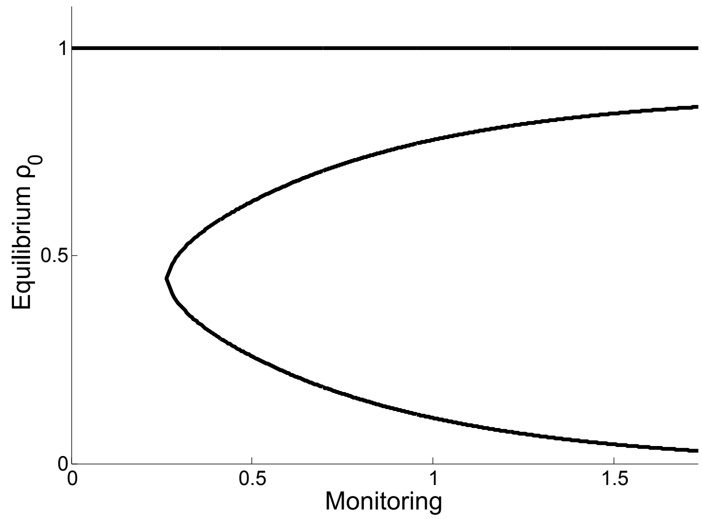

Figure A.5: Initial belief in a stationary equilibrium

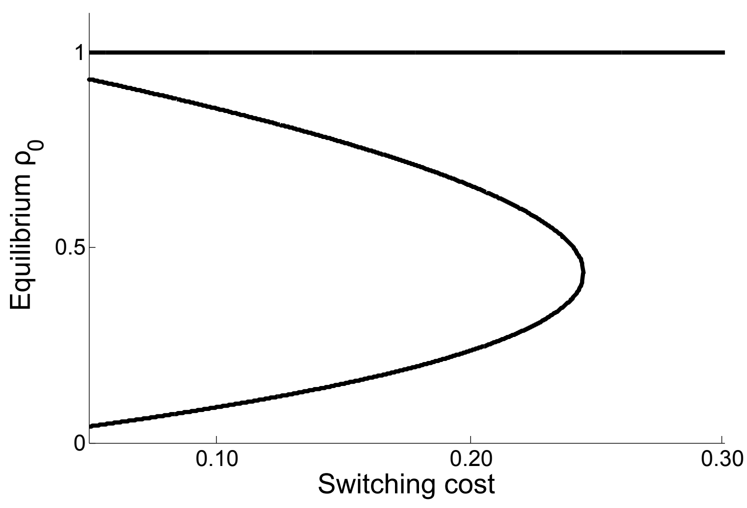

Figure A.6: Initial belief in a stationary equilibrium

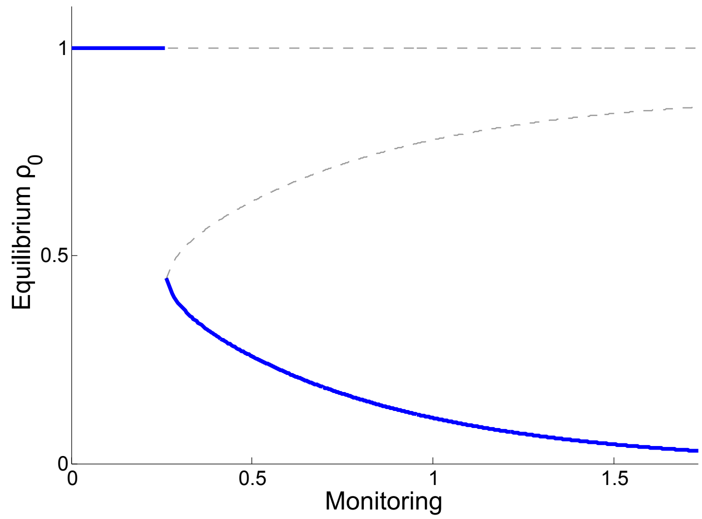

Figure A.7: Equilibrium selection - monitoring

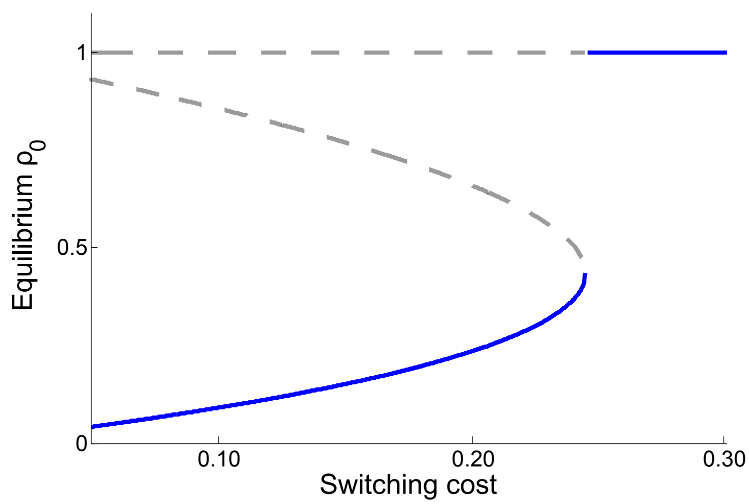

Figure A.8: Equilibrium selection - switching cost

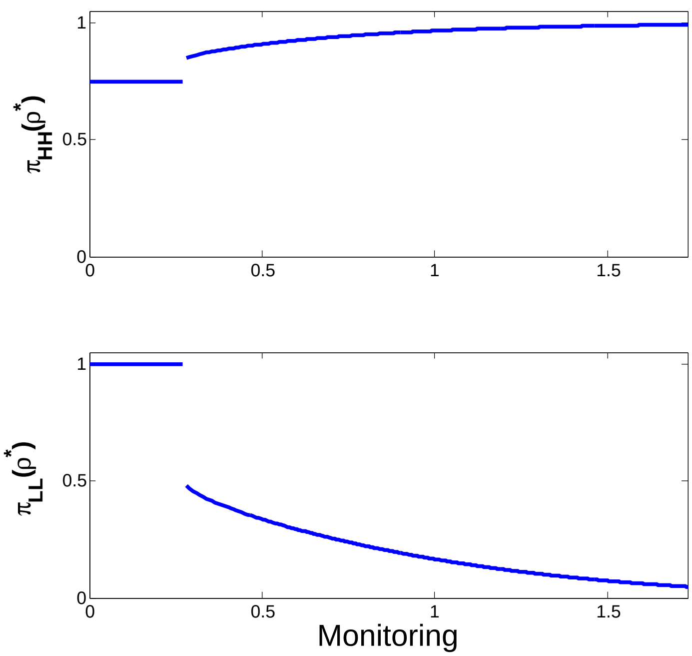

Figure A.9: Persistence of regimes - effect of monitoring

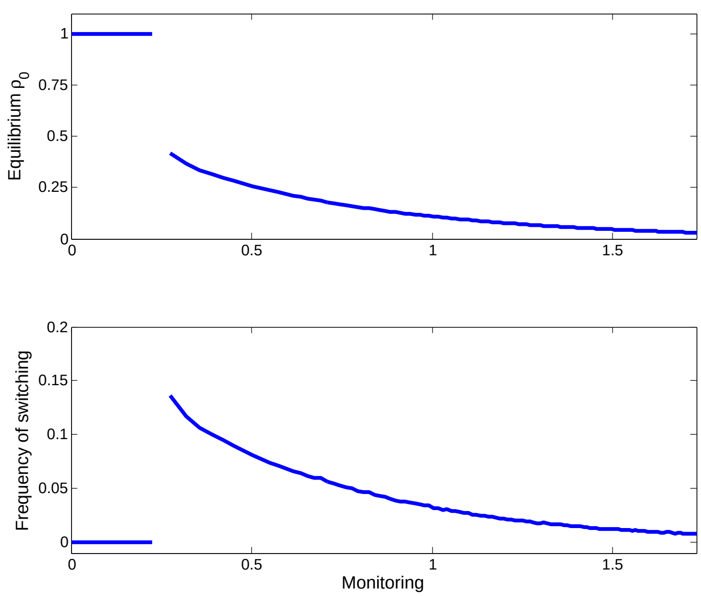

Figure A.10: Frequency of regime switching in a stationary equilibrium

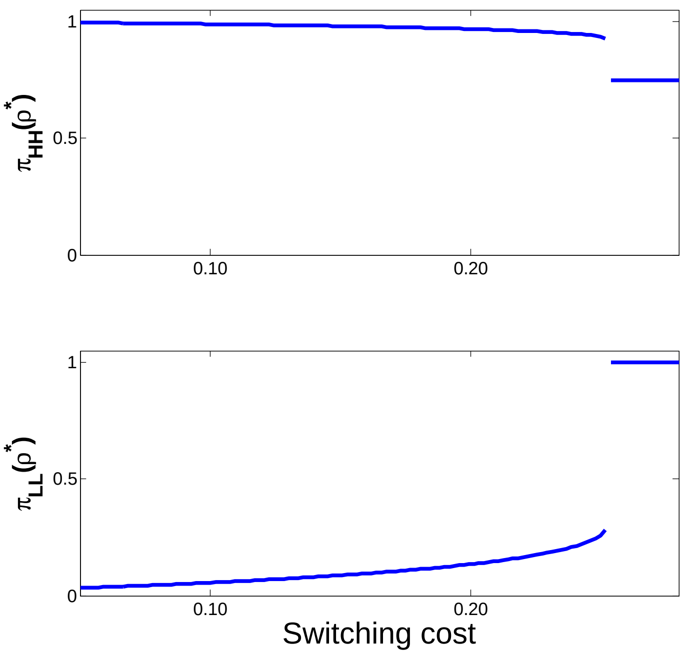

Figure A.11: Persistence of regimes - effect of switching cost

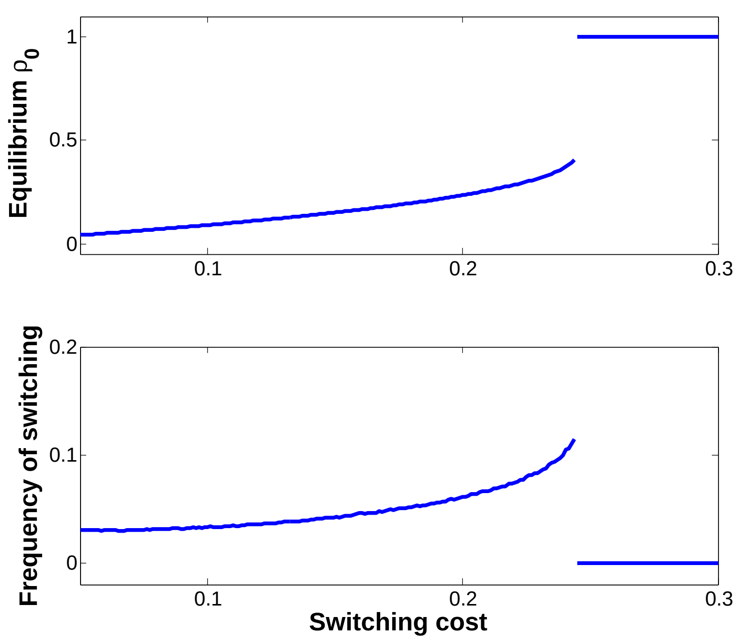

Figure A.12: Switching frequency - switching cost

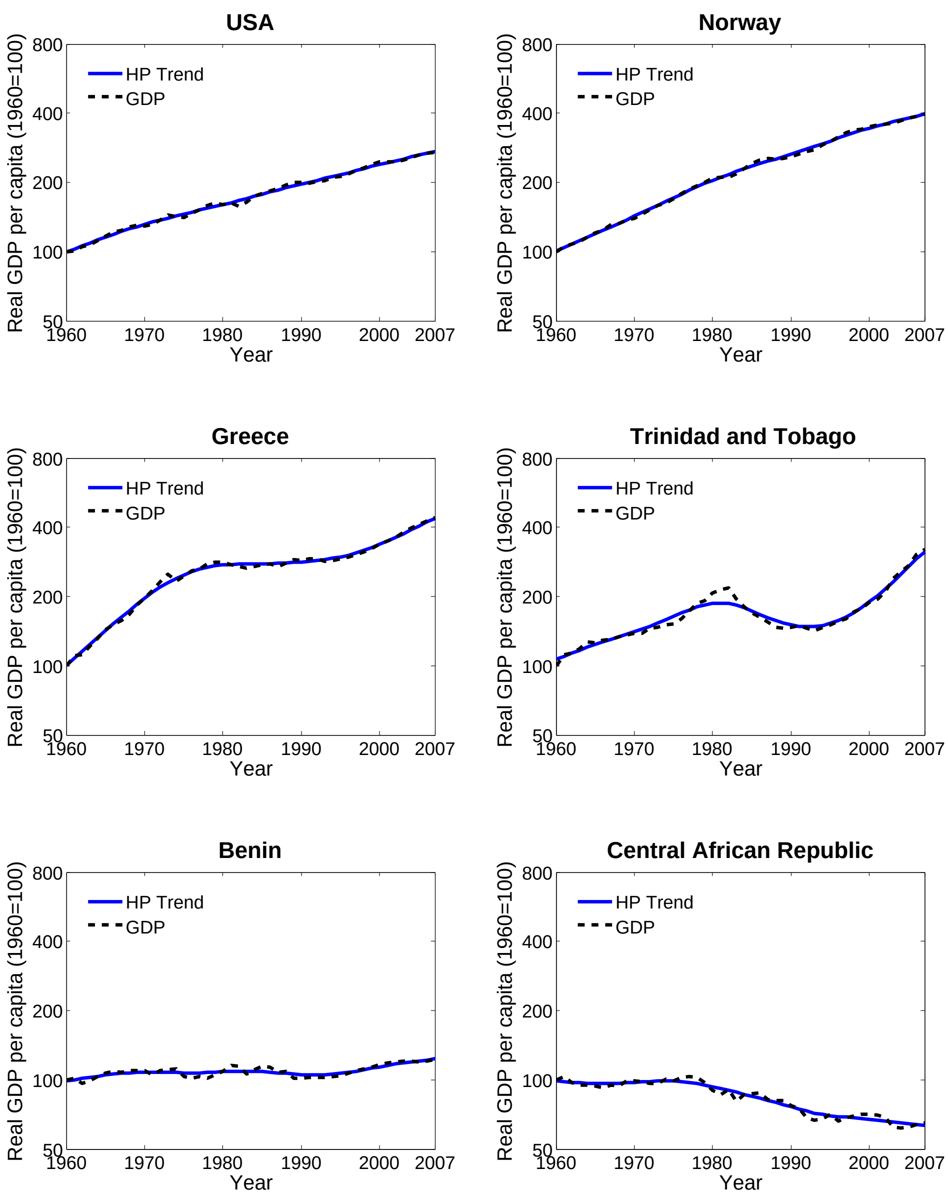

Figure A.13: Volatility in developed, developing and undeveloped countries (Source: WDI)

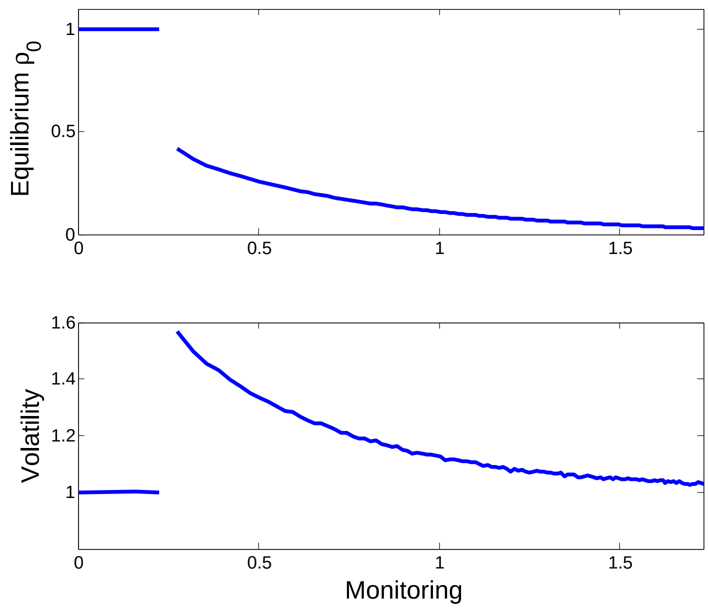

Figure A.14: Volatility in a stationary equilibrium

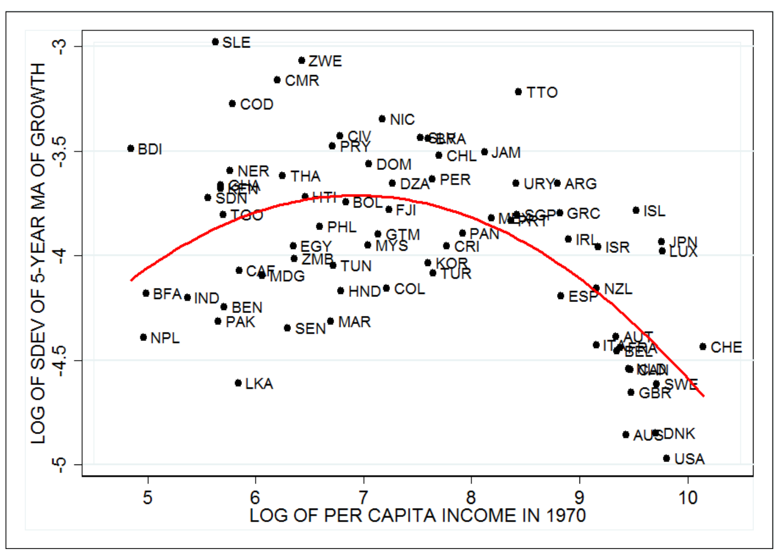

Figure A.15: Income and low-frequency volatility of growth rates

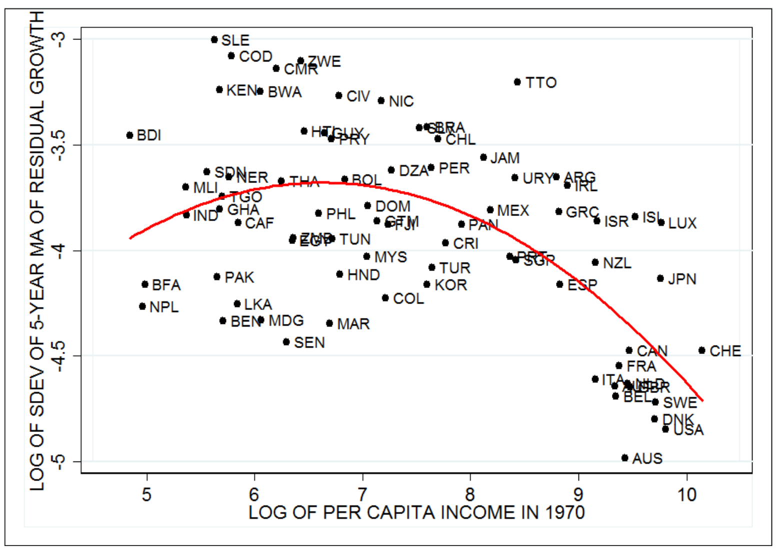

Figure A.16: Income and low-frequency volatility of residuals from regression (2.6.3)

Appendix B

Appendix to Chapter 3

B.1 Proofs

B.1.1 Proof of Proposition 3.3.1

We want to show that $\omega_1^T - c_1^T$ is increasing in ω_2^N iff $\frac{1}{1-b} < \frac{1}{\sigma}$. FOCs for the household imply the following relationship:

$$U_{c_1} \cdot \frac{\partial c_1}{\partial c_1^T} = U_{c_2} \cdot \frac{\partial c_2}{\partial c_2^T} \tag{B.1.1}$$

where

$$U_{c_1} \cdot \frac{\partial c_1}{\partial c_1^T} = [a\omega_1^{N^b} + (1-a)c_1^{T^b}]^{(1-b-\sigma)/b} \cdot (1-a) \cdot c_1^{T^{b-1}} =: f(c_1^T, \omega_2^N)$$

$$U_{c_2} \cdot \frac{\partial c_2}{\partial c_2^T} = [a\omega_2^{N^b} + (1-a)c_2^{T^b}]^{(1-b-\sigma)/b} \cdot (1-a) \cdot c_2^{T^{b-1}} =: g(c_2^T, \omega_2^N)$$

Noting that $c_2^T = \omega_1^T + \omega_2^T - c_1^T$ we can write the equilibrium condition as:

$$h(c_1^T, \omega_2^T) := f(c_1^T, \omega_2^N) - g(\omega_1^T + \omega_2^T - c_1^T, \omega_2^N) = 0 \tag{B.1.2}$$

Note that

$$\begin{aligned} &\tfrac{\partial f(c_1^T,\omega_2^N)}{\partial c_1^T} < 0, \quad \partial f(c_1^T, \omega_2^N)/\partial \omega_2^N = 0 \\ &\tfrac{\partial g(c_2^T,\omega_2^N)}{\partial c_1^T} > 0, \quad \partial g(c_2^T, \omega_2^N)/\partial \omega_2^N > 0 \iff \tfrac{1}{1-b} < \tfrac{1}{\sigma} \end{aligned} \tag{B.1.3}$$

Therefore we have that $\frac{\partial h}{\partial c_1^T} < 0$. We also have that $\frac{\partial h}{\partial \omega_2^N} < 0 \iff \frac{1}{1-b} < \frac{1}{\sigma}$. If ω_2^N increases, for (B.1.2) to hold, c_1^T must fall (i.e. $\omega_1^T - c_1^T$ rise) if and only if $\frac{\partial h}{\partial \omega_2^N} < 0 \iff \frac{1}{1-b} < \frac{1}{\sigma}$. $\square$

B.1.2 Proof of Proposition 3.3.2

We want to show that NX_1 is increasing in A_2^N if and only if $\sigma < 1$. Note that NX_1 is given by:

$$NX_1 = A_1^T K_1^{T\alpha} L_1^{T1-\alpha} + (1-\delta)K_1 - K_2 - C_1^T \tag{B.1.4}$$

We will show that increase in A_2^N will lower C_1^T and increase both K_1^T and L_1^T if and only if $\sigma < 1$. This, together with the fact that both K_2 and K_1 remain unaffected will prove the proposition.

We normalize $p_1^T = p_2^T = 1$. FOCs for the firms in the tradable and non-tradable sector imply that the the relative price of the non-tradable good depends only on the ratio of TFPs in both sectors in the current period:

$$p_t^N = \frac{A_t^T}{A_t^N} \tag{B.1.5}$$

Therefore, the relative price of the non-tradable good in period 1 is unaffected by changes in A_2^N. The intra-temporal choice between tradable and non-tradable goods implies the following relation:

$$\frac{a}{1-a}\left(\frac{C_t^N}{C_t^T}\right)^{b-1} = p_t^N \tag{B.1.6}$$

Equation (B.1.6) states that as long as $b < 1$ (which we assume is always satisfied) then the ratio C^N/C^T is determined by the relative price of the non-tradable good p^N. Hence, the ratio C_1^N/C_1^T will be unaffected by changes in A_2^N and therefore consumption of the tradable good C_1^T will move in the same direction as consumption of the non-tradable good C_1^N and of the aggregate good C_1.

Note that the budget constraint of the household can be written as:

$$P_1C_1 + P_2C_2 \leq M \tag{B.1.7}$$

where C_t is consumption of the aggregate good in period t and P_t is the price of the aggregate good in period t and M is households's nominal income. Therefore, in order to determine the effect of an increase in A_2^N on the consumption of the aggregate good C_1, we need to determine how A_2^N affects P_1, P_2 and M.

The intra-temporal choice between tradable and non-tradable goods determines the price level of the aggregate good (keeping $p^T = 1$ in both periods). The price of the aggregate good in period t is the defined as the value of the following program:

$$P_t := \min C_t^T + p_t^N C_t^N$$

s.t.

$$1 = \left(a C_t^{N^b} + (1-a) C_t^{T^b}\right)^{1/b}$$

Solving this problem yields the following formula for P_t:

$$P_t = \left(a^{\frac{1}{1-b}} + (1-a)^{\frac{1}{1-b}} p_t^{N^{\frac{b}{b-1}}}\right)^{\frac{b}{b-1}} \tag{B.1.8}$$

Equation (B.1.8) implies that P_t moves in the same direction as p_t^N for every $b < 1$. Hence, from (B.1.5) we have:

$$\frac{dP_1}{dA_2^N} = 0, \quad \frac{dP_2}{dA_2^N} < 0 \tag{B.1.9}$$

Consider now the nominal income of the household. It is given by:

$$M = \sum_{t=1}^{2} [r_t K_t + w_t L_t] \tag{B.1.10}$$

Labor is normalized to 1 in both periods. FOCs for the firms together with perfect mobility of both capital and labor between sectors imply that the capital/labor ratios in both sectors have to be the same and have to equal the capital/labor ratio of the economy. Therefore, the rental rate for capital and wage are given by:

$$r_t = \alpha \left(\frac{K_t}{A_t^T}\right)^{\alpha-1} \tag{B.1.11}$$

$$w_t = (1-\alpha) \left(\frac{K_t}{A_t^T}\right)^{\alpha} \tag{B.1.12}$$

Note that K_1 is given. Therefore, r_1 and w_1 are unaffected by the value of A_2^N. Small open economy assumption implies that the capital labor ratio in the second period is pinned down by the world interest rate:

$$R^* = 1 - \delta + \alpha \left(\frac{K_2}{A_2^T}\right)^{\alpha-1} \tag{B.1.13}$$

Equation (B.1.13) has to hold regardless of the value of A_2^N. Hence K_2 is unaffected by A_2^N. With $L_2 = 1$ this pins down the capital/labor ratio and hence r_2 and w_2 is unaffected. Hence, M remains the same.

So far we have shown that an increase in A_2^N will not change P_1, will lower P_2 and will not affect M. How will C_1 and C_2 react to the fall in P_2? FOCs for utility maximization imply:

$$\begin{aligned} P_1 C_1 + P_2 C_2 &= M \\ \left(\frac{C_1}{C_2}\right)^{-\sigma} &= \frac{P_1}{P_2} \end{aligned}$$

Solving that system of equations yields the following formula for C_1:

$$C_1 = \frac{M}{P_1} \cdot \frac{P_2^{\frac{1-\sigma}{\sigma}}}{P_1^{\frac{1-\sigma}{\sigma}} + P_2^{\frac{1-\sigma}{\sigma}}} \tag{B.1.14}$$

Equation (B.1.14) implies that, keeping M and P_1 fixed, C_1 is increasing in P_2 if and only if $\sigma < 1$. This results should not be surprising. For $\sigma < 1$, the substitution effect associated with the change in price of one of the goods dominates the income effect. Then a fall in P_2 will lead to the fall in C_1 - the consumption of the aggregate good in period 1. Note that C_1 decreases if and only if both C_1^T and C_1^N decrease (by (B.1.6)). Market clearing for the non-tradable good then implies that K_1^N and L_1^N must fall. Market clearing for capital and labor then implies that K_1^T and L_1^T rise. With K_1 and K_2 unchanged, equation (B.1.4) then implies that NX_1 increases. Hence we have that after an increase in A_2^N, NX_1 increases if and only if C_1 decreases which happens if and only if $\sigma < 1$. This finishes the proof.

B.2 List of countries

Table B.1: Summary statistics.

Country	Average growth 1980-2000 (%)	Capital outflows*	$\Delta\ell^T$ 1980-2000 (%)**
Argentina	-0.10	-1.03	-38.46
Bangladesh	2.71	-0.57	1.32
Brazil	-0.63	-0.46	-20.00
Chile	2.24	-2.49	-5.00
China	5.69	0.70	-1.14
Colombia	-1.52	-1.88	-22.86
Costa Rica	-0.91	-1.93	-15.38
Cyprus	1.31	-2.64	-40.00
Dominican Republic	2.07	-1.78	5.26
Ecuador	-2.87	-1.48	6.67
Egypt	2.63	0.41	-20.31
El Salvador	-0.26	-0.09	-22.03
Ghana	2.69	-0.68	-9.33
Guatemala	0.05	-1.52	-6.56
Honduras	-1.99	-2.23	-26.32
Hong Kong	2.92	0.45	-59.62
India	4.06	-1.00	-13.48
Indonesia	0.21	-1.07	-10.00
Iran	2.11	-0.06	-3.51
Jamaica	0.84	-0.12	-39.68
Jordan	-3.06	-2.34	-15.63
Kenya	0.03	-2.18	-15.56
Korea	4.12	0.96	-38.10
Malaysia	1.65	-0.74	-16.39
Mexico	-1.06	-1.22	-40.79

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Country	Average growth 1980-2000 (%)	Capital outflows	$\Delta \ell^T$ 1980-2000 (%)
Morocco	0.26	-0.24	-18.75
Pakistan	2.87	-2.16	-8.22
Panama	-1.27	-1.15	-32.00
Paraguay	-1.83	-1.28	77.78
Peru	-0.45	-2.36	-18.75
Philippines	-0.57	-1.04	-19.40
Sri Lanka	1.89	-1.59	-2.86
Syrian Arab Rep.	0.91	1.03	-7.81
Thailand	3.41	-2.04	-16.05
Trinidad and Tobago	0.71	-0.43	-25.53
Turkey	2.36	-1.74	-18.92
Uruguay	0.50	-0.23	7.41
Venezuela	-1.95	0.73	-23.26

* Sum of Current Accounts (1980-2000) as a fraction of initial output

** Percentage change in the fraction of labor employed
in the tradable sector between 1980 and 2000.

B.3 Figures

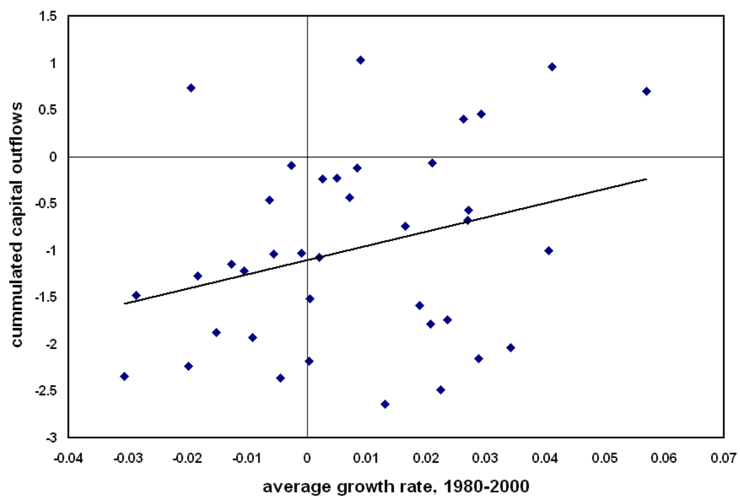

Figure B.1: Capital outflows and TFP growth 1980-2000

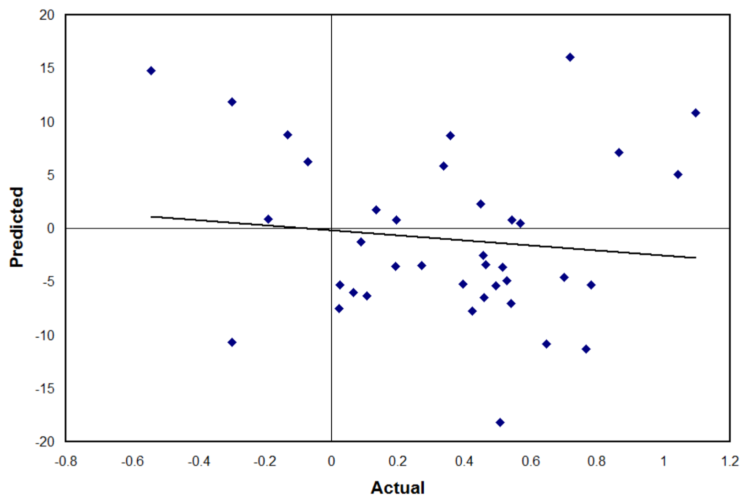

Figure B.2: Capital outflows 1980-2000

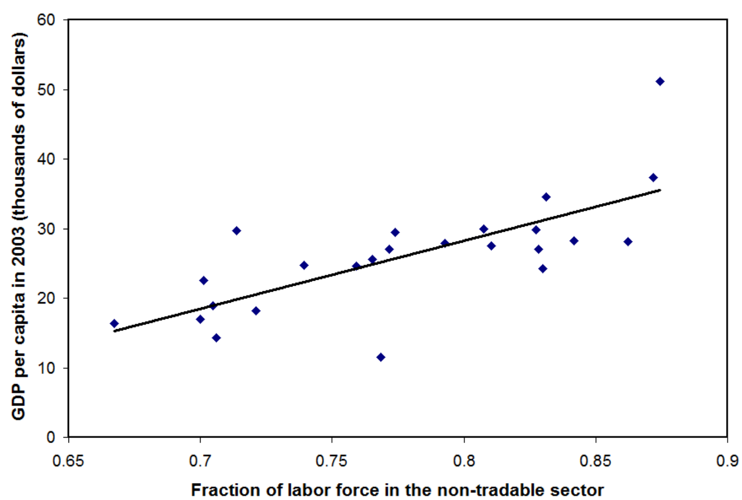

Figure B.3: GDP per capita and fraction of labor in the non-tradable sector - OECD

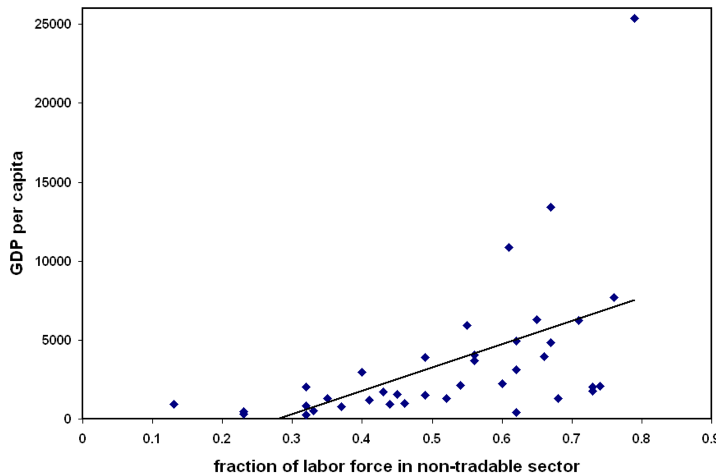

Figure B.4: GDP per capita and fraction of labor in the non-tradable sector - non OECD

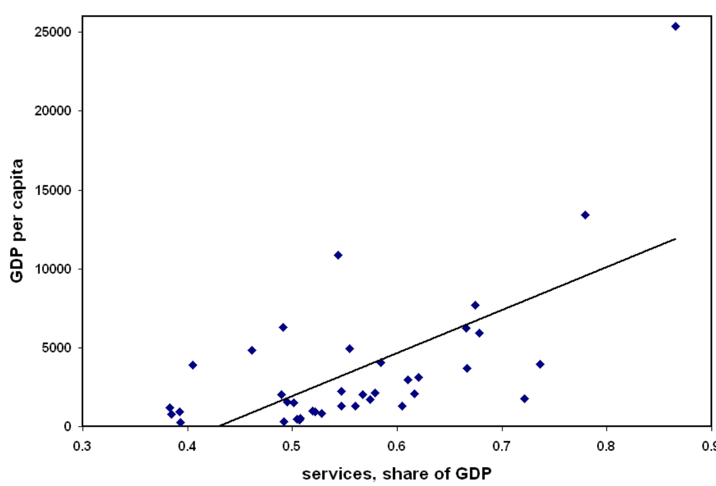

Figure B.5: GDP per capita and services as a share of GDP - non OECD

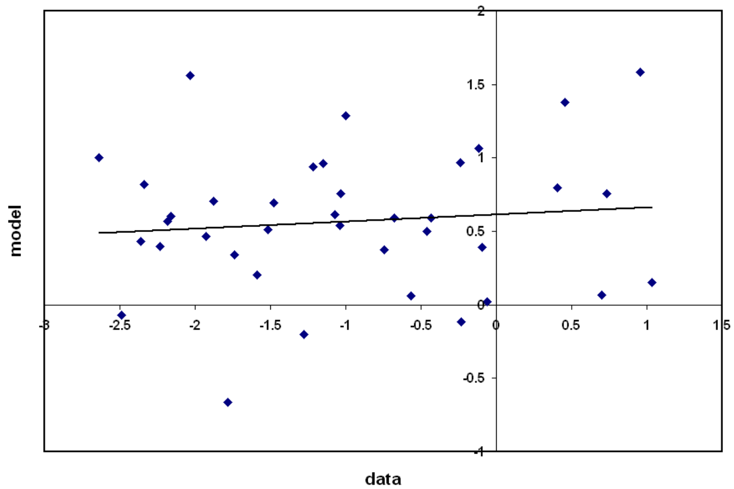

Figure B.6: Cumulated capital flows (1980-2000) as a fraction of initial output.

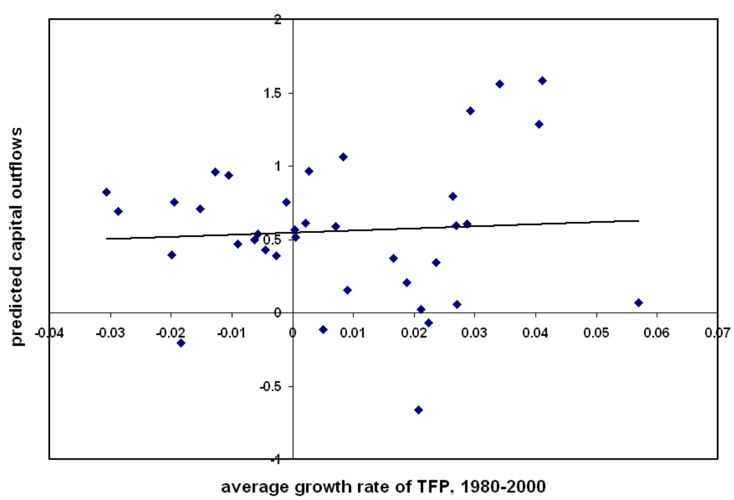

Figure B.7: Predicted capital flows as a fraction of initial output and average TFP growth (1980-2000).

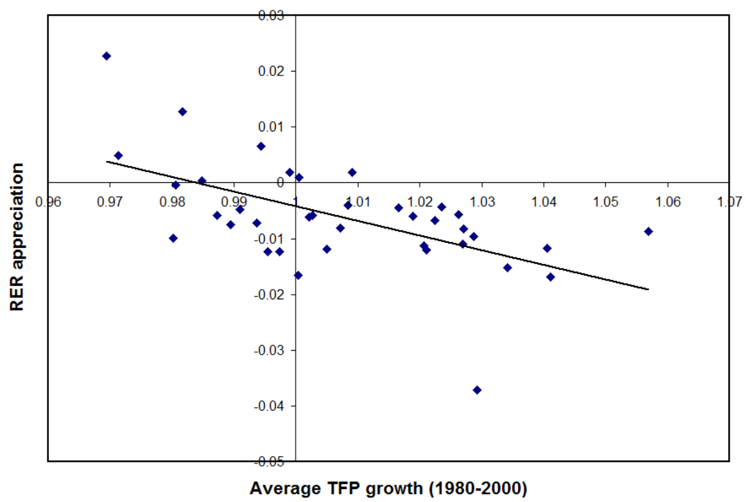

Figure B.8: Real exchange rate appreciation and average TFP growth in the model.