Crime and Uncertain Punishment

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Abstract

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We consider agents in a country in an early stage of transition from a planned to a market economy. As the transition is in progress, the nature of the government's policies are unknown to the agents. Property rights once held by the state have already been transferred to the agents, with each agent owning one firm. However, the agents are uncertain of the level of law enforcement the government will provide. Specifically, they are unsure of the tax and confiscation consequences of both legal and illegal acts. Each agent, having a different cost of stealing, must decide how much of the firm to divert to himself. The agents believe the government may become either a traditional democratic government that supplies law enforcement as well as infrastructure leading to positive firm growth, or a corrupt government that may or may not provide law enforcement, does not provide a climate for firm growth, and may be confiscatory. All agents presume the government will choose its behavior as a function of the tax revenue it will collect under each scenario; however, the tax revenue results from the collective decisions of the agents. This interaction between tax revenue and agents' decisions, together with the uncertainty of law enforcement and tax policy, forms the framework within which the agent chooses his level of honesty. By calculating the percentage of agents who steal some amount from the firm, we investigate the relationship between the level of criminality and the various uncertainties facing the agents. We show how expectations of the agents about the future behavior of their government induce the degree of criminality in society.

JEL Classifications: K42, P14, P26

Key Words: Crime, rule of law, transition, economies in transition, law enforcement, corruption

1. Introduction

Consider an agent in a country in an early stage of transition from a planned to a market economy. Suppose the transfer of property rights, once held by the state, has already occurred. However, the transition is still in progress, and the nature of the government's policies are unknown to the agent. We have in mind that the agent is uncertain as to the level of law enforcement that the government will provide. More precisely, we assume the agent is uncertain as to the tax and confiscation consequences of both legal and illegal actions in which he might partake. For simplicity, we let each agent own one firm, and define an illegal action as the diversion of funds from this firm into the agent's pocket. Each agent must decide how much to steal. In contemplating this decision, we assume that the agent believes that the government can be one of two types: it can be a traditional democratic government that supplies law enforcement as well as infrastructure leading to positive firm growth, or it can be a corrupt government that may or may not provide law enforcement, that does not provide a climate for firm growth, and may be confiscatory in its behavior. Given this uncertainty as to government type, the agent presumes that the government will choose its behavior as a function of the tax revenue it will collect under each scenario. However, the tax revenue is a result of the collective decisions of the agents. This interaction between tax revenue and agents' decisions, together with the uncertainty of law enforcement and tax policy, forms the framework within which the agent chooses his level of honesty. By calculating the percentage of agents who will steal some amount from the firm, we investigate the relationship between the level of criminality and the various uncertainties facing the agents.

In our work, we are able to show how the expectations of the agents about the future behavior of their government induces the degree of criminality in society. This inclusion of the agents' uncertainty regarding the form of government that will evolve is novel. Models of the rule of law in transition economies, for example, Hoff and Stiglitz (2004), Polishchuk and Savvateev (2004) and Sonin (2003), contain agents making their decisions without regard to the form of government that can ensue. In these papers, the governmental form follows passively from the level of crime in the society. A government that interacts with agents who must decide whether or not to steal is studied in Katz and Owen (2005), but the form of government is fixed and known to the agents. Grossman (1995) and Alexeev, Janeba and Osborne (2004) both consider "mafias" that are independent of the government and compete with the state for entrepreneurial rents in a setting where the form of the government is again fixed and known to the agents. The same is true of Dixit (2004), which suggests a principal-agent model to capture the intent of a government to induce efficiency in society. Besides adding to the literature on the evolving rule of law in economies in transition, we also contribute to the literature on the role of institutions in transition (for example, Djankov and Murrell (2002), McMillan (2002) and Bevan and Estrin (2004)), and to that stressing, more generally, that different economic outcomes are to be expected from different institutional arrangements (for example, Shleifer and Vishny (1998) and Acemoglu, Johnson and Robinson (2001, 2002, 2003)). We are able to show that levels of crime increase with the agents' uncertainty as to the form that the government will take, and we do this by endogenizing the decision to commit a crime with the uncertainty of the future form of government.

We present our model in Section 2 and derive its properties. In Section 3, some further implications of the model are investigated through examples. Section 4 contains a discussion of our results and concluding remarks.

2. The Model

We consider a transition economy with a government and a continuum of risk neutral, von Neumann-Morgenstern expected utility maximizing agents. We imagine that the agents must decide the degree to which they wish to be law abiding. The difficulty for the agents in making this decision hinges on the fact that the government has not completely chosen its type. We limit its type to one of two possibilities: a traditional democratic government that supplies law enforcement as well as infrastructure, leading to positive firm growth (G1), or alternatively, a corrupt government about which the agents are uncertain as to the degree of law enforcement, as well as the degree of confiscatory behavior, and in which firms do not grow (G2).

Each agent characterizes G1 as follows. G1 strictly enforces the rule of law and supplies a transparent fiscal policy. In G1, criminals are caught and punished, and the promised tax structure, which differentiates between honestly earned funds and stolen funds, is realized. That is, the tax on honestly earned funds is t, $t \in [0, 1]$. Illicit acts are caught and illicit funds are taxed at the punitive rate $t + \delta$, where $t + \delta \in [0, 1]$. In addition, all agents believe that in G1, firms will grow at the rate r, $r > 0$. Each agent characterizes G2 as follows. G2 does not strictly enforce the rule of law and its fiscal policy is unclear. In G2, criminals may be caught, property may be confiscated and the tax structure may become draconian. An illicit act is detected with probability λ, $\lambda \in [0, 1]$ and, when detected, all of the agent's funds are taxed at the confiscatory rate of b, $b \in [0, 1]$. If illicit acts are not detected, then the illicit funds are kept by the agent, and the honestly earned funds are taxed at a rate t with probability p, $p \in [0, 1]$, or at a rate $t+\Delta$, $t+\Delta \in [0, 1]$, otherwise. All agents believe that in G2, firms will not grow at all.

We assume each agent has already acquired property rights over a firm, whose value at the outset is normalized to one. The agent's problem is to decide whether to steal from his firm, that is, what proportion τ, $\tau \in [0,1]$, of the firm's value to divert to himself. Should the agent elect to steal τ, he incurs expenses $\frac{c\tau^2}{2}$. Agents differ only by the parameter c. We assume that the continuum of agents is characterized by the continuous distribution $H(c)$, where $H(c)$ is strictly increasing on $c \in [0,1]$ with density $h(t)$. The agent's decision about how law abiding to be is made independently by each agent at time 1, with all agents sharing the same information. At time 2, the government makes its choice, and all uncertainty is resolved.

One more bit of information is needed by the agents to enable them to formulate their decisions. This information is the probability with which the government chooses to be either type G1 or G2. We endogenize this probability as follows. Since governments need revenue to function, we assume that the agents believe that the probability that the government will choose a particular type depends on the revenue that that type will produce. Government revenue depends on fiscal policy, and fiscal policy has an impact on each agent's decision. Collectively, the agents' decisions determine the government's tax revenue. Thus, in our model, the probability π, $\pi \in [0,1]$, that the government type will be G1, is determined endogenously as agents equate π to the proportion of revenue generated by G1, this revenue, in turn, being a function of π.

We wish to establish the level of criminality in the society that results from the agents' uncertainty regarding the government's choice of type, together with the uncertainties inherent in G2. We begin by deriving the optimal decision for each agent under the assumption that all of the information described above, including π, is known to each agent. Referring to a particular agent by his cost parameter c, agent c's decision can be summarized by the following decision tree. The end-branch values are given by A $= (1-t)(1+r) - \delta\tau(1+r) - \frac{c\tau^2}{2}$, B $= 1 - b - \frac{c\tau^2}{2}$, C $= \tau + (1-\tau)(1-t) - \frac{c\tau^2}{2}$, D $= \tau + (1-\tau)(1-t-\Delta) - \frac{c\tau^2}{2}$.

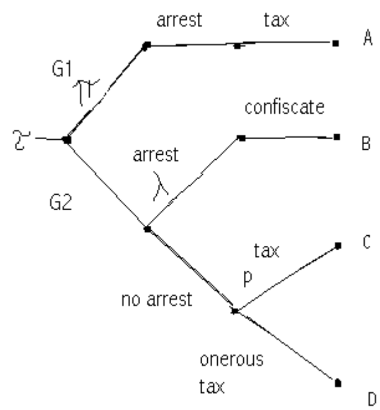

Figure 2.1:

Decision Tree

Our first proposition establishes τ^*, the optimal proportion of the firm that agent c chooses to appropriate. We define $v(\pi) = (1-\lambda)\bar{t} - \pi[(1-\lambda)\bar{t} + \delta(1+r)]$ where $\bar{t} = t + (1-p)\Delta$ is the expected tax rate under G2.

Proposition 1. *Conditional on knowing all the parameters including π, agent c maximizes his expected utility by choosing to appropriate τ^* percent of his firm, where*

$$\tau^* = \begin{cases} 1 & \text{if } v(\pi) \geq c \\ \frac{v(\pi)}{c} & \text{if } 0 < v(\pi) < c \\ 0 & \text{if } v(\pi) \leq 0 \end{cases}.$$

Proof. See Appendix.

From P1, it follows that all agents would choose to be honest if $v(\pi) \leq 0$. Examining $v(\pi)$, we see that this condition would hold if $\pi\delta(1+r)$ were larger than $(1-\pi)(1-\lambda)\bar{t}$. This inequality would occur if π, δ or r were large or if λ were large. Thus, if agents believe the probability of G1 occurring is large, or perceive G1 as guaranteeing a heavy penalty for breaking the law or as producing a good environment, an honest society would follow. It would also follow if, in G2, there were a high probability of catching law-breakers. Conversely, if π were small, some level of crime would result. The condition that $v(\pi) > 0$ would hold if $\pi\delta(1+r)$ were less than $(1-\pi)(1-\lambda)\bar{t}$, that is, if agents expected the economy of G1 to grow moderately, or expected the punitive tax rate to be not too large. Since $(1-\lambda)\bar{t} \leq 1$, it follows that $v(\pi) \leq 1$. So, unless both $\lambda = 0$ and $\bar{t} = 1$, when $v(\pi) > 0$ there will be c values below $v(\pi)$ and the corresponding agents represent the proportion of agents who steal heavily from their firms. Furthermore, there will be c values greater than $v(\pi)$ and the agents corresponding to these c values represent the proportion that steal moderately from their firms. In any event, when $v(\pi) > 0$, crime will persist in the society.

In P1, we assumed π was known to all agents. As described earlier, π has an impact on the level of crime in society, and this level of crime has an impact on the tax revenue collected by the government. Agents believe that the choice of government type depends on the tax revenue that its choice would produce. Using this assumption, we now move to endogenize π.

We define the tax revenue that G1 would receive for an arbitrary value of π and for $c = \bar{c}$, the average value of c, as $R(G1 \mid \pi, \bar{c})$. Similarly, we define the tax revenue to G2 as $R(G2 \mid \pi, \bar{c})$. We let $f(\pi) = \frac{R(G1|\pi,\bar{c})}{R(G1|\pi,\bar{c})+R(G2|\pi,\bar{c})}$ represent the proportion of revenue to G1 corresponding to the average agent $\bar{c}$.

We assume that agents believe that the government will take tax revenue as the basis of its choice of type, and that this tax revenue will be based on the government's perception of the average agent, $\bar{c}$. In sum, we assume that agents will choose π to satisfy $\pi = f(\pi)$ corresponding to $c = \bar{c}$. In the next proposition, we rewrite the result of P1 corresponding to $c = \bar{c}$ and exhibit its dependency on π.

Proposition 2. *If* $c = \overline{c}$*, then* $\tau^*_{\overline{c}} = \begin{cases} 1 & \text{if } 0 \leq \pi \leq \pi_0 \\ \frac{v(\pi)}{\overline{c}} & \text{if } \pi_0 < \pi < \pi_1 \\ 0 & \text{if } \pi_1 \leq \pi \leq 1 \end{cases}$
where $\pi_0 = \max[0, \frac{(1-\lambda)\overline{t}-\overline{c}}{(1-\lambda)\overline{t}+\delta(1+r)}]$ *and* $\pi_1 = [\frac{(1-\lambda)\overline{t}}{(1-\lambda)\overline{t}+\delta(1+r)}]$.

Proof. See Appendix.

If $\overline{c} > (1-\lambda)\overline{t}$, $\pi_0 = 0$ and $\tau^*_{\overline{c}} < 1$ so that the average agent tends to be a smaller thief. Although it is not surprising that large costs of stealing diminish large crime, large costs do not eradicate crime since π_1 is not affected by $\overline{c}$. Note that eradicating the uncertainty of being caught does not eradicate crime. If we remove the uncertainty of being caught by setting $\lambda = 1$, then both $\pi_0 = 0$ and $\pi_1 = 0$, implying that $\tau^*_{\overline{c}} = 0$ and the average agent is honest. However, if alternatively, we remove the uncertainty of being caught by setting $\lambda = 0$, even if $\overline{c}$ is large, $\pi_1 \neq 0$ and some crime could persist, depending on the sizes of $\overline{t}$, δ and r. Thus, the two sources of uncertainty must be considered in determining the level of crime.

Since the government is assumed to be thinking in terms of the average agent, P2 represents the behavior of this agent to the government. This, in turn, permits the agents to calculate the proportion of revenue that the government would be facing. We next evaluate this proportional tax revenue, $f(\pi)$.

Proposition 3. $f(\pi) = \begin{cases} \frac{(1+r)(t+\delta)}{(1+r)(t+\delta)+\lambda b} & \text{if } 0 \leq \pi \leq \pi_0 \\ \frac{(1+r)(t+\frac{v(\pi)}{\overline{c}}\delta)}{(1+r)(t+\frac{v(\pi)}{\overline{c}}\delta)+\lambda b+(1-\lambda)(1-\frac{v(\pi)}{\overline{c}})\overline{t}} & \text{if } \pi_0 < \pi < \pi_1 \\ \frac{(1+r)t}{(1+r)t+\lambda b+(1-\lambda)\overline{t}} & \text{if } \pi_1 \leq \pi \leq 1 \end{cases}.$

Proof. See Appendix.

The agents assume that the proportional tax revenue, $f(\pi)$, which depends on their combined behavior, is the basis upon which the government will choose its type. Thus, the agents will choose as the probability that the type chosen will be G1, the solution to the equation $\pi = f(\pi)$. We next examine the properties of this endogenized probability.

Proposition 4. *$\pi = f(\pi)$ has a unique solution π^* for $\pi \in [0, 1]$.*

Proof. See Appendix.

This proposition shows that there is only one probability that is consistent with the agents' beliefs concerning the government's choice of type. We next locate π^* in terms of the parameters π_0 and π_1 given in P2.

Proposition 5. *a. If $\pi_0 \geq f(\pi_0)$, then $0 \leq \pi^* \leq \pi_0$.*

b. If $\pi_1 \geq f(\pi_1)$ and $\pi_0 < f(\pi_0)$, then $\pi_0 < \pi^* < \pi_1$.

c. If $\pi_1 < f(\pi_1)$, then $\pi_1 \leq \pi^* \leq 1$.

Proof. See Appendix.

We next connect the endogenized value π^* to agent c's choice. In what follows, we let $v^* = v(\pi^*)$

Proposition 6. *a. If $0 \leq \pi^* \leq \pi_0$, then $v^* > \overline{c}$ and $\tau^* > 0$ for all c.*

b. If $\pi_0 < \pi^* < \pi_1$, then $0 < v^* < \overline{c}$ and $\tau^* > 0$ for all c.

c. If $\pi^* \geq \pi_1$, then $v^* \leq 0$ and $\tau^* = 0$ for all c.

Proof. See Appendix.

We can now establish a property of the collective behavior of all agents.

Proposition 7. *a. If $\pi_1 < f(\pi_1)$, then all agents choose to be honest.*

b. If $\pi_1 \geq f(\pi_1)$, then all agents steal some amount from their firms.

Proof. See Appendix.

Based on the last proposition, we are led to define the level of crime, $K(v^* \mid \gamma)$, which results from the collective decisions of the agents, as the proportion of agents who steal at least γ percent of their firms. Recall that c has distribution function $H(c)$.

Proposition 8. *Let* $0 < \gamma \leq 1$. *Then*

$$K(v^* \mid \gamma) = \begin{cases} 0 & \text{if } v^* < 0 \\ H(\frac{v^*}{\gamma}) & \text{if } 0 \leq v^* \leq \gamma \\ 1 & \text{if } v^* > \gamma \end{cases}$$

where $v^* = v(\pi^*)$.

Proof. See Appendix.

P8 establishes the relationship between the level of crime and both the collective evaluation of the future government by all agents as well as the perceived evaluation by the government of all the agents. We next proceed to consider how changes in these evaluations effect the level of crime. Specifically, we investigate how $K(v^* \mid \gamma)$ changes as specific parameters change. When focusing on a specific parameter θ, we write $K(v^* \mid \gamma)$ as $K(\theta \mid \gamma)$.

Before proceeding, we note the following. When either of the cases $v^* < 0$ or $v^* > \gamma$ hold, $K(\theta \mid \gamma)$ is constant. Thus, infinitesimal changes in any parameter θ will not change $K(\theta \mid \gamma)$. The remaining case, when $0 \leq v^* \leq \gamma$, needs closer scrutiny. Here, $K(\theta \mid \gamma) = H(\frac{v^*}{\gamma})$ which is a differentiable function of v^* since $H(c)$ is continuous with density $h(c)$. It follows that $\frac{\partial K(\theta|\gamma)}{\partial \theta} = \frac{1}{\gamma} h(\frac{v^*}{\gamma}) \frac{\partial v^*}{\partial \theta}$. Thus, the sign of $\frac{\partial K(\theta|\gamma)}{\partial \theta}$ is the same as that of $\frac{\partial v^*}{\partial \theta}$. Note that the parameter $\theta = \overline{c}$ cannot be handled this way since a change in $\overline{c}$ causes a change in $H(c)$ also. We handle the case of this parameter by an example presented below.

Proposition 9. *Let* $v^* < \overline{c}$. *Then the sign of* $\frac{\partial v^*}{\partial \theta}$ *is the same as the sign of* $g_{2\theta} {v^*}^2 - g_{1\theta} v^* + g_{0\theta}$ *where* $g_{i\theta}$, $i = 0, 1, 2$, *are the partial derivatives with respect to* θ *of* $g_0 = \overline{c}(1-\lambda)\overline{t}[\lambda b + (1-\lambda)\overline{t}] - \overline{c}\delta t(1+r)^2$, $g_1 = (1+r)\overline{c}t + \overline{c}[\lambda b + (1-\lambda)\overline{t}] + (1-\lambda)^2 \overline{t}^2 + \delta^2 (1+r)^2$, *and* $g_2 = (1-\lambda)\overline{t} - \delta(1+r)$, *respectively.*

Proof. See Appendix.

Proposition 10. *Let $0 \leq v^* \leq \min(\bar{c}, \gamma)$. Then*

a. $K(\theta \mid \gamma)$ decreases as $\theta = r$ or δ increases.

b. $K(\theta \mid \gamma)$ increases as $\theta = b$ or $\bar{t}$ increases.

c. If $(1-\lambda) \leq \frac{\bar{c}}{\bar{t}}[1 - \frac{b-\bar{t}}{\bar{t}}]$, $K(\theta \mid \gamma)$ decreases as $\theta = \lambda$ increases.

Proof. See Appendix.

It is not surprising that the promise of an improvement in G1's economy, i.e., an increase in r, would cause more agents to wish to take advantage of this opportunity. But, if these agents believe that G1 would prevail, then any thievery would be punished. Thus, to take advantage of the improved economic climate, the amount of thievery would have to be reduced. Similarly, an increase in the punitive rate δ imposes a heavier cost on every thief in G1 since each thief will be caught. This, in turn, will dissuade some from stealing and reduce the overall level of crime. Part b of P10 yields an often noted result that links crime to corruption. If we interprete b as a bribe that the government extracts from criminals wishing to avoid punishment, then an increase in this type of corruption causes, rather than deters, an increase in crime. Similarly, if G2 increases the tax rate $\bar{t}$, an increase in the level of crime occurs. Part c of P10 shows the complexity of the factors that can cause an increase or decrease in the level of crime. In particular, the change in the level of crime due to a change in λ cannot be predicted without imposing restrictions on other parameters. The interactions between these parameters, as well as the non-linearities inherent in the model, prevent simple predictions from being made. We illustrate this below by example. In P10 we assumed that $0 \leq v^* \leq \min(\bar{c}, \gamma)$. However, the case where $\bar{c} < v^* \leq \gamma$ can be shown to yield similar results.

3. Examples

In order to illustrate some additional features of the model and the level of crime associated with the parameters, we start with the following set-up. In G1, honest agents are taxed at $t = .3$, the infrastructure is improved so that firms will benefit, i.e., $r = .2$, all thieves are caught, and all stolen funds are taxed (penalized) at the additional rate $\delta = .2$. By contrast, in G2, thieves are caught with probability $\lambda = .5$. If caught, the government confiscates their wealth at the rate $b = .6$. If a thief is not caught, he keeps what was stolen and the part of the firm not stolen is taxed at the rate $t = .3$ only with probability $p = .5$. Otherwise, the tax rate is increased by $\Delta = .4$. There is no improvement of infrastructure assumed in this form of government. Finally, we assume that the distribution of c is given by $H(c) = c \in [0, 1]$, implying that $\bar{c} = .5$. Using P2, it follows that $\pi_0 = 0$ and $\pi_1 = .5102$. From P3, $f(\pi_1) = .3956$. Thus from P5, $\pi^* \in (0, \pi_1)$. Since, from the proof of P9, v^* satisfies $g_2 {v^*}^2 - g_1 v^* + g_0 = 0$, we can solve this equation explicitly here. Solving, we have $\pi^* = .4182$ and $v^* = .0451$. Based on the remarks following P8, the proportions of agents stealing more than 15%, 25% and 50% of their firms are $K(.15) = .30$, $K(.25) = .18$, and $K(.50) = .09$, respectively. When there are as many high cost as low cost agents, moderate crime flourishes and there is a notable number of large crimes.

Turning to comparative statics, we note that increasing r, δ, b or $\bar{t}$ results in an unambiguous change in the proportion of agents who steal from their firms as seen in P10. On the other hand, the impact of a change in λ is more complicated. We now illustrate part c of P10. We increase the value of λ from .5 to.6. We must check two conditions to illustrate part c. First, we must check whether $\pi_0 \leq \pi^* \leq \pi_1$ for $\lambda = .6$, and second, whether $1 - .6 \leq \frac{\bar{c}}{\bar{t}}[1 - \frac{b - \bar{t}}{\bar{t}}]$. The second condition is easily verified since the right-hand-side of the inequality equals .8. To check the first condition, we must resolve the problem for $\lambda = .6$. Solving, we have $\pi^* = .395$, $v^* = .026$, $\pi_0 = 0$, $\pi_1 = .455$ and $f(\pi_1) = .39$. The first condition is satisfied and we illustrate part c by computing the levels of crime. It follows from $v^* = .026$ that $K(\lambda \mid .15) = .17$, $K(\lambda \mid .25) = .10$, and $K(\lambda \mid .50) = .05$. As predicted by P10, each of these is smaller than their counterpart above.

Based on the remark before P9, $\overline{c}$ could not be included in P10 so we next present an example that varies from the original illustration by changing the distribution of c. Let $H(c) = c^2$ for $c \in [0, 1]$. Thus, $\overline{c} = 2/3$. Reworking the illustration (setting $\lambda = .5$ again), we have $\pi^* = .4144$ and $v^* = .0469$. Here, the proportions of agents stealing more than 15%, 25% and 50% of their firms are $K(.15) = .10$, $K(.25) = .035$, and $K(.50) = .009$, respectively. Moderate crime is much lower and large crimes have been substantially reduced.

We consider one final variation of our basic illustration that was not handled by P10, that is, the change in the basic tax rate t shared by both governments. Reworking our illustration after setting $t = .5$, we have $\pi^* = .5046$ and $v^* = .0523$. Here, the proportions of agents stealing more than 15%, 25% and 50% of their firms are $K(.15) = .35$, $K(.25) = .21$, and $K(.50) = .10$. Thus, the increase in the basic tax rate by G1 causes the level of crime to rise.

4. Discussion and Conclusions

Our model was chosen to explore the impact of uncertainty on the level of crime. Uncertainty entered in two ways. First, there was the uncertainty that G2 would enforce the law, would raise taxes or become confiscatory. Though these choices by G2 were not known to the agents, we did assume that the probability of their occurrences were known. The second way that uncertainty entered was through the probability that G1 or G2 would result. Thus, we set out to study how the agents would determine the probability π^* that G1 would come into being as a result of the other uncertainties in the problem.

We assumed that the agents in this society presumed that the government's ultimate choice of type would be based on the level of tax revenues that these types would generate. Since crime would alter these tax revenues, and the agents' decisions to steal had to be made before the government's type was revealed, the probability that the government would choose a particular type was made endogeneously.

Our first set of results established the way in which π^* was calculated by the agents. Having this value, each agent could decide whether to steal and how much to steal. Collectively, a level of crime in society was established. We next showed how π^* and the level of crime would change as different parameter values changed. Our aim was that the study of these changes would have in them the seeds of policy choices.

Some of the changes we found are intuitive. For example, as the level of confiscation increases (b), or the level of taxation increases ($\bar{t}$), the level of crime increases. As the average cost of stealing ($\bar{c}$), or the penalty tax rate (δ) in G1 increases, the level of crime decreases. However, a non-intuitive result also presented itself. One would have expected that crime would decrease as the probability that illicit acts would be caught (λ) increased in G2. However, the nonlinearities inherent in the solution for π^* in the range $\pi_0 < \pi^* < \pi_1$ prevent such a conclusion from being unambiguously drawn. This suggests that while some of the changes will have the anticipated effect, others that seemed reasonable, may be misleading.

The government, though mentioned often in the previous pages, is not an active participant in our model, and in fact only exists as a result of the assumption made by the agents that the government's choice of type depends on received tax revenues. It is not difficult to imagine that the actual government might know its type already, or that it has a criterion different than that assumed by the agents. Moreover, if the government knew the way the agents' choices were made, it could use results like those in P10 to try and influence the agents' behavior for its own interests. In this way, one can interprete P10 as having policy implications. (See Katz and Owen (2005) where the government's benefit function depends on the level of crime.) The introduction of an active government into our model is being investigated.

5. Appendix

Proof of P1.

We first establish the expected revenue of agent c if he steals τ. From the text, $E(G1) = (1+r)(1-t) - \tau\delta(1+r) - \frac{c\tau^2}{2}$. Also, $E(G2) = 1 - \lambda b - (1-\lambda)(1-\tau)\overline{t} - \frac{c\tau^2}{2}$. Finally, the expected revenue of agent c is $\pi E(G1) + (1-\pi)E(G2)$ which after some collection of terms becomes $\pi(1-t)(1+r) + (1-\pi)[1-(\lambda b + (1-\lambda)\overline{t})] + \tau[(1-\pi)(1-\lambda)\overline{t} - \pi\delta(1+r)] - \frac{c\tau^2}{2}$. Maximizing this expression over τ for $0 \leq \tau \leq 1$ yields

$$\tau^* = \begin{cases} 1 & \text{for } v(\pi) \geq c \\ \frac{v(\pi)}{c} & \text{for } 0 < v(\pi) < c \\ 0 & \text{for } v(\pi) \leq 0 \end{cases},$$

where $v(\pi) = (1-\lambda)\overline{t} - \pi[(1-\lambda)\overline{t} + \delta(1+r)]$.♣

Proof of P2.

It follows from the definition of $v(\pi)$ that $v(\pi) \geq c$ if $0 \leq \pi \leq \frac{(1-\lambda)\overline{t}-c}{(1-\lambda)\overline{t}+\delta(1+r)}$, $0 < v(\pi) < c$ if $\frac{(1-\lambda)\overline{t}-c}{(1-\lambda)\overline{t}+\delta(1+r)} < \pi < \frac{(1-\lambda)\overline{t}}{(1-\lambda)\overline{t}+\delta(1+r)}$, and $v(\pi) \leq 0$ if $\frac{(1-\lambda)\overline{t}}{(1-\lambda)\overline{t}+\delta(1+r)} \leq \pi \leq 1$. Thus, setting $c = \overline{c}$, and using the same approach as in P1, we have

$$\tau^* = \begin{cases} 1 & \text{if } 0 \leq \pi \leq \pi_0 \\ \frac{v(\pi)}{\overline{c}} & \text{if } \pi_0 < \pi < \pi_1 \\ 0 & \text{if } \pi_1 \leq \pi \leq 1 \end{cases},$$

where $\pi_0 = \max[0, \frac{(1-\lambda)\bar{t}-\bar{c}}{(1-\lambda)\bar{t}+\delta(1+r)}]$ and $\pi_1 = \frac{(1-\lambda)\bar{t}}{(1-\lambda)\bar{t}+\delta(1+r)}$.♣

Proof of P3.

The government's expected revenue corresponds to the tax revenue that results from the average agent's optimum choices, i.e., $\tau^*_{\bar{c}}$. Thus, if $c = \bar{c}$, $R(G1 \mid \pi, \bar{c}) = (1+r)(t + \tau^*_{\bar{c}}\delta)$, i.e., the tax t on the final value of the firm plus the additional tax on the stolen part of the firm. Also, $R(G2 \mid \pi, \bar{c}) = \lambda b + (1-\lambda)(1-\tau^*_{\bar{c}})\bar{t}$, i.e., the government gets the bribe with probability λ and, with the remaining probability, just taxes the part of the firm not stolen at the expected tax rate $\bar{t}$. It follows that $f(\pi) = \frac{R(G1|\pi,\bar{c})}{R(G1|\pi,\bar{c})+R(G2|\pi,\bar{c})} = \frac{(1+r)(1+\tau^*_{\bar{c}}\delta)}{(1+r)(1+\tau^*_{\bar{c}}\delta)+\lambda b+(1-\lambda)(1-\tau^*_{\bar{c}})\bar{t}}$. Finally, substituting the proper value of τ^* from P2 yields the result. ♣

Proof of P4.

Examination of $f(\pi)$ in P3 shows that it is continuous and non-increasing for $0 \leq \pi \leq 1$. Furthermore, by construction, $0 < f(\pi) < 1$. Thus, the function $\pi - f(\pi)$ is a continuous, increasing function that is negative at $\pi = 0$ and positive at $\pi = 1$. Thus, it crosses the axis at a single point, π^*.♣

Proof of P5.

Since $f(\pi)$ is non-increasing and π is increasing, π^* will be in $[0, \pi_0]$ if and only if $\pi_0 \geq f(\pi_0)$. To be in (π_0, π_1), it is required that $\pi_0 < f(\pi_0)$ and that $\pi_1 \leq f(\pi_1)$. Finally, to be in $[\pi_1, 1]$, it is required that $\pi_1 \leq f(\pi_1)$.♣

Proof of P6.

Since $v^* - \bar{c} = (1-\pi^*)[(1-\lambda)\bar{t} - \bar{c}] - \pi^*[\delta(1+r) + \bar{c}]$, it is proportional to $(1-\pi^*)\pi_0 - \pi^*(1-\pi_0) = \pi_0 - \pi^*$ so $v^* > \bar{c} > 0$ and part a follows from P1. It also follows that $v^* < \bar{c}$ if $\pi^* > \pi_0$. Similarly, $v^* = (1-\pi^*)[(1-\lambda)\bar{t}] - \pi^*[\delta(1+r)]$, which is proportional to $(1-\pi^*)\pi_1 - \pi^*(1-\pi_1) = \pi_1 - \pi^*$. Thus, $v^* > 0$ if $\pi^* < \pi_1$ and $v^* < 0$ if $\pi^* > \pi_1$. Invoking P1 again completes the proof.♣

Proof of P7.

From P5, when $\pi_1 < f(\pi_1)$, then $\pi^* \in [\pi_1, 1]$. Thus, $v(\pi^*) = (1-\lambda)\bar{t} - \pi^*[(1-$

$\lambda)\bar{t}+\delta(1+r)] \leq (1-\lambda)\bar{t}-\pi_1[(1-\lambda)\bar{t}+\delta(1+r)=0$. Evaluating P1 at v^*, it follows that $\tau^*=0$ for all c. Therefore, part a follows.

To prove part b, we note that from P5, when $\pi_1 \geq f(\pi_1)$, v^* is positive. Again, from P1, we have that for every value of c, some fraction, if not all of the firm, will be stolen.♣

Proof of P8.

Given π^* and $\bar{c}$, it follows from P1 that agent c will steal at least γ if $\frac{v^*}{c} \geq \gamma$. If $v^*<0$, no agent would steal this amount so $K(v^* \mid \gamma)=0$. If $0 \leq v^* \leq \gamma$, then all agents c will steal at least γ when $c \leq \frac{v^*}{\gamma}$. Given the definition of $H(c)$, it follows that the proportion of agents that will steal at least γ is $H(\frac{v^*}{\gamma})$. Finally, when $v^*>\gamma$, then every c value will satisfy $\frac{v^*}{c} \geq \gamma$ and the result follows.♣

Proof of P9.

If $v^*<\bar{c}$, then from P3 it follows that π^* satisfies $\pi^*=\frac{(1+r)(t+\frac{v^*}{\bar{c}}\delta)}{(1+r)(t+\frac{v^*}{\bar{c}}\delta)+\lambda b+(1-\lambda)(1-\frac{v^*}{\bar{c}}\bar{t})}$. Since $v^*=(1-\lambda)\bar{t}-\pi^*[(1-\lambda)\bar{t}+\delta(1+r)]$, π^* can be written as $\frac{(1-\lambda)\bar{t}-v^*}{(1-\lambda)\bar{t}+\delta(1+r)}$, making the previous equation a function of v^*. Multiplying through by the denominator of the right-hand-side and rearranging terms yields a quadratic equation in v^*, i.e., $g_2{v^*}^2 - g_1v^*+g_0$, where the functions $g_i,\ i=0,1,2$, are given in the proposition. Implicit differentiation shows that $v^*_\theta=\frac{\partial v^*}{\partial\theta}$ must satisfy $(g_1-2g_2v^*)v^*_\theta = g_{2\theta}{v^*}^2-g_{1\theta}v^*+g_{0\theta}$. It remains to show that $g_1-2g_2v^*>0$. Note

$$\begin{aligned}
g_1-2g_2v^* &= (1+r)\bar{c}t+\bar{c}[\lambda b+(1-\lambda)\bar{t}]+(1-\lambda)\bar{t}^2+ \\
&\quad \delta^2(1+r)^2-2v^*[(1-\lambda)\bar{t}-\delta(1+r))] \\
&\geq \bar{c}(1-\lambda)\bar{t}-v^*(1-\lambda)\bar{t}+(1-\lambda)\bar{t}^2-v^*(1-\lambda)\bar{t} \\
&= (1-\lambda)\bar{t}[\bar{c}-v^*+\bar{t}-v^*].
\end{aligned}$$

It follows that $g_1-2g_2v^*>0$ since $v^*<(1-\lambda)\bar{t}\leq\bar{t}$ and $v^*<\bar{c}$, and the proposition follows.♣

Proof of P10.

Part a. Evaluating $g_{2\theta}v^{*^2} - g_{1\theta}v^* + g_{0\theta}$ for $\theta = r$ yields $-\delta v^{*^2} - v^*[\overline{c}t + 2\delta^2(1 + r)] - 2\overline{c}\delta t(1+r) < 0$. Similarly, evaluating this expression for $\theta = \delta$ yields the same sign.

Part b. When $\theta = b$, the expression becomes $v^*[\overline{c}\lambda]+\overline{c}(1-\lambda)\overline{t}\lambda = \overline{c}\lambda[(1-\lambda)\overline{t}-v^*] > 0$.

Now let $\theta = \overline{t}$. Evaluating $g_{2\theta}v^{*^2} - g_{1\theta}v^* + g_{0\theta}$ for $\theta = \overline{t}$, yields $v^{*^2}(1-\lambda) - v^*[\overline{c}(1-\lambda) + 2(1-\lambda)^2\overline{t}] + \overline{c}(1-\lambda)[\lambda b + (1-\lambda)\overline{t}] + \overline{c}(1-\lambda)^2\overline{t}$

$= (1-\lambda)\{v^*(v^* - \overline{c}) - 2(1-\lambda)\overline{t}(v^* - \overline{c}) + \overline{c}\lambda b\}$

$= (1-\lambda)\{(v^* - \overline{c})[v^* - 2(1-\lambda)\overline{t}] + \overline{c}\lambda b\} > 0$ since $v^* < \overline{c}$ and $v^* < 2(1-\lambda)\overline{t}$.

Part c. Evaluating $g_{2\theta}v^{*^2} - g_{1\theta}v^* + g_{0\theta}$ for $\theta = \lambda$ yields $-\overline{t}v^{*^2} - v^*[\overline{c}(b-\overline{t}) - 2(1-\lambda)\overline{t}^2] + \overline{c}(b-\overline{t})(1-\lambda)\overline{t} - \overline{c}\overline{t}[\lambda b + (1-\lambda)\overline{t}]$

$= \overline{t}v^*[(1-\lambda)\overline{t}-v^*]+\overline{c}(b-\overline{t})[(1-\lambda)\overline{t}-v^*]+(1-\lambda)\overline{t}^2v^*-\overline{c}\overline{t}[\lambda b+(1-\lambda)\overline{t}]$. Remembering that $v^* = (1-\lambda)\overline{t} - \pi^*[(1-\lambda)\overline{t} + \delta(1+r)]$ and the definition of π_1 given in P2, the sign of the last expression is unchanged when we divide through by $[(1-\lambda)\overline{t}+\delta(1+r)]$ and it becomes $\overline{t}v^*\pi^* + \overline{c}(b-\overline{t})\pi^* + [(1-\lambda)\overline{t}^2(\pi_1 - \pi^*) - \overline{c}\overline{t}\pi_1 - \frac{\overline{c}\overline{t}}{(1-\lambda)\overline{t}+\delta(1+r)}]$. Combining terms we have $\overline{t}\pi^*[v^* - (1-\lambda)\overline{t}] + \overline{c}(b-\overline{t})\pi^* + [(1-\lambda)\overline{t}^2 - \overline{c}\overline{t}]\pi_1 - \frac{\overline{c}\overline{t}}{(1-\lambda)\overline{t}+\delta(1+r)}$. This expression is non-positive if $\overline{c}(b-\overline{t})\pi^* + [(1-\lambda)\overline{t}^2 - \overline{c}\overline{t}]\pi_1 \leq 0$ or if $(1-\lambda) \leq \frac{\overline{c}}{\overline{t}}[1 - \frac{\pi^*}{\pi_1}\frac{b-\overline{t}}{\overline{t}}]$. The last inequality would hold if $(1-\lambda) \leq \frac{\overline{c}}{\overline{t}}[1 - \frac{b-\overline{t}}{\overline{t}}]$.♣

6. References

Alexeev, Michael, Janeba, Eckhard and Osborne, Stefan, 2004. "Taxation and evasion in the presence of extortion by organized crime," *Journal of Comparative Economics* 32, 375-387.

Bevan, Alan A. and Estrin, Saul, 2004. "The Determinants of Foreign Direct Investment into European Transition Economies," *Journal of Comparative Economics*

32, 775-787.

Dixit, Avinash K., 2004. *Lawlessness and Economics:Alternative Modes of Governance*. Princeton: Princeton University Press.

Grossman, Herschel I., 1995. "Rival Kleptocrats: The Mafia Versus the State," in Fiorentini, Gianluca and Peltzman, Sam (Eds.), *The Economics of Organized Crime*, Cambridge: Cambridge University Press.

Hoff, Karla and Stiglitz, Joseph E., 2004 "After the Big Bang? Obstacles to the Emergence of the Rule of Law in Post-Communist Societies," *American Economic Review*, 94:3, 753-763.

Katz, Barbara G. and Owen, Joel, 2005. "Moving Toward the Rule of Law in the Face of Corruption: Re-examining the Big-Bang," manuscript.

Polishchuk, Leonid and Savvateev, Alexei, 2004. "Spontaneous (non)emergence of Property Rights," *Economics of Transition*, 12:1, 103-127.

Shleifer, Andrei and Vishny, Robert W., 1998. *The Grabbing Hand: Government Pathologies and Their Cures*. Cambridge: Harvard University Press.

Sonin, Konstantin, 2003. "Why the Rich May Favor Poor Protection of Property Rights," *Journal of Comparative Economics*, 31, 715-731.