Knowing the right person in the right place: political connections and resistance to change*

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Abstract

We develop a political economy model of Schumpeterian growth with entry where excessive red tape and bureaucracy are used strategically by the incumbent politician to acquire incumbency advantage. By setting sufficiently high red tape, the politician induces the monopolist to invest in networking, as bureaucratic costs can be reduced through personal relationships developed with the incumbent politician, and determines a static gain for voters in case of re-election. Our model generates political equilibria where the incumbent politician secures re-election, and that involve either perpetual upgrading or technological inertia. Although blocked entry implies a dynamic loss, the latter equilibrium is supported by forward-looking voters who value the static gain associated to the status quo. The model provides a possible explanation for the persistence of inefficient democracies and political barriers to technology adoption, where these reflect shared rather than conflicting interests.

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1 Introduction

Political barriers to innovation and adoption of superior technologies are considered as an important source of economic backwardness and cross-country differences in income per capita (see, for example, Mokyr [19], and Parente and Prescott [20]).

Tipically, in the economic literature, political barriers result from vested interests, with incumbent producers or workers with old-technology specific skills trying to influence politicians to erect barriers against the diffusion of superior technologies, through licensing or other forms of regulation (see, for example, Acemoglu, Aghion, and Zilibotti [1], Aghion, Alesina and Trebbi [4], [10], Bellettini and Ottaviano [8], Bridgman, Livshits and MacGee [9], and Comin and Hobijn [10]). Acemoglu and Robinson [2] emphasize that political elites may also have a vested interest in maintaining the status quo, as economic development and the associated social turmoil erodes their incumbency advantage. In all these contributions, political barriers to innovation tend to become prohibitively costly for the politician when the level of accountability and political competition are high, as politicians fear to be replaced by voters punishing inefficient policies.

In this paper we propose a different view, where excessive regulation, red-tape and bureaucracy are used strategically in democracies by incumbent politicians to establish a network with incumbent entrepreneurs and prevent entry of outsiders through political barriers. Politicians gain the support of voters and acquire an electoral advantage over their challengers via these political connections, thereby increasing probability of re-election in situations where political competition would otherwise be very high and chances of keeping the power would be relatively low.

Our main contribution is twofold. First, we show that inefficient bureaucracy and barriers to entry may be voluntarily supported by voters in developed democracies rather than being imposed on the society by the political-economic élites. By moving first, politicians have the opportunity to gain political support for an inefficient policy which is a (welfare reducing) second-best policy but increases chances of re-election. Second, we provide a full characterization of an economy where a relationship-based system, with active networks between politicians and firms, and persistence of incumbent politicians and monopolists emerges endogenously.

To grasp our main argument, consider an economy where technological upgrade occurs in every period, through innovation of the incumbent monopolist or entry of a technologically superior competitor, and where the politician in office has no incumbency advantage, as economic outcomes and voters' welfare are unaffected by electoral results. Imposing a sufficiently high level of red tape in this economy, the incumbent politician makes political connections valuable to incumbent firms, as the politician can facilitate access to relevant information and directly intervene in the bureaucratic process, and firms can abate production costs by "knowing the right person in the right in the right place" thereby gaining a competitive advantage over technologically superior outsiders. Networks between politicians in office and operating firms make incumbent politicians intrinsically different from their challengers in the eyes of voters, who recognize that the cost of bureaucracy can be bypassed by firms with political connections. This increases chances of re-election of the incumbent politician, possibly at the cost of less frequent technological upgrades.

To formalize this argument, we consider a dynamic model of growth with quality-improving innovation and entry. In each period, the owner of the latest quality in use in the intermediate good sector can innovate step-by-step and faces an entry threat from an outside firm with state-of-the-art technology. Firms engage in Bertrand price competition and one firm emerges as the monopoly producer in each period.

The incumbent monopolist can escape competition in two ways. On the one hand, as in Aghion and Howitt [7], and Aghion et al. [5], [6], firms at the technological frontier can prevent entry if they succeed in innovation. On the other hand, we introduce the possibility for firms to invest in personal relations with politicians. We assume that networking is a time consuming activity, which reduces managerial time devoted to innovation and the probability that innovation is successful. Moreover, networks pay off provided that the incumbent politician is confirmed in office at the end of the period. In this case, the firm acquires a competitive advantage over outside competitors, as political connections help to reduce the cost of red tape and bureaucracy.

An interesting feature of our model is that the relationship between incentives to invest in innovation and networking depends on firm's distance to frontier. Close to the frontier, political connections hinder innovation activity by the incumbent, as the latter might be able to avoid entry of advanced outsiders through connections alone, without relying on further innovation. On the contrary, far from the frontier, political connections foster innovation, as the incumbent firm might not be able to survive in the market with innovation alone. Thus, networking and innovation can be either substitutes or complements depending on whether the monopolist is a technological leader or laggard, respectively.

When called upon to choose to confirm the politician in office or elect a new one, forward-looking voters will take into account that re-election of the incumbent and the perpetuation of the status quo ensure a static gain (lower production costs) but, when the level of red tape is sufficiently high, they also entail a dynamic loss (blocked entry). Therefore, by optimally choosing the level of red tape, the politician influences voters' preferences, and therefore the probability of being re-elected.

Focusing on stationary Markov perfect equilibria of the infinitely-repeated dynamic game between politician, monopolist and voters, we determine simultaneously the equilibrium level of red tape, electoral results, and expected economic outcomes. We prove the existence of two types of equilibria that we fully characterize. When the opportunity cost of networking and/or the productivity gain of innovation are low, the politician sets relatively low red tape. Voters support the incumbent politician to enjoy lower production costs, perpetual upgrading of technology occurs through innovation of incumbent firms or entry of advanced outsiders. Instead, when the opportunity cost of networking and/or the productivity gain of innovation are high, the politician sets relatively high red tape. Impatient voters still support the incumbent politician, although this implies that technological upgrade will be hindered by political barriers to entry. In this case, the incumbent's desire for re-election imposes high distortions on the economy as technology is below the frontier with positive probability, and new entrants face high red-tape costs.

Instead of being exogenously fixed (as it is tipically assumed in the literature), in our model maximum distance to the frontier becomes an equilibrium outcome. In particular, for a large range of parameters values, the equilibrium level of red tape is such that the technology in use in any period can be at most one step from the frontier in equilibrium. As the politician has no incentive to increase red tape above the level that secures re-election, this maximum distance would emerge in equilibrium even if the politician could set higher level of red tape, thus allowing in principle for the possibility that a firm further away from the frontier survives in the market exploiting political connections.

According to our analysis, persistence in office of politicians will be generally high in democratic countries. The level of red tape will vary across countries depending on structural parameters that influence firms' incentive to network and innovate, and the degree of impatience of voters. Differences in the level of red tape translate into permanent cross-country income differences, with higher red tape implying lower (expected) GDP.

These implications are broadly consistent with stylized facts regarding the quality and extent of bureaucracy and persistence in office of politicians. As it is well-known, there are large cross-country differences in the extent and efficiency of bureaucracy that are widely believed to affect economic performance. A perhaps less well-known fact is that low turnover of politicians seems to be a feature of political systems in most developed countries. A recent cross-country analysis of comparative turnover rates, based on lower house legislative elections from 1979 through 1994 for twenty-five countries, shows that the mean of incumbents returning rate is 67.7% (see Matland and Studlar [16]). Merlo et al. [17] report that re-election rate in the US Congress was never below 80% in the US between 1951 and 1994 and that the re-election rate in the Italian Parliament, though more volatile than in the US, never fell below 60% between 1951 and 2008, and was around 80% in several elections.

Cross-country data on political persistence, measured by the percentage of main political entities ("veto players") who remain in place in the government in any given year relative to the previous one are available from the Database of Political Institutions (World Bank) for a larger set of countries. Using within-country averages for 61 democratic countries over the 1990-2005, we find that the sample mean of political persistence (PP) is close to one with standard deviation close to zero (see Descriptive Statistics, Table 1 in the Appendix). In the same sample, the index of bureaucratic quality (BQ) from the International Country Risk Guide (normalized to the interval 0 -1, with 1 indicating low bureaucratic quality, that is high red tape costs), displays sample mean and standard deviation of comparable size. The index of bureaucratic quality is negatively correlated (see Pairwise Correlations in Table 1) with the (log of) per capita GDP (average value for the 2000-2005 period), from the PPP series Penn World Tables 7.0.

Besides already cited contributions, our paper is related to the political science literature on the strategic use of excessive bureaucracy in representative democracies. In particular, our description of the incumbent politician's behavior is reminiscent of Fiorina and Noll [14] who argue that "As the public bureaucracy grows larger, the importance of the performance of facilitation will grow, and a legislator who is a good facilitator will be increasingly likely to be reelected. ...Because part of facilitation is the possession and use of information which is acquired through experience, and because seniority enhances the influence of a legislator in determining the fate of an agency, incumbents can be more effective facilitators than their challengers" (p. 257). Moreover, according to Golden's [15] analysis of postwar Italian politics, "bureaucratic inefficiency, excessive legislation and widespread bureaucratic corruption were features of Italian public administration that were *deliberately designed by legislators and intended to enhance re-election prospects for incumbents* [our italics] by providing them with opportunities for extensive constituency service" (p. 189). In a political economy model, Acemoglu, Ticchi and Vindigni [3] relate the emergence and persistence of inefficient states to the strategic use of patronage politics by the elite of the rich, who try to limit provision of public goods and redistribution anticipating a democratic transition. In this framework, inefficient bureaucracy would not emerge in developed democracies. None of these contributions considers the link between excessive bureaucracy, barriers to entry and technological innovation which is instead the focus of our analysis.

Finally, our paper is related to the empirical literature that investigate the relevance of political connections on firms' performance (see, for example, Faccio [12] and Faccio et al. [13]). Most closely related to our work is a recent paper by Desai and Olofsgard [11] who investigate the consequences of political connections on about 10.0000 firms surveyed in 40 developing countries and find that influential firms face fewer administrative and regulatory burdens and invest and innovate less.

The rest of the paper is organized as follows. Section 2 introduces the theoretical model, Section 3 analyzes the politico-economic equilibrium and delivers our main results. Section 4 investigates comparative economic performance and Section 5 concludes.

2 The model economy

2.1 The environment

Consider a two-sector economy populated by a continuous mass of infinitely-lived agents. Time is discrete with $t = 0, 1, ..., \infty$. Utility is linear in consumption and future consumption is discounted at the subjective discount factor $\beta = 1/(1+r)$ where r is the interest rate. This implies that, in each period, consumption is equal to income.

In each period t output in the final good sector is given by:

$$Y_t = \widetilde{x}_t^{\alpha} {L_t}^{1-\alpha} \tag{1}$$

where L_t is labor, $\widetilde{x}_t = \sum_{q=0}^{Q_t} \gamma^q x_q$ is a quality-adjusted intermediate input, with q denoting quality rung of intermediate good x_q that has quality γ^q with $\gamma > 1$. Q_t denotes the highest quality level in use at time t. We take the final good as numeraire and normalize its price to one. We assume no population growth and normalize $L = 1$. The final good sector is perfectly competitive.

At the beginning of period t, there is an incumbent monopolist in the intermediate good sector who owns technology Q_{t-1}. The intermediate good is produced using the final good by means of a linear technology.

Following Aghion and Howitt [7], and Aghion et al. [5], [6], we assume that, before production takes place, the incumbent firm can innovate to raise its productivity. Innovation requires resources and entrepreneurial time. If innovation is successful, the quality of the firm's intermediate input increases by the factor γ (step-by-step innovation). Denoting by λ_t the incumbent's investment in innovation, which is also the probability of success per unit of managerial time devoted to innovation, the cost of innovation in terms of final good output is $(c\lambda_t^2\gamma^{\frac{\alpha Q_{t-1}}{1-\alpha}})/2$, with $c > 0$.

We assume that innovation is drastic, that is $\gamma > 1/\alpha$. If successful, innovation may allow the incumbent firm to escape competition from an outside competitor, which operates with frontier technology, growing at exogenous rate $g = \gamma - 1$. The outside firm can observe before entry the incumbent firm's production conditions and will only enter if it can obtain strictly positive profits.

In order to investigate the relationship between innovation, growth and political persistence, we assume that production costs in the intermediate good sector depend on the level of red tape. Bureaucracy and regulation impose external costs on firms, as information on bureaucratic requirements are costly to acquire and bureaucratic processes are time consuming. In our model, these costs will proportionally affect marginal costs of production. The level of red-tape, denoted by σ_t, is set at the beginning of period t by the incumbent politician, who was already in office in period $t-1$. This assumption is meant to capture the idea that reforms of bureaucracy take time to be designed and implemented.

Incumbent monopolist and politician are potentially connected. We have in mind a system of personal relationships between the operating firm and the politician in office whereby the politician serves as facilitator by providing information on how to approach the bureaucracy or directly intervening in bureaucratic processes. By knowing the right person in the right place ("a rolodex effect"), the firm can more easily deal with bureaucratic requirements, reduce operation costs related to red tape, and acquire a competitive advantage over outsiders.

We model the benefit of being politically connected by assuming that the incumbent firm can reduce the marginal cost of production to 1, acquiring a cost advantage $\sigma_t - 1$ over unconnected competitors. However, in order to exploit the network advantage, two conditions must be satisfied. First, the incumbent firm must allocate entrepreneurial time to networking. We denote by $\overline{n}$ the fixed share of time required for this activity. Second, the incumbent politician must remain in office, that is win period-t election and be re-elected. Denoting by $n_t = \{0, \overline{n}\}$ the share of entrepreneurial time devoted to networking at time t, the probability that the incumbent firm succeeds in innovation is equal to $\lambda_t \cdot (1 - n_t)$.[1]

The new entrant cannot exploit political connections and faces marginal cost of pro-

[1] Notice that, if the politician sets $\sigma_t = 1$ at the beginning of the period, there is nothing to gain from networking, so that $n_t = 0$ and the probability that the incumbent innovates is equal to λ_t.

duction σ_t if it operates in period t for the first time. In other words, we assume that the cost of networking is prohibitive for new entrants. This assumption captures the idea that it takes time to build connections with politicians that eventually lead to economic benefits.

In our set up the incumbent firm can exploit the repeated interaction and relationship with the politician to produce at lower costs, a "learning-by-knowing" option. Together with the innovation outcome, this determines its ability to prevent entry and keep the market. Since the cost reduction related to political connections can only be exploited if the incumbent firm invests in networking and the politician is re-elected, the incumbent politician is intrinsically different from the opponent in the eyes of economic agents. Thus, by setting the level of red tape σ_t, the incumbent politician can affect the probability of being re-elected.

We assume that the politician seeks re-election and chooses the level of red-tape to maximize the probability of being re-elected in period t. We also assume that, if more than one level of bureaucratic costs ensures re-election, the politician will choose the *lowest* level of distortion. In other words, once probability of re-election is maximized, the politician will avoid unnecessary distortions. Elections are held in each period and voters decide whether to confirm the incumbent or replace her. As workers represent the majority of the electorate, we focus solely on their political preferences to determine electoral results. In particular, the incumbent politician is re-elected with probability one (zero) when workers benefit (lose) from her remaining in office. If workers are indifferent between maintaining or replacing the incumbent, the probability that the incumbent is re-elected is strictly smaller than one (in particular we will set it equal to 1/2).

2.2 Networks and entry

In the intermediate good sector, given the level of red tape, competition between the incumbent and outside firms depends on their relative technological distance and on political connections.

If the incumbent monopolist is not politically connected and all potential producers face the same marginal cost of production σ_t, the incumbent firm will maintain its monopoly if and only if it succeeds in innovation and produces with leading-edge technology. Otherwise a new firm will enter the market and become the monopolist. In either case the unconstrained monopoly price is equal to σ_t/α.

If the incumbent firm is politically connected, however, it may be able to escape competition even if it is not at the technology frontier by exploiting the competitive advantage due to connections. As σ_t increases, incumbent firms further away from the frontier will be able to avoid entry if politically connected. Denoting with k_t the end-of-period (post-innovation) incumbent's distance to the frontier, the (minimum) level of red-tape ensuring that the politically connected incumbent maintains its monopoly is $\sigma_t = \gamma^{k_t}$. In fact, the outside firm anticipates that, in case of entry, the incumbent firm (whose production cost is equal to one) will set the limit price σ_t/γ^{k_t}, at which both firms make zero profits, and chooses not to enter. Thus, if $\sigma_t \geq \gamma^{k_t}$, a politically connected firm with post-innovation quality k_t-steps to the frontier maintains its monopoly. The unconstrained monopoly price is $1/\alpha$ in this case, as the politically connected firm has marginal cost of production equal to one.[2] If instead, $\sigma_t < \gamma^{k_t}$, entry occurs. The new entrant sets the unconstrained monopoly price σ_t/α, if $\sigma_t < \alpha\gamma^{k_t}$. If $\sigma_t \geq \alpha\gamma^{k_t}$, instead, it must set the limit price γ^{k_t}.

To simplify the exposition, as in Aghion and Howitt [7], and Aghion et al. [5], [6], we focus on the case where, at the beginning of each period t, the monopolist can be at most one step to the frontier, that is $k_{t-1} = \{0, 1\}$.

In our framework, this requires that, in any period, the level of red-tape (or equivalently the cost reduction granted by political connections) σ is bounded above by γ^2. This implies that the incumbent firm, even if politically connected, cannot prevent entry if its quality is two steps from the frontier or higher, and that the operating firm in any period t will be either a firm (incumbent or new entrant) with state-of-the art technology, or an incumbent firm that is at most one step behind the frontier.[3] In the next Section, we will show under which parameters configurations the equilibrium value of σ turns out to be below γ^2, implying that our restriction on k_{t-1} is actually not binding and that our analysis also applies to the general case where $\sigma < \gamma^{\overline{k}}$ and $\overline{k} > 2$.[4]

The optimizing behavior of agents and the equilibrium outcome of their strategic interaction will be examined in the following section. Here, we use profit maximization conditions in the final good sector to derive a general expression for the aggregate level of income as a function of quality, price and marginal cost of production of the intermediate good. In particular, denoting price and cost of the intermediate in period t with p_t and

[2] Even if the owners of previous vintages may also exploit political connections -this may happen if the politician in office in period t was already in office when they were monopolist- they would make negative profits at this price. For example, the highest price that could be set by the owner of the immediately previous vintage is $1/\alpha\gamma$, which is smaller than its marginal cost of production (recall that $1/\alpha < \gamma$).

[3] In both cases there will be scope for cost reduction related to political connections in $t+1$, as the firm operating in period t can establish a network with the politician in office in period t.

[4] By choosing the level of red tape σ, the politician affects also the economy's maximum distance from the frontier. As we will see, under plausible parameter restrictions, the upper limit to the distance from the frontier, $k_{t-1} \leq 1$, is a consequence of politicians' behavior.

c_t, respectively, we can write aggregate income as:

$$\Omega_t = \gamma^{\frac{\alpha}{1-\alpha}Q_t}\left[\left(\frac{\alpha}{p_t}\right)^{\frac{\alpha}{1-\alpha}} - c_t\left(\frac{\alpha}{p_t}\right)^{\frac{1}{1-\alpha}}\right] \tag{2}$$

where $p_t = \{1/\alpha, \gamma, \gamma^2, \sigma_t/\alpha\}$, $c_t = \{1, \sigma_t\}$ and $Q_t = \{Q_{t-1}, Q_{t-1}+1, Q_{t-1}+2\}$.

Notice that, although the level of income is maximum when $\sigma_t = 1$ and there are no networks, once σ_t has been set sufficiently high at the beginning of the period, higher income can be reached in the presence of networks. For example, consider the case where the incumbent firm invested in networks and has state-of-the art quality. If the incumbent politician is confirmed, $p_t = 1/\alpha$ and $c_t = 1$. If the politician is not confirmed, $p_t = \sigma_t/\alpha$ and $c_t = \sigma_t$. Thus, income is higher when the politician is confirmed if $\sigma_t > 1$. In this case, the gain from networks in terms of higher current income has no cost in terms of future productivity.

However, there will be cases where the static gain from networks implies a dynamic loss, generating a trade-off for agents (workers in particular) who must decide whether to replace the incumbent politician or not. To see this, consider the case where the incumbent invested in networks and is one step behind the frontier. If $\sigma_t > \gamma$, it will still be the case that current income is higher when the incumbent politician is confirmed, as the productivity increase granted by entry of a higher quality producer is not large enough to compensate for the cost reduction due to network. However, future productivity is reduced, as entry of the technological leader is blocked by the politically connected laggard.

2.3 The game

Each period t starts with technology Q_{t-1} inherited from period $t-1$, and technological gap k_{t-1} between the incumbent firm and the technological frontier (distance to frontier). The timing of the events is the following. (1) At the beginning of period t, the incumbent politician sets red tape costs $\sigma_t \in \Sigma = [1, \gamma^2)$. (2) The incumbent firm decides R&D effort $\lambda_t \in \Lambda = [0,1]$ and investment in networking $n_t \in N = \{0, \overline{n}\}$. (3) The outcome of R&D effort becomes known: $I_t = \{0,1\}$ if the incumbent firm fails or succeeds in innovation, respectively. (4) Elections are held and voters (workers) decide whether to confirm the incumbent in office or replace her by choosing $v_t \in V = \{0,1\}$ where 0 denotes voting for the opponent and 1 for the incumbent. (5) Outside firm decides whether to keep out or enter the market $e_t \in E = \{1,0\}$. (6) Production and consumption take place.

The history of the game in period t is a vector:

$$h_t \equiv (t, Q_{-1}, .., Q_{t-1}, k_0, ..k_{t-1}, \sigma_0, .., \sigma_{t-1}, \lambda_0, .., \lambda_{t-1}, n_0, ..n_{t-1}, v_0.., v_{t-1}, e_0, ..e_{t-1})$$

The set of all possible history is denoted by H_t. The future in period t is the sequence of future actions and states $(t+1, .., Q_t, .., k_t, .., \sigma_{t+1}, .., \lambda_{t+1}, .., n_{t+1}, .., v_{t+1}, .., e_{t+1}, ..)$. We denote by $H(h_t, \sigma_t, \lambda_t, n_t, v_t, e_t)$ the set of all possible histories h_{t+1} generated by $h_t, \sigma_t, \lambda_t, n_t, v_t$ and e_t. Finally, $h_0 \equiv (0, Q_{-1}, 0)$ and time 0 begins with an incumbent politician and an incumbent firm.

A strategy for the politician is a sequence of actions $\sigma : H_t \rightarrow \Sigma$ which depends on history at time t. A strategy for the firm is a sequence of actions $\lambda : H_t$ x $\Sigma \rightarrow \Lambda$ and $n : H_t$ x $\Sigma \rightarrow N$ which depends on history and the action of the politician. A strategy for voters is a sequence of actions $v : H_t$ x Σ x Λ x $N \rightarrow V$ which depends on history, the action of the politician and the choices of the firm. Finally, a strategy for the outside firm is a sequence of actions $e : H_t$ x Σ x Λ x N x $V \rightarrow E$ which depends on history, the action of the politician, the choices of the incumbent firm and electoral results.

With history h_t, the expected pay-off for the politician of an action σ_t is given by:

$$u^p(h_t, \sigma_t, \lambda_t, n_t, v_t, e_t) = E_t R_t \tag{3}$$

where E_t is the expectations operator conditional on information available at time t and R_t is a variable which takes value $R > 0$ if the politician is re-elected at time t and 0 if the politician is not re-elected. In other words, we assume that the politician cares only about being in office and will therefore seek to maximize the probability of being re-elected. To simplify the analysis, we will assume that, when not re-elected, the politician can no longer run for office.

The expected pay-off for the incumbent firm of actions λ_t and n_t is given by:

$$u^f(h_t, \sigma_t, \lambda_t, n_t, v_t, e_t) = E_t \Pi_t \tag{4}$$

where Π_t denotes incumbent's profit.[5]

The expected pay-off for the voter of an action v_t is given by:

$$u^w(h_t, \sigma_t, \lambda_t, n_t, v_t, e_t) = E_t \sum_{s=0}^{\infty} \beta^s w_{t+s} \tag{5}$$

[5]The assumption that firms maximize current profit greatly simplifies the analysis, without a cost in terms of missing interesting insights. If firms took into account future profits, they would simply invest a bit more in R&D to increase the likelihood of being operative in the future. Relative to our working assumption, no additional incentives or trade-offs would be introduced.

where w_{t+s} denotes the wage rate at time $t+s$.[6]

Finally, the expected pay-off for the outside firm of action e_t is given by:

$$u^o(h_t, \sigma_t, \lambda_t, n_t, v_t, e_t) = E_t \Pi_t^o \tag{6}$$

where Π_t^o denotes profit of the outsider.

3 The politico-economic equilibrium

We will now characterize the equilibrium of our infinitely repeated game. We limit the analysis to stationary Markov perfect equilibria (SMPE). Given the structure of our infinite-horizon model, time is not part of the payoff relevant state so that it seems natural to focus on stationary strategies that do not depend on calendar time (see Maskin and Tirole [18]). Moreover, given the economics of the model, the state of technology at the end of the previous period Q_{t-1} and the technological gap k_{t-1} are the appropriate state variables since current payoffs (and therefore current actions) depend crucially on the inherited level of technology and the distance to frontier. Accordingly:

Definition 1 (Stationary Markov Perfect Equilibrium) *The Markov strategies*

$$\sigma^*(Q_{t-1}, k_{t-1}), \lambda^*(Q_{t-1}, k_{t-1}, \sigma_t(\cdot)), n^*(Q_{t-1}, k_{t-1}, \sigma_t(\cdot)),$$
$$v^*(Q_{t-1}, k_{t-1}, \sigma_t(\cdot), \lambda_t(\cdot), n_t(\cdot)), e^*(Q_{t-1}, k_{t-1}, \sigma_t(\cdot), \lambda_t(\cdot), n_t(\cdot), v_t(\cdot))$$

form a Stationary Markov Perfect Equilibrium (SMPE) if and only if:

(i) for all Q_{t-1}, k_{t-1}, $\sigma_t(\cdot), \lambda_t(\cdot), n_t(\cdot), v_t(\cdot)$, $e^*(Q_{t-1}, k_{t-1}, \sigma_t(\cdot), \lambda_t(\cdot), n_t(\cdot), v_t(\cdot))$ is a solution to:

$$\arg\max_{e_t \in \{1,0\}} u^o(Q_{t-1}, k_{t-1}, e_t)$$

(ii) for all Q_{t-1}, k_{t-1}, $\sigma_t(\cdot), \lambda_t(\cdot), n_t(\cdot)$:

$$u^w(Q_{t-1}, k_{t-1}, v_t^*, e_t^*) \geq u^w(Q_{t-1}, k_{t-1}, \widehat{v}_t, \widehat{e}_t)$$

for any $\widehat{v}_t \neq v_t^*$, where e^* and $\widehat{e}$ are best response actions to v^* and $\widehat{v}$ respectively.

(iii) for all Q_{t-1}, k_{t-1}, and $\sigma_t(\cdot)$:

$$u^f(Q_{t-1}, k_{t-1}, \lambda_t^*, n_t^*, v_t^*, e_t^*) \geq u^f(Q_{t-1}, k_{t-1}, \overline{\lambda}_t, \overline{n}_t, \overline{v}_t, \overline{e}_t)$$

[6] Notice that, from an economic point of view, the only feature that distinguishes the two politicians in the eyes of the voters is the potential connection with the operating firm. If this connection is absent, the two politicians would necessarily deliver the same economic outcome.

for any $\overline{\lambda}_t \neq \lambda_t^*$ *and* $\overline{n}_t \neq n_t^*$ *where* v^*, e^* *and* $\overline{v}, \overline{e}$ *are best response actions to* λ^*, n^* *and* $\overline{\lambda}, \overline{n}$ *respectively.*

(iv) for all Q_{t-1} *and* k_{t-1}*:*

$$u^p(Q_{t-1}, k_{t-1}, \sigma_t^*, \lambda_t^*, n_t^*, v_t^*, e_t^*) \geq u^p(Q_{t-1}, k_{t-1}, \widetilde{\sigma}_t, \widetilde{\lambda}_t, \widetilde{n}_t, \widetilde{v}_t, \widetilde{e}_t)$$

for any $\widetilde{\sigma}_t \neq \sigma_t^*$*, where* $\lambda_t^*, n_t^*, v_t^*, e_t^*$ *and* $\widetilde{\lambda}_t, \widetilde{n}_t, \widetilde{v}_t, \widetilde{e}_t$ *are best response actions to* σ^* *and* $\widetilde{\sigma}$ *respectively.*

In words, given an initial level of technology and technological gap, the incumbent politician chooses the level of bureaucratic costs, the incumbent firm chooses R&D effort and network investment, voters cast their vote and outsiders decide whether to entry or not, in order to maximize their own utility given the actions of all other agents. Each agent must take into account current and future effects of each possible action.

3.1 Firms

In order to characterize the SPME of our dynamic game, let us begin by determining firms' optimal behavior. Since time is not part of the pay-off relevant state, we will omit the subscript t unless necessary and write agents' choices as functions of states Q and k. Given our assumptions, at the beginning of each period the incumbent firm can either be at the technological frontier ($k = 0$) or one step behind ($k = 1$). We will then consider these two cases separately.[7]

3.1.1 One step behind (k=1)

When $k = 1$ and $\gamma^2 > \sigma \geq \gamma$, if the incumbent firm does not innovate, it would end up two-steps from the frontier and could not compete with firms at the technological frontier. However, the incumbent can keep in the market if (i) it succeeds in innovation (so that the technological gap is limited to one step), provided that (ii) it invests in networking, and that (iii) the incumbent politician is re-elected. In all other cases, and in particular when $\sigma < \gamma$, the incumbent firm will be driven out of the market and make zero profits.

The incentives to invest in networking and innovation depend on electoral results $v \in \{0, 1\}$. The firm observes the level of red-tape, and rationally anticipates workers' optimal behavior. As we will see, workers' incentive to confirm the politician depends on the

[7] Although to characterize the equilibrium and prove our main propositions we have solved the game by backward induction, for expositional purposes we chose to begin by illustrating firms' behavior.

post-innovation distance from the frontier which, in turn, is determined by the beginning-of-period distance to the frontier, $k = \{0, 1\}$, and innovation outcome, $I = \{0, 1\}$.

Let us denote with v_{kI} electoral results when the initial technological gap is k, and the innovation outcome is I. If $\sigma \geq \gamma$ and $v_{11} > 0$, the incumbent firm certainly invests in networking, that is $n_1 = \overline{n}$. In this case, with probability $\lambda_1(1 - \overline{n})$ the incumbent firm keeps the market, sets the monopoly price $1/\alpha$ and makes profits $\pi\gamma^{\frac{\alpha(Q+1)}{1-\alpha}}$, where $\pi \equiv \alpha^{\frac{1+\alpha}{1-\alpha}}(1-\alpha)$.[8] On the contrary, with probability $1-\lambda_1(1-\overline{n})$, there is entry and the incumbent firm makes zero profits. If $\sigma < \gamma$, expected profits of the incumbent firm are zero as entry cannot be prevented so that n_1 and λ_1 are also zero.[9]

Expected profits of the incumbent firm which is one step from the frontier at the beginning of the period are thus given by:

$$E\pi_1 = \begin{cases} 0 & \sigma < \gamma \\ \gamma^{\frac{\alpha Q}{1-\alpha}} \left\{ [\lambda_1(1-\overline{n})]\, v_{11}\pi\gamma^{\frac{\alpha}{1-\alpha}} - \frac{c(\lambda_1)^2}{2} \right\} & \sigma \geq \gamma \end{cases} \tag{7}$$

From the first-order condition for investment in R&D we obtain:

$$\lambda_1 = \begin{cases} 0 & \sigma < \gamma \\ C\gamma^{\frac{\alpha}{1-\alpha}} v_{11} & \sigma \geq \gamma \end{cases} \tag{8}$$

where $C \equiv \frac{(1-\overline{n})\pi}{c}$ collects parameters affecting the profitability of investment in R&D.

The innovation rate λ_1 is a step function which takes value zero when $\sigma < \gamma$ and positive otherwise (provided that $v_{11} > 0$). Notice that networking provides the low-quality producer with the incentives to undertake R&D, which would be absent otherwise. Here, innovation and networking are *complements*. Moreover, innovation depends on electoral outcomes: if and only if the firm anticipates that there is a chance that the incumbent politician will be re-elected it would invest in networking and R&D.

3.1.2 At the frontier (k=0)

When $k = 0$ and innovation is successful, the incumbent keeps the leadership in the market regardless of networking and election outcomes. Moreover, when $\sigma \geq \gamma$, the incumbent firm can keep the market even if it does not innovate, provided that (i) it invests in

[8] Notice that if in this case the firm did not invest in networking, expected profit would be equal to zero, as the outside firm would enter the market regardless of the innovation outcome of the incumbent firm.

[9] Notice that if $v_{11} = 0$, there is no way to prevent entry, so that both investment in networking and innovation would be equal to zero even when $\sigma \geq \gamma$.

networking, and (ii) that the incumbent politician is re-elected. In particular, if the firm invests in networks, expected profits are:

$$E\Pi_{0,n} = \begin{cases} \gamma^{\frac{\alpha Q}{1-\alpha}}\{[\lambda_0(1-\overline{n})]\,\pi\gamma^{\frac{\alpha}{1-\alpha}} - \frac{c(\lambda_0)^2}{2}\} & \sigma < \gamma \\ \gamma^{\frac{\alpha Q}{1-\alpha}}\{[\lambda_0(1-\overline{n})]\,\pi\gamma^{\frac{\alpha}{1-\alpha}} + [1-\lambda_0(1-\overline{n})]\,\pi v_{00} - \frac{c(\lambda_0)^2}{2}\} & \sigma \geq \gamma \end{cases} \tag{9}$$

From the first order condition for investment in innovation we get:

$$\lambda_{0,n} = \begin{cases} C\gamma^{\frac{\alpha}{1-\alpha}} & \sigma < \gamma \\ C\left[\gamma^{\frac{\alpha}{1-\alpha}} - v_{00}\right] & \sigma \geq \gamma \end{cases} \tag{10}$$

Once again, the innovation rate when the firm invests in networking is a step function, this time with positive innovation rates for all σ. If $v_{00} > 0$ the innovation rate is lower when $\sigma \geq \gamma$ than when $\sigma < \gamma$. Contrary to the previous case, here networking and innovation turn out to be *substitutes*: when bureaucratic costs are high, political connections reduce the incentive to innovate in order to escape competition by potential entrants.

Since the incumbent firm can survive in the market even without connections, we must also explicitly consider the conditions under which the incumbent firm finds it profitable to invest in networking. Without investment in networking ($\overline{n} = 0$), expected profits turn out to be:

$$E\Pi_{0,-n} = \gamma^{\frac{\alpha Q}{1-\alpha}}\left[\lambda_0\pi\,(\gamma/\sigma)^{\frac{\alpha}{1-\alpha}} - \frac{c\,(\lambda_0)^2}{2}\right] \tag{11}$$

as the firm sets the monopoly price σ/α when it innovates. The optimal investment in innovation yields:

$$\lambda_{0,-n} = \frac{\pi}{c}\,(\gamma/\sigma)^{\frac{\alpha}{1-\alpha}} \tag{12}$$

We can then show the following:

Lemma 1 *Let $\widehat{\sigma} \equiv (1-\overline{n})^{-\frac{1-\alpha}{\alpha}}$. (i) When $\widehat{\sigma} < \gamma$ or $v_{00} = 0$, the incumbent firm chooses to invest in networking if and only if $\sigma \geq \widehat{\sigma}$. (ii) When $\widehat{\sigma} > \gamma$ and $v_{00} = 1$, the incumbent firm chooses to invest in networking if and only if $\sigma \geq \gamma$.*

Proof. (i) Consider first the case where $\widehat{\sigma} < \gamma$ or $v_{00} = 0$. By simple inspection of profit functions it is immediate to see that $E\Pi_{0,n} \geq E\Pi_{0,-n}\ \forall\sigma \geq \widehat{\sigma}$. (ii) Consider now $\widehat{\sigma} > \gamma$ and $v_{00} = 1$. It is easy to show that, for a given level of λ, when $\sigma \geq \gamma$, $E\Pi_{0,n} - E\Pi_{0,-n} \geq [\lambda(1-\overline{n})(\gamma^{\frac{\alpha}{1-\alpha}} - 1) + 1 - \lambda]\pi > 0$. ■

As the previous result establishes, there is a minimum level of bureaucratic costs required in order to induce the firm to devote time to networking, which is increasing with the opportunity cost of networking $\overline{n}$ and the productivity gain of innovation $\gamma^{\frac{\alpha}{1-\alpha}}$. Differently from the previous case where $k = 1$, here the incumbent firm may find it profitable to invest in networking even for $\sigma < \gamma$ provided that $\overline{n}$ is sufficiently low.

3.2 Voters

We can now turn to study workers' voting problem, that is to determine whether workers would prefer to maintain ($v = 1$) or replace ($v = 0$) the incumbent politician in all possible states.

3.2.1 Wages

First of all, it is useful to write down the wage rates prevailing in different states of the world. Let us now denote by $w_k(\sigma, n, I, v)$ the wage rate when the distance to frontier at the beginning of the period is $k = \{0, 1\}$, bureaucratic costs are σ, investment in networking is $n = \{0, \overline{n}\}$, the innovation outcome is $I = \{0, 1\}$ and the election outcome is $v = \{0, 1\}$. Starting with the case where $k = 1$ and $\sigma \geq \gamma$ and given our discussion in section 2.2., we can write:

$$\begin{aligned} w_1(\sigma, \overline{n}, 1, 1) &= w\gamma^{\frac{\alpha(Q+1)}{1-\alpha}} (1/\alpha)^{\frac{\alpha}{\alpha-1}} \\ w_1(\sigma, \overline{n}, 0, 1) &= \begin{cases} w\gamma^{\frac{\alpha(Q+2)}{1-\alpha}} (\sigma/\alpha)^{\frac{\alpha}{\alpha-1}} & if \quad \sigma < \alpha\gamma^2 \\ w\gamma^{\frac{\alpha Q}{1-\alpha}} & if \quad \sigma \geq \alpha\gamma^2 \end{cases} \\ w_1(\sigma, \overline{n}, \cdot, 0) &= w\gamma^{\frac{\alpha(Q+2)}{1-\alpha}} (\sigma/\alpha)^{\frac{\alpha}{\alpha-1}} \end{aligned}$$

where $w \equiv (1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}$.

If instead $\sigma < \gamma$ we know from firms' behavior that $n_1 = \lambda_1 = 0$ so that:

$$w_1(\sigma, 0, 0, \cdot) = w\gamma^{\frac{\alpha(Q+2)}{1-\alpha}} (\sigma/\alpha)^{\frac{\alpha}{\alpha-1}}$$

It is worth emphasizing that $\sigma \geq \gamma$, $n = \overline{n}$, $I = 1$, and $v = 1$ is the *only* case where the incumbent firm keeps the market and sets monopoly price $1/\alpha$. When $\sigma \geq \alpha\gamma^2$, $n = \overline{n}$, $I = 0$, and $v = 1$, there is entry and the outside firm sets the limit price γ^2 as the incumbent firm would make positive profits at the monopoly price σ/α. In all other cases, there is entry and the outside firm sets the monopoly price σ/α. For example, when $n = \overline{n}$, $I = 1$, and $v = 0$, the incumbent firm is out of the market at price σ/α since it has same marginal cost of production σ as the outside firm, and $1/\alpha < \gamma < \gamma^2$.

Notice that, when the incumbent firm succeeds in innovation, the wage rate is higher in the presence of active networks (that is when $n = \overline{n}$ and $v = 1$) that prevent entry of the outside firm. When innovation is not successful and entry occurs, the wage rate is higher with networks for $\sigma \geq \alpha\gamma^2$.

Similarly, when $k = 0$, and conditions for networking are satisfied we can write:

$$\begin{aligned}
w_0(\cdot, \overline{n}, 1, 1) &= w\gamma^{\frac{\alpha(Q+1)}{1-\alpha}} (1/\alpha)^{\frac{\alpha}{\alpha-1}} \\
w_0(\sigma, \overline{n}, 0, 1) &= \begin{cases} w\gamma^{\frac{\alpha(Q+1)}{1-\alpha}} (\sigma/\alpha)^{\frac{\alpha}{\alpha-1}} & if \;\; \sigma < \alpha\gamma \\ w\gamma^{\frac{\alpha Q}{1-\alpha}} & if \;\; \gamma > \sigma \geq \alpha\gamma \\ w\gamma^{\frac{\alpha Q}{1-\alpha}} (1/\alpha)^{\frac{\alpha}{\alpha-1}} & if \;\; \sigma \geq \gamma \end{cases} \\
w_0(\sigma, \overline{n}, \cdot, 0) &= w\gamma^{\frac{\alpha(Q+1)}{1-\alpha}} (\sigma/\alpha)^{\frac{\alpha}{\alpha-1}}
\end{aligned}$$

When $I = 0$, entry occurs for all σ if $v = 0$ (no active networks) and for $\sigma < \gamma$ if $v = 1$. In the latter case, political connections do not award the incumbent laggard a cost reduction large enough to price the competitor out of the market. In case of entry, the outside firm sets the monopoly price σ/α or, when $\sigma > \alpha\gamma$, the limit price γ. In all other cases where the incumbent firm keeps the market leadership, the price is $1/\alpha$ or σ/α, when networks are active ($v = 1$) or not active ($v = 0$) respectively.

Once again, when the firm succeeds in innovation, the wage rate is strictly higher in the presence of active networks. When instead the firm does not succeed in innovation, the level of the wage is strictly higher with networks whenever $\sigma \geq \alpha\gamma$.

Finally, when $n = 0$, the operating firm (incumbent or new entrant) is always at the technological frontier, price is equal to σ/α and the wage rate is given by:

$$w_0(\sigma, 0, \cdot, \cdot) = w\gamma^{\frac{\alpha(Q+1)}{1-\alpha}} (\sigma/\alpha)^{\frac{\alpha}{\alpha-1}}$$

3.2.2 Voting

Having specified the level of wages in each possible state of the world, we can now proceed to the main goal of this section, that is to analyze voters' optimal choice between the incumbent and the opponent.

Voters' decision in period t when $n = 0$ is trivial. In this case, the two candidates are completely equivalent in the eyes of voters, as current and future economic outcomes do not depend on current electoral results: technology is upgraded and the current wage rate is equal to $w_t = w\gamma^{\frac{\alpha(Q_{t-1}+1)}{1-\alpha}}(\sigma/\alpha)^{\frac{\alpha}{\alpha-1}}$.

To further characterize voters' behavior, let us focus on cases where $n = \overline{n}$ in all periods and for all states. Let us denote with $V_k(\sigma_k, \overline{n}, I)$ the maximum level of utility attained by workers when the current state is k, the level of red tape is σ_k, investment in networking is $\overline{n}$ and the innovation outcome is I.

Whenever $k = 0$ and $I = 1$, or $k = 1$ and $I = 0$, technology reaches the frontier at the end of the period, as incumbent firm keeps up with the frontier and high-quality outsider enters the economy, respectively. Thus, the next-period state is $k = 0$, *regardless of workers' current choice*, and we can write:

$$
\begin{aligned}
V_0(\sigma_0, \overline{n}, 1) &= \max_{v_0 \in \{0,1\}} \left\{ w_0(\sigma_0, \overline{n}, 1, v_0) + \beta\gamma^{\frac{\alpha}{1-\alpha}} \left[\Lambda_0 V_0(\sigma_0, \overline{n}, 1) + (1-\Lambda_0) V_0(\sigma_0, \overline{n}, 0) \right] \right\} \\
V_1(\sigma_1, \overline{n}, 0) &= \max_{v_1 \in \{0,1\}} \left\{ w_1(\sigma_1, \overline{n}, 0, v_1) + \beta\gamma^{\frac{2\alpha}{1-\alpha}} \left[\Lambda_0 V_0(\sigma_0, \overline{n}, 1) + (1-\Lambda_0) V_0(\sigma_0, \overline{n}, 0) \right] \right\}
\end{aligned}
$$

where $\Lambda_0 \equiv \lambda_0(1-\overline{n})$ and $\Lambda_1 \equiv \lambda_1(1-\overline{n})$ denote the effective innovation rates.[10]

In these two cases, worker's optimal choice reduces to maximizing current wage, as the continuation value does not depend on worker's current action. In particular, when $k = 0$ it will always be optimal to maintain the incumbent politician. When $k = 1$, the optimal worker's choice is $v = 1$ if $\sigma_1 > \alpha\gamma^2$, as the current wage is higher with active networks in this case. Otherwise, the worker would be indifferent between the two politicians (in this case, the incumbent politician expects to be re-elected with probability equal to 1/2).

When $k = 0$ and $I = 0$, if the level of red tape is not high enough to block entry ($\sigma_0 < \gamma$), entry occurs, technology reaches the frontier and the future state is $k = 0$, no matter what is the worker's choice. In this case workers will vote in favor of the incumbent politician if $\sigma_0 > \alpha\gamma$ (otherwise they are indifferent). Similarly, when $k = 1$ and $I = 1$, entry occurs for sure if $\sigma_1 < \gamma$ and workers are indifferent to the electoral outcome (again, the incumbent is re-elected with probability 1/2).

In both cases, when red tape costs are larger than γ, voters are no longer indifferent between the two candidates. In particular, if the incumbent politician is re-elected, entry is blocked, and the future state is $k = 1$ (*dynamic loss*). However the current wage is higher than what it would be if the incumbent politician were replaced (*static gain*).

[10] We assume that $\beta\gamma^{\frac{\alpha}{1-\alpha}} < 1$ to ensure bounded utility.

Formally, consider the case $k = 0$ and $I = 0$ and let $\sigma_0 \geq \gamma$. Then, we can write:

$$V_0(\sigma_0, \overline{n}, 0) = \max_{v_0 \in \{0,1\}} \left\{ \begin{array}{c} w_0(\sigma_0, \overline{n}, 0, v_0) + \beta v_0[\Lambda_1 V_1(\sigma_1, \overline{n}, 1) + (1 - \Lambda_1) V_1(\sigma_1, \overline{n}, 0)] + \\ +\beta \gamma^{\frac{\alpha}{1-\alpha}} (1 - v_0) [\Lambda_0 V_0(\sigma_0, \overline{n}, 1) + (1 - \Lambda_0) V_0(\sigma_0, \overline{n}, 0)] \end{array} \right\}$$

Similarly, if workers observe $I = 1$ when $k = 1$ and $\sigma_1 \geq \gamma$ we have:

$$V_1(\sigma_1, \overline{n}, 1) = \max_{v_1 \in \{0,1\}} \left\{ \begin{array}{c} w_1(\sigma_1, \overline{n}, 1, v_1) + \beta \gamma^{\frac{\alpha}{1-\alpha}} v_1[\Lambda_1 V_1(\sigma_1, \overline{n}, 1) + (1 - \Lambda_1) V_1(\sigma_1, \overline{n}, 0)] + \\ +\beta \gamma^{\frac{2\alpha}{1-\alpha}} (1 - v_1) [\Lambda_0 V_0(\sigma_0, \overline{n}, 1) + (1 - \Lambda_0) V_0(\sigma_0, \overline{n}, 0)] \end{array} \right\}$$

By inspection of these value functions and taking into account wage equations, it can be verified that $\sigma_0 \leq \sigma_1$ implies $v_{00} = v_{11}$, that is whatever is optimal for voters when $k = 0$ and $I = 0$, it is also optimal when $k = 1$ and $I = 1$. In words, the optimal choice of voters when the incumbent firm's post-innovation quality is one step from the frontier does not depend on the initial state, for $\gamma \leq \sigma_0 \leq \sigma_1$. Moreover, note that $V_1(\sigma_1, \overline{n}, 1) = \gamma^{\frac{\alpha}{1-\alpha}} V_0(\sigma_0, \overline{n}, 0)$ for $\sigma_0 = \sigma_1$. These facts will be useful to prove the following result:

Proposition 1 *Consider the case where in period t the state is either $k = 0$, $I = 0$ or $k = 1$, $I = 1$ and let $\widehat{\sigma} \geq \gamma$. Then, if $\frac{\pi}{c} < \gamma^{\frac{\alpha}{\alpha-1}}$ and $\alpha \geq \overline{\alpha}$ where $\overline{\alpha}$ is defined by $\alpha^{\frac{\alpha}{\alpha-1}}(\alpha^{\frac{\alpha}{\alpha-1}} - 1) = 1$, there exists $\overline{\sigma} \in (\gamma, \gamma^2)$ such that, if from period t onwards the incumbent politician plays $\sigma \geq \overline{\sigma}$, firms invest in networking and voters confirm the incumbent in all other states, the best-response action for voters is to confirm the incumbent in period t.*

Proof. See Appendix. ■

This last result shows that, under some configurations of parameters, there exists a threshold level of red-tape costs $\overline{\sigma}$, consistent with our initial restriction $\sigma < \gamma^2$, such that, for any level of costs above this threshold, voters always choose to confirm the incumbent politician.[11] This threshold level will play a crucial role in the characterization of the politico-economic equilibrium, which will be the focus of the next section.

Notice that restrictions on parameters yielding sufficient conditions for the existence of $\overline{\sigma} < \gamma^2$ are rather mild. In particular, the restriction $\frac{\pi}{c} < \gamma^{\frac{\alpha}{\alpha-1}}$ is equivalent to ruling out the corner solution where the incumbent firm's innovates with probability one in the absence of networks and red tape ($\sigma = 1$). Moreover, the threshold level $\overline{\alpha}$ is rather low (approximately 0.27), implying that condition $\alpha \geq \overline{\alpha}$ is satisfied for most values of α.

[11]Technically, voters would be indifferent between the incumbent and the opponent when $\sigma = \overline{\sigma}$. Clearly in this case the incumbent can secure re-election by setting a level of red tape $\sigma = \overline{\sigma} + \varepsilon$, with ε arbitrarily small. In the remaining of the paper, the same argument will apply to similar cases.

3.3 Characterization of the equilibrium

In the previous sections we have analyzed firms and voters' behavior. We are now left with the analysis of politician's behavior in order to fully characterize the equilibrium of our economy. According to the timing of the game, the politician moves first and chooses the level of red tape costs to maximize the probability of being re-elected, fully anticipating firms and voters' reactions. Clearly, if the politician aims at being re-elected, she has to make sure that the incumbent firm invests in networking. At the same time, the level of red tape costs must be large enough to induce workers to vote for the incumbent politician and perpetuate the network between the politician and the firm. Using our previous results about firms and voters' behavior, we can state the following:

Proposition 2 (Perpetual upgrading) *Let $\overline{n} < 1 - \gamma^{\frac{\alpha}{\alpha-1}}$. Then the only SMPE is such that $\sigma = \max[\widehat{\sigma}, \alpha\gamma]$, the incumbent politician is re-elected with probability one and the operating firm is always at the frontier.*

Proof. We know that whenever $\sigma < \gamma$, the operating firm produces with leading-edge technology. Thus, at any point in time, $k = 0$. By Lemma 1, we have that in this case if $\sigma \geq \widehat{\sigma}$ the incumbent firm invests in networking. If the incumbent firm also succeeds in innovation, any $\sigma \geq \widehat{\sigma}$ ensures re-election. If instead the incumbent firm does not innovate (so that there is entry) re-election is guaranteed only for $\sigma \geq \alpha\gamma$. Since we have assumed that, for a given probability of re-election, the politician minimizes the level of distortion, the claim of the proposition immediately follows. ■

When $\overline{n} < 1 - \gamma^{\frac{\alpha}{\alpha-1}}$, the minimum level of bureaucratic cost that must be set by the politician to induce networking $\widehat{\sigma}$ is lower than γ. Low cost of networking $\overline{n}$ and small productivity gain in case of innovation $\gamma^{\frac{\alpha}{1-\alpha}}$ imply that the firm is easily induced to invest in networking, as the profit loss due to lower probability of innovation is relatively small. Since the level of red tape that induces networking is below γ, it is impossible for the incumbent firm to keep the market without producing with the leading-edge technology. Thus, there is perpetual upgrading of technology through innovation or entry. The equilibrium level of red tape ensures that the incumbent firm always invests in networking, as $\sigma \geq \widehat{\sigma}$, and that workers always vote for the incumbent politician, as political connections imply lower production costs of the incumbent firm and higher wages. In particular, in case of entry, $\sigma \geq \alpha\gamma$ ensures that the level of the wage is higher when the incumbent firm is politically connected, as the new entrant is forced to set the limit price γ rather than the monopoly price σ/α in this case. Instead, when the incumbent firm succeeds in innovation, the wage level is higher with political connections for any $\sigma \geq \widehat{\sigma}$, as the monopoly price set by the politically connected incumbent is $1/\alpha < \sigma/\alpha$. Thus, the politician is re-elected by setting $\sigma = \max[\widehat{\sigma}, \alpha\gamma]$.

In the former equilibrium where $\widehat{\sigma} < \gamma$, political connections and persistence of politicians do not prevent technological upgrade. What happens instead in our economy when the minimum level of distortion necessary to induce the firm to invest in networking is larger than γ? To answer this question, we can use the previous proposition, and prove the following result:

Proposition 3 (Technological inertia) *Let* $\overline{n} \geq 1-\gamma^{\frac{\alpha}{\alpha-1}}$, $\frac{\pi}{c} < \gamma^{\frac{\alpha}{\alpha-1}}$ *and* $\alpha \geq \overline{\alpha}$. *Then*

(i) if $\overline{\sigma} \geq \alpha\gamma^2$ *the only SMPE is such that* $\sigma_0 = \sigma_1 = \overline{\sigma}$

(ii) if $\overline{\sigma} < \alpha\gamma^2$ *the only SMPE is such that* $\sigma_0 \in (\overline{\sigma}, \alpha\gamma^2]$ *and* $\sigma_1 = \alpha\gamma^2$.

In both cases, the incumbent politician is re-elected with probability one and the incumbent firm exploits the network to produce with one-step backward technology.

Proof. See Appendix. ■

When $\overline{n} \geq 1-\gamma^{\frac{\alpha}{\alpha-1}}$, the politician must set $\sigma > \gamma$ to induce investment in networking. This implies that entry of outside competitors that are one-step up in the technological ladder is prevented by political connections (technological inertia). Moreover, by Proposition 1, there exists a minimum constant level of red tape $\overline{\sigma} < \gamma^2$ that ensures re-election when post-innovation technology of the incumbent is one step from the frontier. Thus, setting $\sigma \geq \overline{\sigma}$ the politician ensures re-election when $k = 1, I = 1$ or $k = 0, I = 0$, as the incumbent firm invests in networking and workers enjoy a static gain of political connections (in terms of higher current wage) larger than the dynamic loss due to blocked entry. In all other cases, the operating firm has leading-edge technology and workers vote for the incumbent politician to benefit from the current cost reduction granted by political connections (this requires $\sigma_1 \geq \alpha\gamma^2$, in case of entry, and $\sigma_0 > 1$ in case of innovation by a leading-edge incumbent firm).Notice that, when $\overline{\sigma} < \alpha\gamma^2$, the politician will set lower red tape when $k = 0$, as higher level of distortion provides no further electoral advantage (the probability of re-election is already equal to one).

The last two propositions show that, for reasonable choices of parameters, the politician can always ensure re-election by choosing a level of red tape below γ^2. This implies that, in equilibrium, maximum distance from the frontier is one, and that our initial restriction on k is actually not binding. In other words, even if we dropped the restriction

$\sigma \leq \gamma^2$ and assumed, instead, $\sigma \leq \gamma^{\overline{k}}$ with $\overline{k} > 2$ (thus allowing for the possibility that a politically connected firm with technology $\overline{k} - 1$ steps from the frontier keeps the market), the politician would have no incentive to set $\sigma > \gamma^2$, as she can ensure re-election for lower values of σ. The maximum degree of economic backwardness is therefore *endogenous* and is determined by politicians' strategy for re-election.

Our analysis shows that the equilibrium level of red tape depends on structural parameters that affect the incumbent firms' incentive to network and innovate and voter's impatience. Considering a set of economies that share the same technology for production of the final good (that is with the same values of α and γ), our model predicts that economies where the cost of networking is relatively low - that is where $\overline{n} < 1 - \gamma^{\frac{\alpha}{\alpha-1}}$ - will be characterized by lower level of red tape (here $\sigma < \gamma$) relative to economies where the cost of networking is high (here $\sigma > \gamma$). In the former economies, higher cost of networking is associated to non-decreasing red tape, as $\widehat{\sigma}$ is increasing with $\overline{n}$. For the latter economies, we can establish the following comparative statics result:

Corollary 1 *$\overline{\sigma}$ is increasing with β and decreasing with C.*

Proof. See Appendix. ■

The minimum level of red tape that ensures re-election when post-innovation technology of the incumbent is one step from the frontier, $\overline{\sigma}$, is increasing with the degree of impatience β, as forward-looking voters value more the benefit of technological upgrade and require a larger gain in terms of current wage to be induced to maintain the status quo. Moreover, $\overline{\sigma}$ is increasing with the probability of future innovation by the incumbent, which is determined by the profitability of innovation C. Thus, in economies where the cost of networking is relatively high, higher β and C (that is, lower $\overline{n}$ and c) are associated to non-decreasing red tape.

4 Income and growth

Having characterized the equilibrium strategies of politicians, firms and voters in the previous section, the final step is to compare economies in terms of innovation rates, income levels, and rates of growth.

We begin by noting that the effective innovation rate is always higher in economies with perpetual upgrading. As firms invest in networking, a time consuming activity, the effective innovation rate Λ is determined by the opportunity cost of networking $\overline{n}$, and the investment in innovation λ. By definition, the former is lower in economies with perpetual upgrading than in economies with technological inertia. It is also straightforward to see that the latter is higher in economies with perpetual upgrading. In economies characterized by technological inertia, firms at the frontier invest less than firms one step from the frontier, as they do not need too much innovation to escape competition from outside competitors given their political connections. Moreover, firms that are one step from the frontier in economies with technological inertia invest less than firms in economies with perpetual upgrading, as the probability of success for given investment in innovation is lower due to higher cost of networking.

Turning to the comparison of expected income across economies, the following result can be established:

Proposition 4 (Income) *Consider two economies, one characterized by perpetual upgrading and the other by technological inertia, with the same level of initial technology Q_{-1} and distance to frontier k_{-1}. Then, the expected income at any point in time is higher in the economy with perpetual upgrading.*

Proof. See Appendix. ■

Although quite "natural", the result that perpetual upgrading dominates technological inertia is not trivial to prove as gains from connections and entry can occur in either case. To get the intuition, notice first that maximum income obtains when production is carried out by a leading-edge politically connected firm, an outcome that is possible both in economies with perpetual upgrading and in economies with technological inertia. Second, entry of a technological leader with no political connections in economies where red-tape cost is low yields higher income than the level achieved when a politically connected laggard produces in a high red-tape economy. Finally, the minimum income level is associated to the case of entry in high red-tape economies. Thus, income is always lower in economies with high red-tape cost and technological inertia than in low red-tape economies, with the exception of the case where the maximum income level is achieved. However, the probability that this outcome occurs is lower in economies with high red tape. This probability is given by probability that $k = 0$ multiplied by λ_0. Differently from low red-tape economies, probability that $k = 0$ is strictly smaller than one in high red-tape economies. Moreover, λ_0 is smaller in the latter economies as the firm can survive in the market even without innovating.[12]

[12]Expected income is always below the first-best level that would prevail if the politician did not behave opportunistically. In this case, the level of red tape would be equal to one, technological upgrade would occur in each period, and entry of new producers would not involve any static loss.

The next proposition characterizes the evolution of the expected growth rates in the two economies:

Proposition 5 (Growth rates) *Consider two economies, one characterized by perpetual upgrading and the other by technological inertia, with the same level of initial technology* Q_{-1} *and distance to frontier* k_{-1}*. In the economy with technological inertia, the expected growth rate of the economy converges towards the steady state value* $\frac{\alpha}{1-\alpha}\ln\gamma$ *(in log terms), which is the constant expected growth rate prevailing in the economy with perpetual upgrading. If* $\Lambda_{0n}+\Lambda_{1n}<1$ *, convergence is oscillatory. Otherwise, the growth rate converges monotonically to the steady-state value from below.*

Proof. See Appendix. ■

The model predicts long-run convergence in expected growth rates across countries with different levels of red-tape. Note that, at any point in time, the probabilities that the economy with technological inertia be at the frontier or one step behind (assuming $k_{-1}=0$) are given by:

$$prob(k_t = 0) = \frac{\Lambda_{1n}-1}{\Lambda_{0n}+\Lambda_{1n}-2} + \frac{\Lambda_{0n}-1}{\Lambda_{0n}+\Lambda_{1n}-2}(\Lambda_{0n}+\Lambda_{1n}-1)^t \tag{13}$$

$$prob(k_t = 1) = \frac{\Lambda_{0n}-1}{\Lambda_{0n}+\Lambda_{1n}-2} - \frac{\Lambda_{0n}-1}{\Lambda_{0n}+\Lambda_{1n}-2}(\Lambda_{0n}+\Lambda_{1n}-1)^t \tag{14}$$

The second term in both expressions vanishes in the limit, implying constant probability of being at (one step from) the frontier[13]. Moreover, for $(\pi/c) < \gamma^{\frac{\alpha}{\alpha-1}}$ - a sufficient condition for $\sigma<\gamma^2$ - we get $\Lambda_{0n}+\Lambda_{1n}<1$, so that both probabilities oscillate converging towards their steady-state values. Instead, if $\Lambda_{0n}+\Lambda_{1n}>1$, convergence is monotonic. The dynamic behavior of probabilities implies that the expected growth rate of output in economies with technological inertia will converge to the steady state value $\frac{\alpha}{1-\alpha}\ln\gamma$, which is the constant expected growth rate in economies with perpetual upgrading.

Combining the results of Proposition 4 and 5, we can conclude that the expected income gap between two economies, one with perpetual upgrading and one with technological inertia, is always positive and converges (non necessarily monotonically) to a stationary level. Our analysis shows that persistent income differences across countries due to differences in red tape are generated by the opportunistic behavior of the incumbent politicians seeking re-election, even when politicians are fully accountable to voters

[13]Notice that the limit distribution function is invariant to the initial one as the transition matrix displays strictly positive constant probabilities of moving between states in each period. Thus, the probability of being in either state in the limit does not depend on the initial state.

and political competition is high (in the absence of networks the probability of re-election is 1/2).

The implications of the model are more general than our discussion so far might suggest. In fact, the expected income level is decreasing with the level of red tape, both in the case of perpetual upgrading and in the case of technological inertia. This is due to the fact that higher red tape implies higher production cost in case of entry of a new producer. Since the equilibrium level of red-tape varies with structural parameters, as shown in the previous Section, our model implies that the expected income level will also vary. For example, consider a set of countries with technological inertia, where $\overline{\sigma} > \alpha\gamma^2$. A ceteris paribus increase in the level of red tape (due, for example, to a ceteris paribus increase in β) implies lower expected income, yielding a negative relationship between the level of red tape and (expected) income.

5 Conclusions

Excessive regulatory and administrative burdens due to cumbersome regulatory and administrative requirements and/or inefficient bureaucracy are often pointed out as a major hindrance to growth as they subtract resources to investment and innovation activity and might represent a barrier to entry for new firms and superior technologies.

In this paper, we consider red-tape as a production cost for firms that can be mitigated through political connections in a relationship-based system ("knowing the right person in the right place"). By keeping an inefficient bureaucracy, incumbent politicians induce incumbent firms to spend time in establishing political connections which help to deal with bureaucracy (a sort of "learning-by-knowing"). Connected firms may be able to prevent entry of competitors with superior technology if they can exploit their political relations, that is, if politicians do not change too frequently. For the society as a whole, this creates a trade-off between the short-run benefits of enjoying low production prices by keeping the status quo and the long-run costs of postponing and blocking technological upgrade.

Our analysis shows that the interaction between politicians, firms and voters generates political equilibria where the incumbent politician always secures re-election, and which involve either perpetual technological upgrading or technological inertia, depending on parameters. When the level of red tape that induces technologically advanced firms to invest in networking is larger than the size of innovation, countries may end up in a low-income trap, where a unanimous socioeconomic block emerges which retards the adoption of new technologies and leads to persistent economic inertia.

Our theoretical analysis could be extended in different ways. First, we could extend the analysis of voters' behavior, in order to provide a fully-fledged probabilistic voting model (along the lines of Persson and Tabellini [21], ch. 3) which could allow us to enlarge the set of structural parameters of our model and to incorporate additional political-economy issues. Second, an overlapping-generations version of our model could highlight interesting political and economic conflicts between short-sighted and long-sighted agents, which would give rise to intergenerational conflicts between the young (more inclined to political turnover and economic change) and the old (supporting the status quo). We could then use the model to shed light on important policy aspects, such as the issue of gerontocracy, low socioeconomic mobility and economic backwardness.

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6 Appendix

6.1 Anecdotal evidence

Table 1									
Descriptive Statistics					Pairwise Correlations				
	Mean	Std. Dev.	Min	Max		PP	BQ	GDP
PP	0.875	0.083	0.65	1	PP	1		
BQ	0.313	0.260	0	0.951	BQ	0.13	1	
GDP	43.40	35.65	0.57	157.12	GDP	0.03	-0.85	1
obs.	61	61	61	61	obs.	61	61	61

PP: percentage of "veto players" who remain in place in the government in any given year relative to the previous one, from Database of Political Institutions, World Bank (average over the period 1990-2005); BQ: index of bureaucratic quality, from International Country Risk Guide, normalized to the interval 0 -1, with 1 indicating low bureaucratic quality (average over the period 1990-2005); GDP: log of GDP per capita, from PPP series Penn World Tables 7.0. (average over the 2000-2005 period).

6.2 Proof of Proposition 1

Let us derive the condition for workers to prefer $v_0 = 0$ at $k = 0$, $I = 0$ ($v_1 = 0$ at $k = 1$, $I = 1$), at time t under the assumption that, $\forall t + s$ and $s \geq 1$, $\sigma = \sigma_0 = \sigma_1$, $n_0 = n_1 = \overline{n}$, λ_0, λ_1 are set anticipating $v_{00} = v_{11} = 1$. In words, we are deriving the condition for a one-stage deviation of workers such that they prefer replace today under the assumption of constant actions by the government, networking in all periods, innovation rates chosen under the expectation that they will choose maintain and the incumbent politician will be re-elected everafter.

After some algebra, it yields that workers prefer replace today if and only if:

$$(\sigma^{\frac{\alpha}{\alpha-1}} - \gamma^{\frac{\alpha}{\alpha-1}}) + \beta[\Lambda_0\gamma^{\frac{\alpha}{1-\alpha}}(1 - \sigma^{\frac{\alpha}{\alpha-1}}) + (1 - \Lambda_1)(\sigma^{\frac{\alpha}{\alpha-1}}\gamma^{\frac{\alpha}{1-\alpha}} - (\alpha\gamma)^{\frac{\alpha}{\alpha-1}})] \geq 0 \tag{15}$$

Necessary and sufficient condition for equation (15) to be decreasing with σ can be written also as

$$1 + \beta\gamma^{\frac{\alpha}{1-\alpha}}[1 - (\Lambda_0 + \Lambda_1)] > 0 \tag{16}$$

which is always satisfied as $\beta\gamma^{\frac{\alpha}{1-\alpha}} < 1$.

Thus, if there exists $\overline{\sigma} > \gamma$ such that (15) holds with equality, then voters will support the incumbent politician today for any $\sigma \geq \overline{\sigma}$.

Notice that when $\sigma \to \gamma$, (15) is certainly satisfied. Indeed, when $\sigma \to \gamma$, (15) can be written as:

$$\beta[\Lambda_0\gamma^{\frac{\alpha}{1-\alpha}}(1-\gamma^{\frac{\alpha}{\alpha-1}}) + (1-\Lambda_1)(1-(\alpha\gamma)^{\frac{\alpha}{\alpha-1}})] \geq 0 \tag{17}$$

which holds with strict inequality as $\gamma > 1/\alpha$.

Now let us check what happens when $\sigma \to \gamma^2$. If (15) were still positive then $\overline{\sigma} < \gamma^2$ would not exist. Otherwise, $\overline{\sigma} < \gamma^2$ exists and the incumbent politician would be re-elected for any $\sigma \geq \overline{\sigma}$.

When $\sigma = \gamma^2$, (15) can be rewritten as:

$$(\gamma^{\frac{\alpha}{\alpha-1}} - 1) + \beta[C(1-\overline{n})(\gamma^{\frac{\alpha}{1-\alpha}} - 1)(\gamma^{\frac{2\alpha}{1-\alpha}} - 1) + (1 - C\gamma^{\frac{\alpha}{1-\alpha}}(1-\overline{n}))(1-\alpha^{\frac{\alpha}{\alpha-1}})] \geq 0 \tag{18}$$

where $C = \frac{(1-\overline{n})\pi}{c}$, following the notation introduced in the text. Notice that $C < \gamma^{\frac{2\alpha}{\alpha-1}}$, as $\frac{\pi}{c} < \gamma^{\frac{\alpha}{\alpha-1}}$ and $(1-\overline{n}) \leq \gamma^{\frac{\alpha}{\alpha-1}}$ (as $\widehat{\sigma} \geq \gamma$). Thus a sufficient condition for 18 to hold with strictly negative sign is:

$$-\gamma^{\frac{2\alpha}{1-\alpha}} + 2\gamma^{\frac{\alpha}{1-\alpha}} - \gamma^{\frac{\alpha}{\alpha-1}} \leq 0 \tag{19}$$

which is obtained setting $\beta = \gamma^{\frac{\alpha}{\alpha-1}}$, $C = \gamma^{\frac{2\alpha}{\alpha-1}}$, $(1-\overline{n}) = \gamma^{\frac{\alpha}{\alpha-1}}$ and ignoring the negative terms other than $(\gamma^{\frac{\alpha}{\alpha-1}} - 1)$ in 18. The last inequality can be rewritten as $\gamma^{\frac{\alpha}{1-\alpha}}(\gamma^{\frac{\alpha}{1-\alpha}} - 1) \geq 1$, which is satisfied for all admissible values of γ for $\alpha \geq \overline{\alpha}$, where $\overline{\alpha}$ is defined by $\alpha^{\frac{\alpha}{\alpha-1}}(\alpha^{\frac{\alpha}{\alpha-1}} - 1) - 1 = 0$. To see this, notice that $\gamma^{\frac{\alpha}{1-\alpha}}(\gamma^{\frac{\alpha}{1-\alpha}} - 1)$ is increasing in γ, $\alpha^{\frac{\alpha}{\alpha-1}}(\alpha^{\frac{\alpha}{\alpha-1}} - 1) - 1$ is increasing in α and positive for $\alpha \geq \overline{\alpha}$ and recall that $\gamma > 1/\alpha$.

6.3 Proof of Proposition 2

From Lemma 1, we know that when $\widehat{\sigma} > \gamma$, if $v_{00} = 1$, any $\sigma > \gamma$ induces investment in networking. (i) When $\sigma_0 = \sigma_1 = \overline{\sigma}$ there is no profitable one-stage deviation for the politician. Decreasing σ_0 or σ_1 today will imply losing elections when $I = 0$ and $I = 1$ respectively as current wage in case of replacement of the incumbent would increase. Increasing σ_0 or σ_1 would not affect probability of re-election. (ii) In this case, $\sigma_1 = \overline{\sigma}$ does not guarantee re-election when $k = 1$ and $I = 0$. Thus $\sigma_1 \geq \alpha\gamma^2$ is needed to ensure re-election. Consider next the case $k = 0, I = 0$ (which is equivalent to $k = 1, I = 1$).

Given $\sigma_0 > \gamma$ after some algebra we can solve for the two value functions:

$$V_0(\sigma_0, \overline{n}, 0) \mid_{v_0=0} = \frac{1}{1-\beta\gamma^{\frac{\alpha}{1-\alpha}}} \left[(1-\beta\gamma^{\frac{\alpha}{1-\alpha}}\Lambda_0)w_0(\sigma_0, \overline{n}, 0, 0) + (\beta\gamma^{\frac{\alpha}{1-\alpha}}\Lambda_0)w_0(\cdot, \overline{n}, 1, 1)\right] \tag{20}$$

and

$$V_0(\sigma_0, \overline{n}, 0) \quad \mid \quad_{v_0=1} = \frac{\left(1-\beta\gamma^{\frac{\alpha}{1-\alpha}}\right)^{-1}}{\left[1+\beta\gamma^{\frac{\alpha}{1-\alpha}}(\Lambda_0+\Lambda_1)\right]} \left\{(1-\beta\gamma^{\frac{\alpha}{1-\alpha}}\Lambda_0)w_0(\cdot, \overline{n}, 0, 1) + \right. \tag{21}$$

$$\left. + \beta(1-\Lambda_1)(1-\beta\gamma^{\frac{\alpha}{1-\alpha}}\Lambda_0)w_1(\sigma_1, \overline{n}, 0, 1) + \left[(1-\Lambda_1)\beta^2\gamma^{\frac{2\alpha}{1-\alpha}}\Lambda_0\right] w_0(\cdot, \overline{n}, 1, 1)\right\}$$

It is easy to see that if σ_1 increases from $\overline{\sigma}$ to (at least) $\alpha\gamma^2$, $V_0(\sigma_0, \overline{n}, 0) \mid_{v_0=1}$decreases as $w_1(\sigma_1, \overline{n}, 0, 1)$ decreases. Thus, it is necessary for the incumbent politician to increase σ_0 in order to get re-elected. Clearly, $\sigma_0 = \sigma_1$ guarantees re-election (as they are larger than $\overline{\sigma}$), but $\sigma_0 \in (\overline{\sigma}, \sigma_1)$ could also deliver re-election.

Can there be other politician's strategies which imply a probability of re-election equal to one? We now show that there are none. Notice that, in equilibrium, it cannot be that $\sigma_0 > \sigma_1$. By deviating today and decreasing σ_0 down to σ_1, the politician is still re-elected for sure, since $\sigma_1 > \overline{\sigma}$. Also, in equilibrium, it cannot be the case that $\sigma_1 > \sigma_0$ with $\sigma_1 > \alpha\gamma^2$. In this case, it would always be possible for the politician to lower σ_1 to $\alpha\gamma^2$ (if $\sigma_0 < \alpha\gamma^2$) or to σ_0 (if $\sigma_0 > \alpha\gamma^2$) and still win the elections.

6.4 Proof of Corollary 1

If $\overline{\sigma}$ exists, it must be the case that the term which multiplies β in (15) is positive. Then, $\partial\overline{\sigma}/\partial\beta > 0$. With regard to C, notice that for $\sigma \geq \alpha\gamma^2 \rightarrow (\sigma^{\frac{\alpha}{\alpha-1}}\gamma^{\frac{\alpha}{1-\alpha}} - (\alpha\gamma)^{\frac{\alpha}{\alpha-1}}) \leq 0$. Thus, $\lambda_0(1-\overline{n})\gamma^{\frac{\alpha}{1-\alpha}}(1-\sigma^{\frac{\alpha}{\alpha-1}}) - \lambda_1(1-\overline{n})(\sigma^{\frac{\alpha}{\alpha-1}}\gamma^{\frac{\alpha}{1-\alpha}} - (\alpha\gamma)^{\frac{\alpha}{\alpha-1}}) \geq 0$. It is immediate to see that the sign of $\partial\sigma/\partial C$ is the same as the sign of the last inequality, since C is a multiplicative term in that inequality.

6.5 Proof of Proposition 3

Consider equation (2). With perpetual upgrading, we can write:

$$E_t\Omega_{t+s}^{PU} = \left[\Lambda_{0n}(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}} + (1-\Lambda_{0n})\gamma^{\frac{\alpha}{\alpha-1}}\alpha^{\frac{\alpha}{1-\alpha}}(1-\frac{\alpha\sigma}{\gamma})\right]\gamma^{\frac{\alpha(Q_t+s)}{1-\alpha}} \tag{22}$$

with $s \geq 0$. Similarly, with technological inertia, we have:

$$\begin{aligned}
E_t\Omega_{t+s}^{TI} &= prob(k_{t+s-1} = 0)\Lambda_{0n}(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}\gamma^{\frac{\alpha(Q_t+s)}{1-\alpha}} + \\
+prob(k_{t+s-1} &= 0)(1-\Lambda_{0n})\gamma^{\frac{\alpha}{\alpha-1}}(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}\gamma^{\frac{\alpha(Q_t+s)}{1-\alpha}} + \\
+prob(k_{t+s-1} &= 1)\Lambda_{1n}\gamma^{\frac{\alpha}{\alpha-1}}(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}\gamma^{\frac{\alpha(Q_t+s)}{1-\alpha}} + \\
+prob(k_{t+s-1} &= 1)(1-\Lambda_{1n})\gamma^{\frac{2\alpha}{\alpha-1}}\alpha^{\frac{\alpha}{1-\alpha}}(1-\frac{\alpha\sigma}{\gamma^2})\gamma^{\frac{\alpha(Q_t+s)}{1-\alpha}}
\end{aligned} \tag{23}$$

Clearly, when $s = 0$, k_{t-1} is known.

First, notice that in equation (22) $(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}} > \gamma^{\frac{\alpha}{\alpha-1}}\alpha^{\frac{\alpha}{1-\alpha}}(1-\frac{\alpha\sigma}{\gamma})$ as $\sigma \geq \alpha\gamma$ and $\gamma > \frac{1}{\alpha}$. Moreover, $\alpha^{\frac{\alpha}{1-\alpha}}(1-\frac{\alpha\sigma}{\gamma}) > (1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}$ as $\sigma \leq \gamma$ and $(1+\alpha)\alpha^{\frac{\alpha}{1-\alpha}} < 1$. Finally in equation (23) $(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}} > \gamma^{\frac{\alpha}{\alpha-1}}\alpha^{\frac{\alpha}{1-\alpha}}(1-\frac{\alpha\sigma}{\gamma^2})$ as $\sigma \geq \alpha\gamma^2$ and $\gamma > \frac{1}{\alpha}$. Since Λ_{0n} is higher in PU is higher than in TI, we can conclude that $E_t\Omega_{t+s}^{PU} > E_t\Omega_{t+s}^{TI}$.

6.6 Proof of Proposition 4

Notice that $(prob(k_t = 0), prob(k_t = 1)) = (prob(k_{t-1} = 0), prob(k_{t-1} = 1)) \cdot \Lambda$ where

$$\Lambda = \begin{pmatrix} \Lambda_{0n} & 1-\Lambda_{0n} \\ 1-\Lambda_{1n} & \Lambda_{1n} \end{pmatrix} \tag{24}$$

Thus, at any point in time t :

$$prob(k_t = 0) = \frac{\Lambda_{1n}-1}{\Lambda_{0n}+\Lambda_{1n}-2} + \frac{\Lambda_{0n}-1}{\Lambda_{0n}+\Lambda_{1n}-2}(\Lambda_{0n}+\Lambda_{1n}-1)^t \tag{25}$$

$$prob(k_t = 1) = \frac{\Lambda_{0n}-1}{\Lambda_{0n}+\Lambda_{1n}-2} - \frac{\Lambda_{0n}-1}{\Lambda_{0n}+\Lambda_{1n}-2}(\Lambda_{0n}+\Lambda_{1n}-1)^t \tag{26}$$

Let $E_t g_{t+s}$ denote the expected growth rate where $E_t g_{t+s} \equiv E_t \ln\Omega_{t+s+1} - E_t \ln\Omega_{t+s}$. With PU, $E_t g_{t+s}^{PU} = \frac{\alpha}{1-\alpha}\ln\gamma$. Consider now TI. We can write:

$$\begin{aligned}
E_t \ln\Omega_{t+s+1}^{TI} &= prob(k_{t+s} = 0)\Lambda_{0n}\ln[(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}]\gamma^{\frac{\alpha(Q_t+s+1)}{1-\alpha}} + \\
+prob(k_{t+s} &= 0)(1-\Lambda_{0n})]\ln[\gamma^{\frac{\alpha}{\alpha-1}}(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}]\gamma^{\frac{\alpha(Q_t+s+1)}{1-\alpha}} + \\
+prob(k_{t+s} &= 1)\Lambda_{1n}\ln[\gamma^{\frac{\alpha}{\alpha-1}}(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}]\gamma^{\frac{\alpha(Q_t+s+1)}{1-\alpha}} + \\
+prob(k_{t+s} &= 1)(1-\Lambda_{1n})\ln[\gamma^{\frac{2\alpha}{\alpha-1}}\alpha^{\frac{\alpha}{1-\alpha}}(1-\frac{\alpha\sigma}{\gamma^2})]\gamma^{\frac{\alpha(Q_t+s+1)}{1-\alpha}}
\end{aligned} \tag{27}$$

A similar expression holds for $E_t \ln\Omega_{t+s}^{TI}$. After some algebra, $E_t \ln\Omega_{t+s+1}^{TI} - E_t \ln\Omega_{t+s}^{TI}$

can be written as:

$$\begin{aligned}
&\frac{\alpha}{1-\alpha}\ln\gamma + \\
&+(\Lambda_{0n}-1)\,(\Lambda_{0n}+\Lambda_{1n}-1)^{t+s-1}\,\Lambda_{0n}\ln[(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}]+ \\
&+(\Lambda_{0n}-1)\,(\Lambda_{0n}+\Lambda_{1n}-1)^{t+s-1}\,(1-\Lambda_{0n})\ln[\gamma^{\frac{\alpha}{\alpha-1}}(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}]- \\
&-(\Lambda_{0n}-1)\,(\Lambda_{0n}+\Lambda_{1n}-1)^{t+s-1}\,\Lambda_{1n}\ln[\gamma^{\frac{\alpha}{\alpha-1}}(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}]- \\
&-(\Lambda_{0n}-1)\,(\Lambda_{0n}+\Lambda_{1n}-1)^{t+s-1}\,(1-\Lambda_{1n})\ln[\gamma^{\frac{2\alpha}{\alpha-1}}\alpha^{\frac{\alpha}{1-\alpha}}(1-\frac{\alpha\sigma}{\gamma^2})]
\end{aligned} \tag{28}$$

Exploiting the facts used to prove Proposition 3 and $\Lambda_{0n} < \Lambda_{1n}$, it is immediate to see that the sum of terms multiplying $(\Lambda_{0n}-1)\,(\Lambda_{0n}+\Lambda_{1n}-1)^{t+s-1}$ is positive. Notice that the term $(\Lambda_{0n}-1)\,(\Lambda_{0n}+\Lambda_{1n}-1)^{t+s-1}$ converges to zero as $s \to \infty$, since $\Lambda_{0n}+\Lambda_{1n} < 2$. Thus the expected growth rate converges to $\frac{\alpha}{1-\alpha}\ln\gamma$ as $s \to \infty$. If $\Lambda_{0n}+\Lambda_{1n} < 1$ - as it it is implied by assuming $(\pi/c) < \gamma^{\frac{\alpha}{\alpha-1}}$ and by considering $(1-\overline{n}) < \gamma^{\frac{\alpha}{\alpha-1}}$ - the term $(\Lambda_{0n}-1)\,(\Lambda_{0n}+\Lambda_{1n}-1)^{t+s-1}$ takes positive (negative) value when $t+s-1$ is odd (even), so that convergence of the expected growth rate towards its steady state value is oscillatory. Finally, if $\Lambda_{0n}+\Lambda_{1n} > 1$, the term $(\Lambda_{0n}-1)\,(\Lambda_{0n}+\Lambda_{1n}-1)^{t+s-1}$ takes is negative and converges to zero monotonically, implying that the growth rate converges to the steady state value from below.