Essays in Macroeconomics and Political Economy

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Dedication

A mi familia, que no vaciló en inmolarse con tal que yo alcanzara mi sueño.

Abstract

The first chapter presents a dynamic game of imperfect information that encompasses previous analyses on political budget cycles (PBCs) and matches the following recently documented facts: first, PBCs mostly occur in developing countries and are financed with debt; second, PBCs have little correlation with incumbent's reelection probability in developing countries, and third, PBCs are negatively correlated with incumbent's reelection probability in developed countries. The set of sequential equilibria of the game is shown to be tightly bound to the size of political rents. In the unique equilibrium capable of matching the three facts above, PBCs arise exclusively from the behavior of unproductive incumbents who attempt to mimic competent governments by issuing debt. I introduce a set of costly signals that convey information about incumbents' performance and show that voters acquire signals of increasing quality as economies grow. The ensuing information asymmetry across income levels is shown to generate observed PBCs patterns. I discuss possible long term effects of initial unproductive politicians in office.

The second chapter builds a multisector growth model with monopolistically competitive markets to gauge the quantitative relevance of sectoral shocks in explaining fluctuations of the US Industrial Production (IP) Index between 1972-2007. The incorporation of market power and increasing returns hampers the transmission of sector-specific shocks into related industries, which thereby erodes the quantitative importance of sectoral perturbations for explaining economy-wide fluctuations. In some calibrations, the fraction of aggregate IP fluctuations explained by sectoral shocks when departing from perfect competition falls 44% between 1984-2007.

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Chapter 1

Political Budget Cycles, Information and Development

1.1 Introduction

Since the cornerstone work of Downs (1957) there has been an extensive inquiry on the relationship between politicians and economic aggregates, summarized for instance in Drazen (2000) and Persson and Tabellini (2000). A salient feature of this line of research has been the study of the link between fiscal policy and elections, where a regular pattern has been established. In effect, starting with the book by Tufte (1978), and continuing with the sweeping, more rigorous empirical work by Blais and Nadeau (1992), Brender (2003), Brender and Drazen (2005) and Schuknecht (2000), it has been determined that government spending increases during election years in a systematic way across countries, a regularity coined with the term Political Budget Cycle (PBC).

The landmark theoretical appraisal of this phenomenon given by Rogoff (1990) characterizes PBCs as the equilibrium outcome of a signalling game between politicians and voters. In his formulation, office-seeking politicians have different, privately known skills which evolve with time, but present some persistence. Voters, in turn, use public information—taxes and government spending—to infer types and thus select the best candidate. In the unique separating equilibrium that Rogoff obtains, only productive incumbents increase public spending in election years, and hence the political budget cycle is a welfare-enhancing phenomenon because it reflects efficient signaling by the most able politicians. Additionally, unproductive politicians are always removed from office unless voters have an intrinsic, bold taste for them.[1] Finally, a key assumption underlying his analysis is that, apart from tax revenue, which is publicly observed, skills are the only determinant of the amount of public good that a politician may produce.

Recent empirical studies, however, have bestowed new information on political budget cycles. In particular, the panel evidence from Shi and Svensson (2006) and Brender and Drazen (2008) suggests three facts: (*i*) political budget cycles occur mostly in developing countries and are financed with debt; (*ii*) in developing countries, election year increases in public spending do not hurt the incumbent politician's reelection prospects, and (*iii*) in developed countries, election year increases in public spending do hurt the incumbent's reelection prospects.

This evidence is unattained by Rogoff's equilibrium in the following aspects. First, the fact that rich-country voters punish rather than reward those politicians who generate PBCs suggests that voters may perceive that increases in election-year spending are caused by unproductive incumbents attempting to mimic efficient outcomes. In other words, the evidence seems to point toward a moral hazard perspective of PBCs stemming from the behavior of office-seeking, unproductive politicians. Secondly, the fact voters in low-income countries show lesser disapproval of PBCs, suggests the presence of more information in developed countries, which would allow the detection of hidden debt more easily. This informational channel, in turn, would explain the empirical erosion of political budget cycles in relatively richer countries.

The purpose of this paper is to build a model capable of matching the evidence (*i*)—(*iii*) described above, and then use such model to ask what type of

[1]In the model voters have random preferences (McFadden (1974)) and thus voting is probabilistic (Coughlin (1982)).

politician is behind election-year increases in government spending. For this task I borrow unrestrainedly from Rogoff's original insights, namely politicians differing in productivity and asymmetric information between voters and incumbents. I introduce two main ingredients. First, apart from privately observe their productivity, office holders have the possibility of hidden borrowing; that is, incumbents may borrow abroad and such move is only observed by voters with a lag. This feature allows the separation of government spending from public good outcomes, and plays a key role in the empirical match of the model. Second, voters may buy a costly signal of varying precision that is correlated with politician's hidden action. This information market enables rich voters to afford accurate information regarding incumbent's performance.

I present a full characterization of the set of sequential equilibria of the game I build. The key determinants behind these equilibria are two parameters: non-pecuniary *ego* rents of politicians and the likelihood that unproductive politicians become productive. For certain thresholds I obtain three ensuing equilibriums: one in which there are no PBCs, another that corresponds to Rogoff's outcome, and finally an equilibrium where only unproductive politicians generate political budget cycles.

The main thrust from the paper, however, stems from the third equilibrium obtained. I show that for parameter values supported by the work of Besley (2005), Caselli and Morelli (2004), Mattozzi and Merlo (2008), and Messner and Polborn (2004), such equilibrium is capable of matching the facts (*i*)—(*iii*). In this equilibrium outcome, unproductive incumbents end up using debt to mimic the public spending standard of productive politicians. In such case, when voters face a increase of public goods in election years, they cannot distinguish what type of politician is actually in office and thereby randomize at the polls, which generates fact (*iii*). This result still holds when voters may acquire informative signals, but as voters get richer and therefore improve their monitoring over incumbents, the PBC end up disappearing and any election-year increase in spending is punished by voters at the polls, which resembles facts (*i*)–(*ii*).

In the third equilibrium that I characterize then, I infer that political budget cycles are far from reflecting efficient signalling, and instead may be harmful. As long as voters cannot afford the cost of precise information, in which case they are not able to figure out incumbent's type, it is very likely that after elections they will face both interest payments and, more importantly, an unproductive politician again in office. I discuss possible long term effects of unproductive incumbents in economies on early stages of development.

The rest of the chapter is organized as follows: in § 1.2 I briefly review the literature on political budget cycles. In § 1.3 I lay out the game with no information market and characterize its equilibrium set. In § 1.4 I introduce an information market to study the transition of political budget cycles along income path documented in the data.

1.2 Literature

Rogoff (1990) is the landmark theoretical work on political political budget cycles, a line of research initiated with the empirical work by Tufte (1978) and then studied with the subsequent work by Blais and Nadeau (1992), Brender (2003), Brender and Drazen (2005), Brender and Drazen (2008), Schuknecht (2000) and Shi and Svensson (2006). There are different explanations, however, for the relationship between budget deficits and elections. Brender and Drazen (2005) argue a new democracies effect: voters of young democracies are not familiarized with elections, and thence subject to manipulation by opportunistic incumbents. Saporiti and Streb (2008) relate PBCs to separation of powers and the role of legislature. Drazen and Eslava (2010) and Brender and Drazen (2013) document that instead of changes in level, elections go along with modifications in the composition of government spending.

Apart from Rogoff (1990), my work is closely related to Shi and Svensson (2006) and Alt and Lassen (2006). The former established empirically that PBCs mainly occur in developing countries, and both papers study the reasons behind such regularity. The authors argue that since corruption is higher and there are fewer voters with access to information in poorer countries, it follows that opportunistic governments have ample space to issue debt and manipulate voters' expectation regarding incumbent's ability. They use a career-concerns model (Holmström (1999)) where an exogenous fraction of the population cannot observe debt and politicians set policy before they learn their productivity. They obtain a PBC, where each politician, regardless from his type, will increase debt in election years and will face a 50% probability of reelection.

While I share their heuristic argument that information is the channel behind fact (i) in § 1.1, we have three stark differences. First, I model information as an endogenously determined, equilibrium object along the lines of Amir and Lazzati (2011), Martinelli (2006) and Persico (2000). Second, building from Besley (2005), Caselli and Morelli (2004), Mattozzi and Merlo (2008), and Messner and Polborn

(2004), I make explicit the point that politicians do not behave equally, in particular, since political and market skills correlate positively, incumbents may have heterogenous preferences for keeping office. Finally, I state that politicians set policy having private information, which is demonstrably an important ingredient in this area or research (v.gr. Ferejohn (1986)).

Starting from these building blocks I am able to characterize clearly the relationship between political budget cycles, quality of information and income, and also make more transparent the transition of the equilibria as income increases. Moreover, I also take into account voters' response to make it consistent with the data, which was not considered by previous work. Finally, and more importantly, my setup enables the comparison with Rogoff's claim regarding the efficiency of PBCs, which is the core issue behind this strand of literature.

The idea that underlies my analysis is the possible endogenous erosion of moral hazard as economies develop, and idea that has been studied in a different context by Acemoglu and Zilibotti (1999). The conclusion of my analysis is related to Acemoglu, Egorov, and Sonin (2010) and Caselli and Morelli (2004) regarding possible explanations for the endogenous persistence of bad politicians in office. Following Banks and Sundaram (1998), however, I completely shut down the adverse selection of the model and I just consider that the unique tool of voters to provide incentives is given by the reelection decision.

This paper is also related to the empirical and theoretical literature on transparency and economic policy across countries, a sample given by Alesina et al. (1999), Gavazza and Lizzeri (2009), Hameed (2005), Islam (2006), Kopits and Craig (1998) and Kaufmann, Kraay, and Mastruzzi (2010). Finally, my work is consistent with the experimental literature on the impact of information on the quality of choice by voters in developing countries, which is summarized by Pande (2011).

1.3 Model

Consider the following environment: there is a set of politicians P with measure one, where a fraction $\rho \in (0,1)$ of them are productive, i.e. have associated a number $\overline{\theta} \in \mathbb{R}_+$, while the rest are associated with $\underline{\theta}$, where $0 < \underline{\theta} < \overline{\theta} \leq 1$. In each of the periods $t = 1, 2, 3$, a voter is endowed with $y \in R_+$ units of a consumption good, which may also be transformed into a public good through a linear technology which is under the control of a politician. In order to finance the provision of such public good there is an exogenously fixed tax rate $\tau \in [0,1]$ on voter's endowment. Additionally, it is also possible for the politician to borrow some extra units of the consumption good abroad at an interest rate $r > 0$.

In this environment the following dynamic game of imperfect information between a single voter v and a randomly selected politician $p \in P$ ensues. Denote this game by Γ. Each $t \in \{1, 2, 3\}$, the politician chooses an action $a_t^p \in A_p = \{b, 0\}$, where $b \equiv (\overline{\theta} - \underline{\theta})\tau y / \underline{\theta} > 0$ is the feasible amount of debt that p may issue abroad.[2] On the other hand, v may keep or fire the incumbent politician at the beginning of the last period, that is, v chooses the action $a_t^v \in A_v(t)$, where

$$A_v(t) = \begin{cases} \{k\} & \text{if } t = 1, 2, \\ \{k, f\} & \text{if } t = 3. \end{cases}$$

There are two sources of asymmetric information: First, p's action is observed by v after one period lag. Additionally, p's productivity $\theta_t \in \Theta = \{\overline{\theta}, \underline{\theta}\}$ is private information. Moreover, as in Phelan (2006), a politician's type may change. Formally, the following Markov process is assumed for the productivity sequence $\{\theta_t\}$, where the state $\overline{\theta}$ is assumed absorbing for the sake of simplicity

$$\Pr(\theta_{t+1} = \overline{\theta} | \theta_t = \underline{\theta}) = \varepsilon \in (0,1).$$

[2] In Rogoff's model politicians choose taxes and spending over compact, convex spaces. While p's action space here is simpler, it has the advantage of not centering the analysis on out-of-equilibrium beliefs as Rogoff does by using the framework of Bagwell and Ramey (1988) and Cho and Kreps (1987).

Each pair $(a_t^p, \theta_t) \in A_p \times \Theta$ together with the endowment y, the tax rate τ and the interest payments $(1+r)a_{t-1}^p$, determines the publicly observed amount of public good g_t as follows

$$g_t \equiv g(a_t^p, \theta_t; a_{t-1}^p) = \theta_t \left(\tau y + a_t^p - (1+r)a_{t-1}^p\right).$$

Both the voter and the incumbent politician derive utility from the consumption of the public good. The incumbent, in addition, gets nonpecuniary rents $e(\theta_t) \in \mathbb{R}_+$ from holding office. For simplicity, I assume that v's endowment is fully taxed, i.e. $\tau \equiv 1$. In this case, stage rewards are given by[3]

$$u_t^p \equiv u^p(a_t^p, a_t^v, \theta_t; a_{t-1}^p) = g_t + e(\theta_t) I_{\{a_t^v = k\}},$$
$$u_t^v \equiv u^v(a_t^p, a_t^v, \theta_t; a_{t-1}^p) = g_t,$$

There are two kinds of histories in this game: private and public. A private history $h_p^t = (a_1^p, \ldots, a_t^p, \theta_1, \ldots, \theta_t) \in H_p^t$ keeps track of the incumbent politician's actions and type. A public history of events, in turn, is a sequence $h^t = (a_1^p, \ldots, a_t^p, g_1, \ldots, g_t) \in H^t$, where $H \equiv \bigcup_t H^t$. Such public histories are used by v to assess the probability of having a productive incumbent in office. That is, v's beliefs regarding p's type are a sequence

$$\mu = \{\mu_t\}_{t=1}^3, \quad \mu_t : H \to \Delta(\Theta), \quad \mu_t = (\pi_t, 1 - \pi_t),$$

where $\pi_t(h^{t-1}) = \Pr(\theta_t = \overline{\theta} \mid h^{t-1})$ is the posterior probability of facing a productive politician. Since there is a fraction $\rho \in (0,1)$ of productive politicians in P, it follows that $\pi_1 \equiv \rho$.

A strategy for p in this game is a function σ^p specifying the probability of borrowing $\sigma_t^p(h_p^{t-1}, \theta_t) \in [0,1]$ for each t, h_p^{t-1}, θ_t. A strategy for v, instead, is a function σ^v specifying the probability of reelection $\sigma_t^v(h^{t-1}) \in [0,1]$ for each t, h^{t-1}.

[3] In § 1.4.2 I discuss the role of τ on the information acquisition decision of the voter.

A profile of strategies $\sigma = (\sigma^p, \sigma^v) \in \Sigma$ induces payoffs

$$U_\iota(\sigma) = E^{\sigma,\mu} \sum_{t=1}^{3} u_t^\iota, \quad \iota \in \{p, v\},$$

where $E^{\sigma,\mu}$ denotes the expectation operator given the assessment $(\sigma, \mu) \in \Sigma \times \Delta(\Theta)^3$.

The following assumptions are in force throughout the paper[4]

$$\rho > \varepsilon. \tag{1.1}$$

$$\underline{\theta} > \chi\,\overline{\theta}. \tag{1.2}$$

Assumption 1.1 states that it is more likely to pick a productive politician randomly selecting from P than expect a productivity jump by an unproductive politician throughout his tenure. Hence, if types were observable by voters, they would dismiss unproductive incumbents. Assumption 1.2, in turn, prevents the productivity gap between politicians of different types from being *too* wide. Under this assumption, if the voter confronts an scenario in which he faces a public history possibly caused by an unproductive politician, it may be still sequentially rational for him to respond to such history with a positive probability of reelection.

I begin the study of this game with the following definition that simplifies notation.

Definition 1. *A public history $h^{t-1} \in H$ is revealing if $\pi_t(h^{t-1}) \in \{0, 1\}\, \forall \sigma^p$.*

The first result of the analysis is that there is a unique history $h^2 \in H$ that inhibits v from certainly inferring p's type before the election. That history is precisely a relatively higher public good production right before the election.

[4] The parameter $\chi \in (0, 1)$ is given by

$$\chi \equiv \max\left\{\frac{1+r}{2-\rho}, \frac{(1+r)(1-\varepsilon)(\rho-\varepsilon)}{(2+r)(1-\varepsilon)(\rho-\varepsilon)-\varepsilon(1-\rho)}\right\}.$$

Lemma 1. *Every public history* $h^2 = (a_1^p, g_1, g_2) \neq (0, \underline{\theta}y, \overline{\theta}y)$ *is revealing.*

Proof. Since A_p and Θ are finite, debt has one-period maturity, and $\overline{\theta}$ is an absorbing state, it follows by construction that there is a finite set of histories possibly faced by v at the end of $t = 2$. If v faces $h^2 \in \underline{H} = \{\, (0, \underline{\theta}y, \underline{\theta}y)\,,\, (b, \overline{\theta}y, \underline{\theta}y - \underline{\theta}(1 + r)b)\,,\, (b, \overline{\theta}y, \overline{\theta}y - \underline{\theta}(1 + r)b) \,\}$, then $\pi_3(h^2) = 0$, as each g_2 embedded in this set of histories is strictly less than what a $\overline{\theta}$–type would produce. On the other hand, if $h^2 \in \overline{H} = \{\, h^2 \in \underline{H}^c : h^2 \neq (0, \underline{\theta}y, \overline{\theta}y) \,\}$ it follows that $\pi_3(h^2) = 1$ because each second-period public good outcome arising from these histories is infeasible for the $\underline{\theta}$–type. Finally, if $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$, and since $\overline{\theta}y = g(0, \overline{\theta}; 0) = g(b, \underline{\theta}; 0)$, then v cannot distinguish whether this history is the result of a productivity shock according to the Markov process followed by θ_t or the consequence of unobserved borrowing, and therefore, because of Bayesian consistency, any $\sigma_2^p(h^1, \theta_2) > 0$ induces beliefs $\mu_3(h^2)$ that lie in the interior of $\Delta(\Theta)$. □

By Lemma 1 then, we can express the set of public histories possibly faced by the voter before the election as the partition $\overline{H} \bigcup \underline{H} \bigcup \{(0, \underline{\theta}y, \overline{\theta}y)\,\}$, where $\overline{H}$ corresponds to histories that reveal the presence of a productive incumbent, and histories in $\underline{H}$ reveal an unproductive type in office.

Consider now the following partition of the space of nonpecuniary rents of politicians: $(e(\overline{\theta}), e(\underline{\theta})) \in \mathbb{R}_+^2 \;=\; A \bigcup B \bigcup C$, where

$$
\begin{aligned}
A =& \{\, (e(\overline{\theta}), e(\underline{\theta})) \in \mathbb{R}_+^2 \,:\, e(\overline{\theta}) < \overline{e},\ \varepsilon e(\overline{\theta}) + (1 - \varepsilon) e(\underline{\theta}) < \underline{e} \},\\
B =& \{\, (e(\overline{\theta}), e(\underline{\theta})) \in \mathbb{R}_+^2 \,:\, e(\overline{\theta}) \geq \overline{e} \;\forall\, e(\underline{\theta}) \,\},\\
C =& \{\, (e(\overline{\theta}), e(\underline{\theta})) \in \mathbb{R}_+^2 \,:\, e(\overline{\theta}) < \overline{e},\ \varepsilon e(\overline{\theta}) + (1 - \varepsilon) e(\underline{\theta}) \geq \underline{e} \},
\end{aligned}
$$

and the thresholds $\underline{e}$, $\overline{e}$ are defined by

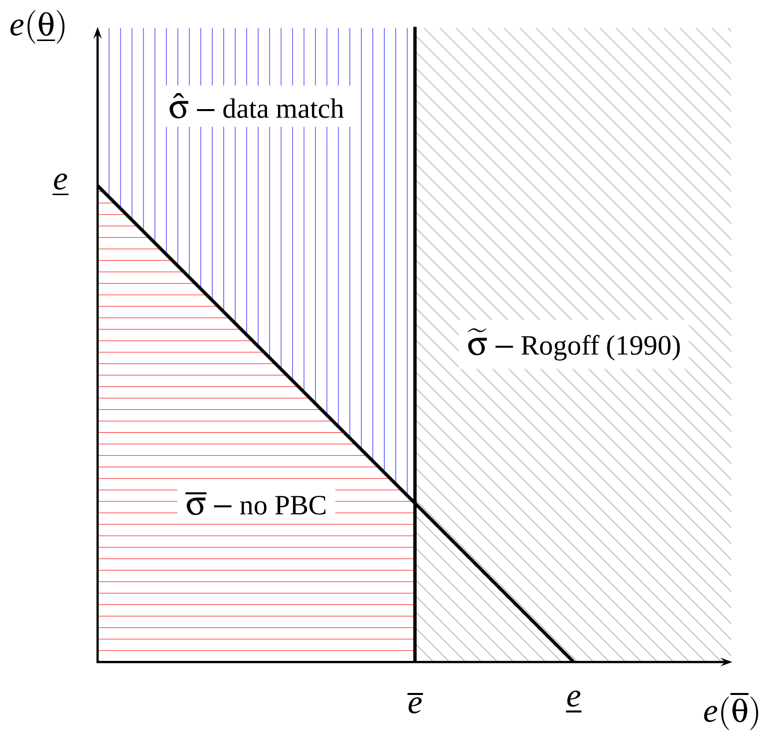
$$
\begin{aligned}
\underline{e} &= (\overline{\theta} - \underline{\theta})(y - (1 + r)b),\\
\overline{e} &= r\overline{\theta}b - (1 - \rho)(\overline{\theta} - \underline{\theta})y.
\end{aligned}
$$

The number $\underline{e}$ reflects the amount of ego rents that makes a $\underline{\theta}$–type indifferent between facing a low production of public goods after being reelected or enjoy a high amount of public goods as a citizen ousted from office; that is $\underline{e} + g(0, \underline{\theta}; b) = g(0, \overline{\theta}; b)$. The number $\overline{e}$ on the other hand, indicates the amount of ego rents that exactly compensate a $\overline{\theta}$–type from the interest payments he would face as a reelected incumbent after election-year borrowing.

One particular area deserves special attention. The set of nonpecuniary rents C reflects that elections are high-stake tests for unproductive politicians only. Its rationale builds from the work of Caselli and Morelli (2004), which puts forward the argument that market and political skills are positively correlated, and then productive politicians may disregard the perks of holding office because they may opt to higher rents in the private sector, a point also illustrated by Besley (2005). Additionally, highly productive politicians may be willing to pursue spells in public office in the first place as a showcase to make their skills publicly known, as Mattozzi and Merlo (2008) point out. This reasoning finds support in the evidence of Diermeier, Keane, and Merlo (2005) who use data of the U.S. Congress and find that reelections increase future market wages of politicians in a substantial manner.

As I describe and prove in propositions 1–4, the thresholds of nonpecuniary rents $\overline{e}$ and $\underline{e}$—and the corresponding partition (A, B, C)—give rise to different equilibrium outcomes: one that features no PBCs, one that captures Rogoff's (1990) equilibrium, and finally an equilibrium based on rents belonging to C that matches of evidence described in § 1.1. These equilibria are shown in Figure 1.1.

Figure 1.1: Equilibrium strategies as a function of rents



The strategy profile $\overline{\sigma}$ corresponds to a sequential equilibrium of Γ where no politician ever borrows, because nonpecuniary rents in the set A are not enough to compensate incumbents for interest payments in the case of the $\overline{\theta}$–type, or lower future public goods in the case of the $\underline{\theta}$–type.

Proposition 1. *If* $(e(\overline{\theta}), e(\underline{\theta})) \in A$*, then* $\overline{\sigma}$ *is the unique sequential equilibrium of* Γ*, where*

$$\overline{\sigma}_t^p(h_p^{t-1}, \theta_t) = \; 0 \quad \forall\, t,\; h_p^{t-1},\; \theta_t.$$

$$\overline{\sigma}_3^v(h^2) = \begin{cases} 0 & \textit{if } h^2 \in \underline{H}, \\ 1 & \textit{if } h^2 \in \overline{H} \bigcup \{(0, \underline{\theta}y, \overline{\theta}y)\}. \end{cases}$$

Proof. Consider v's strategy. Under Assumption 1.1, it is optimal for v to fire the incumbent after observing public histories $h^2 \in \underline{H}$ and reelect in the case that $h^2 \in \overline{H}$. Since the incumbent will never borrow under $\overline{\sigma}^p$, v is sure to be facing a $\overline{\theta}$–type if observes $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$. Thus, $\overline{\sigma}^v$ is optimal. On the other hand, since $(e(\overline{\theta}), e(\underline{\theta})) \in A$ it is never profitable for the incumbent to borrow before the election, regardless of his type. In effect, in the case of the $\overline{\theta}$–type, since $\overline{\sigma}^v$ awards reelection after $h^2 \in \overline{H} \bigcup \{(0, \underline{\theta}y, \overline{\theta}y)\}$, productive incumbents may avoid interest payments and still be reelected with probability one.

In the case of the $\underline{\theta}$–type, if he borrows he gets for sure ego rents $\varepsilon e(\overline{\theta}) + (1-\varepsilon)e(\underline{\theta})$, but since he also faces interest payments and $(e(\overline{\theta}), e(\underline{\theta})) \in A$, it follows that $a_2^p = b$ is strictly dominated by zero borrowing. The optimality of no borrowing in the first period follows from the same logic as in $t = 2$ for the both types.

Concerning uniqueness, suppose there is another equilibrium $\overline{\sigma}'$. In the case of the voter, under Assumption 1.1, $\overline{\sigma}_3^v{}'(h^2) = \overline{\sigma}_3^v(h^2)\ \forall\, h^2 \in \underline{H} \bigcup \overline{H}$. If $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$, then—under $(e(\overline{\theta}), e(\underline{\theta})) \in A$—there is no optimal strategy $\overline{\sigma}^p{}'$ specifying a positive probability of borrowing, and then it is also the case that $\overline{\sigma}_3^v{}'(h^2) = \overline{\sigma}_3^v(h^2)$ for $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$. Suppose finally that $\overline{\sigma}^p{}' \neq \overline{\sigma}^p$. This implies that borrowing is optimal for some type under some history of events, but then it must be the case that ego rents compensate an incumbent after election-year borrowing, which contradicts the fact that $(e(\overline{\theta}), e(\underline{\theta})) \in A$. Hence $\overline{\sigma}' = \overline{\sigma}$. □

The strategy profile $\widetilde{\sigma}$ in Figure 1.1 captures the essence of Rogoff's (1990) equilibrium. In this case, the $\overline{\theta}$–type increases election-year spending to separate himself from the unproductive type. As the $\underline{\theta}$–type foresees separation, he decides not to borrow and so avoid interest payments after being fired. This equilibrium is sustained by the decision of the voter of conceding reelection only to histories in $\overline{H}$, which encourages the $\overline{\theta}$–type to borrow and is consistent with the fact that such type gets sufficient ego rents to make up for interest payments after reelection.

Proposition 2. *If $(e(\overline{\theta}), e(\underline{\theta})) \in B$ then $\widetilde{\sigma}$ is the unique sequential equilibrium of*

Γ, *where*

$$\widetilde{\sigma}_t^p(h_p^{t-1}, \theta_t) = \begin{cases} 0 & \textit{if } t = 1 \,\forall\, \theta_1, \\ 0 & \textit{if } \theta_2 = \underline{\theta}, h_p^1 = (a_1^p, \underline{\theta}) \,\forall\, a_1^p, \\ 0 & \textit{if } \theta_2 = \overline{\theta}, h_p^1 = (a_1^p, \overline{\theta}) \,\forall\, a_1^p, \\ 1 & \textit{if } \theta_2 = \overline{\theta}, h_p^1 = (a_1^p, \underline{\theta}) \,\forall\, a_1^p. \end{cases}$$

$$\widetilde{\sigma}_3^v(h^2) = \begin{cases} 0 & \textit{if } h^2 \in \underline{H} \bigcup \{(0, \underline{\theta}y, \overline{\theta}y)\}, \\ 1 & \textit{if } h^2 \in \overline{H}. \end{cases}$$

Proof. Consider v's strategy. Since $\overline{\theta}$ is absorbing, it is optimal for v to reelect incumbents after public histories $h^2 \in \overline{H}$. Under Assumption 1.1, instead, it is optimal for v to fire incumbents when observing $h^2 \in \underline{H}$. Now consider $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$. Such history is feasible for any type, but under $\widetilde{\sigma}^p$ it can be only the result of an unproductive incumbent. In this case, v's action prescribed by $\widetilde{\sigma}^v$, $a_3^v = f$, is optimal.
Now consider p's strategy. In the first period no incumbent is willing to borrow: if $\theta_1 = \overline{\theta}$, then no extra borrowing is necessary for such incumbent to reveal his type, and if $\theta_1 = \underline{\theta}$, then such politician prefers not to face interest payments because he will be ousted from office anyways. If $h_p^1 = (a_1^p, \underline{\theta})$ and $\theta_2 = \overline{\theta}$, then p's expected utility is given by

$$E^{\widetilde{\sigma}} \sum_{t=2}^{3} u_t^p = \begin{cases} \overline{\theta}y + (\rho\overline{\theta} + (1-\rho)\underline{\theta})y & \text{if } a_2^p = 0, \\ \overline{\theta}(y+b) + \overline{\theta}(y - (1+r)b) + e(\overline{\theta}) & \text{if } a_2^p = b. \end{cases}$$

Since $e(\overline{\theta}) \geq \overline{e}$ it follows that $\widetilde{\sigma}_2^p(h_p^1, \overline{\theta}) = 1$ is optimal. If $\theta_2 = \underline{\theta}$ after $h_p^1 = (a_1^p, \underline{\theta})$, since $\widetilde{\sigma}^v(h^2) = 0$ after $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$, if follows that it is optimal for p not to borrow as $\widetilde{\sigma}^p$ indicates. Finally, since a productive-born type automatically generates public histories $h^2 \in \overline{H}$, it is optimal for him to set $a_1^p = 0$. Uniqueness follows from the same steps in Proposition 1 under $(e(\overline{\theta}), e(\underline{\theta})) \in B$. $\square$

Now, consider the strategy profile $\hat{\sigma} = (\hat{\sigma}^p, \hat{\sigma}^v)$, defined as follows

$$\hat{\sigma}_t^p(h_p^{t-1}, \theta_t) = \begin{cases} 0 & \text{if } t = 1 \ \forall\, \theta_1, \\ 0 & \text{if } \theta_2 = \overline{\theta} \ \forall\, h_p^1, \\ 0 & \text{if } \theta_2 = \underline{\theta}, h_p^1 = (b, \underline{\theta}), \\ \hat{\lambda}_p & \text{if } \theta_2 = \underline{\theta}, h_p^1 = (0, \overline{\theta}). \end{cases}$$

$$\hat{\sigma}_3^v(h^2) = \begin{cases} 0 & \text{if } h^2 \in \underline{H}, \\ 1 & \text{if } h^2 \in \overline{H}, \\ \hat{\lambda}_v & \text{if } h^2 = (0, \underline{\theta}y, \overline{\theta}y), \end{cases}$$

where

$$\hat{\lambda}_p = \frac{\varepsilon(1-\rho)y}{(1-\varepsilon)(\rho-\varepsilon)(y-R)} \in (0,1), \tag{1.3}$$

$$\hat{\lambda}_v = \frac{(\,\rho\overline{\theta} + (1-\rho)\underline{\theta}\,)R - (\overline{\theta}-\underline{\theta})y}{(1-\varepsilon)X - (\overline{\theta}-\underline{\theta})(\rho-\varepsilon)(y-R)} \in (0,1). \tag{1.4}$$

This strategy profile establishes one the one hand that productive politicians never borrow, and the other that all of those unproductive-born incumbents that keep their type borrow right before elections. In other words, $\hat{\sigma}^p$ induces a political budget cycle that is exclusively generated by unproductive politicians. In the case of the voter, $\hat{\sigma}^v$ calls for reelection of productive incumbents in the event in which v may infer types, that is, in the case in which $h^2 \in \underline{H} \bigcup \overline{H}$. If the voter, however, faces the non-revealing public history $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$, then $\hat{\sigma}^v$ prescribes randomization at the polls. As the following result shows, if the possibility that an unproductive politician becomes productive is sufficiently unlikely, then the strategy profile $\hat{\sigma}$ actually corresponds to equilibrium behavior.

Proposition 3. *If* $(e(\overline{\theta}), e(\underline{\theta})) \in C$ *then* $\exists\, \overline{\varepsilon} > 0 : \ \forall \varepsilon \in (0, \overline{\varepsilon}),\ (\hat{\sigma}, \hat{\mu})$ *is a sequential equilibrium of* Γ*.*

Proof. Consider first v's strategy. If $h^2 \in \underline{H}$, Lemma 1 implies $\hat{\pi}_3(h^2) = \Pr(\theta_2 = \overline{\theta} \mid h^2) = 0$, and then Assumption 1.1 entails that it is optimal for v playing the pure strategy $a_3^v = f$, because it is more likely to select a $\overline{\theta}$–type from a new draw than expect a productivity switch of the incumbent. If $h^2 \in \overline{H}$, then $\hat{\pi}_3(h^3) = 1$, and since $\overline{\theta}$ is an absorbing state, it follows that setting $a_3^v = k$ is the best response by v. When v faces the unique non-revealing history $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$, his expected utility is

$$E^{\hat{\sigma},\hat{\mu}} u_3^v = \begin{cases} \hat{\pi}_3 \overline{\theta} y + (1-\hat{\pi}_3) E_\varepsilon \theta (y - (1+r)b) & \text{if } a_3^v = k, \\ \hat{\pi}_3 E_\rho \theta y + (1-\hat{\pi}_3) E_\rho \theta (y - (1+r)b) & \text{if } a_3^v = f, \end{cases} \tag{1.5}$$

where $E_j\theta \equiv j\overline{\theta} + (1-j)\underline{\theta},\ j = \rho, \varepsilon$. Bayesian consistency of beliefs $\hat{\mu}_3(h^2) = (\hat{\pi}_3, 1-\hat{\pi}_3) \in \Delta(\Theta)$ requires

$$\hat{\pi}_3 = \frac{\varepsilon}{\varepsilon + (1-\varepsilon)\hat{\lambda}_p},$$

and then, given (1.3), v ends up indifferent between keeping or firing the incumbent, and therefore randomization is a sequentially rational move after h^2. Hence, given $\hat{\mu}$, $\hat{\sigma}^v$ is optimal.

On p's side, if $\theta_t = \overline{\theta}$, it follows that borrowing in any period is a strictly dominated strategy. In effect, given that $\overline{\theta}$ is an absorbing state, $e(\overline{\theta}) = 0$, and $r > 0$, each time the $\overline{\theta}$–type borrows his payoff is reduced by $rb > 0$, and therefore $\hat{\sigma}_t^p(h_p^{t-1}, \overline{\theta}) = 0$ is a best response, regardless of the evolution of the game. If $\theta_1 = \underline{\theta}$, $\hat{\sigma}^p$ calls for $a_1^p = 0$. If p deviates nonetheless, according to Lemma 1, he generates revealing histories that will drive him with probability one to be either fired or reelected, depending on his second-period type. The value of the deviation

$a_1^p = b$ by the $\underline{\theta}$–type is then[5]

$$\Delta(\varepsilon) \equiv \Lambda(\overline{\theta} - \underline{\theta}) - \left\{ \left(\varepsilon\overline{\theta} + (1-\varepsilon)\underline{\theta}\right)(1+r)b + (1-\varepsilon)^2\hat{\lambda}_v X \right\}.$$

The first term on the RHS represents the expected benefit of the deviation, while the term in curly brackets represents its expected cost. Since $\varepsilon e(\overline{\theta}) + (1-\varepsilon)e(\underline{\theta}) > \underline{e}$, it follows from Assumption (1.2) that $\lim_{\varepsilon \to 0} \Delta(\varepsilon) < 0$, and since $\Delta : (0,1) \to \mathbb{R}$ is a continuous function, then there exists a neighborhood $N_{\overline{\varepsilon}}(0)$ such that $\Delta(\varepsilon) < 0$ for each $\varepsilon \in (0, \overline{\varepsilon})$. Roughly speaking, since the $\underline{\theta}$–type at $t = 1$ foresees that it is very likely that he will keep his type during the next term, and that he does not lose to much g if reelected ($\underline{\theta} > \chi\,\overline{\theta}$), then his best response is borrowing just before the election to try to get the political rent X. In the event, however, in which a $\underline{\theta}$–type borrows in the first period and does not change his type, his best response at $t = 2$ is not borrowing, because under Lemma 1 he will be dismissed, and in such contingency he prefers to avoid interest payments at $t = 3$.

Finally, if a $\underline{\theta}$–type followed $\hat{\sigma}^p$ in the first period and also keeps his type for the second period, then—given (1.4)—p is indifferent between borrowing or not, and thus willing to randomize during $t = 2$. Hence $\hat{\sigma}^p$ is optimal and consequently $(\hat{\sigma}, \hat{\mu})$ is a sequential equilibrium. □

Proposition 4. *For* $(e(\overline{\theta}), e(\underline{\theta})) \in C$ *and* $\varepsilon \in (0, \overline{\varepsilon})$, $(\hat{\sigma}, \hat{\mu})$ *is unique.*

Proof. Suppose there is another sequential equilibrium $(\sigma, \mu) \in \Sigma \times \Delta(\Theta)^3$. Consider σ^v first. By Lemma 1, if $h^2 \in \underline{H} \bigcup \overline{H}$, then v plays pure strategies because he knows which θ_2–type is actually facing. If $h^2 \in \underline{H}$, then Assumption 1.1 implies $\sigma_3^v(h^2) = 0$, and if $h^2 \in \overline{H}$, then $\sigma_3^v(h^2) = 1$, because $\overline{\theta}$ is absorbing.

Now assume that v faces $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$ instead. Suppose that $\sigma_3^v(h^2)$ calls for the

[5] Where

$$\Lambda \equiv \left\{ y + \varepsilon(1-\hat{\lambda}_v)(1-\rho)y + (1-\varepsilon)\hat{\lambda}_v(\rho - \varepsilon)(y - \hat{\lambda}_p(1+r)b) + (1-\varepsilon)\hat{\lambda}_p(E_\rho\theta(1+r) - \underline{\theta})\frac{y}{\underline{\theta}} \right\}.$$

pure strategy $a_3^v = f$. In this case, a $\underline{\theta}$–type would prefer not borrow so as to avoid interest payments when thrown out of office. Therefore, $h^2 = (0, \underline{\theta}y, \overline{\theta}y)$ would be the result of a productivity shock, and then, since v would be facing unequivocally a $\overline{\theta}$–type, $a_3^v = f$ is not optimal. If $\sigma_3^v(h^2)$ requires $a_3^v = k$ instead, then—since $\varepsilon e(\overline{\theta}) + (1-\varepsilon)e(\underline{\theta}) \geq \underline{e}$—a productive type plays $a_2^p = b$ with probability one. Hence, according to Bayes' rule, the probability that v faces a $\overline{\theta}$–type—given that a $\overline{\theta}$-type does not borrow—is $\pi_3(h^2) = \varepsilon$. Under this beliefs, and $(e(\overline{\theta}), e(\underline{\theta})) \in C$, the optimal strategy for v is $a_3^v = f$. As a result σ^v must involve a mixed strategy, but then v must be indifferent between keeping or firing p, and the only way this happens is when $\sigma_2^p((0, \underline{\theta}y), \underline{\theta})$ equals $\hat{\lambda}_p$.

On p's side, if $\theta_t = \overline{\theta}$, then σ^p must specify no borrowing for each t, as it is the case of $\hat{\sigma}^p$, because $r > 0$, $\overline{\theta}$ absorbing, and $e(\overline{\theta}) = 0$, imply that each loan cuts p's payoff by $rb > 0$.

If a $\underline{\theta}$–type borrows in the first period then he induces revealing histories that trigger pure-strategy responses by v, which in turn will induce no borrowing in the second period by p, regardless of his type. Since $\sigma_2^p((0, \underline{\theta}y), \underline{\theta}) = \hat{\lambda}_p$, it follows that p's expected gain of playing $a_1^p = b$ instead of $a_1^p = 0$ is given by $\Delta(\epsilon)$, possibly for a different $\hat{\lambda}_v$. But even if the probability of reelection is different, (1.2) implies $\Delta(\overline{\varepsilon}) < 0$, so $a_1^p = b$ is not optimal.

Finally, suppose σ^p calls for the pure strategy $a_2^p = b$ for a $\underline{\theta}$–type. After the history $h^1 = (0, \underline{\theta}y)$, the strategy $\sigma_2^p(h^1, \underline{\theta}) = 1$ induces beliefs $\pi_3(h^1, \overline{\theta}y) = \varepsilon$, that in turn force v to play the pure strategy $a_3^v = f$, which thereby breaks the optimality of setting $a_2^p = b$ with probability one. On the contrary, if $\sigma_2^p(h^1, \underline{\theta}) = 0$, then Bayes' rule implies $\pi_3(h^1, \overline{\theta}y) = 1$, and therefore v plays the pure strategy $a_3^v = k$, but this move again contradicts the optimality of the pure strategy $a_2^p = 0$. Consequently, $\sigma_2^p(h^1, \underline{\theta})$ must comprise a mixed strategy, which is only the case when p is indifferent, and that occurs exclusively when $\sigma_2^p(h^1, \underline{\theta}) = \hat{\lambda}_v$. In sum, $(\sigma, \mu) = (\hat{\sigma}, \hat{\mu})$. □

1.3.1 Multiple Elections

As it is hitherto formulated, the game Γ depicts a one-shot election, but it can be equivalently considered as a single piece from an infinite-horizon endowment economy with elections every other period, where there is a term limit on incumbent reelection. Hence, every time that a fresh incumbent jumps into office the game Γ ensues.

Consider the evidence that could be generated by the sequential equilibrium profile $\hat{\sigma}$. There are three possible combinations of types before an election, and each of those give rise to different equilibrium actions specified by $\hat{\sigma}$. In the case of permanently unproductive incumbents $(\theta_1, \theta_2) = (\underline{\theta}, \underline{\theta})$—which sum $(1-\rho)(1-\varepsilon)$—they increase spending with probability $\hat{\lambda}_p$ before the election, say from 1 to 2, and this generates an amount of public goods $(g_1, g_2) = (\underline{g}, \overline{g})$, where $\overline{g}$ denotes a high amount of public goods. In Table 1.1 I show spending, output and probability of reelections generated by the equilibrium $\hat{\sigma}$.

Table 1.1: Empirical evidence induced by $\hat{\sigma}$.

Types	Quantity	Spending	Output	Prob. re-election
$(\underline{\theta}, \underline{\theta})$	$(1-\rho)(1-\varepsilon)$	$\hat{\lambda}_p$: (1,2)	$(\underline{g}, \overline{g})$	$\hat{\lambda}_v$
		$(1-\hat{\lambda}_p)$: (1,1)	$(\underline{g}, \underline{g})$	0
$(\underline{\theta}, \overline{\theta})$	$(1-\rho)\varepsilon$	(1,1)	$(\underline{g}, \overline{g})$	$\hat{\lambda}_v$
$(\overline{\theta}, \overline{\theta})$	ρ	(1,1)	$(\overline{g}, \overline{g})$	1

If an econometrician observes data from Table 1.1 and runs a probit regression between reelections and government spending, he would obtain that the probability of reelection for incumbents conditional on flat spending, that is, without political budget cycles, is given by

$$\Pr(\text{ re-election} \mid \text{spending } (1{,}1)\ ) = \frac{\hat{\lambda}_v(1-\rho)\varepsilon + \rho}{(1-\rho)(1-\varepsilon)(1-\hat{\lambda}_p) + (1-\rho)\varepsilon + \rho}. \quad (1.6)$$

In the following table I show that for parameter values satisfying Assumptions 1.1–1.2 and rents $(e(\overline{\theta}), e(\underline{\theta})) \in C$, the equilibrium $\hat{\sigma}$ matches fact (*iii*) in § 1.1, i.e. an incumbent that generates a political budget cycle may face the same probability of reelection as if spending had been flat. This is a result for developing countries because—as § 1.4 will show—I am still implicitly assuming that additional information regarding incumbents is unaffordable for the voter, a fact that is associated with developing countries.

The intuition behind the result in Table 1.2 lies in the different information sets between the voter and the econometrician. Suppose that there was a low amount of public good in $t = 1$. Now, when the voter attends the polls, he merely knows the current amount of public goods g_2. If before the election there is a higher amount of public goods, the voter does not know whether spending increased—i.e. a PBC occured—or there was a productivity improvement, and thus randomizes according to (1.4). This is not the case for econometrician, who is capable of incorporating information regarding spending in his regressions and therefore automatically spots election-year extra spending to calculate (1.6).

Table 1.2: Calibration.

	$\overline{\theta}$	$\underline{\theta}$	ε	ρ	y	τ	r
Parameters	1	0.7	0.15	0.4	1.15	1	0.1
Results	Pr(re-election | spending (1,1)) $= \hat{\lambda}_v = 0.79$						

1.4 Information Acquisition

The main thrust of the evidence uncovered by Brender and Drazen (2005, 2008) and Shi and Svensson (2006) is that political budget cycles do not occur evenly across countries. In particular, Shi and Svensson (2006) and Brender and Drazen (2008) draw a complimentary picture: on the one hand Shi and Svensson (2006) argue that political budget cycles belong mostly to developing countries, and on the other Brender and Drazen (2008) shows that the probability of reelection for an incumbent of a less developed country is not affected by PBCs; it is in developed countries where incumbents are punished at the polls if they increase fiscal deficits in election years.

This evidence is at odds with voter's response of Rogoff's equilibrium. In effect, if the random part of voter's utility in such formulation is left aside, then the political budget cycle is accompanied by assured reelection for the incumbent, but this fact is not supported by the data (Brender and Drazen (2008)). The evidence does suggest, in turn, that as countries get richer they tend to monitor more closely the performance of incumbents. This vision is also embraced by the experimental evidence summarized by Pande (2011), which shows that poor-country voters struggle to select able incumbents because they cannot afford information. Furthermore, when they are exogenously endowed with the relevant information they, for instance, remove corrupt incumbents from office.

1.4.1 Exogenous Signals

From now on I assume that $(e(\overline{\theta}), e(\underline{\theta})) \in C$. Building from all of these insights and from the work of Persico (2000); Martinelli (2006) and Amir and Lazzati (2011), I modify the game of the previous section by giving v the possibility of getting partially informed regarding p's hidden action, so as to investigate the fate of the political budget cycle and voter's equilibrium behavior as more information is accessed.

Suppose that after the history $h^1 = (0, \underline{\theta} y)$—i.e. a public record of low first-period public good—player v has the option of buying a signal that conveys information about p's second-period action at some cost. Since a_2^p is privately known, v appraises p's action as a random variable $\widetilde{a} \in A_p$. Let the signal s be a A_p-valued random variable and, as in Martinelli (2006), assume

$$\Pr(s(\eta) = \omega \,|\, \widetilde{a} = \omega) = \frac{1}{2} + \eta, \quad \omega \in A_p,\, \eta \in [0, 0.5]\,.$$

In other words, the signal s is right with probability $0.5 + \eta$, and hence the parameter η determines the precision of $s(\eta)$. The cost of such accuracy is given by a linear function $C : [0, \frac{1}{2}] \to \mathbb{R}_+$, where $C(0) = 0$.

In this modified environment thus, the history $h^1 = (0, \underline{\theta} y)$ induces a subgame where player v must decide the precision of the signal $s(\eta)$ before making his choice $a_3^v \in \{k, f\}$, and consequently player p must take into account such choice of η when deciding his own action a_2^p.

For example, in the extreme case in which hidden borrowing is perfectly detected by the signal, player p prefers not borrow before the election so as to avoid interest payments under a certain dismissal arising from Assumption 1.1.
Suppose first that v is publicly and exogenously endowed with $\eta \in (0, \frac{1}{2})$. Then, in the subgame after $h^1 = (0, \underline{\theta} y)$ and after observing $s(\eta) \in \{0, b\}$, a strategy for v is a probability of reelection $\phi^v : \{0, b\} \to [0, 1]$, and a strategy for p is a probability of borrowing $\phi^p(\eta, \cdot\,) : \Theta \to [0, 1]$. Consider the strategy profile $\phi = (\phi^p, \phi^v) \in \Phi$, defined by

$$\phi^p(\eta, \theta_2) = \begin{cases} 0 & \text{if } \theta_2 = \overline{\theta}, \\ \lambda_p(\eta) & \text{if } \theta_2 = \underline{\theta}. \end{cases}$$

$$\phi^v(s(\eta)) = \begin{cases} 0 & \text{if } s(\eta) = b, \\ \lambda_v(\eta) & \text{if } s(\eta) = 0, \end{cases}$$

where $\lambda_p(\eta)\,,\lambda_v(\eta) \in (0,1)$ are given by

$$\lambda_p(\eta) = \frac{(\frac{1}{2}+\eta)(1-\rho)y}{(1-\varepsilon)\left(\,(\frac{1}{2}+\eta)(1-\rho)y + (\frac{1}{2}+\eta)(\rho-\varepsilon)(y-(1+r)b)\,\right)}, \tag{1.7}$$

$$\lambda_v(\eta) = \frac{E_\rho\theta y - (\overline{\theta}-\underline{\theta})y}{(\frac{1}{2}-\eta)(E_\varepsilon\theta(y-(1+r)b) + \varepsilon e(\overline{\theta}) + (1-\varepsilon)e(\underline{\theta}))}. \tag{1.8}$$

The strategy profile ϕ resembles its no-information counterpart of Proposition 3. Now an unproductive incumbent still attempts to generate a budget cycle, but voter behavior is slightly different: v randomizes only if the signal he gets indicates that p is not borrowing. As the following result shows, the profile ϕ conforms to equilibrium behavior and more importantly, there is a threshold of quality of information such that after that point voter's monitoring over the incumbent is sufficiently tight to deter any election-year spending, which causes the elimination of PBCs.

Proposition 5. $\exists\, \overline{\eta} < \frac{1}{2}$: *for each* $\eta \in (0, \overline{\eta})$, ϕ *is a Bayesian equilibrium of the subgame after* $h^1 = (0, \underline{\theta}y)$.

Proof. Consider p's strategy. As in the case of no information acquisition by v, the optimal strategy of a $\overline{\theta}$–type is $a_2^p = 0$ because his payoff is certainly reduced by $rb > 0$ each time he borrows. In the case of the $\underline{\theta}$–type, however, his expected utility of borrowing is given by

$$E^{\phi\,,s}\sum_{t=2}^{3} u_t^p \;=\; \overline{\theta}y + \left(\frac{1}{2}-\eta\right)\lambda_v(\eta)\left(\,E_\varepsilon\theta(y-(1+r)b) + e(\overline{\theta}) + (1-\varepsilon)e(\underline{\theta})\,\right),$$

while if $a_2^p = 0$, p gets $\underline{\theta}y + E_\rho\theta y$. When v randomizes with probability $\lambda_v(\eta)$ after observing $s(\eta) = 0$, then p is indifferent and prone to randomize as ϕ^p describes. This only works for a maximal amount $\overline{\eta}$, after which the expected utility of borrowing is strictly lower than setting $a_2^p = 0$.

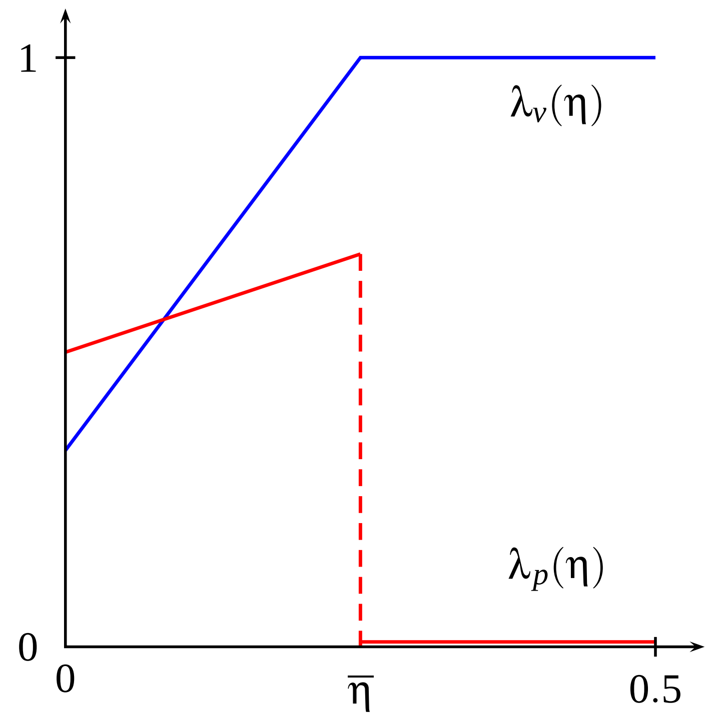
Now consider ϕ^v, and suppose first that $s(\eta) = 0$. In this case, v's posterior beliefs are given by

$$\Pr(\widetilde{a} = 0 | s(\eta) = 0) = \frac{(\frac{1}{2} + \eta)\,(\,\varepsilon + (1-\varepsilon)(1-\lambda_p(\eta))\,)}{(\frac{1}{2} + \eta)\,(\,\varepsilon + (1-\varepsilon)(1-\lambda_p(\eta))\,) + (\frac{1}{2} - \eta)(1-\varepsilon)\lambda_p(\eta)}.$$

From equation (1.5), v is indifferent if $\Pr(\widetilde{a} = 0|s(\eta) = 0)(1-\rho)y = \Pr(\widetilde{a} = b|s(\eta) = 0)(\rho - \varepsilon)(y - R)$, and this is actually the case when p borrows with probability $\lambda_p(\eta)$. Therefore randomization after $s(\eta) = 0$ is optimal for v. On the other hand, if $s(\eta) = b$, then $v's$ posterior beliefs make $a^v = k$ a strictly dominated strategy for each signal quality, and thus it is optimal for v to fire p with probability one, as ϕ^v describes. The uniqueness of ϕ follows from the proof of Proposition 4. $\square$

Figure 1.2 shows the probabilities of borrowing by the $\underline{\theta}$–type and the probability of reelection after $s(\eta) = 0$. When the voter is endowed with a quality of information $\eta \geq \overline{\eta}$, the unproductive politician is deterred from borrowing and thus any increase in election-year public goods arise from productivity shows. In this case political budget cycles no longer surge in equilibrium.

Figure 1.2: Equilibrium profiles as a function of η.



By Lemma 1, the history $h^1 = (0, \underline{\theta} y)$ is the only contingency of the game Γ in which v would use $s(\eta)$. If we incorporate the presence of the—still exogenously given—signal into the strategy profile σ of Proposition 3, we may define $\varphi = (\varphi^p, \varphi^v) \in \Sigma$, where

$$\varphi_t^p(\eta, h_p^{t-1}, \theta_t) = \begin{cases} 0 & \text{if } \theta_t = \overline{\theta}\,\forall\, t, h_p^{t-1} \;\text{ or }\; \theta_1 = \underline{\theta}, \\ 0 & \text{if } (h_p^1, \theta_2) = (\,(b, \underline{\theta})\,, \underline{\theta}), \\ \lambda_p(\eta) & \text{if } (h_p^1, \theta_2) = (\,(0, \underline{\theta})\,, \underline{\theta}). \end{cases}$$

$$\varphi_3^v(s(\eta), h^2) = \begin{cases} 0 & \text{if } h^2 \in \underline{H},\, \forall\, s(\eta) \\ 1 & \text{if } h^2 \in \overline{H},\, \forall\, s(\eta) \\ 0 & \text{if } h^2 = (0, \underline{\theta} y, \overline{\theta} y) \;\text{ and }\; s(\eta) = b, \\ \lambda_v(\eta) & \text{if } h^2 = (0, \underline{\theta} y, \overline{\theta} y) \;\text{ and }\; s(\eta) = 0. \end{cases}$$

The difference between σ and φ lies in $\lambda_\iota(\eta)$, $\iota \in \{p, v\}$, and in the use of information by v and its corresponding effect on p's action. Denote $\Gamma(\eta)$ the game where v is endowed with a signal of precision η. The following result shows that a political budget cycle is still an equilibrium outcome even in the presence of informed voters.

Proposition 6. *For each $\eta \in (0, \overline{\eta})$, φ is the unique sequential equilibrium of $\Gamma(\eta)$.*

Proof. The result follows from Propositions 3–5. □

1.4.2 Endogenous Information

Until now it has been assumed that v is endowed with $s(\eta)$. The exercise, therefore, has been the theoretical counterpart of the studies for developing countries summarized by Pande (2011), where voters are exogenously provided with information regarding politicians' record and where it is also documented that better choices easily follow from higher η.

Since the book of Downs (1957)—and the more recent results of Martinelli (2006)—however, it has been established that non-pivotal voters optimally decide gather no information if they must pay for it. Even if the value of information is positive, once voters take into account the chance of affecting election outcome, they prefer not to buy info at all, or an arbitrarily small amount in the case that garbled info is freely available (Martinelli (2006)).

Building from the work of Harsanyi (1980, 1992), the analysis by Feddersen and Sandroni (2006a,b) shows that a fraction of non-pivotal voters still optimally pay for information out of a sense of civic duty. While in the two-player game $\Gamma(\eta)$ the voter is pivotal by construction, a positive demand for information is still the case even if $v \in [0,1]$ when the *ethical* motive is introduced.

Suppose v must decide the quality of the signal to use after $h^1 = (0, \underline{\theta} y)$. The expected benefit for the voter from buying a signal with precision $\eta \in (0, \frac{1}{2})$ is given by

$$\Pi(\eta;\tau) = \sum_{\omega \in A_p} \sum_{\widetilde{a} \in A_p} \left(g(0, \theta_3; \widetilde{a}, \tau) I_{\{a_v^*\}} \Pr(\widetilde{a}|s(\eta)) \Pr(s(\eta) = \omega) \right),$$

where $\Pr(s(\eta))$ is the prior probability of gazing $s(\eta) = \omega$, $\Pr(\widetilde{a}|s(\eta))$ represents posterior beliefs after each value of $s(\eta) = 0$, and a_v^* represents optimal action for the voter in each contingency. This whole expression depends on τ: the higher the tax rate, the higher the difference of the public good outcomes between different types of incumbents.

The amount of information endogenously determined by v therefore, is the solution to the following program

$$\eta(y) \in \arg\max_{\eta \in [0, \frac{1}{2}]} \Pi(\eta;\tau) - C(\eta).$$

Proposition 7. *$\eta(y)$ is monotone increasing.*

Proof. Since $\Pi : \left(0, \frac{1}{2}\right) \times [0,1] \to \mathbb{R}$ is twice continuously differentiable, by theorem 4 and 6 of Milgrom and Shannon (1994), we just need to check whether Π has increasing differences in $(\eta;\tau)$. In effect, since $\partial\lambda_p(\eta)/\partial y = 0$, it follows that

$$\frac{\partial^2\Pi(\eta;y)}{\partial\eta\partial y} = (\overline{\theta} - E_\varepsilon\theta(1-R'))\Big(q'(\eta)(\widehat{\pi}(\eta) - \widetilde{\pi}(\eta)) + q(\eta)\widehat{\pi}'(\eta)\Big),$$

where $q'(\eta)$ represents the prior probability of gazing $s(\eta) = 0$, $\widehat{\pi} = \Pr(\widetilde{a} = 0|s(\eta) = 0)$, and $\widetilde{\pi} = \Pr(\widetilde{a} = 0|s(\eta) = b)$. By Assumption (1.2), $1 - R' > 0$, and since $\varepsilon \in (0, \overline{\varepsilon})$, it follows that $\widehat{\pi}(\eta) > \widetilde{\pi}(\eta)$, and thus Π has increasing differences. The result follows from the monotonicity theorem in Milgrom and Shannon (1994). □

Propositions 6 and 7 establish that sufficiently rich economies are eventually free of political budget cycles, because voters are allowed to get arbitrarily well informed regarding incumbent performance. The map of this result into actual economies, however, is more subtle. Suppose that $\tau < 1$, so v derives utility from $c = (1-\tau)y - C(\eta)$ units of the consumption good. Since the after-election g is a random variable, it follows from Persico (2000) that the higher the share of the public good in the consumption bundle, the better informed that v gets, because they have more resources at stake.

The evidence of Persson and Tabellini (2003) shows that government spending is higher in economies that are both richer and with a higher fraction of population over 65 years. Since the latter fact is also positively related with income, the evidence, in sum, shows that richer countries have higher g, and then voters of those countries invest more resources in monitoring incumbents.

1.4.3 Data Match

As in § 1.3.1, we can obtain the predictions of $\Gamma(\eta)$ regarding spending, output and probability of reelections generated by the equilibrium φ. These data are shown in Table 1.3.

Table 1.3: Evidence from the model.

Signal	Type	Spending		Prob. re-election
$\eta \leq \overline{\eta}$	$(\underline{\theta}, \underline{\theta})$	$\lambda_p(\eta)$:	(1,2)	$\left(\frac{1}{2} - \eta\right) \lambda_v(\eta)$
		$1 - \lambda_p(\eta)$:	(1,1)	0
	$(\underline{\theta}, \overline{\theta})$		(1,1)	$\left(\frac{1}{2} + \eta\right) \lambda_v(\eta)$
	$(\overline{\theta}, \overline{\theta})$		(1,1)	1
$\eta > \overline{\eta}$	$(\underline{\theta}, \underline{\theta})$	(1,1)		0
	$(\underline{\theta}, \overline{\theta})$	(1,1)		1
	$(\overline{\theta}, \overline{\theta})$	(1,1)		1

The conspicuous feature of Table 1.3 is that PBCs no longer arise in economies with information sufficiently high quality. In other words, there is no variation in spending.

In the data there actually is variation in spending, which implies that to map the equilibrium outcome φ into the data, it must be the case that the set of Developed Countries (DC) is given by

$$\mathrm{DC} = \{\, j \ : \eta_j \geq \overline{\eta} - \delta \,\}, \qquad \text{where } \delta > 0.$$

Let q be the fraction of developed countries below the threshold $\overline{\eta}$, that is

$$q \equiv \frac{|\,\{\, j \ : \ j \in \mathrm{DC}\,, \quad \eta_j < \overline{\eta} \,\}\,|}{|\,\mathrm{DC}\,|}.$$

When an econometrician runs a probit regression between reelection and spending taking into account only Less Developed Countries (LDCs), i.e. countries with

$\eta \leq \overline{\eta}$, he obtains the following probability of reelection conditional on flat spending

$$\Pr(\text{ re-elec } |(1,1)) = \frac{(0.5+\eta)\lambda_v(\eta)(1-\rho)\varepsilon+\rho}{(1-\rho)(1-\varepsilon)(1-\lambda_p(\eta))+(1-\rho)\varepsilon+\rho} \equiv \Phi.$$

And thus we can put together the evidence for DCs and LDCs as in Table 1.4.

Table 1.4: Match with evidence.

Statistic	LDC		DC
Pr(PBC)	$(1-\rho)(1-\varepsilon)\lambda_p(\eta)$	$>$	$q(1-\rho)(1-\varepsilon)\lambda_p(\eta)$
Pr(re-elec | PBC)	$\left(\frac{1}{2}-\eta\right)\lambda_v(\eta)$		$q\left(\frac{1}{2}-\eta\right)\lambda_v(\eta)$
	$\wr\wr$		$\wedge$
Pr(re-elec | PBC)	Φ		$q\Phi+(1-q)(\rho+(1-\rho)\varepsilon)$

Table 1.4 summarizes the results of the paper. It shows that political budget cycles are more likely to occur in LCDs, and since such outcome comes from the equilibrium φ, it follows that such PBCs are caused by hidden borrowing by unproductive politicians. As Table 1.2 shows, we can calibrate the parameters of the game to make the probabilities of reelection under PBC and flat spending equal, as § 1.3.1 describes. Finally, in developed countries, since all of those politicians that generate more public goods in election years are reelected, we obtain that the small fraction q of politicians that generate PBCs in those countries are punished at the polls. This features match evidence (i)–(iii) in § 1.1.

Chapter 2

Sectoral Origin of Aggregate Fluctuations Under Monopolistic Competition

2.1 Introduction

One of the main objectives in the study of business cycles is identifying the driving force behind the regular variations in economic activity. Regarding one of such primitive forces—the occurrence of technology shocks—it has been customary assumed, based on a law of large numbers argument, that only aggregate, economy-wide perturbations are capable of generating business cycle fluctuations.

A fairly recent strand of research, however, has investigated to extent to which aggregate economic fluctuations may be associated with idiosyncratic, sectoral shocks. The papers by Long and Plosser (1983) and Horvath (1998) have provided an important insight in this matter: individual, sectoral perturbations may actually translate into aggregate fluctuations because of the transmission of such individual shocks through input-output linkages into the rest of the economy—even as the numbers of sectors grows unboundedly as in Acemoglu et al. (2012)—and therefore aggregate fluctuations ensue.

While the bulk of the literature on the relevance of sectoral shocks has taken a theoretical approach, the comprehensive study by Foerster, Sarte, and Watson (2011) has shown that sectoral shocks may indeed be empirically associated with the aggregate variability of the US Industrial Production (IP) Index. They build a multisector model calibrated with US data and they show that sectoral shocks may explain up to half of IP growth variability since 1984, but the actual magnitude of such quantitative importance is quite sensitive to the assumptions of the model.

The main thrust from the work by Foerster, Sarte, and Watson (2011), however, is the following: if we want to figure out the fraction of aggregate fluctuations originating from sectoral shocks, we should first build a multisector growth model that fairly represents sectoral technology and market structure.

One of the important empirical features ignored in this line of research about the importance of sectoral perturbations has been the evidence provided by Hall (1986) and Domowitz, Hubbard, and Petersen (1988), which states that US manufacturing data shows signs of noncompetitive markets and increasing returns to scale across many industries. When these empirical insights were embedded by Hornstein (1993) and Rotemberg and Woodford (1995) into a dynamic general equilibrium one-sector growth model, the authors found that monopolistic competition ends up reducing the importance of technology shocks for economic fluctuations. In other words, market structure has been shown to be an important determinant of the effects of technology shocks for output fluctuations in environments composed of a single sector.

Based on this set of arguments, the purpose of this paper is to build a multisector growth model to figure out the quantitative importance of idiosyncratic fluctuations in explaining aggregate business cycles, where the key contribution is to depart from perfectly competitive markets. More specifically, I build a multisector growth model with monopolistic competition for which I obtain a reduced-form factor model as the linearized approximation of its steady state. I then calibrate the input-output matrix to US data and finally obtain the fraction of IP growth variability explained by sectoral shocks between 1972-2007. For this exercise I borrow heavily from the insights given by Foerster, Sarte, and Watson (2011).

Why a non-competitive market structure may matter in a multi-sector model? Suppose a technology shock hits a specific sector. Since producers now face a downward sloping demand, it follows that factor employment and productivity shocks are negatively related. This effect dampens the traditional positive effect of technology shocks on labor demand arising from intertemporal substitution, and therefore I expect the ensuing economy-wide relocation effects of a sectoral perturbation to be lower.

The quantitative results of the paper show that indeed market structure is a relevant, potentially overlooked ingredient in the analysis on the importance of sectoral shocks for aggregate IP fluctuations.

The calibrations show that the presence of monopolistic competition and increasing returns to scale cause a decrease in the fraction of aggregate IP variability explained by sectoral shocks. In particular, for example, when considering the period 1984-2007, the fraction of the standard deviation of the Industrial Production Index explained by sectoral fluctuations falls from 50% to 28%, that is a 44% drop. Moreover, the higher the degree of returns to scale in production, the higher the fraction of IP volatility explained by aggregate shocks.

The rest of the chapter is organized as follows: in section § 2.2 I review the key papers mentioned in this introduction and the quantitative assessment of Foerster, Sarte, and Watson (2011) in particular. In section § 2.3 I review US evidence regarding IP fluctuations since 1972 until 2008. Then in section § 2.4, which is the core of the paper, I present the multisector growth model, I characterize its equilibrium and finally obtain its reduced-form factor model. In section § 2.5 I use US the input-output matrix data to calibrate the reduced form of the model and carry out the quantitative exercises.

2.2 Literature

The research that concerns this paper has two main branches. The first one is about the debate initiated with the work of Horvath (1998) that highlights the theoretical importance of sectoral shocks for aggregate fluctuations. While this mechanism was previously ruled out based on a law of large numbers type of argument, Horvath used the framework of Long and Plosser (1983) to make the point that shocks hitting particular sectors may end up causing aggregate fluctuations due to the interactions caused by intermediate goods transactions across linkages of the input-output matrix of the economy.

While Horvath's argument was contested by Dupor (1999), Horvath showed that as long as the demand of intermediate goods is uneven across sectors, the possibility of aggregate effects of sectoral shocks ensued. This conclusion was also obtained in related formulations by Gabaix (2011) and Acemoglu et al. (2012). In the former if large sectors are hit then aggregate fluctuations follow, and in the latter, depending on the topology of the input-output matrix, sectoral shocks also may cause fluctuations across the whole network.

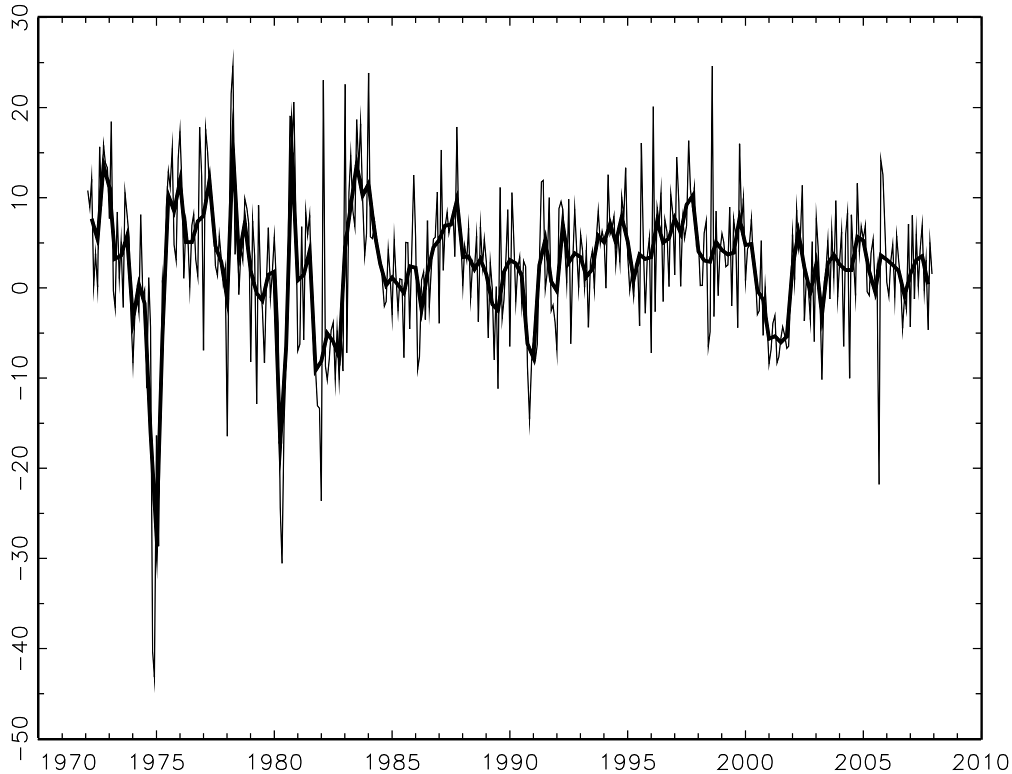
The main reference for this paper, however, is the work by Foerster, Sarte, and Watson (2011). In this paper the authors bridge the gap between the two approaches used for the aggregate effects of sectoral fluctuations. The first approach comprises the use of statistical factor models (Anderson (1984)) to disentangle the effect of common versus idiosyncratic shocks in time series volatilities. The second approach is given by structural models as Long and Plosser (1983). The leading contribution by Foerster, Sarte, and Watson (2011) is to derive a reduced-form factor model from their structural version. In this fashion, they are able of identifying structural sectoral shocks when they calibrate their model using the input-output US data in its 1998 version. They find that sectoral shocks account for 50% of IP growth volatility between 1984-2007, but such magnitude could be considerably lower when varying different ingredients of the model.

The second strand of literature from which this paper builds is given by Hornstein (1993) and Rotemberg and Woodford (1995). These papers build dynamic general equilibrium growth models where the equilibrium concept is given by monopolistically competitive markets. In particular, the quantitative results of Hornstein (1993) show that technology shocks cause lower output growth volatility compared to perfectly competitive markets.

2.3 Evidence

The statistical and quantitative results provided by Foerster, Sarte, and Watson (2011) are based upon the aggregate and sectoral decomposition of the US Industrial Production Index between 1972 and 2007. The salient feature of these date is the decline in the IP variability after 1984 as Figure 2.1 shows.

Figure 2.1: Industrial Production Annual Growth: Y-o-Y percentage variation.



In order to identify the source of such lower underlying IP volatility after 1984, Foerster, Sarte, and Watson (2011) estimate the following factor model[1]

$$X_t = \Lambda F_t + u_t,$$

where X_t is the vector containing sectoral growth rates, F_t is the vector of latent factors, Λ is a matrix of coefficients called loadings, and u_t corresponds to sectoral perturbations.

Building from this model, the authors calculate the importance of sectoral shocks for IP variability in the following way: they first calculate the covariance matrix of X_t, that is $\Sigma_{XX} = \Lambda\Sigma_{FF}\Lambda' + \Sigma_{uu}$, and then they obtain the fraction of IP variability explained by common factors across the sample as

$$R^2(F) = \frac{\overline{\omega}\Lambda\Sigma_{FF}\Lambda'\overline{\omega}}{\sigma_g^2}, \tag{2.1}$$

where $\overline{\omega}$ is the vector of average sectoral weights across the sample, and σ_g^2 is the sample IP variance. They find that 87% of IP standard deviation after 1984 is caused by aggregate shocks, but they acknowledge that such statistical result may underestimate the importance of sectoral shocks because such local perturbations may appear as common shocks due to the contagion of initial, local shocks through input-output linkages. This is why they build the structural, multisector model from which they identify sectoral shocks and re-run the sectoral decomposition exercise. In the benchmark model they propose, sectoral shocks account for 50% of aggregate IP standard deviation for the period 1984-2007. The results they obtain, though, are very sensitive to the assumptions they impose and all the models they consider are based on perfectly competitive markets. Since Hornstein (1993) found relatively lower effects of technology shocks on output fluctuations in a one-sector model when markets depart from perfect competition, such result may carry over into a multisector setting. Therefore, that is the question I tackle in the following section.

[1]See Anderson (1984).

2.4 Model

Consider an economy composed by N sectors indexed by $j = 1, \ldots, N$. In each of these sectors there exists a firm that produces a final good Y_{jt} in period t using both intermediate goods $q_{jt}(s)$, $s \in [0, 1]$—arising from the same sector—and final goods M_{ijt} from sectors $i = 1, \ldots, N$.

The technology employed by these final good producers is given by

$$Y_{jt} = Q_{jt}^{1-\sum_{i=1}^{N} \gamma_{ij}} \prod_{i=1}^{N} M_{ijt}^{\gamma_{ij}}, \tag{2.2}$$

$$Q_{jt} = \left(\int_0^1 q_{jt}(s)^{\frac{1}{\mu}} ds \right)^{\mu}, \tag{2.3}$$

where $1 < \mu < \infty$, and γ_{ij} corresponds to the typical element of the economy-wide input-output matrix Γ. In this layer markets are perfectly competitive, that is, final good producers take prices of their input as given.

Each variety $s \in [0, 1]$ of intermediate good in any sector, in turn, is produced by monopolists that use the following technology

$$q_{jt}(s) = A_{jt} \left(K_{jt}(s)^{\alpha_j} L_{jt}(s)^{1-\alpha_j} \right)^{\xi} - \phi \,, \tag{2.4}$$

where $\alpha_j \in (0, 1)$, $\xi \geq 1$, $K_{jt}(s)$ and $L_{jt}(s)$ denote capital and labor services, and $\phi > 0$ is a fixed cost of production.

The sector-specific productivity shock A_{jt} follow the process

$$\ln A_{jt} = \ln A_{jt-1} + \varepsilon_{jt}. \tag{2.5}$$

To complete the description of the environment, consider an infinitely lived representative consumer with preferences over the stream of consumption of final goods C_{jt} and aggregate labor L_{jt} given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \sum_{j=1}^{N} \left(\frac{C_{jt}^{1-\sigma} - 1}{1-\sigma} - \psi L_{jt} \right). \tag{2.6}$$

As is customary, assume a positive rate of depreciation $\delta \in (0,1)$, which implies that aggregate capital evolves according to

$$K_{jt} = (1-\delta) K_{jt-1} + X_{jt}, \qquad \delta \in (0,1). \tag{2.7}$$

An allocation $\{\, C_{jt}, X_{jt}, M_{ijt}, Y_{jt},\ (K_{jt}(s), L_{jt}(s))_{\, s\in[0,1]} \,\}_{i,j=1}^{N}$ for this environment is feasible if it satisfies the following resource constraints

$$\int_0^1 K_{jt}(s) ds \leq K_{jt} \tag{2.8}$$

$$\int_0^1 L_{jt}(s) ds \leq L_{jt} \tag{2.9}$$

$$C_{jt} + X_{jt} + \sum_{i=1}^{N} M_{jit} \leq Y_{jt} \tag{2.10}$$

2.4.1 Equilibria

Assuming that the representative consumer is the owner of both capital and firms, that intermediate good producers hire sector-specific capital and labor services in perfectly competitive factor markets at prices r_{jt} and w_{jt}, and that there is no entry or exit of firms in the intermediate goods sector, it follows that profit maximization by final good producers implies

$$q_{jt}(s) = \frac{p_{jt}(s)^{\frac{\mu}{1-\mu}} Q_{jt}}{\left(\int_0^1 p_{jt}(s)^{\frac{1}{1-\mu}} ds \right)^{\mu}}, \tag{2.11}$$

$$M_{ijt} = \gamma_{ij} \frac{Y_{jt}}{P_{it}}, \tag{2.12}$$

where $p_{jt}(s)$ is the price of variety s of intermediate good in sector j, and P_{it} is the price of the final good of sector i.

Intermediate good producers, thereby, face the intermediate variety demand (2.11), which they consider to solve the following program

$$\max_{p_{jt}(s)} p_{jt}(s) q_{jt}(s) - C(w_{jt}, r_{jt}; q_{jt}(s)),$$

where the cost function $C : \mathbb{R}^2 \to \mathbb{R}$ is defined by

$$C(w, r; q) = \min_{K,L} wL + rK \quad \text{s.t.} \quad (2.4).$$

Profit maximization by monopolists then, implies the customary pricing rule

$$p_{jt}(s) = \mu\, C_{q_{jt}(s)}\,, \tag{2.13}$$

that calls for price as a fixed markup over marginal costs, which are in turn given by

$$C_{q_{jt}(s)} = \xi^{-1} A_{jt}^{-\frac{1}{\xi}} \left(\frac{w_t}{1-\alpha_j}\right)^{1-\alpha_j} \left(\frac{r_t}{\alpha_j}\right)^{\alpha_j} (q_{jt}(s) + \phi)^{\frac{1}{\xi}-1}$$

Since I assume that sectoral shocks are embedded in the production of final goods, it follows that each monopolist faces the same within-sector shock, and therefore they all end up setting the same within-sector intermediate good price. In such symmetric case consequently, it is the case that $p_{jt}(s) = p_t$, and as in Hornstein (1993) I normalize to one.

Hence, using (2.13), I get factor prices as functions of sectoral capital and labor services given by

$$\begin{aligned} w_{jt} =& (1-\alpha_j)\frac{\xi}{\mu} A_{jt} \left(K_{jt}^{\alpha_j} L_{jt}^{1-\alpha_j}\right)^{\xi} L_{jt}^{-1} \\ r_{jt} =& \alpha_j \frac{\xi}{\mu} A_{jt} \left(K_{jt}^{\alpha_j} L_{jt}^{1-\alpha_j}\right)^{\xi} K_{jt}^{-1}, \end{aligned}$$

and finally I can express monopolists' profits as follows

$$\Pi(K_{jt}, L_{jt}, A_{jt}) = \left(1 - \frac{\xi}{\mu}\right) A_{jt} \left(K_{jt}^{\alpha_j} L_{jt}^{1-\alpha_j}\right)^{\xi} - \phi \tag{2.14}$$

Now it is possible to setup the optimization problem faced by the representative consumer

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \sum_{j=1}^{N} \left(\frac{C_{jt}^{1-\sigma} - 1}{1 - \sigma} - \psi L_{jt} \right)$$

$$\begin{aligned} \text{s.t.} \quad C_{jt} + X_{jt} &\leq w_{jt} L_{jt} + r_{jt} L_{jt} + \Pi_{jt} \\ K_{jt+1} &= (1 - \delta) K_{jt} + X_{jt} \\ K_0 &\text{ given} \end{aligned}$$

Assuming, for the sake of simplicity, that profits from the intermediate sector are fully taxed, the first-order necessary conditions for an optimal allocation are given by the following marginal conditions and Euler equations

$$\psi L_{jt} = C_{jt}^{-\sigma} (1 - \alpha_j) \frac{\xi}{\mu} A_{jt} \left(K_{jt}^{\alpha_j} L_{jt}^{1-\alpha_j}\right)^{\xi} \tag{2.15}$$

$$C_{jt}^{-\sigma} = \beta C_{jt+1}^{-\sigma} \left(\alpha_j \frac{\xi}{\mu} A_{jt+1} \left(K_{jt+1}^{\alpha_j} L_{jt+1}^{1-\alpha_j}\right)^{\xi} K_{jt+1}^{-1} + 1 - \delta \right) \tag{2.16}$$

An equilibrium allocation for this environment is characterized by the following equations

$$\psi L_{jt} = C_{jt}^{-\sigma}(1-\alpha_j)\frac{\xi}{\mu}A_{jt}\left(K_{jt}^{\alpha_j}L_{jt}^{1-\alpha_j}\right)^{\xi} \tag{2.17}$$

$$C_{jt}^{-\sigma} = \beta C_{jt+1}^{-\sigma}\left(\alpha_j\frac{\xi}{\mu}A_{jt+1}\left(K_{jt+1}^{\alpha_j}L_{jt+1}^{1-\alpha_j}\right)^{\xi}K_{jt+1}^{-1}+1-\delta\right) \tag{2.18}$$

$$Y_{jt} = \left(A_{jt}\left(K_{jt}^{\alpha_j}L_{jt}^{1-\alpha_j}\right)^{\xi}-\phi\right)^{1-\sum_{i=1}^{N}\gamma_{ij}}\prod_{i=1}^{N}M_{ijt}^{\gamma_{ij}} \tag{2.19}$$

$$C_{jt}+X_{jt}+\sum_{i=1}^{N}M_{jit} \leq Y_{jt} \tag{2.20}$$

$$K_{jt} = (1-\delta)K_{jt-1}+X_{jt} \tag{2.21}$$

$$M_{ijt} = \gamma_{ij}\frac{Y_{jt}}{P_{it}}, \tag{2.22}$$

where (2.17)-(2.18) come from representative consumer's problem, (2.19) is the technology of final goods production, (2.20)-(2.21) are the resource constraints and evolution of capital, and finally (2.19) comes from final producer's optimal behavior.

Since I assumed the normalization $p_{jt} = 1$ across intermediate good producers, and moreover the final goods sector operates under perfect competition, it follows that by replacing optimal monopolist behavior (2.11)-(2.12) into the zero-profits condition of final sector firms

$$P_{jt}Y_{jt} - \int_0^1 p_{jt}(s)q_{jt}(s)ds - \sum_{i=1}^{N}P_{it}M_{ijt} = 0,$$

I can solve for the vector of prices of final goods $P = (P_{1t}, \ldots, P_{Nt})$ as the fixed point of the mapping $T : [0,1]^N \to [0,1]^N$, where

$$T_j(P) = \prod_{i=1}^{N}\left(\frac{P_{it}}{\gamma_{ij}}\right)^{\frac{\gamma_{ij}}{1-\sum_i\gamma_{ij}}} + \sum_{i=1}^{N}\gamma_{ij}. \tag{2.23}$$

Now, a log-linear approximation around the steady state of the equilibrium characterized by (2.17)–(2.22) gives the following set of equations for each sector, where the *hat* notation denotes percent deviation of the respective steady state value

$$\widehat{L}_{jt} = -\sigma\widehat{C}_{jt} + \widehat{A}_{jt} + \xi\left(\alpha_j\widehat{K}_{jt} + (1-\alpha_j)\widehat{L}_{jt}\right) \tag{2.24}$$

$$-\sigma\left(\widehat{C}_{jt} - \widehat{C}_{jt+1}\right) = (1-\beta(1-\delta))\left(\widehat{A}_{jt+1} + (\xi\alpha_j - 1)\widehat{K}_{jt+1} + \xi(1-\alpha_j)\widehat{L}_{jt+1}\right) \tag{2.25}$$

$$\widehat{Y}_{jt} = \widehat{A}_{jt} + \xi(1 - \sum_{i=1}^{N}\gamma_{ij})\left(\alpha_j\widehat{K}_{jt} + (1-\alpha_j)\widehat{L}_{jt}\right) + \sum_{i=1}^{N}\gamma_{ij}\widehat{M}_{ijt} \tag{2.26}$$

$$C_j\widehat{C}_{jt} + X_j\widehat{X}_{jt} + \sum_{i=1}^{N} M_{ji}\widehat{M}_{jit} = Y_j\widehat{Y}_{jt} \tag{2.27}$$

$$\widehat{K}_{jt} = (1-\delta)\widehat{K}_{jt-1} + \delta\widehat{X}_{jt} \tag{2.28}$$

$$\widehat{M}_{ijt} = \widehat{Y}_{jt} \tag{2.29}$$

In order to write down the equilibrium equations across sectors more compactly, let $l_t = (\widehat{L}_{1t}, \ldots, \widehat{L}_{Nt})^T$, $m_t = (\widehat{M}_{11t}, \ldots, \widehat{M}_{1Nt}, \widehat{M}_{21t}, \ldots, \widehat{M}_{NNt})^T$, and so forth.

Hence, (2.24)–(2.29) can be expressed in vector form as follows

$$l_t = -\sigma c_t + a_t + \xi\left(\alpha_d k_t + (I_N - \alpha_d) l_t\right) \tag{2.30}$$

$$-\sigma c_t = \widetilde{\beta}\left(a_{t+1} + (\xi\alpha_d - I_N)k_{t+1} + \xi(I_N - \alpha_d)l_{t+1}\right) - \sigma c_{t+1} \tag{2.31}$$

$$y_t = a_t + \xi(I_N - \Sigma_\gamma)\left(\alpha_d k_t + (I_N - \alpha_d)l_t\right) + \widetilde{\Gamma} m_t \tag{2.32}$$

$$y_t = s_c c_t + s_x x_t + s_m m_t \tag{2.33}$$

$$k_{t+1} = (1-\delta)k_t + \delta x_t \tag{2.34}$$

$$m_t = M_y y_t \tag{2.35}$$

where $\widetilde{\beta} \equiv 1 - \beta(1-\delta)$, $M_y \equiv 1_{N\times 1} \otimes I_N$,

$$\alpha_d = \begin{pmatrix} \alpha_1 & 0 & \cdots & 0 \\ 0 & \alpha_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \alpha_N \end{pmatrix},$$

$$\widetilde{\Gamma} = \begin{pmatrix} \gamma_{11} & 0 & \cdots & 0 & \gamma_{21} & 0 & \cdots & 0 & \cdots & \gamma_{N1} & 0 & \cdots & 0 \\ 0 & \gamma_{12} & \cdots & 0 & 0 & \gamma_{22} & \cdots & 0 & \cdots & 0 & \gamma_{N2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \gamma_{1N} & 0 & 0 & \cdots & \gamma_{2N} & \cdots & 0 & 0 & \cdots & \gamma_{NN} \end{pmatrix},$$

$$\Sigma_\gamma = \begin{pmatrix} \sum_{i=1}^N \gamma_{i1} & 0 & \cdots & 0 \\ 0 & \sum_{i=1}^N \gamma_{i2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sum_{i=1}^N \gamma_{iN} \end{pmatrix},$$

and s_c and s_x are diagonal matrices containing the steady state sectoral ratios C_j/Y_j and X_j/Y_j on its diagonal, respectively, and finally

$$s_m = \begin{pmatrix} \frac{M_{11}}{Y_1} & \cdots & \frac{M_{1N}}{Y_1} & 0 & \cdots & 0 & 0 & \cdots & 0 \\ 0 & \cdots & 0 & \frac{M_{21}}{Y_2} & \cdots & \frac{M_{2N}}{Y_2} & 0 & \cdots & 0 \\ \vdots & \cdots & \vdots & \vdots & \cdots & \vdots & \vdots & \cdots & \vdots \\ 0 & \cdots & 0 & 0 & \cdots & 0 & \frac{M_{N1}}{Y_N} & \cdots & \frac{M_{NN}}{Y_N} \end{pmatrix}.$$

2.4.2 System reduction

In the appendix section A I use (2.30)–(2.35) to get the following stochastic system difference equation

$$\begin{pmatrix} -\sigma\Delta_c & \widetilde{\beta}\Delta_k \\ 0 & \Theta_k \end{pmatrix} E_t \begin{pmatrix} c_{t+1} \\ k_{t+1} \end{pmatrix} = \begin{pmatrix} -\sigma & 0 \\ -\Omega_c & \Omega_k \end{pmatrix} \begin{pmatrix} c_t \\ k_t \end{pmatrix} + \begin{pmatrix} -\widetilde{\beta}\Delta_a \\ 0 \end{pmatrix} E_t a_{t+1} + \begin{pmatrix} 0 \\ \Delta_{ya} \end{pmatrix} a_t \tag{2.36}$$

As in Foerster, Sarte, and Watson (2011), I use the solution algorithm by King and Watson (2002) to solve the first-order linear difference system (2.36). Such algorithm tries to pick iteratively from the array of endogenous variables those governed by dynamic identities, so as to get smaller systems in each iteration. By means of such algorithm, I finally get the following solution in state space form

$$\begin{pmatrix} k_{t+1} \\ c_t \end{pmatrix} = \begin{pmatrix} M_k & M_a \\ \Pi_{ck} & \Pi_{ca} \end{pmatrix} \begin{pmatrix} k_t \\ a_t \end{pmatrix} \tag{2.37}$$

Now, by replacing (2.37) into the linearized version of the production function of final goods (2.32), it follows that

$$y_{t+1} = \Psi y_t + \Xi a_t + \Pi a_{t+1},$$

where[2]

$$\Psi \equiv \overline{\Pi} M_k \overline{\Pi}^{-1},$$
$$\Xi \equiv \overline{\Pi} M_a - \overline{\Pi} M_k \overline{\Pi}^{-1} \Pi,$$
$$\Pi \equiv \Delta_{ya} - \sigma \Delta_{yc} \Pi_{ca},$$
$$\overline{\Pi} \equiv -\sigma \Delta_{yc} \Pi_{ck} + \xi \Delta_{yk}.$$

Since the model is aimed at studying output fluctuations, I first differentiate the latter equation and use the log-linear structure of sectoral shocks (2.5) to get the following vector ARMA(1,1) model for sectoral output growth

$$\Delta y_{t+1} = \Psi \Delta y_t + \Xi \varepsilon_t + \Pi \varepsilon_{t+1}. \tag{2.38}$$

By means of (2.38) therefore, and denoting L as the lag operator, I can identify structural sectoral shocks from data on sectoral IP growth Δy_{t+1} as follows

$$\varepsilon_t = (\Pi + \Xi L)^{-1} (I_N - \Psi L) \Delta y_{t+1}. \tag{2.39}$$

[2] See appendix A for details.

2.5 Quantitative Evidence

By means of the structural identification (2.39) I proceed with que quantitative analysis in the following way. For Δy_{t+1} I use data of sectors coming from the IP index, and for the input-output matrix I use the 1998 data as in Foerster, Sarte, and Watson (2011). I take the rest of parameters from customary values in business cycle literature, namely $\sigma = 1$, $\psi = 1$, $\beta = 0.99$, and $\delta = 0.025$. For the the fixed cost of production of intermediate goods I set the value given by Hornstein (1993), that is $\phi = 1$. Finally, I set different values for the degree of returns to scale ξ.

I perform two alternative calibrations for $\Sigma_{\varepsilon\varepsilon}$: the first one is given by a diagonal matrix with variances given by the values implied by (2.39). For the second one I associate the following factor model with ε

$$\varepsilon_t = \Lambda_s S_t + \nu_t, \tag{2.40}$$

where I estimate Λ_s through factor analysis and consequently compute the fraction of aggregate variability that comes from sectoral shocks as follows

$$R^2(S) = \frac{\overline{\omega}^T \Lambda_s \Sigma_{SS} \Lambda_s^T \overline{\omega}}{\sigma_g^2}.$$

Table 2.1 contains the results of the quantitative exercise. It has two panels, which differ in the degree of returns to scale ξ. In each panel I show the results for the subperiods 1972-1983 and 1984-2007. The first two columns show the data, where $\overline{\rho}_{ij}$ is the average correlation between sectoral growth rates across the sample period, and σ_g corresponds to the standard deviation of the IP index. The third and fourth columns show the statistics when the covariance matrix of sectoral shocks ε_t is given by a diagonal matrix with variances calculated from (2.39). And the last three columns show the corresponding results using (2.40). Since the latter calibration of $\Sigma_{\varepsilon\varepsilon}$ allows the estimation of a factor model, the last column of Table 2.1 shows the fraction of model IP variability explained by aggregate shocks.

Table 2.1: Sectoral correlation and IP growth volatility.

A. $\xi = 1.05$.

	Data		$\Sigma_{\varepsilon\varepsilon}$: diagonal		$\Sigma_{\varepsilon\varepsilon}$: factor model		
Period	$\overline{\rho}_{ij}$	σ_g	$\overline{\rho}_{ij}$	σ_g	$\overline{\rho}_{ij}$	σ_g	$R^2(S)$
1972-1983	.26	8.35	.16	4.5	.11	8.1	0.87
1984-2007	.11	3.51	.16	3.4	.11	6.0	0.53

B. $\xi = 1.1$.

	Data		$\Sigma_{\varepsilon\varepsilon}$: diagonal		$\Sigma_{\varepsilon\varepsilon}$: factor model		
Period	$\overline{\rho}_{ij}$	σ_g	$\overline{\rho}_{ij}$	σ_g	$\overline{\rho}_{ij}$	σ_g	$R^2(S)$
1972-1983	.26	8.35	.17	5.1	.24	9.17	.89
1984-2007	.11	3.51	.17	3.7	.36	2.7	.72

The third column of Panel A shows that the reduced form of the model with monopolistic competition spits out a much lower sectoral average correlation across sectors than the data for the first subsample, although it overestimates it during the great moderation. In the case of the factor model, such average correlation is still lower, but the main point is the fraction of IP variability explain by aggregate shocks: the model shows that 87% of IP standard deviation is explained by common sources. The perfect competition setting of Foerster, Sarte, and Watson (2011) shows 80% for the same period. In other words, the consideration of monopolistic competition and increasing returns reduces the importance of sectoral shocks in 35%.

Panel B repeats the calculations for a higher degree of returns to scale. When ξ grows in roughly five percent there is a slightly increase in the sectoral correlation for both subsamples in the case of $\Sigma_{\varepsilon\varepsilon}$ diagonal, which is also the case in when the factor model is used.

The main result of the paper though lies in the las column. For $\xi = 1.05$ the fraction of aggregate IP variability accounted for by sectoral shocks falls to 11% for 1972-1983 and to 28% for the latter subsample, respectively. In other words, the introduction of monopolistic competition and increasing returns imply that the fraction of IP standard deviation explain by local perturbations falls from 50%—which is the benchmark by Foerster, Sarte, and Watson (2011)—to 28%, which is a drop of 44% in such measure.

Chapter 3

Conclusion and Discussion

I have developed a simple dynamic game of imperfect information that is capable of encompassing previous analyses on PBCs and matching recent panel data. The main thrust of the analysis is that in the unique data-matching equilibrium, increases in election-year government spending are exclusively caused by unproductive incumbents, which portraits dismal perspective on PBCs, i.e. they are far from reflecting efficient signalling by productive incumbents. Information acquisition has a key role in the scarce presence of PBCs in developed countries.

A straightforward, relevant avenue of research is considering the case in which public goods help promote private investment (v.gr. Jones, Manuelli, and Rossi (1993)). In such case, economies with unskilled politicians in office in the first place may become stagnant because voters may only afford inexpensive, noisy information regarding incumbents, which translates into sloppy choices at the polls, and ensuing low future output, which affords again only garbled information. In sum, there is the possibility of economic stagnation due to the endogenous, permanent presence of *bad* politicians in office.

In the second chapter I have built a multisector growth model to contribute to the discussion on the importance of sectoral shocks for aggregate fluctuations. The main technical point has been the incorporation of monopolistic competition and increasing returns, ingredients that were supposedly relevant in heuristic discussions.

The quantitative results have indeed shown that assuming competitive markets across sectors amplify the importance of sectoral perturbations for the aggregate performance of the US Industrial Production Index. When departing from the competitive setting, intermediate good producers face a downward sloping demand that drives them to modify input demands when technology shocks show up. This effect, in theory, should imply less transmission of such local technological perturbations.

The quantitative results derived from the reduced form of the structural model have confirmed such intuition. On the one hand sectoral shocks now explain a lower fraction of aggregate IP variability, and on the other one, the quantitative relevance of sectoral shocks appears to be a decreasing function of the degree of returns to scale in production.

Since the evidence of US sectors appears to be consistent with non competitive markets in some studies (Hall (1986) and Domowitz, Hubbard, and Petersen (1988)), the model and the quantitative exercise carried out here seems a direction not to be overlooked.

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Appendix A

Derivation of (2.36)

Replacing the linearized Euler equation (2.31) into (2.30) we get

$$l_t = (I_N - \xi(I_N - \alpha_d))^{-1} \left(-\sigma c_t + a_t + \xi \alpha_d k_t\right),$$

which is reinserted into (2.31) to get

$$-\sigma \Delta_c \, c_{t+1} + \widetilde{\beta} \Delta_k k_{t+1} = -\sigma c_t - \widetilde{\beta} \Delta_a a_{t+1},$$

where $\Delta_c \equiv \widetilde{\beta} \xi (I_N - \alpha_d) \Phi_l + I_N,\ \Delta_k \equiv \xi \alpha_d - I_N + \xi^2 (I_N - \alpha_d) \Phi_l \alpha_d,\ \Delta_a \equiv I_N + \xi (I_N - \alpha_d) \Phi_l$, and $\Phi_l \equiv (I_N - \xi(I_N - \alpha_d))^{-1}$. Hence we have the first part of Eq. (2.36).

For deriving the second equation comprising (2.36), I replace (2.30) and (2.35) into the linearized production function of final goods (2.32) to get

$$y_t = \Delta_{ya} a_t - \sigma \Delta_{yc} \, c_t + \Delta_{yk} k_t,$$

where

$$\Delta_{ya} \equiv (I_N - \Sigma_\gamma)^{-1} \left(I_N + \xi(I_N - \Sigma_\gamma)(I_N - \alpha_d)\Phi_l\right)$$
$$\Delta_{yc} \equiv \xi(I_N - \alpha_d)\Phi_l$$
$$\Delta_{yk} \equiv \xi(\alpha_d + \xi(I_N - \alpha_d)\Phi_l\alpha_d)$$

I finally use (2.33)-(2.35) into the last equation to get

$$\Theta_k\, k_{t+1} = \Delta_{ya} a_t - \Omega_c\, c_t + \Omega_k\, k_t,$$

where

$$\Theta_k \equiv \delta^{-1}(I_N - s_m M_y)^{-1} s_x$$
$$\Omega_c \equiv \sigma\Delta_{yc} + (I_N - s_m M_y)^{-1} s_c$$
$$\Omega_c \equiv \Delta_{yk} + \delta^{-1}(1-\delta)(I_N - s_m M_y)^{-1} s_x.$$