Rent-Seeking Bureaucracies in a Schumpeterian Endogenous Growth Model : Effects on Human Capital Accumulation, Inequality and Growth

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Rent-Seeking Bureaucracies in a Schumpeterian Endogenous Growth Model: Effects on Human Capital Accumulation, Inequality and Growth

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Abstract

Some empirical works from the nineties have shown the existence of a negative relationship between inequality and growth. In this paper I show that the inefficiency of the Public Sector due to agency problems can be a new element that must be considered to explain the negative empirical relationship between inequality and growth. Considering a neo-Schumpeterian endogenous growth model, I envisage the relationship between rent-seeking bureaucracies and both the private market and political authority. I show that the inefficiency of the Public Sector can contribute to widening income inequality and reducing the per-capita output growth rate because of the skills waste in oversight of rent-seeking bureaucracies. Therefore bureaucratic quality can contribute to explaining the long-run negative relationship between inequality and growth. I show that these effects operates mostly in developed countries, where human capital accumulation and technological progress are fundamental engines for growth. Moreover, I show that more costly oversight reduces the consume of each existing product.

Keywords: technological progress, inequality and growth, asymmetric infomation, rent-seeking bureaucracies.

JEL Classification: D31, D82, H42, O30

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1 Introduction

Is inequality harmful for growth? In their seminal paper Persson and Tabellini (1994) answered positively to this question. Following this work, other empirical analysis showed the existence of a negative relationship between inequality and growth due to a variety of mechanisms and factors such as the redistributive pressures of voters, social conflicts, expropriation, and financial market imperfections.[1] However, the existence of a negative relationship between inequality and growth is not unanimously recognized in the literature.[2] Although a recent paper by Banerjee and Duflo (2003) does not come to a conclusive argument, they maintain: "...the conclusions of Forbes (2000) and Li and Zou (1998) are not warranted: there is no evidence in the data that increase in inequality are good for growth. In fact, the bulk of the evidence goes in the opposite direction."

The aim of this work is to suggest a new theoretical channel through which it is possible to explain the long-run negative relationship between inequality and growth. In this paper I show how institutional quality - in the form of bureaucratic quality[3] - can contribute to explaining the negative relationship between inequality and growth.

Endogenous growth literature has greatly spurred the study of the effects of public policy on economic growth.[4] The role of good institutions - and therefore also of a high level of bureaucratic quality - has been emphasized in recent years as key for development and growth effectiveness. For example, it has been argued that merely allocating public resources to the right goods and services may not lead to desiderable outcomes if budget institutions are malfunctioning (World Bank 1998). In fact, as Rajkumar and Swaroop (2002) write: "well-functioning public institutions are critical for translating public spending into effective services."[5] A very recent paper by Glaeser *et al.* (2004) shows that

[1] See Alesina and Rodrik (1994); Perotti (1996); Benhabib and Rustichini (1996); Benabou (1996); Galor and Zeira (1993) Benarjee and Newman (1993).

[2] See Forbes (2000), Benhabib and Spiegel (1998), Li and Zou (1998), Barro (2000).

[3] Bureaucratic quality is part of the wider concept of institutional quality. Institutional quality is measured in a variety of ways: Government stability, corruption, bureaucratic quality, civil liberties, law and order, Government repudiation of contracts, risk of expropriation, rule of law, etc. I this paper I consider a wider concept of bureaucratic quality than the usual one. In fact, in this theoretical framework bureaucratic quality also encompasses corruption phenomena.

[4] Following the empirical works by Mauro (1995) and Knack and Keefer (1995), this body of research has expanded to include the analysis of various distortions introduced by inefficient or corrupt bureaucracies.

[5] Rajkumar and Swaroop (2002) use corruption and bureaucratic quality as measures of governance (these measures are taken from the Political Risk Services Group). The authors empirically examine whether public health spending is more effective in improving health status in countries with good governance. Their results show that the link between public health spending and child and infant mortality is negative, but the efficacy of public spending in lowering child and infant mortalities is positively related to the level of governance. In countries rated very corrupt or rated to have a very ineffective bureaucracy, public health spending at the margin will be inefficacious. The observations are for two years (1990 and 1997) for two different samples: the sample with child (under 5) mortality as dependent variable (148 observations from 90 developed and developing countries), and the sample with

commonly used measures of institutions do not reflect either constraints on Government or permanent feature of political landscape,[6] and then cannot be used to establish causality from institutions to growth. Moreover, the authors find empirical evidence showing that causality runs from growth to good institutions: higher level of human capital and growth in income lead to institutional improvements and democratization. I will argument later that the theoretical results of this work are also compatible with these findings.

Several empirical works show that lack of bureaucratic quality harms the growth performance of both developed and developing countries. Sarte (2001) shows the existence of an inverse relationship between bureaucratic delays and per-capita output growth rate.[7] Lamsdorff (2003, 2004) shows that corruption, and therefore lack of bureaucratic quality, has a negative impact on productivity.[8] Moreover Lambdsorff (2004) shows that "the crucial reason why corruption has an adverse impact on productivity is related to accompanying low levels of bureaucratic quality...This type of corruption is particularly relevant with corrupt agents."[9]

An important and interesting map has been developed recently tracing the route through which bureaucratic quality affects economic growth. A recent paper by Sarte (2001) suggests that the adverse effect a more inefficient bureaucracy has on economic growth depends not only on the interaction between the bureaucracies themselves and the private market, but also on the political authority's interactions with its executive agencies. This means that the growth effects of Government spending are partially linked to the agency problem be-

infant mortality as dependent variable (169 observations from 98 developed and developing countries).

[6] The authors find that, in several definition of institutions, a key word is constraints on government which, in addition, must be reasonably permanent or durable. Then in their analysis Glaeser *et al.* (2004) ask if the current measures of institutions reflect constraints on government, and permanent or durable features of the environment.

[7] Sarte (2001) uses an index of Bureaucratic Delays obtained from the Business Environmental Risk Service (BERI), which is meant to capture the "speed and the efficiency of the civil service". The same author maintains that "the vague definition of the BERI indices allows for multiple interpretations."

[8] Lamsdorff (2003, 2004) measures productivity as the ratio of GDP to the capital stock for the period 1974-2000 for 69 developed and developing countries. Lamsdorff (2003) writes: "An increase in corruption by one point on a scale from 10 (highly clean) to 0 (highly corrupt) lowers productivity by 2 percent...A reduction of Tanzania's level of corruption to that of United Kingdom would increase productivity by 10 percent, leading to a 20 percent increase in the GDP. Decomposing this impact reveals that bureaucratic quality is the crucial determinant...". Lamsdorff (2004) comes to the same results.

[9] Other empirical analysis in this direction are Grigorian and Martinez (2001) who find evidence that a higher level of bureaucratic quality has a positive impact on industrial growth through total factor productivity (the authors use a sample of 27 Asian and Latin American countries containing data from 1982 to 1997). Rodrik (1997) finds that bureaucratic quality affects the long run growth of GDP per worker: better institutional quality - and therefore also better bureaucratic quality - positively affects total factor productivity growth (Rodrik, 1997 uses an index of institutional quality for eight East Asian countries: Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailandia, Taiwan, for the period 1960-1994. Tanzi and Davoodi (1997) provide evidence that corruption actually increases public investment, especially in unproductive projects, and squeezes public expenditure allocations for operations and maintenance, thereby lowering the productivity of the public capital stock.

tween political authority and its bureaucracy.[10]

Differently to Sarte (2001), I consider the interaction of the rent-seeking bureaucracy with both the private market and the Government. In this paper I focus on bureaucratic quality as a fundamental element for the economic performance of a country. However, consideration of bureaucratic quality does not mean excluding consideration of the important and widespread phenomena of corruption. In fact, Lamsdorff (2003, 2004) studies the empirical relationship between corruption and productivity and he finds that (see Lamsdorff 2003): "Bureaucratic quality exerts a significant impact...Once including bureaucratic quality into the regressions, the influence exerted by corruption becomes insignificant. This suggest that the adverse impact of corruption on productivity largely runs via its correlation with lack bureaucratic quality." Therefore I can use bureaucratic quality to encompass both rent-seeking and corruption phenomena. As usual in literature I assume rent-seeking bureaucracies, that is the bureaus act to maximize their discretionary budget and have better information with respect to the Government about the costs and technology of the existing products.[11] This implies that the efficiency of Government expenditures is related to the need for some form of monitoring over the bureaucratic agencies.[12]

I consider the agency problem between the political authority and its bureaucracy as incorporated in a neo-Schumpeterian endogenous growth model, in which the fundamental engine of growth is tied to technological progress conducted in the existing industry lines (Grossman and Helpman, 1991; Aghion and Howitt, 1992-1998, etc.). I assume that the Government uses tax proceeds levied on consumers to acquire a fraction of the existing industry lines.[13] The

[10] Sarte (2001) refers to at least two lines of ongoing research which support this hypothesis: Barro (1990) and Glomm and Ravikumar (1994, 1997).

[11] See Niskanen (1971, 1994) and Migué and Bélanger (1974). Sarte (2001) writes: "public goods and services do not originate from the central government directly, but rather from a variety of agencies under its control. These bureaus are typically better informed than political authority as to the technology they use to provide public services and, furthermore, generally act in their self interest."

[12] In the U.S.A. the existence of the Office Management Budget (OMB) and of the General Accounting Office (GAO) testifies that government uses some form of oversight agency to control bureaucratic endeavour. As we can read on the OMB web-site (www.whitehouse/gov/omb/): "OMB's predominant mission is to assist the President in overseeing the preparation of the federal budget and to supervise its administration in Executive Branch agencies. In helping to formulate the President's spending plans, OMB evaluates the effectiveness of agency programs, policies, and procedures, assesses competing funding demands among agencies, and sets funding priorities." Moreover on the GAO web-site we can read (www.gao.gov/): "GAO examines the use of public funds, evaluates federal programs and activities, and provides analyses, options, recommendations, and other assistance to help the Congress make effective oversight, policy, and funding decisions. In this context, GAO works to continuously improve the economy, efficiency, and effectiveness of the federal government...GAO is dedicated to good government through its commitment to the core values of accountability, integrity, and reliability." In 1997 Italy constituted Consip, a company belonging to the Ministry of Economics and Finance. Consip manages all the purchases of the Public Sector and its fundamental target is to guarantee public expenditure efficiency and rationalization, the efficiency of bureaucracy and the quality of the goods and services provided by the Public Sector. On the Consip website we can read that in 2003 "Consip's activity has allowed a saving of over 90%" for the public sector purchases.

[13] I assume that this fraction is exogenously given. However, the results of the model hold

price of each product is established by the rent-seeking bureaucracy, which has an informational advantage over the Government and knows the quality of the products. The price reflects the monopsonistic power exerted by the Government over the monopolistic private firms (see Cozzi, 2003), and the rent-seeking behavior of the bureaucracy. Moreover, the prices could reflect a corruption phenomena of bureaus.[14] A fraction of these goods and services is wasted by the Government to monitor the bureaucracy, the remaining quantity is consumed by the population.

In this environment the costs of monitoring the rent-seeking bureaucracies are meant to identify the degree of technical and informational advantage the bureaus have over the political authority: the bureaus have an informational advantage on the technology used by private firms in producing existing goods and services, and the Government tries to limit this informational gap by using the oversight agencies. With this aim these oversight agencies must use skills in order to at least mitigate the informational gap between the bureaus and the Government. As Rajkumar and Swaroop (2002) write: "Managing public resources to promote development requires well-trained, skillful personnel...".[15]

In this economic environment I show that the existence of rent-seeking bureaucracies with an informational advantage with respect to the political authority negatively affects both the per-capita output growth rate of the economy and inequality, widening the wage gap between skilled and unskilled workers.[16] In fact, in economies with more costly oversight, the public sector absorbs more and more skill resources in order to monitor the rent-seeking bureaucratic agencies. The higher demand for skills resources raises the skill premium and wage inequality. This, in turn, reduces the skill resources engaged in research activity and thus reduces the innovation rate of the economy. Therefore, in this framework, there exists a negative relationship between inequality and growth.

for any value of this fraction.

[14] In fact, since each bureau acts to maximize its budget, the manufacturing firm could corrupt bureaucracy by rebating back them a fraction of the higher price obtained thanks to a lower monopsonistic power exerted by bureau. This mechanism is not explicitly inserted in the model, but it is absolutely compatible with both the theoretical framework and prediction of the model.

[15] As we can read on the OMB web-site: "OMB staff are highly-motivated and well-trained individuals. Over ninety percent of the staff hold career, rather than political, appointments. Over seventy percent of the staff are professionals, most with graduate degrees in economics, business and accounting, public administration and policy, law, engineering, and other disciplines...OMB's work requires the following: sharp analytical and quantitative skills..." On the GAO web-site we can read: "Our employees are at the front line of congressional oversight, and our work depends on their knowledge, analyses, and specialized skills...More than half of our staff have doctoral or master's degrees from leading universities in such areas as public administration, public policy, law, business, computer science, accounting, economics, and the social sciences." Furthermore, also Consip's workers are highly skilled, as we can read on the Consip website: "Consip is surely equivalent to an important know-how company, that is with high knowledge intensity, in which the most important production factor is its intellectual capital." 72% of Consip's workers have a Bachelors degree.

[16] Since in this framework the entire public sector and fiscal system (in the form of proportional taxes for acquiring products, lump sum transfers to individuals, monitoring costs) is highly related to skill accumulation and waste, I envisage skill premium as a proxy for the wider concept of income inequality, at least for developed countries.

Chong and Calderon (2000) find that better institution quality - also in the form of better bureaucratic quality - reduces income inequality in developed countries and worsens income inequality in developing countries.[17] The empirical analysis shows that lack of bureaucratic quality and corruption are bad for growth performance in both developed and developing countries. At the same time, the empirical study by Chong and Calderon (2000) shows that bureaucratic quality only reduces income inequality in richer countries.

In this theoretical framework the negative effect rent-seeking bureaucracy has on income inequality and on per-capita output growth operates to a major degree through skill waste. This process is more likely to happen in countries with a high level of skill accumulation in which human capital accumulation, technological progress, and R&D are the prime engines of economic growth, such as developed countries.[18] In such countries the existence of rent-seeking bureaucracies and corrupt agents can produce a waste of skill resources by diverting them from productive activities toward unproductive ones, and therefore negatively affect income inequality and the per-capita output growth rate.[19] I argue that in developing countries, the same causal mechanism can be at work, but it is a second-order problem for such countries. In fact, since R&D and human capital accumulation in less developed countries are not as advanced as in developed countries, the adverse effect of lack bureaucratic quality on income inequality and on output growth probably operates through other channels than the waste of skill resources. Moreover, in developing countries other elements and causal mechanisms can play a role more important than lack of institutional quality in determining skill premium and per-capita output growth. Then, the theoretical results of this work are also compatible with Glaeser *et al.* (2004) empirical evidence. In fact, I show that human capital and technological progress are the fundamental engines of economic growth for both developed and developing countries, but lack of institutional quality can undermine the growth performance of developed countries by wasting skill resources which are the core of economic prosperity.

The paper is organized as follows. Section 2 sets up the model. Section 3

[17] Chong and Calderon (2000) use two sets of institutional quality measure from the International Country Risk Guide (ICGR) and Business Environmental Risk Intelligence (BERI). These data sets contain measure on corruption, quality of bureaucracy, law and order, risk of expropriation, and risk of contract repudiation (ICGR data are available from 1982 to 1995 for 105 developed and developing countries; BERI data are available from 1972 to 1995 for 55 developed and developing countries). Chong and Calderon (2000) find a nonmonotonic relationship between institutional quality and income inequality. They show that for almost all the developing countries in their sample, there is a positive relationship between institutional quality and income inequality, while for most developed countries, it is a negative one. The authors find similar results for each institutional quality measure.

[18] Galor (2000) shows how in the early stage of economic development physical capital is a prime engine for growth, while in the later stage of economic development human capital accumulation becomes a prime engine for growth due to capital-skill complementarity. In this paper I do not envisage physical capital, but it is worth noting that, in this framework, human capital and technological progress are the prime engines for economic growth.

[19] Grigorian and Martinez (2001) maintain: "the more a production process relies on suppliers, sources of credit, and technological innovations, the more *institutional-quality-intensive* the production process becomes."

derives the balanced growth properties of the economy. Section 4 draws the effects of a more costly oversight activity, and of a larger public sector. Section 5 concludes.

2 The model

2.1 Households

Let households differ in their uniformly distributed personal ability $\theta \in [0,1]$ of their individual members to become skilled workers.[20] All individuals have identical intertemporally additively separable preferences for a mass of publicly provided goods and services indexed by $\tilde{\omega} \in [0,\beta]$, with $\beta \in (0,1)$, produced by the private sector, and for an infinite set of private goods and services indexed by $\omega \in (\beta, 1]$, and are endowed with a unit labor/study time endowment whose supply generates no disutility.

Following Sarte (2001) I assume that the public sector supplies a given and equal amount $(1-\alpha)\, q_{\tilde{\omega}}$ of each public good and service to consumer, where $(1-\alpha)$ indicates the fraction of product $\tilde{\omega} \in [0,\beta]$ acquired by the Government and that is not wasted in overseeing rent-seeking bureaucracies.[21] Therefore each household does not solve its own maximization utility problem for the mass of products provided by the public sector. The intertemporal and instantaneous preferences are described as follows

$$\int_0^{\infty} N_0 e^{-(\rho-n)s} \log u_\theta(s)\, ds \tag{1}$$

where

$$\begin{aligned} \log u_\theta(s) \quad \equiv \quad & \int_0^{\beta} \log \left[\sum_{j=0}^{j^{\max}(\tilde{\omega},s)} \lambda_{\tilde{\omega}}^{j} (1-\alpha)\, q(j,\tilde{\omega},s) \right] d\tilde{\omega} + \\ & + \int_{\beta}^{1} \log \left[\sum_{j=0}^{j^{\max}(\omega,s)} \lambda_{\omega}^{j} q_\theta(j,\omega,s) \right] d\omega \end{aligned}$$

The consumption value of the public goods and services for an individual with ability θ is defined as

[20] As Dinopoulos and Segerstrom (1999) all members of households θ have the same ability level equal to θ, and all households have the same number of members at each point in time.

[21] In this framework I assume that the Government acquires from monopolistic private firms a given and equal quantity of product $q_{\tilde{\omega}}$ for each consumer. A fraction α of this quantity is wasted in overseeing rent-seeking bureaucratic agencies. Therefore, each individual consume the remaining fraction $(1-\alpha)$ of the product.

$$c_\theta(s) \equiv \int_0^\beta \left[\sum_{j=0}^{j^{\max}(\tilde{\omega},s)} p(j,\tilde{\omega},s)(1-\alpha)\, q(j,\tilde{\omega},s)\right] d\tilde{\omega} + \\ + \int_\beta^1 \left[\sum_{j=0}^{j^{\max}(\omega,s)} p(j,\omega,s)\, q_\theta(j,\omega,s)\right] d\omega,$$

and the budget constraint for each individual with ability θ is

$$W_\theta(t) + Z_\theta(t) + Tr = \int_t^\infty N_0 e^{-\int_t^s [r(\tau)-n]d\tau} c_\theta(s)\, ds$$

where N_0 is the initial population of the economy and n is its constant growth rate, ρ is the constant and common rate of subjective time preferences - with $\rho > n$ - and $r(s)$ is the market interest rate. $q_\theta(j,\omega,s)$ is ability $\theta \in [0,1]$ household's per member quantity flow of quality $j \in \{0,1,2,...\}$ of good/service $\omega \in (\beta,1]$ at time $s \geq 0$ - $p(j,\omega,s)$ being the price of good ω of quality j at time s - $c_\theta(s)$ is the nominal expenditure. $q(j,\tilde{\omega},s)(1-\alpha)$ is the given amount of public product flow $\tilde{\omega} \in [0,\beta]$ at time $s \geq 0$ of quality $j \in \{0,1,2,...\}$ provided to each household whichever is its ability $\theta \in [0,1]$ - $p(j,\tilde{\omega},s)$ being the price of good $\tilde{\omega}$ of quality j at time s. $W_\theta(t)$ and $Z_\theta(t)$ are human and non-human wealth levels, Tr are the public transfers representing the bureaucratic rents. A new vintage of public good/service delivers $\lambda_\omega > 1$ more quality services than its previous version.[22] Different versions of the same good ω are regarded by consumers as perfect substitutes after adjusting for their quality ratios, and $j^{\max}(\omega,s)$ denotes the time s top quality of good ω (the same for the industry lines $\tilde{\omega} \in [0,\beta]$). I assume Bertrand competition at all dates between the incumbent and the innovating firm as common in quality ladder models, with the implication that in equilibrium only the top quality product will be produced and acquired by the public sector in order to guarantee a given amount of public services.

Individuals are finitely lived members of infinitely lived households, being continuously born at the constant rate β, and dying at the constant rate δ, with $\beta - \delta = n > 0$. $D > 0$ denoting the exogenous given duration of their life.[23]

Each individual chooses to train and becomes skilled at the beginning of her life (this choice is irreversible once done); the duration of her training period - in which the individual cannot work - is exogenously fixed at $T < D$.

[22] I assume heterogeneous quality jumps both between the existing industry lines and within the same industry line. Usually j indicates both the quality level and the number of quality jumps achieved in an industry line, when the quality jump is exogenous and constant (see Grossman and Helpman, 1991). In such a case j also indicates the quality level of a product, but - since the quality jumps are heterogeneous within an industry line - j summarizes both the number of quality jumps and their different size.

[23] As in Dinopoulos and Segerstrom (1999), it is easy to show that the parameters above must satisfy $\delta = \frac{n}{e^{nD}-1}$ and $\beta = \frac{ne^{nD}}{e^{nD}-1}$, in order for the number of births at time t to match the number of deaths at $t + D$.

Hence an individual with ability θ decides to train if and only if the following arbitrage condition is satisfied:

$$\int_{t}^{t+D} e^{-\int_t^s r(\tau)} (1-\tau)\, w_L(s)\, ds < \int_{t+T}^{t+D} e^{-\int_t^s r(\tau)} \max(\theta-\gamma, 0)(1-\tau)\, w_H(s)\, ds, \tag{2}$$

with $0 < \gamma < 1/2$, and τ is the constant proportional tax rate levied on workers. Notice that an individual with ability $\theta > \gamma$ is pustulatedly able to accumulate human capital $(\theta - \gamma)$ after training, while an individual with ability lower than γ (i.e. $\theta < \gamma$) never gets any skill from schooling.

Like Dinopoulos and Segerstrom (1999) I will focus on the steady state analysis, in which all variables grow at a constant rate and w_L, w_H, and c_θ are all constant, furthermore $r(s) = \rho$ at all dates.[24] Considering (2) with the equality the ability threshold θ_0 is easily obtained which renders individual indifferent to becoming skilled or to remaining unskilled for all her life. Hence the individual will train if and only if her ability is higher than

$$\theta_0 = \left[\left(1-e^{-\rho D}\right) / \left(e^{-\rho T} - e^{-\rho D}\right)\right] \frac{w_L}{w_H} + \gamma = \sigma \frac{w_L}{w_H} + \gamma. \tag{3}$$

where $\sigma \equiv \left(1-e^{-\rho D}\right) / \left(e^{-\rho T} - e^{-\rho D}\right)$. An individual with ability $\theta > \theta_0$ will decide to train and will accumulate quantity $(\theta - \gamma)$ of human capital. The higher the individual ability, the higher the accumulated human capital and the higher is the total amount of wages earned by the individual. Budget constraint in (1) imply that an individual with higher ability will benefit from a higher value of consumption flow.

Following the same steps as Dinopoulos and Segerstrom (1999) it is easily verified that the supply of unskilled labor at time t is

$$L(t) = \theta_0 N(t) = \left(\sigma \frac{w_L}{w_H} + \gamma\right) N(t) \tag{4}$$

and that the supply of skilled labor at time t is

$$H(t) = (\theta_0 + 1 - 2\gamma)(1-\theta_0) \frac{\phi}{2} N(t), \tag{5}$$

where $\phi = \left(e^{n(D-T)}\right) / \left(e^{nD} - 1\right) < 1$. Along the steady state the growth rate of both unskilled and skilled labor is equal to n. Notice that the proportional tax does not affect the individual choice to accumulate human capital from schooling or to remain unskilled.

[24] Since we concentrate on the steady state analysis the results are also compatible with the findings of Forbes (2000) which are valid in the short-medium term. Moreover, because the existence of rent-seeking bureaucracies, and their strength and breadth, can vary between countries and within the same country at different times, the analysis is compatible with both the cross-countries and within countries empirical analysis mentioned in the introduction.

2.2 Manufacture

The production of publicly provided goods and services is conducted by private monopolistic firms which are protected by a perfectly enforceable patent law for the production of their products. The Government provides institutional protection for the innovation represented by an infinitely lived patent granted to the researcher who introduces a novel, useful, and non-obvious improvement of any existing product. This allows the researcher to gain monopolistic rents for all of the real duration of the patent, because - as usual in neo-Schumpeterian growth models with vertical innovation (see e.g. Grossman and Helpman, 1991, and Aghion and Howitt, 1992-1998) - the incumbent monopolist can be replaced by the next innovator in the same sector. Intellectual property rights spur the innovation and the research effort. The Government exerts a monopsonistic power over a mass $\beta \in (0,1)$ of monopolistic firms by acquiring the product at a price lower than the monopolistic limit price. This is done in order to publicly provide goods and services reducing the fiscal burden on consumers and therefore their expenditures for the acquisition of this mass of products.

Manufacturing firms hire unskilled workers to produce any consumption good/service $\tilde{\omega} \in [0,\beta]$, and $\omega \in (\beta,1]$ of the second-best quality under a one-to-one constant returns to scale (CRS) technology, described by a simple unit cost function w_L.[25] However, in each industry the top quality product can only be manufactured by the firm that has discovered it - or by the firm that has acquired the patent from the inventor - whose rights are protected by a perfectly enforceable patent law.

As mentioned above - in the neo-Schumpeterian growth models with vertical innovation - the next quality of a given good or service is invented by the R&D performed by challenger researchers in order to replace the incumbent producer and gain monopolistic rents. During the temporary monopoly the patent holder can sell her product at a price higher than the marginal cost, but the existence of a competitive economy-wide frange sets a ceiling to it equal to the economy-wide lowest unit cost of the previous quality product. For the mass of products $[1-\beta) \in (0,1)$ the Government does not exert its monopsonistic power and then the price $p\left(j^{\max}(\omega,s),\omega,s\right)$ of every top quality product is equal to $\lambda_\omega w_L$, where $\lambda_\omega > 1$ is the quality jump for the industry line $\omega \in [0,1]$. I choose the unskilled labor wage as the numeraire of the economy, that is $w_L = 1$.

Since there exist asymmetric quality jumps along the existing industry lines, and since a mass $\beta \in (0,1)$ of the existing goods and services are acquired by the Government through rent-seeking bureaucratic agencies which know the quality of the acquired product, each bureau could exert an asymmetric monopsonistic power. Therefore the bureau acquiring the good $\tilde{\omega} \in [0,\beta]$ will pay a price $(\lambda/\varepsilon)_{\tilde{\omega}}$ which is lower than the monopolistic limit market price. In fact $\varepsilon \in [1,\lambda_{\tilde{\omega}})$ indicates the monopsonistic power of the bureau supplying the product $\tilde{\omega}$: when $\varepsilon = 1$ the bureau does not exert its monopsonistic power and buys the good $\tilde{\omega}$

[25] It could be possible to introduce a technical coefficient $\eta > 0$ common to all industries without altering the qualitative results of the model. I prefer to adopt a one-to-one technology as in Grossman and Helpman (1991) for the sake of simplicity.

at the usual monopolistic limit market price $\lambda_{\tilde{\omega}} w_L$; when $\varepsilon = \lambda_{\tilde{\omega}}$ the bureau exerts its maximum monopsonistic power because it acquires the innovative good/service at a price corresponding to the marginal cost w_L, and hence does not pay any premium for the quality jump. Since this does not give any profit to the innovating firm there will be no innovation in the market when the bureau exerts its maximum monopsonistic power, that is, there will be no incentive to innovate. I do not envisage such a case because I am interested in endogenous growth models with technological improvements on the existing goods/services. The publicly provided goods and services allow the consumers to pay a price lower than the quality adjusted price that they would pay for the same privately provided goods.

Since the quantity produced $q_{\tilde{\omega}}$ is given by the Government choice and it is common to all industries, the quantity of the product $\tilde{\omega}$ consumed is

$$Q_{\tilde{\omega}} \equiv N(t)(1-\alpha)\int_0^1 q_{\tilde{\omega}} d\theta \equiv (1-\alpha) q_{\tilde{\omega}} N(t) \quad (6)$$

Notice that only a fraction $(1-\alpha)$, with $\alpha \in (0,1)$, of each product $\tilde{\omega}$ is consumed by individuals. In fact, a fraction α of each final good and service is used by the Government to finance the overseeing activity on bureaus. Therefore the total quantity of each industry line $\tilde{\omega}$ acquired by the Government is

$$Q_{\tilde{\omega}} \equiv (1-\alpha) q_{\tilde{\omega}} N(t) + \alpha q_{\tilde{\omega}} N(t) = q_{\tilde{\omega}} N(t) \quad (7)$$

The asymmetric monopsonistic power among bureaus implies that the effective price paid to manufacturing firm producing good $\tilde{\omega} \in [0,\beta]$ is $(\lambda/\varepsilon)_{\tilde{\omega}}$; it follows that the stream of monopoly profits accruing to the $\tilde{\omega}$'s state-of-the-art quality good monopolist producer is

$$\pi(\tilde{\omega}, s) = Q_{\tilde{\omega}}\left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}} - 1\right] = q_{\tilde{\omega}} N(t)\left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}} - 1\right] \quad (8)$$

A mass $[1-\beta) \in (0,1)$ of the existing industry lines is directly sold by monopolistic firms to households. In light of the instantaneous household preferences I can boil down the consumer θ demand quantity for each product $\omega \in (\beta, 1]$ as

$$q_\omega \equiv N(t)\int_0^1 \frac{c_\theta - (1-\alpha) q\Lambda_{\tilde{\omega}}}{(1-\beta)\lambda_\omega} d\theta = N(t)\frac{c - (1-\alpha) q\Lambda_{\tilde{\omega}}}{(1-\beta)\lambda_\omega} \quad (9)$$

where c indicates the per-capita consumption fraction of product ω, q is the constant exogenous quantity of each publicly provided product, and $\Lambda_{\tilde{\omega}} \equiv \int_0^\beta \left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}} d\tilde{\omega}$. In equilibrium the above quantity coincide with the production of every consumption good by the firm that monopolizes it. It follows that the stream of monopoly profit flows accruing to the monopolist which manufactures the state-of-the-art quality product ω will be equal to:

$$\pi(\omega, s) = q_\omega[\lambda_\omega - 1] = N(t)\frac{c - (1-\alpha) q\Lambda_{\tilde{\omega}}}{(1-\beta)}\left[1 - \frac{1}{\lambda_\omega}\right] \quad (10)$$

2.3 R&D Sector

In a vertical R&D framework in each industry the incumbent producer is challenged by outsider R&D firms that employ skilled workers in order to introduce better versions of the existing goods and services. As usual in quality ladder models à la Grossman and Helpman (1991) and Aghion and Howitt (1992, 1998) Arrow's effect is at work. Each incumbent monopolist has no informational advantage over the outsider firms; hence it has no incentive to perform R&D in its own sector because it destroys its own monopolistic rents reducing its innovation value with respect to that of any other outsider firm. Therefore the monopolist does not find it profitable to undertake any R&D at the equilibrium wage. Instead each outsider firm has the incentive to perform R&D in any existing industry lines.

Every R&D firm i can produce an instantaneous Poisson arrival rate of innovation $I_i(\omega, s)$ in the product line $\omega \in (\beta, 1]$ it targets using a CRS technology described by unit cost function $bw_H \; X(\omega, s)$, with $b > 0$ common to all industries, and $X(\omega, s) > 0$ measuring the degree of complexity in the invention of the next quality product in industry $\omega \in (\beta, 1]$. For the R&D firms targeting the industry lines $\tilde{\omega} \in [0, \beta]$ over which the Government exerts its monopsonistic power, the instantaneous Poisson arrival rate of innovation is $I_i(\tilde{\omega}, s)$, and the degree of complexity in the invention of the next quality product is $X(\tilde{\omega}, s) > 0$. I assume that the returns to R&D investment are indipendently distributed across firms, across industries, and over time. Therefore the industry-wide arrival rate of innovation in industry ω at time s is $I(\omega, s) = \sum_i I_i(\omega, s)\, d\omega$, which represents the aggregate summation of the Poisson arrival rate of innovation produced by all R&D firms targeting product $\omega \in (\beta, 1]$, while the industry-wide arrival rate of innovation in industry $\tilde{\omega}$ at time s is $I(\tilde{\omega}, s) = \sum_i I_i(\tilde{\omega}, s)\, d\tilde{\omega}$, which represents the aggregate summation of the Poisson arrival rate of innovation produced by all R&D firms targeting product $\tilde{\omega} \in [0, \beta]$.

The Poisson specification of the innovation process implies the independence of the individual instantaneous arrival rate of the innovation. Each individual contribution to R&D by each skilled worker gives an independent contribution to the aggregate instantaneous probability of innovation. There does not exist any externality among researchers in the individual productivity even though there exists reciprocal collaboration at the idea-creation moment.[26]

The technological complexity argument as indexed by factor $X(\omega, s)$ was introduced into R&D-based endogenous growth models after Charles Jones' (1995 a,b) empirical criticism of the first strand of neo-Schumpeterian endogenous growth models, which showed scale effects on per-capita output growth rate.[27]

[26] Each researcher benefits from the whole knowledge accumulated in an industry, but the 'parallel' interaction between two or more researchers working in the same firm in order to introduce the next innovation does not alter their individual productivity. This implies that R&D productivity is the same if each research worker undertakes R&D by employing herself as if they are working together in the same firm.

[27] The first strand of Schumpeterian endogenous growth models (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992) showed the per-capita output growth rate as dependent on the level of resources or labor engaged in research activity. Therefore an

I follow one of the two alternative laws of motion of the technological complexity index, that is, the PEG[28] specification suggested by Dinopoulos and Segerstrom (1999)

$$X(\omega, s) = X(\tilde{\omega}, s) = kN(t) \tag{11}$$

with $k > 0$, thereby formalizing the idea that it is more difficult to introduce a new product in a more crowded market. In the present framework with quality improving consumer goods and services, the per-capita growth rate of the economy is represented by the increase over time of the representative consumer utility level.

Let $v(\tilde{\omega}, s)$ denotes the expected discounted profits of a successful firm in industry $\tilde{\omega}$ at time s. Because each leader is targeted by R&D firms that try to discover the next quality leader product, the shareholder suffers a loss $v(\tilde{\omega}, s)$ with probability $I(\tilde{\omega}, s)\, ds$. Whereas the event of no innovation occurs with probability $[1 - I(\tilde{\omega}, s)]\, ds$. Over a time interval ds, the shareholder of a stock issued by a successful R&D firm receives a dividend $\pi(\tilde{\omega}, s)\, ds$ and the value of the firm appreciates by $dv(\tilde{\omega}, s) = \dot{v}(\tilde{\omega}, s)\, ds$. Since the stock market is assumed perfectly efficient, the expected rate of return of a stock issued by a successful R&D firm must be equal to the riskless rate of return r:

$$rds = \frac{\dot{v}(\tilde{\omega}, s)}{v(\tilde{\omega}, s)} \left[1 - I(\tilde{\omega}, s)\, ds\right] ds - \frac{v(\tilde{\omega}, s) - 0}{v(\tilde{\omega}, s)} \left[I(\tilde{\omega}, s)\right] ds + \frac{\pi(\tilde{\omega}, s)}{v(\tilde{\omega}, s)} ds$$

Taking the limits as $ds \to 0$, I obtain the following condition for the expected discounted value of the firm producing good $\tilde{\omega}$

$$v(\tilde{\omega}, s) = \frac{\pi(\tilde{\omega}, s)}{\rho + I(\tilde{\omega}, s) - \frac{\dot{v}(\tilde{\omega}, s)}{v(\tilde{\omega}, s)}} = \frac{q_{\tilde{\omega}} N(t) \left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}} - 1\right]}{\rho + I(\tilde{\omega}, s) - \frac{\dot{v}(\tilde{\omega}, s)}{v(\tilde{\omega}, s)}} \tag{12}$$

where I have posed $r = \rho$ since I analyze the balanced growth path. The same argument applies for all industry lines $\omega \in (\beta, 1]$. Hence a firm producing

increase in the level of research effort would raise the per-capita output growth rate of the economy. Jones (1995 a,b) showed that, since the 50's, the labor force engaged in research activity raised in several OECD countries but - in the same period for the same countries - the per-capita output growth rate remained constant or declined on average. Therefore the scale effect predicted by the first strand of Schumpeterian endogenous growth models is at odds with this empirical evidence.

[28] The acronym "PEG" refers to the "permanent effects on growth" of policy measures such as R&D direct subsidies and tariffs: these measures can alter the steady state per-capita growth rate of the economy. This is distinguished by the law of motion for technological complexity defined as "TEG", which produces "temporary effects on growth" of policy measures such as R&D direct subsidies and tariffs: these measures cannot alter the steady state per-capita growth rate of the economy, which is pinned down by the population growth rate, by a negative externality, and by the number of countries where R&D is active.

good ω has an expected discounted value that satisfied the following

$$v(\omega, s) = \frac{\pi(\omega, s)}{\rho + I(\omega, s) - \frac{\dot{v}(\omega,s)}{v(\omega,s)}} = \frac{q_\omega [\lambda_\omega - 1]}{\rho + I(\omega, s) - \frac{\dot{v}(\omega,s)}{v(\omega,s)}} \tag{13}$$

As in Dinopoulos and Segerstrom (1999) in the steady state the per-capita variables all grow at the same rate, it follows that $\frac{\dot{v}(\omega,s)}{v(\omega,s)} = \frac{\dot{\pi}(\omega,s)}{\pi(\omega,s)} = n$, and $\frac{\dot{v}(\tilde{\omega},s)}{v(\tilde{\omega},s)} = \frac{\dot{\pi}(\tilde{\omega},s)}{\pi(\tilde{\omega},s)} = n$. Hence the discounted expected profit values (13) and (12) boil down respectively to

$$v(\omega, s) = \frac{q_\omega [\lambda_\omega - 1]}{\rho + I(\omega, s) - n} \tag{14}$$

and

$$v(\tilde{\omega}, s) = \frac{Q_{\tilde{\omega}} \left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}} - 1 \right]}{\rho + I(\tilde{\omega}, s) - n} \tag{15}$$

Each R&D firm targeting product $\omega \in (\beta, 1]$ and $\tilde{\omega} \in [0, \beta]$ chooses its R&D intensity to maximize respectively $v(\omega, s) I_i(\omega, s) - bX(\omega, s) w_H I_i(\omega, s)$, and $v(\tilde{\omega}, s) I_i(\tilde{\omega}, s) - bX(\tilde{\omega}, s) w_H I_i(\tilde{\omega}, s)$. The R&D sector is characterized by a perfectly competitive environment, with free entry and exit and CRS technology. This implies that for all industries $\omega \in (\beta, 1]$ and $\tilde{\omega} \in [0, \beta]$ targeted by positive R&D the following no-arbitrage conditions respectively hold

$$v(\omega, s) = \frac{q_\omega [\lambda_\omega - 1]}{\rho + I(\omega, s) - n} = bX(\omega, s) w_H \tag{16}$$

and

$$v(\tilde{\omega}, s) = \frac{q_{\tilde{\omega}} N(t) \left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}} - 1 \right]}{\rho + I(\tilde{\omega}, s) - n} = bX(\tilde{\omega}, s) w_H \tag{17}$$

Since each bureau exerts a different monopsonistic power over the private firm from which acquires the product, there will exist an innovation Poisson arrival rate structure in the economy, where the Poisson arrival rate $I(\omega, s)$ and $I(\tilde{\omega}, s)$ will be higher for the industry lines which sell their product at a higher price. The no-arbitrage equations (16) and (17) imply that the Poisson arrival rate targeting the industry lines with higher price, and hence gaining higher profits, will have a correspondingly higher Poisson arrival rate. In fact higher profit flows in an industry spur more innovative effort in it until the higher increasing creative destruction exactly offsets the higher rents in the same industry. This process will continue and in equilibrium the equations (16) and (17) will be satisfied for each industry line $\omega \in (\beta, 1]$, and $\tilde{\omega} \in [0, \beta]$ respectively.

2.4 Public Sector

The public sector supplies a continuum of public goods and services indexed by $\tilde{\omega} \in [0, \beta]$ subject to vertical technological innovation à la Grossman and Helpman (1991, ch.4). The goods/services are acquired from privately producing firms thanks to tax proceeds levied on consumers.

As usual in neo-Schumpeterian growth models where there exists vertical innovation over a continuum of goods and where the innovations are no-drastic, each monopolistic producer will charge a limit price corresponding to the quality jump $\lambda_{\tilde{\omega}} > 1$ over the marginal cost of production. I assume that the Government will exert its monopsonistic power over the private firms producing the existing products, thus it reduces the price at which the goods are acquired. This is done because it allows to supply public goods and services with a lower tax level for each consumer. Since the Government has not full information about the technological level and innovations in each of the existing sector, the goods and services are acquired through bureaus that possess the technical information about the product they buy. Therefore, for each good/service, the Government exerts a monopsonistic power through the rent-seeking bureaucratic agency acquiring the product. The monopsonistic power is measured by the parameter $\varepsilon \in [1, \lambda_{\tilde{\omega}})$[29] which allows the Government to reduce the price paid to each private monopolistic firm. In fact, given the quality jump $\lambda_{\tilde{\omega}} > 1$, the effective price paid by the bureau acquiring the product $\tilde{\omega}$ is $(\lambda/\varepsilon)_{\tilde{\omega}}$.

Like Sarte (2001), the discussion focuses on how to efficiently allocate public expenditures across bureaus, hence I do not envisage the fiscal policy set-up. Since bureaus act to maximize their discretionary budget, the monitoring agencies of bureaus serve to economize on total Government outlays. The budget allocation process is assumed to occur through an oversight agency which takes policy as given. As remarked by Sarte (2001) "in the US, the task of bureau oversight, including budget review and allocation, is largely carried out by The Office of Management and Budget. As such the Office of Management and Budget does not decide on policy per se, which is typically decided in Congress, but rather helps the executive branch of Government with respect to managing public expenditures."

The supply of each final public good and service is associated with a particular bureau; furthermore, as mentioned above, each bureau is required to acquire a given and common level of good/service $Q_{\tilde{\omega}} = Q$, $\forall \tilde{\omega}$, for which it requests a corresponding budget from the Government. Since the per-capita quantity of public products is constant over time, and since there exists perfect symmetry between the existing industry lines β - i.e. for each industry line the interval in which the quality jumps can vary is the same - I define $\mu_{\tilde{\omega}} \equiv [(\lambda/\varepsilon)_{\tilde{\omega}} - 1]$ as the per-unit profit flow for the industry line $\tilde{\omega} \in [0, \beta]$.

I assume, like Sarte (2001), that $\mu_{\tilde{\omega}}$ is a random variable with support

[29] Notice that the upper bound of the interval, i.e. the value $\lambda_{\tilde{\omega}}$, is excluded by the set. This is because given quality jump $\lambda_{\tilde{\omega}} > 1$, when the monopsonistic power destroys all the monopolistic rents of private firms, the incentive to innovate disappears, as said above.

$\left(0, \bar{\lambda} - 1\right]$[30] which is distributed according to the continuously differentiable probability density function $f\left(\mu_{\tilde{\omega}}; z\right)$, with the corresponding cumulative distribution $F\left(\mu_{\tilde{\omega}}; z\right)$. Hence the profit flows of the innovation - and then the costs associated with the provision of Government services - are themselves random. All bureaus draw from the distribution $f\left(\mu_{\tilde{\omega}}; z\right)$, z orders distributions by first-order stochastic dominance.[31] While the distribution $F\left(\mu_{\tilde{\omega}}; z\right)$ is publicly known, only the bureaus have full information about technological quality of their supplied goods/services; the realization of $\mu_{\tilde{\omega}}$ - and hence the quality of each product - is only costless observable by the bureau which supplies the product $\tilde{\omega}$.

Since the oversight agency has the aim of monitoring the bureaus which possess an informational advantage, the oversight agency requires skills in order to better understand the effectiveness of the bureaus' endeavours. The monitoring activity of the Government requires $\alpha w_H Q$, with $\alpha \in (0, 1)$, units of final product expressed in units of skilled workers in order to observe the bureau's realization of $\mu_{\tilde{\omega}}$ when bureau output is $Q_{\tilde{\omega}} = Q$, $\forall \tilde{\omega} \in [0, \beta]$. Hence $\alpha w_H Q$

represents the oversight cost for each bureau.[32] Since each bureau is required to acquire a common level of public good it follows that

$$\int_0^{\lambda - 1} \beta Q \mu_{\tilde{\omega}} dF\left(\mu_{\tilde{\omega}}; z\right) = \beta Q \mu_m\left(z\right) \tag{18}$$

Following Sarte (2001) - and having postulated an informational advantage of each bureau on the technological quality of the acquired product - that is the bureaucratic agent knows the true quality jump, and quality, of the product - I model the budget allocation process as a static optimal contract between each bureau and the oversight agency, which serves to economize on public expenditures. The static process relative to the public sector repeats in each instant: it is like having discrete time with duration of each interval tending to zero.

In a world where monitoring never takes place, bureaus will always announce $\mu_{\tilde{\omega}} = \lambda_{\tilde{\omega}} - 1$ and require the maximum budget. I therefore define the optimal budget allocation mechanism as one which minimizes total Government expenditures while ensuring that the budget allocated to bureaus at least covers the costs to acquire the products. Moreover, I require that each bureau's budget

[30] The support is $\left(0, \bar{\lambda} - 1\right]$ respectively when $\varepsilon \to \lambda_{\tilde{\omega}}$ for any $\tilde{\omega} \in [0, \beta]$, and when $\varepsilon = 1$, where $\bar{\lambda}$ is the upper bound of the quality jumps which is common for all the industry lines.

[31] Formally $\frac{\partial F\left(\mu_{\tilde{\omega}}; z\right)}{\partial z} < 0$, for $0 < z \leq 1$. An increase in z, therefore, generally renders per-unit provision of Government goods and services more costly by shifting the distribution in a first-order sense.

[32] Notice that a higher price can also reflect corruption of the oversight agencies. In fact, monitoring agencies can be corrupted in order to reducing monitoring effectiveness of rent-seeking and corrupt bureaus. This can be done by rebating back to monitoring agencies a fraction of the higher price paid to manufacturing firm selling product to the Government. This phenomena is not explicitly inserted in the model.

request correspond to its true realization of $\mu_{\tilde{\omega}}$.[33] In other words, the contract must satisfy incentive compatibility. Since only the bureau knows the true realization of $\mu_{\tilde{\omega}}$, the Government does not know the degree of monopsonistic power exerted by the bureau. In this environment it is optimal for the Government to monitor institution to allocate to each bureau $\bar{\mu}$, measured in units of output, when $\mu_{\tilde{\omega}} < \bar{\mu}$ is reported, and $\mu_{\tilde{\omega}}$ when $\mu_{\tilde{\omega}} \geqslant \bar{\mu}$ is reported, where $\bar{\mu}$ satisfies

$$\min_{\bar{\mu}} \int_{\bar{\mu}}^{\lambda-1} \left[\mu_{\tilde{\omega}}\beta Q + \alpha w_H \beta Q\right] dF\left(\mu_{\tilde{\omega}}; z\right) + \beta Q \bar{\mu} F\left(\bar{\mu}; z\right) \tag{19}$$

The threshold $\bar{\mu}$ minimizes total Government spending while ensuring that bureaus obtain a budget that covers the cost of acquiring the goods; moreover the contract is such that bureaus report the truth. Bureaus that exert a low level of monopsonistic power over the private manufacturing firms, and hence have a higher price, obtain a relatively large budget in the amount of $\mu_{\tilde{\omega}}Q$. However, these bureaus are also subject to oversight by the political agency.[34] Bureaus that exert a high degree of monopsonistic power - and therefore that report a relatively low value of $\mu_{\tilde{\omega}}$ - are not monitored and allocate a flat budget, $\bar{\mu}Q$, in excess of the true profit flow guaranteed to the private firm, $\mu_{\tilde{\omega}}Q$, with $\mu_{\tilde{\omega}} < \bar{\mu}$. Since the oversight agency can not discriminate between bureaus that are not monitored, assigning a flat budget across these bureaus ensures that incentive compatibility holds in that region. Therefore the bureaus which exert a high level of monopsonistic power over the private manufacturing firms - and therefore over the researchers who introduce an innovative good along a product line - obtain a discretionary surplus in the amount of $Q\left(\bar{\mu} - \mu_{\tilde{\omega}}\right)$, that is, the bureaus appropriate a part of the innovation value. To the degree that the allocation of budgets allows for informational rents to be earned by the bureaucracy, I assume these rents to be rebated back to households as a lump-sum transfer.[35] The solution to the minimization problem above is (see Appendix A):

[33] As in Sarte (2001) the lexicographic preferences of each bureau - where the first place in the utility is occupied by the bureau maintainment while the second priority is the budget maximization - are implicitly assumed.

[34] The static optimal contract between each bureau and the oversight agency could generate some form of distortion. In fact, suppose that quality jumps across industry lines are very heterogeneous. Then the bureau acquiring a product from an industry line which has a high quality jump could be monitored even if the bureau exerted a high level of monopsonistic power because $\mu_{\tilde{\omega}} > \bar{\mu}$, due to the high quality jump in industry $\tilde{\omega}$. Instead, the bureau acquiring a product from an industry line which has a low quality jump would not be monitored even if the bureau exerted a low level of monopsonistic power because $\mu_{\tilde{\omega}} < \bar{\mu}$ due to the low quality jump. This can also happen in the same industry line because of the heterogeneous quality jumps in each instant of time for each product $\tilde{\omega} \in [0, \beta]$.

[35] I assume lump-sum transfers. The analysis is conducted supposing that bureaus' discretionary rents are entirely consumed before being subject to taxation. Such hidden consumption may take the form of public perks. In the opposite case in which the lump-sum transfers are subject to taxation - i.e. are considered in the equation (2) - an increase in transfers, when oversight costs rise, tends to raise ability threshold θ_0 reinforcing the results of the model. While if the transfers decrease as oversight costs rise - and hence there exists a strong reduction of the produced quantity of goods and services and hence of θ_0 - this will tend to reduce the threshold ability mitigating the results of the model.

$$F(\bar{\mu}^{*};z)=\alpha w_{H}f(\bar{\mu}^{*};z) \tag{20}$$

The solution to the minimization problem indicates the existence of two opposite forces at work. On the one hand, a higher value of threshold $\bar{\mu}$ indicates that a smaller fraction of the bureaucracy will be monitored. This in turn reduces the quantity of final goods and services used in the oversight of the bureaus. On the other hand, a higher monitoring threshold also means that bureaucratic informational rents rise. The result in equation (20) is quite intuitive, the LHS represents the marginal gain from decreasing a bureau's informational rents, which offsets the additional increase in oversight resources as represented by the RHS. It is obvious that the solution depends on both the difficulty of monitoring, as summarized by α, and the distribution that characterizes the cost of providing Government services, as summarized by z.

By considering equation (19) I am able to determine the equilibrium level of the proportional tax rate of the economy (see Appendix A):

$$\tau^{*}=\frac{\left\{\int_{\left(\frac{\bar{\lambda}}{\varepsilon}\right)_{\omega}^{*}}^{\lambda}\left[\left(\frac{\lambda}{\varepsilon}\right)_{\omega}\beta Q+\alpha w_{H}\beta Q\right]dF(\mu;z)+\beta Q\left(\frac{\bar{\lambda}}{\varepsilon}\right)_{\omega}^{*}F(\bar{\mu}^{*};z)\right\}}{N(t)\left[\theta_{0}+(\theta_{0}+1-2\gamma)(1-\theta_{0})\frac{\phi}{2}w_{H}\right]} \tag{21}$$

I have to envisage that a part of this per-worker proportional tax is rebated back to consumers as lump-sum transfers for the total amount of discretional bureaucratic informational rents.[36]

3 Balanced Growth Path

Given the economic environment described in section 2, I analyze the general equilibrium implications of the economy. Like Dinopoulos and Segerstrom (1999) I focus on the steady state properties of the model.

Since each final good monopolist employs unskilled labor economy-wide to manufacture each product, the unskilled market clearing equilibrium condition is

$$N(t)\theta_{0}=\int_{0}^{\beta}q_{\tilde{\omega}}N(t)\,d_{\tilde{\omega}}+\int_{\beta}^{1}N(t)\frac{c-(1-\alpha)q\Lambda_{\tilde{\omega}}}{(1-\beta)\lambda_{\omega}}d\omega. \tag{22}$$

which can be rewritten as

$$N(t)\theta_{0}=N(t)\beta q+\frac{N(t)\Lambda_{\omega}}{(1-\beta)}\left[c-(1-\alpha)q\Lambda_{\tilde{\omega}}\right] \tag{23}$$

[36] Notice that, although lump-sum transfers are not taxed, a higher value of these transfers determines a higher value of the proportional tax rate.

where I have used the fact that $q_{\tilde{\omega}} = q$, $\forall \tilde{\omega} \in [0, \beta]$, and I have defined $\int_{\beta}^{1} \frac{1}{\lambda_{\omega}} d\omega \equiv \Lambda_{\omega}$.

From (23) I obtain the per-capita consumption fraction

$$c = (\theta_0 - \beta q) \frac{(1-\beta)}{\Lambda_{\omega}} + (1-\alpha) q \Lambda_{\tilde{\omega}} \tag{24}$$

Notice that mere existence of Government monitoring costs on bureaus (i.e. $\alpha \in (0,1)$) - and therefore the existence of rent-seeking bureaucratic agents with an informational advantage over the Government - negatively affects consumption.

Substituting equation (24) into (9), it is possible to write the quantity of each industry line $\omega \in (\beta, 1]$ as

$$q_{\omega} = \frac{N(t)}{\lambda_{\omega} \Lambda_{\omega}} [\theta_0 - \beta q] \tag{25}$$

which assumes positive value if and only if $\theta_0 > \beta q$. From now onward I assume that this condition holds.[37]

Considering equations (16) and (25), it is possible to write down the quantity for each good/service as

$$\frac{N(t)}{\Lambda_{\omega} \lambda_{\omega}} [\theta_0 - \beta q] = bX(\omega, s) w_H \frac{\rho + I(\omega, s) - n}{[\lambda_{\omega} - 1]}, \tag{26}$$

which - since $w_H = \frac{\sigma}{\theta_0 - \gamma}$ and $X(\omega, s)/N(t) = k$ - can be rewritten as

$$\frac{1}{\Lambda_{\omega} \lambda_{\omega}} [\theta_0 - \beta q] = \frac{\sigma b k}{\theta_0 - \gamma} \frac{\rho + I(\omega, s) - n}{[\lambda_{\omega} - 1]}, \tag{27}$$

I can easily obtain the industry-wide Poisson arrival rate targeting the product $\omega \in (\beta, 1]$

$$I(\omega, s) = \frac{(\theta_0 - \gamma)}{\sigma b k \Lambda_{\omega}} [\theta_0 - \beta q] \left(1 - \frac{1}{\lambda_{\omega}}\right) - (\rho - n) \tag{28}$$

In the same way, considering equation (17) it is possible to write down the no-arbitrage equation for each publicly provided good/service as

$$N(t) q = bX(\tilde{\omega}, s) w_H \frac{\rho + I(\tilde{\omega}, s) - n}{\left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}} - 1\right]} \tag{29}$$

which - since $w_H = \frac{\sigma}{\theta_0 - \gamma}$ and $X(\tilde{\omega}, s)/N(t) = k$ - can be rewritten as

[37] If condition $\theta_0 > \beta q$ does not hold there will survive only monopolistic firms selling their products to Government. In such a case Spinesi (2005) shows that the same qualitative results hold.

$$q=\frac{\sigma bk}{\theta_0-\gamma}\frac{\rho+I(\tilde{\omega},s)-n}{\left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}}-1\right]} \tag{30}$$

Therefore the industry-wide Poisson arrival rate targeting the product $\tilde{\omega}\in[0,\beta]$ is

$$I(\tilde{\omega},s)=\frac{(\theta_0-\gamma)\,q}{\sigma bk}\left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}}-1\right]-(\rho-n)\,. \tag{31}$$

As for unskilled labor, it is possible to boil down the market clearing equilibrium condition for the skilled labor force. Using equation (5) and the CRS technology production function of innovating firms, the skilled labor market equilibrium condition is

$$(\theta_0+1-2\gamma)(1-\theta_0)\frac{\phi}{2}=b\left[\int_0^{\beta}I(\tilde{\omega},s)\,x_{\tilde{\omega}}d\tilde{\omega}+\int_{\beta}^{1}I(\omega,s)\,x_{\omega}d\omega\right]+\alpha\beta q \tag{32}$$

where $X(\tilde{\omega},s)/N(t)\equiv x_{\tilde{\omega}}=x_{\omega}\equiv X(\omega,s)/N(t)=k$. In eq.(32) I have envisaged both the skilled labor force directly engaged in the research activity on the existing goods and services, and the skilled resources engaged in the monitoring activity as expressed by a fraction of final goods and services publicly provided.

Considering the PEG formulation of the increasing technological complexity it immediately follows that the population adjusted difficulty index is always equal to the constant k. Therefore it is possible to rewrite equation (32) as

$$(\theta_0+1-2\gamma)(1-\theta_0)\frac{\phi}{2}=bk\left[\int_0^{\beta}I(\tilde{\omega},s)\,d\tilde{\omega}+\int_{\beta}^{1}I(\omega,s)\,d\omega\right]+\alpha\beta q\equiv bkI^*+\alpha\beta q. \tag{33}$$

where $I^*\equiv\left[\int_0^{\beta}I(\tilde{\omega},s)\,d\tilde{\omega}+\int_{\beta}^{1}I(\omega,s)\,d\omega\right]$. Then, considering equations (28), (31), and (33), it is possible to derive the following

Proposition 1 *Under PEG specification, if the public sector acquires a quantity of public goods and services sufficiently low, a steady state exists for every distribution of $\mu_{\tilde{\omega}}\in\left(0,\bar{\lambda}-1\right]$ satisfying (A3) such that $\theta_0>\gamma$. At the steady state, θ_0 is a decreasing function of α.*

Proof. See Appendix B ■

Along the balanced growth path, any increase in oversight costs - as represented by an increase of parameter $\alpha\in(0,1)$ - spurs skill acquisition by a larger fraction of the population. This happens because of the increased demand for skill resources from the public sector, which must limit the informational gap between the political authority and the rent-seeking bureaucratic agencies.

4 Costly Oversight: effects on economies

As remarked by Sarte (2001) and Ayal and Karras (1996), the institutional setting of Government bureaus differs widely across economies. At the same time, as indicated in the introduction, one notices the existence of a negative relationship between rent-seeking bureaucracies and the per-capita output growth rate of the economy. I now envisage the possibility that these observations may endogenously arise in an economy where the political authority finds it difficult to oversee its bureaucracy.

In order to show how more Government costly oversight activity affects the economic performance of a country I envisage proposition 1. The existence of a negative relationship between oversight difficulty parameter α and threshold ability θ_0 implies that more costly oversight - as represented by an increase of the parameter α - reduces the threshold ability above which the individual will decide to acquire skills. At the same time it reduces the fraction - and hence the absolute number - of the unskilled labor force living at time t. This immediately determines a reduction in the total quantity of goods and services that can be produced with the existing unskilled labor force. Although the fraction of population which decides to acquire skills has raised because of the reduction of threshold ability θ_0, the aggregate rate of innovation of the economy decreases.

In order to show these results I consider equation (17) - for the industry lines over which the Government exerts its monopsonistic power - and equations (16) and (25), for the monopolistic private sector that directly sells the products to the market. Then for each product line $\tilde{\omega}$, and ω I respectively obtain

$$v\left(\tilde{\omega}, s\right) = \frac{q\left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}} - 1\right]}{\rho + I\left(\tilde{\omega}, s\right) - n} = bkw_H. \tag{34}$$

and

$$v\left(\omega, s\right) = \frac{\frac{1}{\Lambda_\omega}\left[\theta_0 - \beta q\right]\left[1 - \frac{1}{\lambda_\omega}\right]}{\rho + I\left(\omega, s\right) - n} = bkw_H \tag{35}$$

where equation (35) is obtained by sobstituting equation (25) into equation (16).

The decrease of threshold ability θ_0 raises skilled wage w_H and therefore raises the skill premium and income inequality (see equation 3). In fact, even if a larger fraction of population decides to accumulate human capital through schooling, the increase of the skill resources spent on oversight produces a positive demand excess in the skill labor market raising the skill premium. Since skilled wage w_H rises, the costs of innovation activity rise as well.

Considering equation (35), and since $\frac{\partial \theta_0}{\partial \alpha} < 0$, it is easily showed that the profit flows of private firms selling their products directly to consumers decreases. The costs of innovation activity outweigh the profit flows of the manufacturing firm producing variety $\omega \in (\beta, 1]$, and so research activity is no longer profitable. This in turn reduces the innovation effort in each industry line $\omega \in (\beta, 1]$. The aggregate Poisson arrival rate targeting product ω will decrease until the innovative effort becomes profitable. This process will continue until - along the balanced growth path - the no-arbitrage equation (35) will be satisfied. Since this argument applies for all industry lines $\omega \in (\beta, 1]$, the aggregate private innovation rate decreases.[38] In the same way considering equation (34) it is easy to show that the profit flows for each ndustry line $\tilde{\omega} \in [0, \beta]$ remain constants. In fact, the Government acquires the same fixed per-capita quantity q for all industry lines $\tilde{\omega}$. Therefore the costs of innovation activity - and hence of acquisition of the patent - outweigh the profit flows of the manufacturing firm producing product $\tilde{\omega}$, and so research activity is no longer profitable. This in turn reduces the innovation effort in each of the industry lines $\tilde{\omega} \in [0, \beta]$ and therefore reduces the aggregate Poisson arrival rate targeting product $\tilde{\omega}$ until - along the balanced growth path - the no-arbitrage equation (34) will be satisfied. Since this argument applies for all industry lines $\tilde{\omega} \in [0, \beta]$, the aggregate public innovation rate decreases.

Hence, as more and more skill resources are spent on oversight, the increase in population fraction deciding to acquire skills is not sufficient to generate a higher per-capita output growth rate. Furthermore, the decrease in ability threshold above which individuals decide to acquire skills determines an increase in skill premium widening wage inequality. In last, any increase in the oversight cost α reduces the consumption of any existing product.

Therefore I can state the following

Proposition 2 *An increase in the oversight difficulty as represented by the increase in parameter $\alpha \in (0, 1)$ determines: 1) an increase in the skill premium and therefore determines higher wage inequality; 2) a decrease in the industry-wide and in the aggregate rate of innovation, and thus a reduction in the per-capita output growth rate of the economy. Furthermore, an increase in the oversight cost spurs human capital accumulation, and it reduces the consumption of each existing good and service.*

Hence any increase in the oversight difficulty, and then any reduction in the transparency of the public sector - as represented by an increase in the parameter $\alpha \in (0, 1)$ - depresses the innovative effort of the economy, and then the per-capita output growth rate.

Along the balanced growth path there exists a negative relationship between inequality and growth. As the public sector transparency better off, a lower fraction of the existing skill resources are wasted for monitoring activity. Despite the fraction of population that decides to acquire skills decreases, the research costs reduce. This in turn spurs the industry-wide and the aggregate innovation

[38] For the sake of simplicity I refer to the fraction of sectors $\beta \in (0, 1)$, which products are acquired by the government, as public goods and services, and then I refer to the Poisson arrival rate $I(\tilde{\omega}, s)$ as public innovation rate, and to the Poisson arrival rate $I(\omega, s)$ as private innovation rate. This definition is made to simplify exposition. In such an economy the research effort and the costs for innovation is conducted by private firms and/or individuals.

effort, and then the per-capita output growth rate. Moreover the wage inequality between skilled and unskilled labor is reduced.

Moreover, the increase in the oversight difficulty determines an increase in threshold unit profit flow $\bar{\mu}^*$, but the effect on the public expenditures - and hence on the tax levied on consumers - remains not univocally determined. In fact, by using equation (A2), the effect of a higher oversight difficulty on equilibrium threshold $\bar{\mu}^*$ can be obtained as

$$\frac{\partial \bar{\mu}^*}{\partial \alpha} = \frac{w_H f\left(\bar{\mu}^*, z\right)}{f\left(\bar{\mu}^*, z\right) - \frac{\alpha w_H \partial f\left(\bar{\mu}^*, z\right)}{\partial \bar{\mu}}} > 0 \tag{36}$$

which is strictly positive because I have assumed equation (A1) to be a strictly convex function of $\bar{\mu}$.

An upwards shift in the monitoring costs naturally leads to less oversight, that is a lower number of bureaus will be monitored.

Moreover, since $\int_0^{\bar{\mu}^*} \left(\bar{\mu}^* - \mu\right) dF\left(\mu; z\right)$ is strictly increasing in $\bar{\mu}^*$, a higher monitoring cost directly leads to raising of the total quantity of discretionary surplus accruing to the bureaucracy for a given level of product q. The effect on total public expenditures, and hence on tax levied on consumers is, however, ambiguous. In fact, considering equations (A5), (A6), and (B3) the increase in the oversight cost determines opposite effects on different variables. Therefore more costly oversight produces a depressive effect on the economy, reducing the quantity of the existing goods and services consumed, but not necessarily determining higher levels of public expenditures level and therefore a higher fiscal burden on consumers.

5 Conclusions

Several empirical works show that institutional quality - in the form of bureaucratic quality - positively affects the growth performance of both developed and developing countries. Moreover, an important contribution by Chong and Calderon (2000) shows that, in developed countries, lack of bureaucratic quality contribute to widening income inequality.

In this paper I envisage the interactions of rent-seeking bureaucratic agencies with both the public authority and the private market. I show that bureaucratic quality encompasses both rent-seeking and corruption phenomena in bureaus, and that corruption plays a role through lack bureaucratic quality. The Government has to limit the informational gap with respect to its bureaus, using a monitoring agency which requires skill resources in order to oversee the rent-seeking bureaucratic agents. Moreover the Government exerts its monopsonistic power - through its bureaucratic agencies - over the private producing firms which manufacture goods and services subject to technological improvement conducted by private researchers.

I show that in such an economic environment more costly oversight - as represented by a larger amount of skill resources spent on oversight - widens income inequality and negatively affects the aggregate rate of innovation, and hence the per-capita output growth rate of the economy. This happens because - as the oversight difficulty increases - more and more skill resources are absorbed by the public sector in order to monitor the bureaus, so increasingly fewer skill resources can be employed in research activity. This reduces the per-sector and the aggregate rate of innovation although a larger fraction of population will have been stimulated to accumulate skills by an increase in the skills demand and in the skill premium. Finally, there exists an uncertain effect of more costly oversight on the public budget and expenditures. In fact, I have shown that the effect on tax burden and transfers are not univocally determined.

This theoretical analysis matches well the data for developed countries in which the fundamental engines of economic growth are technological progress and human capital accumulation. This means that lack of bureaucratic quality widens income inequality and reduces the per-capita output growth rate because it contributes to diverting skill resources from productive activities toward unproductive ones. This does not mean that the same causal mechanism is not at work in developing countries, it may well be. However, in less developed countries R&D and human capital accumulation are not as advanced as in developed countries, and so the adverse effect of lack institutional quality on growth performance probably operates through other channels than the waste of skill resources, or at least this channel is not as important as it is in developed countries. Moreover, since in developing countries human capital accumulation and technological progress are not as diffuse and advanced as in developed countries, it is more difficult for income inequality to be proxied by the skill premium in developing countries.

Appendix A

In the first part of Appendix A I calculate the per-unit profit flow optimal threshold $\bar{\mu}^*$. Following the same steps as Sarte (2001) the minimization problem in equation (19) can be rewritten as:

$$\beta Q\mu_m(z) + \alpha w_H \beta Q\left[1 - F(\bar{\mu}; z)\right] + \int_0^{\bar{\mu}} \beta Q(\bar{\mu} - \mu_{\tilde{\omega}})\, dF(\mu_{\tilde{\omega}}; z) \tag{A1}$$

In this equation the first two terms measure the value of public goods and services used in the acquisition and monitoring respectively. The third term represents the total discretionary surplus accruing to bureaus, measured as a fraction of the total profit flows earned by the incumbent firms. Using Leibniz's rule, the solution to the problem above is

$$\beta QF(\bar{\mu}; z) - \alpha w_H \beta Qf(\bar{\mu}; z) = 0. \tag{A2}$$

I assume that the second-order condition for a minimization problem is satisfied, equation (A1) is strictly convex in $\bar{\mu}$, that is

$$\beta Qf(\bar{\mu}; z) - \frac{\alpha w_H \beta Q \partial f(\bar{\mu}; z)}{\partial \bar{\mu}} > 0 \tag{A3}$$

It directly follows that the solution to the minimization problem in (19) solves

$$F(\bar{\mu}^*; z) = \alpha w_H f(\bar{\mu}^*; z) \tag{A4}$$

The first-order condition (A2) determines optimal threshold $\bar{\mu}^*$.

Q.E.D.

In this part of Appendix A I determine the equilibrium level of per-worker proportional tax τ. Notice that because of the constant term in $\mu_{\tilde{\omega}}$ and $\bar{\mu}$, I can rewrite equation (19) by considering prices. Hence by considering equation (19) and the threshold equilibrium price $\left(\frac{\bar{\lambda}}{\varepsilon}\right)^*_\omega$, it is possible to write down the public balance as

$$\begin{aligned} &\int_{\left(\frac{\bar{\lambda}}{\varepsilon}\right)^*_\omega}^{\lambda} \left[\left(\frac{\lambda}{\varepsilon}\right)_\omega \beta Q + \alpha w_H \beta Q\right] dF(\mu; z) + \beta Q \left(\frac{\bar{\lambda}}{\varepsilon}\right)^*_\omega F(\bar{\mu}^*; z) \\ = \;& \theta_0 N(t)\tau + (\theta_0 + 1 - 2\gamma)(1 - \theta_0)\frac{\phi}{2} N(t) w_H \tau \end{aligned} \tag{A5}$$

The equilibrium balanced public budget univocally determines the equilibrium per-worker proportional tax

$$\tau^* = \frac{\left\{\int_{\left(\frac{\bar{\lambda}}{\varepsilon}\right)^*_\omega}^{\lambda} \left[\left(\frac{\lambda}{\varepsilon}\right)_\omega \beta Q + \alpha w_H \beta Q\right] dF(\mu; z) + \beta Q \left(\frac{\bar{\lambda}}{\varepsilon}\right)^*_\omega F(\bar{\mu}^*; z)\right\}}{N(t)\left[\theta_0 + (\theta_0 + 1 - 2\gamma)(1-\theta_0)\frac{\phi}{2} w_H\right]} \tag{A6}$$

Q.E.D.

Appendix B

In this appendix I show the conditions for a steady-state solution for the ability threshold $\theta_0 \in (\gamma, 1)$, and I prove the existence of a negative relation between threshold ability θ_0 and oversight cost α.

Under PEG specification of R&D difficulty the economywide Poisson arrival rate of innovation I^* is

$$\begin{aligned} I^* &= \left[\int_0^\beta I(\tilde{\omega}, s)\, d\tilde{\omega} + \int_\beta^1 I(\omega, s)\, d\omega\right] = \\ &= \frac{(\theta_0 - \gamma)(\theta_0 - \beta q)}{\sigma b k \Lambda_\omega}(1 - \beta - \Lambda_\omega) + \frac{q(\theta_0 - \gamma)}{\sigma b k}(\Lambda_{\tilde{\omega}} - \beta) - bk(\rho - n) \end{aligned} \tag{B1}$$

where the terms $(1-\beta-\Lambda_\omega)$, and $(\Lambda_{\tilde{\omega}} - \beta)$ are strictly positive since they are obtained by summing-up positive quantities, i.e. $(1-\beta-\Lambda_\omega) = \int_\beta^1 \left(1 - \frac{1}{\lambda_\omega}\right) d\omega$, and $(\Lambda_{\tilde{\omega}} - \beta) = \int_0^\beta \left[\left(\frac{\lambda}{\varepsilon}\right)_{\tilde{\omega}} - 1\right] d\tilde{\omega}$.

Therefore I can write equation (33) as:

$$\begin{aligned} (\theta_0 + 1 - 2\gamma)(1-\theta_0)\frac{\phi}{2} &= \frac{(\theta_0 - \gamma)(\theta_0 - \beta q)}{\Lambda_\omega \sigma}(1 - \beta - \Lambda_\omega) + \\ &\quad + \frac{q(\theta_0 - \gamma)}{\sigma}(\Lambda_{\tilde{\omega}} - \beta) - bk(\rho - n) + \alpha\beta q \end{aligned} \tag{B2}$$

The LHS of equation (B2) is a strictly concave quadratic polynomial with roots $(2\gamma - 1)$ and 1. Moreover, by posing $q = 0$, the RHS of equation (B2) is a strictly convex quadratic polynomial with two real roots, one negative and one positive, where the positive root is

$$\theta_0 = \frac{1}{2}\left\{\gamma + \sqrt{\gamma^2 + 4\frac{bk(\rho - n)}{a}}\right\} \in (\gamma, 1)$$

if the stated parameter restrictions are satisfied, where $a \equiv \frac{(1-\beta-\Lambda_\omega)}{\Lambda_\omega \sigma}$. Therefore because of continuity of the functions I conclude that - whenever the Government acquires a sufficiently low quantity of each product $\tilde{\omega}$, there exists one, and only one, real and positive steady state solution $\theta_0 \in (\gamma, 1)$.

Using the Implicit Function Theorem for equation (B2) I am able to prove the inverse relationship between threshold ability θ_0 and oversight cost α,

$$\frac{\partial \theta_0}{\partial \alpha} = -\frac{\beta q}{(\theta_0 - \gamma)\,\phi + (2\theta_0 - \gamma - \beta q)\,a + \frac{q}{\sigma}\,(\Lambda_{\tilde{\omega}} - \beta)} < 0 \qquad \text{(B3)}$$

where I have used the fact that along the steady state $\theta_0 > \gamma$, and $\theta_0 > \beta q$ by assumption.

Q.E.D.

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