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Optimal government regulations and red tape in an economy with corruption

Fabio Mendez and Facundo Sepulveda

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Fabio Mendez, University of Arkansas

Facundo Sepulveda, Economics Program, Research School of Social Sciences, Australian National University
Email: facundo.sepulveda@anu.edu.au

ABSTRACT

We study an economy where agents are heterogeneous in entrepreneurial ability, and may decide to become workers or entrepreneurs. The government is motivated by a production externality to impose regulations on entrepreneurship, and sets a level of red tape -administered by public officials-to test regulation compliance. In an environment where some officials are corrupt, we study what are the optimal levels of regulations and red tape, and to what extent such policies reduce the welfare losses created by corruption. For each level of externalities, we find that high and low levels of corruption create qualitatively different distortions, which in turn changes the nature and reach of optimal policies. Under low levels of corruption and externalities, the government sets low levels of regulations and minimal red tape, and with these policies achieves the first best allocation. When externalities and corruption are above a threshold, only a second best allocation can be achieved. Moreover, when externalities are large, mandating higher levels of red tape is a Pareto improving policy.

JEL codes: D73, D60, D63, H21

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1 Introduction

In The Other Path (de Soto [1990]), Hernando de Soto presents a rendition of the effects of bureaucratic corruption and red tape on entrepreneurship, describing how burdensome requirements and delays caused by government mandated red tape discourage the poorest entrepreneurs from setting up shop. A large part of the academic literature on corruption focuses on the same issues: How regulations, red tape, and corruption interact to affect growth, investment, and economic efficiency in general. The image of corrupt economies with high levels of regulatory burden transpires throughout.

However, a summary look at the country level data on the level of regulations, understood as government mandated restrictions on emissions levels, zoning regulations, and the like, as well as red tape, taken to be the paperwork and time resources necessary to, say, set up a business, suggests a different picture: Developed economies with low levels of corruption display typically very high levels of regulation, and relatively low levels of red tape, while corrupt economies tend to have low levels of regulations, but high red tape. Djankov et al. [2002] describe the time delays and number of procedures necessary to start a business in a cross section of countries. In their data, countries in the first quartile of the income distribution require 7.17 procedures, taking up 43.17 days in average, while countries in the fourth quartile require 11.21 procedures which take an average of 73 days. These measures of red tape are also correlated with corruption. For the stringency of regulations policies, the point can be exemplified by comparing emmissions standards in the EU and Asian countries: New EU standards are implemented in Asia with a median lag of up to nine years (see IADB [2003]).

In this paper, we build on the distinct nature of government mandated regulations and red tape and study their effects in the presence of corruption. We are motivated by the question of what are the optimal choices with regards to these two policy variables in a corrupt economy, and to what extent a judicious choice of both the level of regulations and red tape may reduce the distortions caused by corruption.

We present a model with agents that are heterogeneous in entrepreneurial ability, and may choose to become either salaried workers -for the public bureaucracy or the private sector- or entrepreneurs. The existence of the public bureaucracy is motivated by a Pigovian role: Investment projects create negative externalities, government mandated regulations aim to impose private abatement of these externalities, and public bureaucrats test that such regulations have been complied with. Some officials are corrupt, and will ask for a bribe in exchange for extending the investment permit. Officials are assigned randomly to entrepreneurs, who may choose to abide by the regulations or not beforehand. Entrepreneurs also have the choice of searching for a different official, making the problem effectively dynamic for them. In this context, regulations take the form of a fixed cost to entrepreneurs, while red tape is the number of investment permits necessary to start operations, and therefore its cost is in the form of time delays between investment and production.

Although the distorsions caused by corruption are endogenous to policy choices, our paper takes the corrupt behavior of some officials as given, and is silent on the effects of policies destined at penalizing such behavior. This approach recognizes the fact that corruption is persistent and difficult to erradicate, and examines alternative policy tools that can be used to limit its effects.

This paper falls within a growing theoretical literature on the economics of corruption. Cadot [1987] presents a model where agents need to be granted a permit to invest and are assigned government officials randomly. The stage game of our model borrows the basic idea of random assignment of officials to entrepreneurs. Acemoglu and Verdier [1998] present a model where the bureaucrats' role is to enforce property rights. While both these papers focus on bureaucrats wages as the relevant policy tool, Bliss and Tella [1997] examine the effects of changes in the level of competition on the effects of corruption. In contrast, our paper focuses on the level of regulations and red tape as tools to limit the effects of corruption. Finally, Guriev [2004] is one of the first papers to address explicitly the role of government mandated red tape in an economy with corruption. In that model, red tape is costly, but serves to disclose information to bureaucrats about the project type. In contrast with most of the literature, excepting Acemoglu and Verdier [1998], we adopt a general equilibrium approach, where the size of the public sector is endogenous to the need for public officials.

There is a small empirical literature that examines the nature of corruption at the firm and individual level. Svensson [2003] reports on the nature of bribery in a sample of Ugandan firms, and finds evidence for bribes being related to profits and to the outside options of the firms. Hunt and Laszlo [2005] study individual level bribery using responses from a peruvian household survey. They also find that officials are price discriminators, and bribes are a function of income. Our model is broadly consistent with these facts.

The study by Djankov et al. [2002] mentioned above is also of direct relevance to our paper. In that work, the authors find that stricter regulation of entry is not associated with better public goods across countries, but is associated with higher corruption. They conclude that the evidence points to regulations and red tape being installed by corrupt officials to their own benefit. In this paper, while allowing officials to be corrupt, we give a benevolent government the possibility of determining the levels of such variables, and focus on the normative aspect of the problem.

A common theme reappears through our results: high and low corruption give rise to qualitatively different economies. Not only the nature of optimal government policies is different in both cases, but also the extent to which such policies reduce the deadweight losses caused by corruption. Technically, our model is characterized by two types of equilibria. In the first equilibrium, with low corruption and a low level of externalities, all entrepreneurs follow the regulations, but investment is inefficiently low if regulations are set at their no-corruption level. In this case, a minimal level of red tape, and a level of regulations lower than with no corruption is optimal, and such policies actually achieve the first best. The second equilibrium obtains for a level of corruption and externalities above a threshold. In this case, entrepreneurs at the lower end of the ability distribution choose not to follow the regulations. The optimal policies in this equilibrium cannot achieve the first best, and may include a higher-than-minimal level of red tape. In particular, when production externalities are large, a higher level of red tape will improve welfare by discouraging inefficient entrepreneurs.

This paper has four other sections. The next section presents the model and defines the equilibrium concept. Section three examines the equilibrium, while section four studies what are the socially optimal policies. Section five concludes.

2 Model

We study an economy with a continuum of infinitely lived agents of size one. Each agent is endowed with a unit of labor supply and with a level of entrepreneurial ability R, drawn from a distribution with c.d.f. $G(R)$. We assume that $G(R)$ is once differentiable with $G' = g$.

Agents have preferences for consumption c and a public good X represented by

$$U = E \sum_{t=0}^{\infty} \delta^t \{c_t - X_t\} \tag{1}$$

Subject to the constraint

$$a_t(1 + r_t) + income_t = c_t + a_{t+1} + \tau \tag{2}$$

Where δ is a discount factor, a_t are assets at the beginning of period t, and τ is a lump sum tax. The variable *income* depends on the agents occupation in a way that will be made clear in what follows.

Agents may choose to use their skills in one of two different occupations. They may be workers -either for the government or the private sector- and supply labor at the market wage w, or they can become entrepreneurs.

The corrupt nature of some officials is imposed exogenously: Once agents become government officials, they are revealed to be corrupt with probability p. Because corruption incidence is at best slow to control, it is sensible to take the corrupt nature of government officials as given, and study what government policies will limit the effects of such corruption on efficiency. This is the approach we take in this paper.

Because the wage rates in the government and private sectors are equal, expected utility suggests that all workers -as well as some entrepreneurs- would prefer to become government officials. To simplify the analysis, we assume that the government chooses its officials among those with the lowest entrepreneurial ability. This assumption simplifies the analysis by making the choice of becoming a public official exogenous to the agents. In turn, this ensures that the choice of becoming a worker/entrepreneur is not affected by the possibility of earning bribes in the public sector. An alternative assumption would be to penalize corrupt officials with an amount and a frequency that makes their expected income equal to the competitive wage.

With the government picking its officials, we can focus on the agents' decisions to invest vs. work. The timing of decisions is shown in figure 1. The value function for an individual who has to decide whether to work or become an entrepreneur is the solution to [1]

$$v = \max\{v_e, w + \delta v\} \tag{3}$$

where w is the wage rate, and v_e is the value of becoming an entrepreneur and following the optimal policies thereafter. A solution to 3 is a function

[1] Since utility is linear, agents can be seen as maximizing discounted wealth.

$\Pi : \mathbb{R}^{+} \rightarrow \{1, 0\}$ that maps values of R to an occupational choice: Whether to become an entrepreneur (1), or a worker (0). In order to define v_e, we proceed to discuss the problem faced by entrepreneurs.

If an agent decides to become an entrepreneur, she incurs in an investment cost of i, and must have the project certified for regulations compliance by government officials. Such regulations, if followed, impose a cost α on investors. Our measure of red tape is the number of certifications needed to make a project operational. Since certifications can only be obtained sequentially, red tape imposes a burden in terms of a time delay between the time of investment and that of production. In this paper we study the case of Low red tape, where only one certification is needed, and that of High red tape, where two certifications are needed. In this section we describe the model for a Low red tape economy, the extension to a High red tape environment being mechanic.

After investing and obtaining a certification, entrepreneurs organize production by hiring labor (L) and using their own entrepreneurial ability (R_i) according to the production function

$$F(R_i, L) = L + R_i, \tag{4}$$

After the project becomes operational and produces output, it depreciates completely. We adopt a linear technology for simplicity. The expression for the wage rate is F_L. After paying wages, entrepreneurs obtain a gross profit of $F - F_L L$.

Because entrepreneurs are heterogeneous in their ability R_i, which determines the rate of return of their projects, it is sensible to normalize the cost of the project to i, as we have done. In the current framework investors may only manage one project at a time and, as will become clear below, investment and production will not necessarily take place in the same period.

To obtain certifications for their projects, investors get a random draw of a government official. Officials are of two types: A proportion $1-p$ of them is honest, and verify that regulations have been followed. If they have not, the certification is simply not given. The remaining officials are corrupt and ask for a bribe β in exchange of the certification. When faced with either type of official, investors may also decide to keep searching for a different type (or to withdraw from the process altogether, but we disregard this possibility as it is never chosen in equilibrium). We assume for simplicity that each official reviews one project.

In choosing whether to follow the regulations, the entrepreneur chooses the compliance policy that solves

$$v_e = -i + \max\{v_s(0), -\alpha + v_s(1)\} \tag{5}$$

Where $v_s(1_{[\alpha]})$ is the expected value of searching for an official. The argument in $v_s(.)$ is an indicator that takes the value one when the regulations have been followed. A solution to (5) is a policy function $\Lambda : \mathbb{R}^+ \rightarrow \{0, 1\}$ that maps values of R to a decision of whether to comply (1) or not (0) with the regulations The function v_s is defined as

$$\begin{aligned} v_s(0) &= pv_c(0) + (1-p)v_h(0) && (6) \\ v_s(1) &= pv_c(1) + (1-p)v_h(1) && (7) \end{aligned}$$

The functions v_c and v_h in turn represent value functions for agents who have already drawn an official from the lottery, where the subscript of the value functions refers to the type of official (corrupt or honest). They are solutions to the following Bellman equations:

$$\begin{aligned} v_c(0) &= \max\{R_i - \beta + \delta v, \delta v_s(0)\} && (8) \\ v_c(1) &= \max\{R_i - \beta + \delta v, \delta v_s(1)\} && (9) \\ v_h(0) &= \delta v_s(0) && (10) \\ v_h(1) &= \max\{R_i + \delta v, \delta v_s(1)\} && (11) \end{aligned}$$

In expressions 8 to 11 we impose the equilibrium result that $\frac{1}{1+r_t} = \delta$, where r_t is the interest rate. In expressions 8 and 10 we also impose the equilibrium feature that, if no compliance was optimal at time zero, it will remain the optimal choice regardless of the history of draws [2]. Equilibrium search costs are then constant over time and proportional to δ. The solution to $\{v_c, v_h\}$ in (8) to (11) is a pair of policy functions $s_{c,h} : \{1, 0\} \times \mathbb{R}^+ \rightarrow \{accept, search\}$ that map a value of R and a compliance choice Λ to a decision of whether to accept the official's offer (*accept*) or keep searching for a different official (*search*). Note that the decision to accept the offer involves paying a bribe if the official is corrupt, and simply accepting the certification if it is honest.

We now describe how the bribe level (β) is determined. When the investor draws a corrupt official, the bribe will be determined by Nash bargaining,

[2] Otherwise we would substitute $\delta v_s(0)$ for the equivalent, but more cumbersome $\delta \max\{v_s(0), -\alpha + v_s(1)\}$.

where the bargaining power of the official is θ. While the reservation value for the corrupt official is zero, the reservation value for the investor is the discounted value of searching (δv_s). The bribe is then determined by solving

$$\max_{\beta}(\beta)^{\theta}(R_i - \beta + \delta v_e - \delta v_s)^{1-\theta} \tag{12}$$

So the equilibrium bribe will be a function of the return of the project R_i, which is observable by the official [3]. Using Nash bargaining as the solution concept for the bribe game allows for a simple rule of surplus sharing between corrupt officials and investors:

$$\beta(R) = \theta(R_i + \delta(v_e - v_s)) \tag{13}$$

At this point, it should be clear that the variable $income_t$ is random both for the corrupt official and for the entrepreneur

$$income_t = \begin{cases} w_t & \text{if work, honest official} \\ w_t + \beta_t & \text{if corrupt official} \\ \pi_t(R) & \text{if entrepreneur} \end{cases} \tag{14}$$

Where we use the convention that $\beta_t = 0$ if the bribe is not paid, and $\pi_t(R)$ are the net profits for an entrepreneur of type R at time t. Note that β_t is a random variable for the official, who will be given a draw of an entrepreneur. For the entrepreneur, net profits π_t are also random, as they depend on the draw of government officials.

The government finances the public wage bill by levying a lump sum tax τ on all agents, since it maintains a balanced budget, and there are as many officials as projects, we have:

$$\tau_t = w_t \int_{i \ is \ entrepreneur} dG(i) \tag{15}$$

The existence of the government is motivated by a Pigovian role: Each investment project creates a negative externality of γ when it becomes operational; a technology is available that corrects this externality, and the government mandates its use by imposing restrictions to investment in the form of government regulations. As mentioned above, such regulations imply a cost α

[3] We use v and v_e interchangeably for investors, as they will be equal in all future periods

on projects. The net externality created by an individual investment project takes the form

$$x = \gamma - \alpha \tag{16}$$

Where α is a policy variable for the government, and we take $\alpha = 0$ if the entrepreneur decides not to follow the regulations. The externality as perceived by the agents is naturally the integral of x over all operational projects.

The agents' problem is then to maximize the utility function in 1 subject to the budget constraint 2, by choosing compliance, occupation and search policies that solve 3 to 11, taking α, β and X as given.

The equilibrium objects for this economy are a set of Bellman equations for $\{v, v_e, v_c, v_h\}$, along with a bribe function $\beta : \mathbb{R}^+ \to \mathbb{R}^+$ that solves 12, a rule to determine the agent's occupation $\Pi : \mathbb{R}^+ \to \{1, 0\}$ that solves 3, a set of search policies for honest and corrupt officials contingent on R, and the compliance choice $\{s_h, s_c\} : \{0, 1\} \times \mathbb{R}^+ \to \{accept, search\}$ that solves 8 to 11, and a compliance rule $\Lambda : \mathbb{R}^+ \to \{0, 1\}$ that solves 5.

This environment may be seen as a repeated game between corrupt officials and entrepreneurs, with nature determining the type of official. It is natural in this case to impose subgame perfection on the equilibrium policies. In particular, when the bribe is bargained we restrict the reservation value for the entrepreneur to be that which is derived from policies that are optimal in the subgame that starts from next period on (if the entrepreneur keeps on searching). We refer to this as the threat points being credible.

Equilibrium An equilibrium is a set of Bellman equations for $\{v, v_e, v_c, v_h\}$, a bribe function β, an investment rule Π, a rule for following regulations Λ and a set of search policies $\{s_h, s_c\}$, that satisfy:

1. The bribe function β is a solution to problem (12), where the threat points δv_s are credible.

2. Given β, the search policy functions $\{s_h, s_c\}$ solve the Bellman equations $\{v_h, v_c\}$ in (8) to (11).

3. Given $\{\beta, s_h, s_c\}$, the investment rule Π solve the Bellman equation v in 3.

4. The compliance rule Λ solves Bellman equation v_e in (5).

5. The government budget given by 15 is balanced.

In the next section we characterize the equilibrium.

3 Equilibrium

We consider stationary equilibria of the model, where the proportion of entrepreneurs who follow a given optimal plan, as well as workers, are constant. For the model just described, focusing on the stationary equilibrium involves little loss of generality, as the economy would jump to this equilibrium starting from an initial condition with no sunk investments. We begin by noting that prices in this competitive environment are

$$w = 1 \tag{17}$$

$$r = \frac{1-\delta}{\delta} \tag{18}$$

Expression 17 follows from the linearity of the production function, while 18 follows from the linearity of preferences as well.

3.1 Equilibrium under Low red tape

To characterize the optimal strategies [4], we proceed by backwards induction, first deriving the optimal choices and payoffs of an agent who chose to invest, and then deriving the conditions under which this decision is optimal. We begin by noting that, because of the recursive nature of the problem, we can focus on time invariant plans. For an agent who has become entrepreneur by investing i, a plan is a compliance choice plus a search policy $\{\Lambda, s_h, s_c\}$. Note that there is potentially a large number of candidate plans to consider. As the next result shows however, we can limit our attention to two such plans.

Lemma 1 *For entrepreneurs, at most two plans are used in equilibrium*

$$\{\Lambda, s_h, s_c\} \in \{\{1, accept, accept\}, \{0, search, accept\}\} \tag{19}$$

The proof is in appendix A. For simplicity we will refer to $\{1, accept, accept\}$ as plan 1, and $\{0, search, accept\}$ as plan 2. An immediate consequence of there being two observed plans is that there will be two bribes (as functions of R), since the threat points δv_s -the value of searching- will be different for both plans.

[4] We use 'strategy' and 'plan' interchangeably.

For plan 1, the entrepreneur decides to follow the regulations, in which case she will receive the certification if facing an honest official in the draw. If she draws a corrupt official on the other hand, she will pay the bribe. Note that in this case all investment projects become operational in the same period the investment takes place.

For plan 2, the investor does not comply with the regulations, so she will search for a corrupt official that can be bribed. Only a fraction p of the projects following this strategy will become operational every period.

Some intuition can be offered for this lemma. Note that searching when the agent draws a corrupt official cannot be optimal, as Nash bargaining by definition gives the agent a share of the surplus *above* the payoff from searching. On the other hand, searching if an honest official is drawn is the only possibility when $\Lambda = 0$, and could not be optimal if $\Lambda = 1$, since accepting the certification is done at no marginal cost.

To complete the characterization of the optimal choices by investors and workers, we need to map the values of R to a choice of plan. Because of the linear structure of the model, the optimal choices between pairs of plans can be simply characterized in terms of cutoff points in R.

Lemma 2 *There are three levels of R, $\{R1, R2, R3\}$, such that*

1. *Strategy 1 is preferred to strategy 2 for all $R_i > R1$ with*

$$R1 = i\delta + \alpha\frac{1 - p\theta\delta}{1 - p} \tag{20}$$

2. *Strategy 2 is preferred to not investing for all $R_i > R2$, with*

$$R2 = i(\frac{1 - \delta}{p(1 - \theta)} + \delta) + \frac{1}{p(1 - \theta)} \tag{21}$$

3. *Strategy 1 is preferred to not investing for all $R_i > R3$, with*

$$R3 = (i + \alpha)\frac{1 - p\theta\delta}{1 - p\theta} + \frac{1}{1 - p\theta} \tag{22}$$

Proof: *The payoffs are, for not investing*

$$U = \frac{1 - X}{1 - \delta} \tag{23}$$

From following strategy 1,

$$\begin{aligned} U &= -\frac{1-p\theta\delta}{1-\delta}(i+\alpha) + \frac{1-p\theta}{1-\delta}R - \frac{X}{1-\delta} \\ &\equiv a_1 + a_2 R_i - a_3 X \end{aligned} \tag{24}$$

From following strategy 2,

$$\begin{aligned} U &= -i(1+\delta p\frac{1-\theta}{1-\delta}) + \frac{p(1-\theta)}{1-\delta}R - \frac{X}{1-\delta} \\ &\equiv d_1 + d_2 R_i - d_3 X \end{aligned} \tag{25}$$

For 1, note that $a_1 < d_1$, $a_2 > d_2$, and $a_3 = d_3$. Since $R \in \mathbb{R}^+$, there is a cutoff point such that strategy 1 is preferred to strategy 2 for all R that are higher. Simple algebra shows that this point is $R1$. For 2, note that $d_1 < 1$ and $d_2 > 0$, so a cutoff point for the choice between strategy 2 and working exists. Again simple algebra shows that it is $R2$. For 3, a similar argument to 2 applies.

Since R is unbounded, and strategy 1 is optimal for all $R > \max\{R1, R3\}$, strategy 1 will always be observed in equilibrium. The following corollary defines the conditions under which strategy 2 will also be observed.

Corollary 1 *Strategy 2 is observed iff $R1 > R2$. This implies the following condition on the parameters*

$$\begin{aligned} \alpha &> i\frac{(1-\delta)(1-p)}{p(1-\theta)(1-p\theta\delta)} + \frac{1-p}{p(1-\theta)(1-p\theta\delta)} \\ &\equiv h(i; p, \delta, \theta) \end{aligned} \tag{26}$$

The proof is in appendix B, and the condition is plotted in figure 2 for selected values of $\{i, \delta, \theta\}$. Note that plan 2 is observed for $\{\alpha, p\}$ above a convex threshold. Agents who follow plan 2 effectively trade in lower investment costs, as they do not incur in the costs of complying with the regulations, for a lower probability (p) of being given a certification. This implies a reduced expected level of profits, which comes from two sources: First, the expected delay in implementing the project is now $\frac{1}{p}$, reducing the present value of profits. Second, the bribe to be paid is higher if the agent follows plan 2. Indeed, the value of searching (v_s) is lower if this plan is followed , so the rents to be divided between the entrepreneur and the corrupt official are higher, and the bribe is an increasing function of these rents.

For entrepreneurs who follow plan 1 on the other hand, the payoffs from obtaining a certification are high enough that the expected costs of waiting until a corrupt official is drawn, plus the higher bribes to be paid in this case, would dominate the reduction in costs from not following the regulations.

As expected, entrepreneurs following plan 2 will have lower ability than those following plan 1. In equilibrium, they will be observed if the economy displays high costs of regulations α, and low bargaining power of corrupt officials ($h_\theta > 0$). High levels of corruption p raise expected costs by increasing the bribe level, but also decrease such costs by reducing the expected time until a corrupt official is drawn. In this case the latter effect dominates and higher corruption is associated with more entrepreneurs following this plan ($h_p > 0$). Finally, the effect of δ is ambiguous.

We can now summarize the characterization of the equilibrium of the model. We do this in the following proposition, which implicitly describes the optimal policies $\{s, \Pi, \Lambda\}$.

Proposition 1 (Equilibria) *In the model with Low red tape there are two types of equilibria.*

Equilibrium 1 *If condition 26 does not hold, agents with $R \in (0, R3)$ will choose to work. Agents with $R \in [R3, \infty)$ will become entrepreneurs, abide by the regulations, and choose to pay bribes if they draw a corrupt official.*

Equilibrium 2 *If condition 26 holds, agents in $R \in (0, R2)$ will choose to work, agents with $R \in [R2, R1)$ will invest, not abide by the regulations, and search for a corrupt official. Finally, agents with $R \in [R1, \infty)$ will follow the regulations, and pay the bribe if they draw a corrupt official.*

The proof follows from previous results. As will be discussed below, the two equilibria have very different policy and welfare implications. The first equilibrium, which is observed under low corruption, describes an economy where corruption has similar effects to those of a capital earnings tax. In the second equilibrium, under high corruption, some investors are induced to engage in a form of rent seeking behavior, and the distorsions caused by corruption are more complex than those of a tax. In this sense the model provides a formal interpretation of the common observation that low and high corruption are associated with different types of deadweight losses.

3.2 Comparative statics: Regulations

We now examine the effects of changing the level of regulations α and red tape on the equilibrium level of net output and the public good. Note that output net of depreciation costs i and compliance costs α is the relevant metric for available resources, and it is the output measure we consider in what follows. The expression for net output is

$$Y = \begin{cases} \int_{R3}^{\infty}(R-i-\alpha)dG(R) + (2G(R3)-1) & \text{in Eq. 1} \\ p\int_{R2}^{R1}(R-i)dG(R) + \int_{R1}^{\infty}(R-i-\alpha)dG(R) + (2G(R2)-1) & \text{in Eq. 2} \end{cases} \tag{27}$$

Where $(2G(.)-1)$ is the size of the labor input, which we assume is strictly positive. The following comparative statics result follows

$$\frac{\partial Y}{\partial \alpha} = \begin{cases} -\frac{\partial R3}{\partial \alpha}g(R3)(R3-i-\alpha-1) - (1-G(R3)) + g(R3)\frac{\partial R3}{\partial \alpha} & \text{in Eq. 1} \\ -g(R1)\frac{\partial R1}{\partial \alpha}(R1-i-\alpha) + pg(R1)\frac{\partial R1}{\partial \alpha}(R1-i) - (1-G(R1)) & \text{in Eq. 2} \end{cases} \tag{28}$$

In Equilibrium one there are three effects. First, as $R3$ shifts to the right, some entrepreneurs become workers, reducing net output (first term in 28, Eq. 1). Second, all remaining entrepreneurs face higher compliance costs, which reduces output accordingly (second term). Third, as $R3$ shifts and the number of investment projects is reduced, the size of the government bureaucracy is also reduced, and therefore the labor supply increases (last term in 28, Eq. 2). This equilibrium effect on the size of the public sector tends to increase output. Were entrepreneurs to bear the costs of government bureaucrats' wages, the first effect would dominate this last one, and the overall effect of the level of regulations on output would be unambiguously negative.

In Equilibrium two, an increase in α does not change the set of agents who become entrepreneurs, but it alters, at the margin, the compliance decision and therefore the nature of the optimal plan: First, there are fewer plan 1 entrepreneurs (first term in 28, Eq. 2), and more plan 2 entrepreneurs (second term). Only a fraction p of the new plan 2 entrepreneurs will produce, but they will produce more net output. The overall effect of α on output is therefore ambiguous. Finally, there is an inframarginal effect on the remaining plan 1 entrepreneurs, captured by the last term in (28, Eq. 2).

For the effects of α on the public good, note that we have defined X as a public 'bad', so a decrease in X is welfare enhancing. The expression for X

is

$$X = \begin{cases} (\gamma - \alpha)(1 - G(R3)) & \text{in Equilibrium 1} \\ p\gamma(G(R1) - G(R2)) + (\gamma - \alpha)(1 - G(R1)) & \text{in Equilibrium 2} \end{cases} \tag{29}$$

Taking derivatives with respect to α yields

$$\frac{\partial X}{\partial \alpha} = \begin{cases} -(1 - G(R3)) - (\gamma - \alpha)g(R3)\frac{\partial R3}{\partial \alpha} & \text{in Equilibrium 1} \\ -g(R1)\frac{\partial R1}{\partial \alpha}(\gamma(1-p) - \alpha) - (1 - G(R1)) & \text{in Equilibrium 2} \end{cases} \tag{30}$$

In Equilibrium one, an increase in α reduces the number of projects, so if $\alpha < \gamma$ and each project creates a net (negative) externality, increasing α will induce both marginal and inframarginal improvements (reductions) in the level of the public good X.

In Equilibrium two, there are two effects. First, there is an inframarginal effect of a higher α on all the remaining plan 1 entrepreneurs, which reduces X. Second, for the marginal entrepreneurs who switched to plan 2 (there are $g(R1)\frac{\partial R1}{\partial \alpha}$ of them), they do not contribute α to abate the externality anymore, but only a fraction p of them will create new externalities by producing. The net addition to the public good for each one of these marginal projects is $(\alpha - \gamma(1-p))$. If this expression is negative, the overall sign is also negative.

Note that in both cases, if regulations are low with respect to the externality, so that $\alpha \leq \gamma(1-p)$, an increase in the strength of the regulations will improve (reduce) unambiguously the level of the public good.

3.3 Equilibrium under High red tape

Before examining the comparative static results, it will be useful to state here the main characteristics of the equilibrium under high red tape. In the economy with High red tape, entrepreneurs are required to obtain two certifications from public officials, and do so sequentially, as only one official can be drawn per period. In appendix D we derive explicitly the expressions characterizing this equilibrium. The first result we obtain is that, as in the previous economy, at most two plans are used in equilibrium.

Lemma 3 *In an economy with High Red Tape,*

1. *There are two non dominated strategies:*

$$\{\Lambda, s_h, s_c\} \in \{\{1, accept, accept\}, \{0, search, accept\}\} \tag{31}$$

2. *There are three levels of* R, $\{R4, R5, R6\}$, *with* $R4 = z_1(\delta, p, \theta) \times \alpha + z_2(\delta, p, \theta) \times i$, $R5 = z_3(\delta, p, \theta) \times i + z_4(\delta, p, \theta)$, *and* $R6 = z_5(\delta, p, \theta) \times (\alpha + i) + z_6(\delta, p, \theta)$, *such that:*

   (a) *Plan 1 is preferred to plan 2 for all* $R > R4$.

   (b) *Plan 2 is preferred to working for all* $R > R5$.

   (c) *Plan 1 is preferred to working for all* $R > R6$.

Proof: See appendix D.

We are interested in comparing the cutoff points $R4$ to $R6$ with the respective cutoff points for the Low red tape economy. Note that these cutoff points have the same structure as $R1$ to $R3$: linear in α, R, and i, and nonlinear in the parameters $\{\delta, p, \theta\}$, but they are cumbersome and hard to compare analytically with the equivalent expressions for the equilibrium under Low red tape. We resort to simulations in order to compare the coefficients in the equilibrium expressions. Note that these coefficients are functions of $\{\delta, p, \theta\}$ and therefore map the bounded set $(0, 1)^3$ into $\mathbb{R}$. We use a fine grid for the domain in obtaining the numerical results that follow, so they must be understood to hold for all parameter values.

Numerical Result 1 *In the economy with High red tape we have* $R4 > R1$, $R5 > R2$, *and* $R6 > R3$.

Appendix D documents the derivation of this result. The structure of optimal plans is the same as in the economy with Low red tape, because the draws of officials are independent. It is natural then that the equilibria are similar.

Corollary 2 *Equilibria with High red tape*

In an economy with High red tape there are two types of equilibria, and the condition separating them is

$$\begin{aligned} \alpha \;>\; & \left(\frac{\delta(1-p\theta)^2}{(1-p\theta\delta)^2}\frac{(1-\delta)+2\delta p(1-\theta)}{\delta p^2(1-\theta)^2} - \frac{(1-p\theta\delta)^2-\delta^2(1-p\theta)^2}{(1-\delta)(1-p\theta\delta)^2}\right) \\ & +i\left(\frac{\delta(1-p\theta)^2}{(1-p\theta\delta)^2}\frac{(1-\delta)^2+2\delta p(1-\delta)(1-\theta)}{\delta p^2(1-\theta)^2} - \frac{(1-p\theta\delta)^2-\delta^2(1-p\theta)^2}{(1-p\theta\delta)^2}\right). \end{aligned} \tag{32}$$

This condition separates the equilibria as follows:

Equilibrium 1 *If 32 does not hold, agents with* $R \in (0, R6)$ *will choose to work. Agents with* $R \in [R6, \infty)$ *will become entrepreneurs, abide by the regulations, and choose to pay bribes if they draw a corrupt official.*

Equilibrium 2 *If 32 holds, agents in $R \in (0, R5)$ will choose to work, agents with $R \in [R5, R4)$ will invest, not abide by the regulations, and search for a corrupt official. Finally, agents with $R \in [R4, \infty)$ will follow the regulations, and pay the bribe if they draw a corrupt official.*

Note that the condition on the parameters that separates the two equilibria has the same structure as condition 26 for the Low red tape economy. The main effect of red tape in this model is to create a time delay between investment and production. The tradeoffs between the costs of waiting and those of complying that drove choice of optimal plan in the Low red tape economy are the same that drive such choice in this economy.

3.4 Comparative statics: Red tape

We now examine the effects of red tape on output and the level of the public good. We have in mind a policy change from a Low to a High red tape environment. Because searching takes time, an entrepreneur will be able to produce at most at a frequency of one half periods (or every two periods). Hence, to obtain a stationary level of output and the public good, we assume that the policy transition occurs as follows: At the time of the policy change from a Low to a High red tape environment, the government awards half of the agents with one of the two certifications. In appendix C we show that this is sufficient to guarantee a stationary level of aggregate outcomes, as well as convergence to this level after a transition. In what follows we disregard the transition period and focus on stationary states.

Because the condition that separates the two equilibria is different in both economies, it is important for the comparative static analysis to determine whether the type of equilibrium will switch as a result of the policy change. The next result states the type of equilibrium switching that may occur.

Numerical Result 2 *After a policy change from a Low red tape to a High red tape environment,*

1. *If the economy is in equilibrium 1, it will stay in equilibrium 1 in the new environment.*
2. *If the economy is in equilibrium 2, it may be in either type of equilibrium in the new environment.*

Result 2 simplifies the comparative static analysis by dividing the parameter space into three, as figure 3 shows. If conditions 26 and 32 hold (A_3), the economy is in Equilibrium 2 in both red tape regimes; If 26 holds but not 32 (A_2), the economy switches from Equilibrium 2 in the Low red tape regime to Equilibrium 1 in the High red tape regime; If neither condition holds (A_1), the economy stays in Equilibrium 1 in both regimes.

We begin by examining the effects of red tape on output:

$$\frac{\triangle Y}{\triangle RT} = \begin{cases} \frac{1}{2}\int_{R6}^{\infty}(R-i-\alpha)dG(R) + (2G(R6)-1) \\ -\int_{R3}^{\infty}(R-i-\alpha)dG(R) - (2G(R3)-1) & \text{if } \{i,\alpha,\delta,p,\theta\} \in A_1 \\ \\ \frac{1}{2}\int_{R6}^{\infty}(R-i-\alpha)dG(R) + (2G(R6)-1) \\ -\frac{1}{2}p\int_{R2}^{R1}(R-i)dG(R) - \frac{1}{2}\int_{R1}^{\infty}(R-i-\alpha)dG(R) \\ -(2G(R2)-1) & \text{if } \{i,\alpha,\delta,p,\theta\} \in A_2 \\ \\ \frac{1}{2}p\int_{R5}^{R4}(R-i)dG(R) + \frac{1}{2}\int_{R4}^{\infty}(R-i-\alpha)dG(R) \\ +(2G(R5)-1) - p\int_{R2}^{R1}(R-i)dG(R) \\ -\int_{R1}^{\infty}(R-i-\alpha)dG(R) - (2G(R2)-1) & \text{if } \{i,\alpha,\delta,p,\theta\} \in A_3 \end{cases} \tag{33}$$

In general, these expressions cannot be signed given the equilibrium effect of a reduction in investment projects on the size of the public sector bureaucracy. We consider in detail the case of $\{\delta,p,\theta\} \in A_1$. There are three effects: First, there are fewer profitable projects, as $R6 > R3$, and therefore output is reduced. The expression for this effect is

$$\int_{R6}^{\infty}(R-i-\alpha)dG(R) - \int_{R3}^{\infty}(R-i-\alpha)dG(R) + (G(R6)-1) - (G(R3)-1),$$

and is smaller than zero. Second, the projects that remain profitable are operational with a lower frequency, and the expression for this effect is $-\frac{1}{2}\int_{R6}^{\infty}(R-i-\alpha)dG(R)$, which is negative. Finally, because of the first effect the externality that operates on the size of the public sector tends to increase output by a margin equal to $G(R6)-G(R3)$, as government workers are put to productive use. The sum of the three effects gives the expression for $\frac{\triangle Y}{\triangle RT}$ above. For the case $\{\delta,p,\theta\} \in A_2$, it can be shown that $R3 < R5$, so in this case as well as in $\{\delta,p,\theta\} \in A_3$ a similar picture emerges. For the effects of red tape on the public good, the expressions are

$$\frac{\triangle X}{\triangle RT} = \begin{cases} \frac{1}{2}(\gamma-\alpha)(1-G(R6)) - (\gamma-\alpha)(1-G(R3)) & \text{if } \{i,\alpha,\delta,p,\theta\} \in A_1 \\ \\ \frac{1}{2}(\gamma-\alpha)(1-G(R6)) & \\ -p\gamma(G(R1)-G(R2)) - (\gamma-\alpha)(1-G(R1)) & \text{if } \{i,\alpha,\delta,p,\theta\} \in A_2 \\ \\ \frac{1}{2}p\gamma(G(R4)-G(R5)) + \frac{1}{2}(\gamma-\alpha)(1-G(R4)) & \\ -p\gamma(G(R1)-G(R2)) - (\gamma-\alpha)(1-G(R1)) & \text{if } \{i,alpha,\delta,p,\theta\} \in A_3 \end{cases} \tag{34}$$

Under $\{\delta, p, \theta\} \in A_1$, because there are fewer projects, if projects create a net externality ($\gamma > \alpha$ so $X > 0$), the level of the public good will improve ($\frac{\triangle X}{\triangle RT} < 0$). In the remaining two cases, the existence of plan 2 entrepreneurs who create high levels of net externalities makes it difficult to sign the expressions. We expect however that the reduction in the overall quantity of operational projects under High red tape would empirically dominate compositional effects, so that X would be decreased in absolute value in a High red tape environment. These results leave open the possibility that an increase in red tape may bring a welfare improvement with it, a point that we explore in the next section.

4 Optimal government policies

We are interested in characterizing the socially optimal levels of regulations and red tape in economies with corruption, and comparing them with the optimal policies in a no corruption economy. In particular, we are interested in whether the level of regulations can be used effectively to reduce the deadweight loss caused by corruption, and whether -and in which conditions- a higher level of red tape can be used as a second best policy.

The social welfare function used here gives all agents, including corrupt officials, the same weight. It can be represented by

$$W = Y - X \tag{35}$$

We begin by studying the optimal level of regulations in an economy with low red tape. In an economy with no corruption, the planner solves

$$\max_{\alpha} \int_{R^\star}^{\infty} (R-i)dG(R) + (2G(R^\star)-1) - \gamma(1-G(R^\star)) \tag{36}$$

With $R^\star = \alpha + i + 1$. In this case, the optimal level of regulations is

$$\alpha_0 = \gamma + 1 \tag{37}$$

At this level of α entrepreneurs internalize the marginal social costs of both the public good (γ), and the government bureaucracy ($w = 1$). With no corruption, everyone complies with the regulations, so there is no scope for more red tape to improve on the allocation: A Low level of red tape is optimal in this case.

In an economy with corruption, we need to distinguish optimal regulations under the two types of equilibrium. The optimal level of regulations, at the interior of the parameter space for each Equilibrium, takes the following form:

$$\alpha_p = \begin{cases} \gamma\frac{1-p\theta}{1-p\theta\delta} + i\frac{-p\theta(1-\delta)}{1-p\theta\delta} + \frac{1-p\theta}{1-p\theta\delta}(2 - \frac{1}{1-p\theta}) & \text{in Eq. 1} \\ \gamma\frac{1-p}{1-p\theta\delta} + i\frac{(1-\delta)(1-p)}{1-p\theta\delta} & \text{in Eq. 2} \end{cases} \tag{38}$$

The role of α_p in Equilibrium 1 is to align private costs of investment with social costs by setting $R3 = R^\star$. For Equilibrium 2, α does not affect the choices of plan 2 entrepreneurs, who do not follow the regulations. The planner sets α so that $R1 = \gamma + i$, which makes plan 1 entrepreneurs internalize the full marginal social cost of their decision. Since their alternative at the margin is to follow plan 2, the wages of government bureaucrats are not in this case part of their social marginal costs. Note that $R1 < R^\star$, so all plan 2 entrepreneurs, as well as some plan 1 entrepreneurs, are socially inefficient, but α cannot be used as a policy tool to drive marginal entrepreneurs out of the market.

Compared to an economy with no corruption, the socially optimal level of regulations α_p is lower in Equilibrium 1, and may be higher or lower in Equilibrium 2. In Equilibrium 1, the coefficient of $\alpha_p$multiplying γ is positive and smaller than one; the coefficient multiplying i is negative, and we have $(2 - \frac{1}{1-p\theta} < 1)$. In Equilibrium 2, the coefficient on i is positive, and that on γ is smaller than one.

Figure 4 depicts α_p for given parameter values in the $\{\gamma, p\}$ space. For a small interval of γ neither solution given by 38 falls on the interior of the parameter space for the respective equilibrium. In this case the solution is at a corner, and given by $h(i, p, \theta, \delta)$ in expression 26. Optimal regulations are decreasing in corruption incidence, except for a jump where the economy switches from equilibrium 1 to 2. As discussed above, optimal regulations solve qualitatively different problems in both equilibria.

An important question is to what extent this policy tool allows the planner to correct the distortions caused by corruption. The following proposition states that under certain conditions setting the level of regulations optimally may restore the first best.

Proposition 2 *Correcting the distortions caused by corruption using the level of regulations:*

1. *In Equilibrium 1, the optimal level of regulations achieves the first best allocation*

2. *In Equilibrium 2, the optimal level of regulations achieves a second best allocation*

***Proof**: In Equilibrium 1, the objective function is*

$$W = \int_{R3}^{\infty} (R - i) dG(R) + (2G(R3) - 1) - \gamma(1 - G(R3)) \tag{39}$$

And substitution of the optimal level of regulations in $R3$ *gives* $R3 = i + \gamma + 1$, *which is the socially optimal cutoff point in the economy without corruption. The social welfare function in 39 is therefore the same as that with no corruption, in 36. In Equilibrium 2, this policy tool cannot align the incentives for plan 2 entrepreneurs, as they do not internalize the cost of the public good.*

Clearly, the result for Equilibrium 1 is not without distributional implications. In setting the level of α lower than in the first best, the planner corrects for the underinvestment caused by the costs of bribes, and aligns the prices faced by entrepreneurs with the socially optimal prices. The consequence is that the level of the public good worsens, as X is higher, and therefore workers are worse off.

We now consider the joint choice of α and Red Tape by the planner. From the discussion in the previous section, it should be clear that, if no structure is placed on the level of regulations, there is scope for more Red Tape to improve welfare. We are interested rather on the conditions, if any, under which more Red Tape can improve on the allocation in an economy with an optimal level of regulations. From the previous proposition we know that this will not happen if the economy is in Equilibrium 1. If the economy starts in Equilibrium 2 however, high levels of externalities (γ), which in turn imply high optimal levels of regulations, will turn red tape into a Pareto improving policy. These results are formalized below

Proposition 3 *Red Tape and welfare under optimal regulations:*

1. *If the economy is in Equilibrium 1 ($\{i, \alpha, \delta, p, \theta\} \in A_1$) Red Tape will always decrease welfare.*

2. *If $\{i, \alpha, \delta, p, \theta\} \in A_3$, as $\gamma \to \infty$ more red tape increases welfare.*

Proof: *Point 1 follows from the fact that in Equilibrium 1 optimal regulations can achieve the first best. For point 2, note that the derivative of $\frac{\triangle W}{\triangle RT}$ with respect to γ is*

$$\frac{\partial \frac{\triangle W}{\triangle RT}}{\partial \gamma} = -\frac{1}{2}(G(R4)-G(R5))-\frac{1}{2}(1-G(R4))+p(G(R1)-G(R2))+(1-G(R1)) \tag{40}$$

The limit of this expression as $\gamma \to \infty$ is $p(1-G(R2)) - \frac{1}{2}p(1-G(R5)) > 0$, so increasing the level of red tape improves welfare for γ above a threshold.

In the intermediate case where $\{i, \alpha, \delta, p, \theta\} \in A_2$ whether Red tape improves welfare or not depends on the form of the distribution $G(R)$, as well as the parameters. When $\{i, \alpha, \delta, p, \theta\} \in A_3$, the level of regulations is a poor policy tool to restrict the number of inefficient firms from operating, as it only affects the margin of the optimal plan for entrepreneurs. If the negative externality is large enough, there will be a large number of inefficient firms operating. In this case it may be efficient to drive some firms out of the market by increasing the costs associated with red tape, even if this creates large intframarginal losses to the remaining firms. It is worth recalling that this case will occur under high levels of corruption for a given γ.

To complete the analysis in this section we turn to the effects of corruption in an economy with optimal regulations. An important question in the literature is whether corruption may have positive effects on output and welfare (see, for instance, Huntington [1968]). In particular, it has been suggested that corruption has a "speed money" effect, which may "grease the wheels of commerce" by allowing investors to circumvent costly regulations. The following result summarizes the effects of corruption on output and welfare when regulations are set optimally. We assume that a Low level of red tape is optimal

Proposition 4 *Effects of corruption on output and welfare under optimal regulations:*

1. *In Equilibrium 1, corruption increases output but leaves welfare unchanged.*

2. *In Equilibrium 2, corruption increases output , up to the effect on the size of the public bureaucracy, and decreases welfare.*

Proof: *For point 1, note that the effects of corruption on output in Equilibrium 1 are*

$$\frac{\partial Y}{\partial p} = \frac{\partial \alpha}{\partial p}(1 - G(R3)) \tag{41}$$

Where the derivative is taken with respect to the optimal level of α, and is negative. As for welfare, the effects are zero by the envelope theorem.

For point 2, the effects of corruption on output in Equilibrium 2 are given by

$$\frac{\partial Y}{\partial p} = \int_{R2}^{R1} (R - i)dG(R) + g(R2)\frac{\partial R2}{\partial p}(2 - p(R2 - i - \gamma)) \tag{42}$$

The first effect is the speed money effect: as corruption increases, entrepreneurs who follow plan 2 have a higher probability of obtaining a certification. The second effect is the effect of increasing the measure of entrepreneurs who follow plan 2, and should be positive (as $\frac{\partial R2}{\partial p} < 0$) save for the effect that increasing entrepreneurship has on the demand for public officials.

The effect of corruption on welfare is

$$\frac{\partial W}{\partial p} = \int_{R2}^{R1} (R-i)dG(R)+g(R2)\frac{\partial R2}{\partial p}(2-p(R2-i-\gamma))-\gamma(G(R1)-G(R2)) \tag{43}$$

So a third negative effect enters into play, as plan 2 entrepreneurs will create more externalities. Since the marginal plan 2 entrepreneurs are socially inefficient, their marginal contribution to social welfare is negative, so the sign of $\frac{\partial W}{\partial p}$ is negative.

Note that these results hold when the level of regulations is set optimally. In Equilibrium 1 in particular, if the level of regulations is lower than the optimum, more corruption increases welfare, by closing the gap between social and private costs. If α is higher than the optimum, the effect is reversed and welfare decreases.

5 Conclusion

We present an economy where the government sets up regulations to correct a production externality. Red tape is imposed as a mechanism to test regulation compliance, and is administered by government officials. In an environment where some officials are corrupt, we derive positive and normative results regarding the two policy tools the government has access to.

For a given level of externalities, we find that high and low corruption create distortions that are qualitatively different, and call for government policies that are also different in nature and reach. In our model, the equilibrium is characterized by a convex threshold in the externalities and corruption space, below which the government can mandate levels of regulations and (minimal) levels of red tape such that the economy is first best efficient. Above this threshold, optimal policies cannot achieve the first best. Moreover, we obtain the somewhat surprising result that , with the levels of externalities above a second threshold, more red tape is Pareto improving. In this case, a large class of entrepreneurs choose to operate without abiding by the regulations, so the level of these is ineffective to increase the cost and drive out of the market socially inefficient producers.

The normative results derived in this paper are necessary to make sense of the efficiency effects of the two policy tools under study. As discussed in Joel S. Hellman and Kaufmann [2000] and Djankov et al. [2002] however, in highly corrupt economies the correlations between corruption, regulations, and red tape need to be understood as a political economy equilibrium where corrupt bureaucrats seek to manipulate institutional rules to their advantage. Because corruption itself is slow to get rid of, the analysis in this paper provides a normative benchmark to the studies just cited.

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A There are two policies that are not dominated

The list of possible plans $\{\Lambda, s_h, s_c\}$ is

1. $\{1, accept, accept\}$
2. $\{0, search, accept\}$
3. $\{1, search, accept\}$
4. $\{1, accept, search\}$
5. $\{1, search, search\}$
6. $\{0, search, search\}$

Plans 5 and 6 can be eliminated, since they lead to negative profits of $-i-\alpha$ and $-i$ respectively, which are dominated by working.

We first derive the payoffs for plans 1 to 4.

- Plan 1: $\{1, accept, accept\}$

  The value functions take the form

$$\begin{aligned} v_c(1) &= R - \beta + \delta v_e && (44) \\ v_h(1) &= R + \delta v_e && (45) \\ v_s(1) &= p v_c + (1-p) v_h && (46) \\ v_e &= -i - \alpha + v_s(1) && (47) \end{aligned}$$

  Substitution of v_c and v_h in v_s, and v_s in v yields

$$v_e(R) = \frac{1}{1-\delta}(R - i - \alpha - p\beta) \tag{48}$$

  For the bribe, the problem is

$$\max_{\beta} \beta^{\theta}(R - \beta + \delta v_e - \delta v_s)^{1-\theta} \tag{49}$$

  Which yields

$$\beta = \theta(R + \delta(v_e - v_s)) \tag{50}$$

Since $v_e - v_s = -i - \alpha$, we have

$$\beta = \theta(R - \delta(i + \alpha)) \tag{51}$$

and

$$v_e(R) = R\frac{1 - p\theta}{1 - \delta} - (i + \alpha)\frac{1 - p\theta\delta}{1 - \delta} \tag{52}$$

- Plan 2: $\{0, search, accept\}$

  The value functions take the form

$$\begin{aligned} v_c(0) &= R_i - \beta + \delta v_e & (53)\\ v_h(0) &= \delta v_e & (54)\\ v_s(0) &= p v_c + (1 - p) v_h & (55)\\ v_e &= -i + v_s(0) & (56) \end{aligned}$$

  The bribe is

$$\beta = \theta(R - \delta i) \tag{57}$$

  Substitution of v_c and v_h in v_s yields

$$v_s = \frac{p}{1 - \delta(1 - p)}(R - \beta + \delta v_e) \tag{58}$$

  Substitution of β in v_s and v_s in v_e yields

$$v_e(R) = R\frac{p(1 - \theta)}{1 - \delta} - i(1 + \frac{\delta p(1 - \theta)}{1 - \delta}) \tag{59}$$

- Plan 3: $\{1, search, accept\}$

  The value functions take the form

$$\begin{aligned} v_c(1) &= R_i - \beta + \delta v & (60)\\ v_h(1) &= \delta v_e & (61)\\ v_s(1) &= p v_c + (1 - p) v_h & (62)\\ v_e &= -i - \delta + v_s(1) & (63) \end{aligned}$$

  The bribe is

$$\beta = \theta(R + \delta(i + \delta)) \tag{64}$$

  which implies

$$v_e(R) = R\frac{p(1 - \theta)}{1 - \delta} - (i + \alpha)(1 + \frac{\delta p(1 - \theta)}{1 - \delta}) \tag{65}$$

- Plan 4: $\{1, accept, search\}$

  The value functions take the form

$$\begin{aligned} v_c(1) &= \delta v_s & (66) \\ v_h(1) &= R + \delta v_e & (67) \\ v_s(1) &= p v_c + (1-p) v_h & (68) \\ v_e &= -i - \delta + v_s(1) & (69) \end{aligned}$$

  The bribe offered is

$$\beta = \theta(R + \delta(i + \delta)) \tag{70}$$

  and we have

$$v_s(1) = v_h \frac{1-p}{1-\delta p} \tag{71}$$

  which implies

$$v_e(R) = R\frac{1-p}{1-\delta} - (i+\alpha)\frac{1-\delta p}{1-\delta} \tag{72}$$

Note that plan 3 is dominated by plan 2:

$$v_e(plan\ 2) - v_e(plan\ 3) = \alpha(1 + \frac{\delta p(1-\theta)}{1-\delta})$$

Plan 4 is dominated by plan 1 for all R such that work is not the dominant choice. Plan 1 dominates plan 4 for all $R > \delta(i + \alpha)$. In turn, under the following condition plan 4 dominates work

$$\begin{aligned} R(1-p) - (i+\alpha)(1-p\delta) &> 1 & (73) \\ R &> (i+\alpha)\frac{1-p\delta}{1-p} + \frac{1}{1-p} & (74) \\ &> i + \alpha & (75) \\ &> \delta(i+\alpha) & (76) \end{aligned}$$

So plan 4 dominates plan 1 only for R such that work is the dominant plan.

B Plan 2 is observed if and only if $R1 > R2$

The proof:
$\Rightarrow$ If plan 2 is observed, then $R1 > R2$. Let R_0 be such that plan 2 dominates

both working and plan 1. Since plan 2 dominates working, we must have $R_0 > R2$. Since plan 2 dominates plan 1, we must have $R_0 < R1$. This implies $R1 > R2$.

$\Leftarrow$ If $R1 > R2$ there is an R such that plan 2 dominates both plan 1 and work. Take $R_0 \in (R2, R1)$. Since $R_0 > R2$, plan 2 dominates work. Since $R_0 < R1$, plan 2 dominates plan 1.

C Stationary distribution in the model with high Red Tape

There is a unique stationary equilibrium with one half of the entrepreneurs holding zero certifications.

We need to look separately at both types of equilibria in the environment with high red tape.

1. In Equilibrium 1, all entrepreneurs obtain one certification each period, and those with $v_s(., 1)$ at the beginning of the period produce, so the only stationary equilibrium is to have 1/2 of the entrepreneurs in $v_s(., 0)$, and 1/2 in $v_s(., 1)$.

2. In equilibrium 2, the above argument holds for entrepreneurs who choose plan 1. For entrepreneurs who follow plan 2, only a fraction p of them will obtain a new certification each period. The Markov process for the proportion of plan 2 entrepreneurs in states $v_s(., 0)$ and $v_s(., 1)$ is

$$\begin{matrix} 1-p & p \\ p & 1-p \end{matrix}$$

which has a stationary distribution $\{1/2, 1/2\}$.

D Equilibrium in the model with high Red Tape

We begin by stating the problem. We let the arguments in $v_{c,h,s}(.,.)$ be the number of certifications held (0 or 1) and the indicator function for compliance with the regulations (1 if complied, 0 otherwise).

The Bellman equations are, for entrepreneurs with zero certifications,

$$\begin{aligned} v_c(0,0) &= \max\{\delta v_s(1,0) - \beta_1, \delta v_s(0,0)\} && (77)\\ v_c(0,1) &= \max\{\delta v_s(1,1) - \beta_1, \delta v_s(0,1)\} && (78)\\ v_h(0,0) &= \delta v_s(0,0) && (79)\\ v_h(0,1) &= \max\{\delta v_s(0,1), \delta v_s(1,1)\} && (80) \end{aligned}$$

For entrepreneurs with one certification,

$$\begin{aligned} v_c(1,0) &= \max\{R_i - \beta_2 + \delta v_e, \delta v_s(1,0)\} && (81)\\ v_c(1,1) &= \max\{R_i - \beta_2 + \delta v_e, \delta v_s(1,1)\} && (82)\\ v_h(1,0) &= \delta v_s(1,0) && (83)\\ v_h(1,1) &= \max\{R_i + \delta v_e, \delta v_s(1,1)\} && (84) \end{aligned}$$

For v_s

$$v_s(.,.) = pv_c(.,.) + (1-p)v_h(.,.) \quad (85)$$

For v_e

$$v_e(R) = \max\{-i + v_s(0,0), -i - \alpha + v_s(0,1), \frac{w}{1-\delta}\} \quad (86)$$

Note that there will be a different bribe for entrepreneurs who have not obtained a certification yet (β_1), and one for entrepreneurs with one certification (β_2). These bribes take the following general form

$$\begin{aligned} \beta_1 &= \theta\delta(v_e - v_s(1,.)) && (87)\\ \beta_2 &= \theta(R + \delta v_e - \delta v_s(1,.)) && (88) \end{aligned}$$

In what follows we characterize the equilibrium.

1. Two plans are not dominated.

   Note that, because draws of government officials are independent for the first and second certification, optimal plans will not be made contingent on the history of draws. This implies that we have to look at the same four plans as in the model with low red tape. These plans are:

   (a) $\{1, accept, accept\}$

   (b) $\{0, search, accept\}$

(c) $\{1, search, accept\}$

(d) $\{1, accept, search\}$

We compute the payoffs of these plans for completeness. Then we show that plans 3 and 4 are dominated.

(a) Plan 1: $\{1, accept, accept\}$

$$v_s(1,1) = (R - \delta(i+\alpha))\frac{(1-p\theta\delta)(1-p\theta)}{(1-p\theta\delta)^2 - \delta^2(1-p\theta)^2} \tag{89}$$

$$v_s(0,1) = (R - \delta(i+\alpha))\frac{\delta(1-p\theta)^2}{(1-p\theta\delta)^2 - \delta^2(1-p\theta)^2} \tag{90}$$

$$\begin{aligned} v_e &= R\frac{\delta(1-p\theta)^2}{(1-p\theta\delta)^2 - \delta^2(1-p\theta)^2} \\ &\quad -(i+\alpha)(1 + \frac{\delta^2(1-p\theta)^2}{(1-p\theta\delta)^2 - \delta^2(1-p\theta)^2}) \end{aligned} \tag{91}$$

(b) Plan 2: $\{0, search, accept\}$

$$v_s(1,0) = (R - \delta i)\frac{p(1-\theta)(1-\delta p\theta - (\delta(1-p)}{(1-\delta)^2 + 2p\delta(1-\delta)(1-\theta)} \tag{92}$$

$$v_s(0,0) = (R - \delta i)\frac{\delta p^2(1-\theta)^2}{(1-\delta)^2 + 2p\delta(1-\delta)(1-\theta)} \tag{93}$$

$$\begin{aligned} v_e &= R\frac{\delta p^2(1-\theta)^2}{(1-\delta)^2 + 2p\delta(1-\delta)(1-\theta)} \\ &\quad -i(1 + \frac{\delta^2 p^2(1-\theta)^2}{(1-\delta)^2 + 2p\delta(1-\delta)(1-\theta)}) \end{aligned} \tag{94}$$

(c) Plan 3: $\{1, search, accept\}$

$$v_s(1,1) = (R - \delta(i+\delta)\frac{p(1-\theta)}{1-\delta(1-p+p\theta)} + v_s(0,1)\frac{\delta p(1-\theta)}{1-\delta(1-p+p\theta)} \tag{95}$$

$$v_s(0,1) = (R - \delta(i+\delta))\frac{\delta p^2(1-\theta)^2}{(1-\delta(1-p+p\theta))^2 - \delta^2(1-\theta)^2} \tag{96}$$

$$\begin{aligned} v_e &= R\frac{\delta p^2(1-\theta)^2}{(1-\delta(1-p+p\theta))^2 - \delta^2(1-\theta)^2} \\ &\quad -(i+\delta)\frac{(1-\delta(1-p+p\theta))^2}{(1-\delta(1-p+p\theta))^2 - \delta^2(1-\theta)^2} \end{aligned} \tag{97}$$

(d) Plan 4: $\{1, accept, search\}$

$$\begin{aligned} v_s(1,1) &= (R-\delta(i+\alpha))\frac{(1-p)(1-p\delta)}{(1-p\delta)^2-\delta^2(1-p)^2} && (98)\\ v_s(0,1) &= (R-\delta(i+\alpha))\frac{(1-p)^2\delta(1-p\delta)}{(1-p\delta)^2-\delta^2(1-p)^2} && (99)\\ v_e &= R\frac{(1-p)^2\delta(1-p\delta)}{(1-p\delta)^2-\delta^2(1-p)^2} \\ &\quad -(i+\alpha)(1+\frac{(1-p)^2\delta^2(1-p\delta)}{(1-p\delta)^2-\delta^2(1-p)^2} && (100) \end{aligned}$$

2. Plans 3 and 4 are dominated
For plan 3 $\{1, search, accept\}$, we show that it cannot be optimal. Note that in this case

$$v_h(0,1) = \max\{\delta v_s(0,1), \delta v_s(1,1)\}.$$

For this plan to be optimal it is necessary that $v_s(0,1) > v_s(1,1)$, but we know that $v_s(0,1) < v_s(1,1)$, because someone with one certification can always mimic the search behavior of someone with zero certifications, and obtain the payoff $R_i + \delta v$ in a lower expected time.

For plan 4 $\{1, accept, search\}$ to be optimal, it must be that

$$\begin{aligned} v_c(1,1) &= \max\{(1-\theta)(R+\delta v)+\theta\delta v_s(1,1), \delta v_s(1,1)\} && (101)\\ &= \delta v_s(1,1) && (102) \end{aligned}$$

But note that

$$\begin{aligned} v_s(1,1) &= pv_c(1,1)+(1-p)v_h(1,1) && (103)\\ &< v_h(1,1) && (104)\\ &= R+\delta v && (105)\\ & \quad \text{Since } \delta < 1 \text{ we have} && (106)\\ \delta v_s(1,1) &< R+\delta v && (107)\\ \delta v_s(1,1)(1-\theta) &< (1-\theta)(R+\delta v) && (108)\\ (1-\theta)(R+\delta v)+\theta\delta v_s(1,1) &> \delta v_s(1,1) && (109) \end{aligned}$$

Which implies tha $v_c(1,1) = (1-\theta)(R+\delta v)+\theta\delta v_s(1,1)$: Search if facing a corrupt official cannot be optimal.

3. The cutoff points

   (a) Plan 1 is preferred to plan 2

$$R4 = i\delta + \alpha \frac{1+\frac{\delta^2(1-p\theta)^2}{(1-p\delta\theta)^2-\delta^2(1-p\theta)^2}}{\frac{\delta(1-p\theta)^2}{(1-p\delta\theta)^2-\delta^2(1-p\theta)^2}-\frac{\delta p^2(1-\theta)^2}{(1-\delta)^2+(1-\delta)+2p\delta(1-\delta)(1-\theta)}} \tag{110}$$

   (b) Plan 2 is preferred to working

$$R5 = i(\delta + \frac{(1-\delta)^2 + 2p\delta(1-\delta)(1-\theta)}{\delta p^2(1-\theta)^2}) + \frac{(1-\delta) + 2p\delta(1-\theta)}{\delta p^2(1-\theta)^2} \tag{111}$$

   (c) Plan 1 is preferred to working

$$R6 = (i+\alpha)\frac{(1-p\theta\delta)^2}{\delta(1-p\theta)^2} + \frac{(1-p\theta\delta)^2}{\delta(1-\delta)(1-p\theta)^2} - \frac{\delta}{1-\delta} \tag{112}$$

4. Numerical result 1
   We perform pairwise numerical comparisons of the coefficients on R and $(i+\alpha)$, which are functions of $\{p, \alpha, \delta\}$, by using a discrete grid for the parameters, which lie in $(0,1)^3$. We use a 30^3 point grid.

Figure 1: Timing of decisions for entrepreneurs

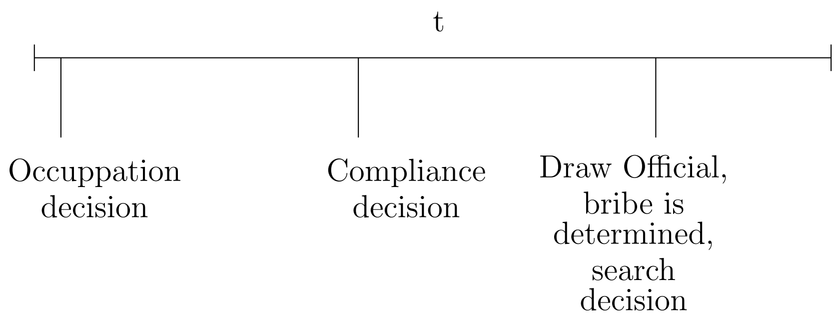


Figure 2: Equilibria in the Low red tape economy ($i = 1$, $\theta = .6$, $\delta = .9$).

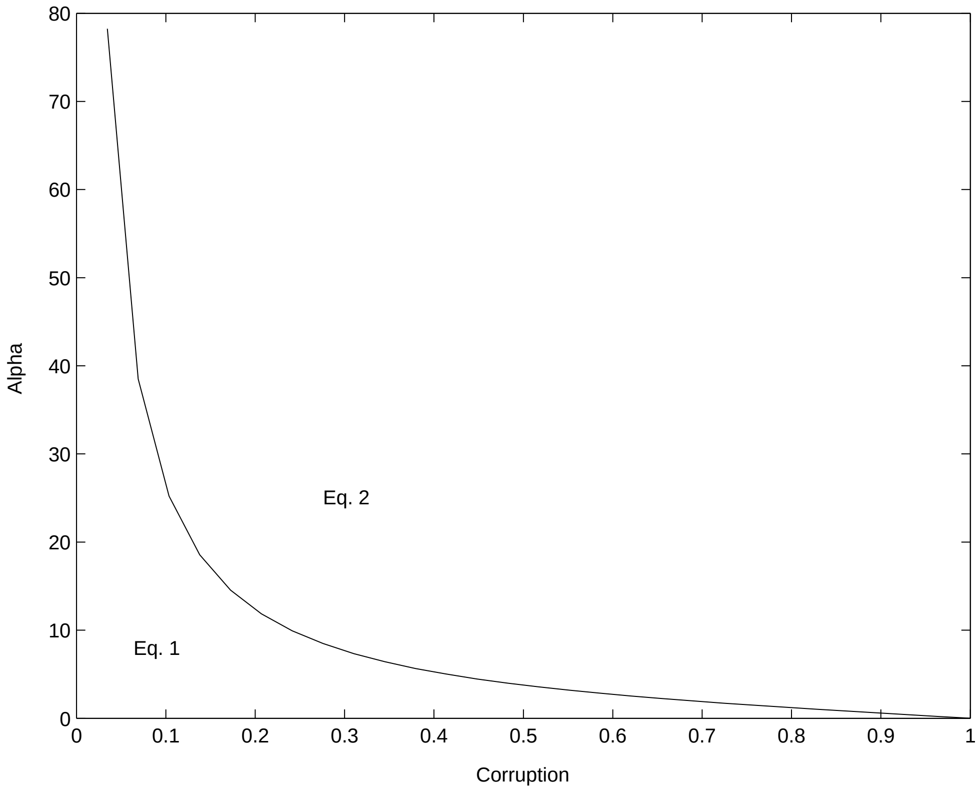
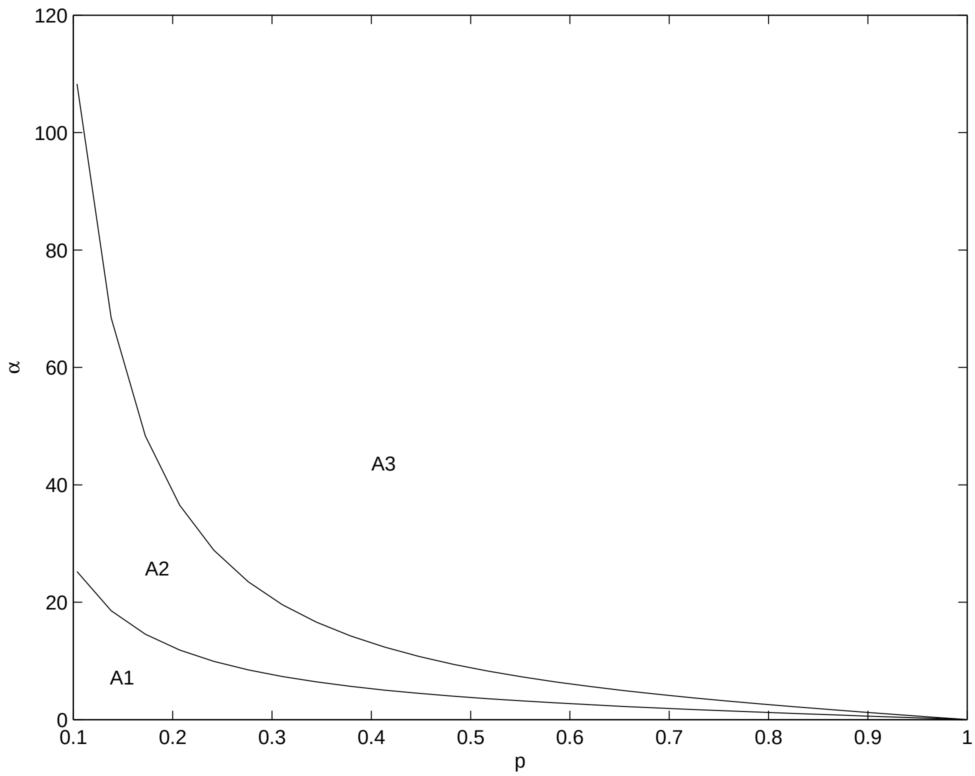


Figure 3: Equilibrium switching in the transition to a High red tape economy ($\theta = .6$,$\delta = .9$, $i = 1$).



$$\begin{array}{ll} Note: & A1 : Eq1 \rightarrow Eq1 \\ & A2 : Eq2 \rightarrow Eq1 \\ & A3 : Eq2 \rightarrow Eq2 \end{array}$$

Figure 4: Optimal level of regulations in the Low red tape economy. ($\theta = .6$,$\delta = .9$, $i = 10$)..