

Bureaucrats vs the Mafia: Corruption, Extortion and Illegal Waste Disposal.

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Abstract

We develop a simple model where an economic agent chooses the level of legal and illegal disposal. Illegal disposal implies corruption of a bureaucrat in charge of waste management. In the absence of a criminal organization, illegal disposal is performed by the agent, who is subject to enforcement and bribes the bureaucrat; on the contrary, when mafia is present, it performs illegal disposal, requiring an extortion rate from the agent and bribing the public official; in this latter case no enforcement on individuals is possible. In the first stage of the game, an environmental authority sets the enforcement effort as well as the waste tax rate. We allow both for a budget balancing tax and for the optimal tax to be chosen. Our results suggest that the presence of the mafia leads to a larger illegal disposal and a larger economic activity. Enforcement is always smaller in the presence of the mafia under the optimal tax rate, while the results are ambiguous under a budget balancing tax rate. Interestingly, the optimal tax rate implies smaller incentives for the criminal organization to enter the market, and welfare might be higher when the mafia is present.

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1 Introduction

Illegal disposal is gaining attention worldwide. The related distortions are particularly evident in Italy, where organized crime makes things even worse. Indeed, recent evidence (D'Alisa [7]) suggests a major role for criminal organizations in controlling the illegal disposal and trafficking of both urban and

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hazardous wastes. The illegal waste business in Italy has enlarged over years, reaching a turnover of approximately 7 billion euros in 2009 (Legambiente [14]), while millions tonnes of hazardous waste find yearly their way outside legal circuits¹.

Though the Italian case is famous worldwide, the role of criminal organizations in the waste cycle is well documented also in other countries; among others, Block and Scarpitti [3] and Rebovich [21] focus on toxic waste disposal in the US, while Liddick [15] underlines the importance of criminal groups in the international traffic of garbage and hazardous wastes.

A crucial though underinvestigated issue is related to the role played by local bureaucrats in the management of illegal disposal. In other words, real life observation and anecdotal evidence suggests that in several countries illegal disposal is made possible by connivent local authorities, receiving bribes in exchange of a weaker attention towards illegal dumping by individuals or criminal organizations. Indeed, among others, Liddick [15] shows the importance of "...corrupt public officials..." in illegal wast traffic and management.

The aim of this work is to move a first step in the investigation of the role played by criminal organizations in a setting where illegal disposal implies corruption of a local waste authority.

We develop a simple model where an economic agent chooses the level of economic activity as well as the level of legal and illegal disposal of the consequent waste. For legally disposing of waste, the agent has to pay a waste tax. In the absence of a criminal organization, illegal disposal is performed directly by the agent, that has to bribe a corrupt bureaucrat; both the agent and the bureaucrat are subject to enforcement when the mafia is not present. In the presence of a criminal organization, at the opposite, illegal disposal is exclusively done by the mafia, which requires an extortion rate to be paid by the agent and has to bribe the public official. In this case, enforcement is assumed to be devoted to the criminal organization (and, as before, to the bureaucrat), while no enforcement on individuals is possible: such an assumption is motivated by the commonly observed ability of criminal organizations to provide individuals with a seemingly lawful documentation². Under any circumstances, the bureaucrat chooses the amount of the bribe required from the agent or from the criminal

¹The mafia's role is now documented in various reports by the National Commission on Waste Disposal and Related Crimes (see, for instance, [6]) and Legambiente, as well as by other publications in the field (among others, Bianchini and Sicurella [2]).

²See Commissione Parlamentare di inchiesta sul ciclo dei rifiuti e sulle attività illecite ad esso connesse [6] and Legambiente [13]. One of the main characteristics of the illegal waste management is the capacity of getting around controls and dumping hazardous waste in non-authorized sites by simply "transforming" them in non-hazardous waste. The most common method is known as "giro bolla" (invoice switch): toxic wastes are taken from the producer and transferred to an intermediate storage centre, where accompanying documents are falsified and wastes are declassified from hazardous to non-hazardous without undergoing any treatment. This "reategorization" process is clearly crucial and can be done in several ways (Massari [17, p. 6]): false analysis provided by conniving laboratories, counterfeiting or improper use of identifying codes assigned to waste, and so on. In other cases, waste producers do not even declare their waste generation figures and organized crime provide them declarations themselves, besides storage areas and treatment facilities.

organization. Finally, in the first stage of the game, an environmental authority sets the enforcement effort as well as the waste tax rate. We compare two settings: one where the tax rate is set to cover waste management expenses and one where the optimal tax is chosen.

Our results suggest that the presence of the mafia lowers enforcement and might lead to larger illegal disposal and a larger economic activity. Enforcement is always larger in the presence of the mafia under the optimal tax rate, while the results are ambiguous under a budget balancing tax rate. Interestingly, the optimal tax rate implies smaller incentives for the criminal organization to enter the market, and welfare might indeed be higher when the mafia is present. The latter result is entirely driven by the enforcement cost savings due to a smaller enforcement under the mafia, which under certain conditions more than counteract environmental damages.

The model rests on the theoretical literature on waste policy. Specifically, we move from Sullivan [24] and Fullerton and Kinnaman [9], where different waste policy options are compared in the presence of illegal waste disposal. Fullerton and Kinnaman [9], in particular, analyze the optimal waste policy in a general equilibrium setting, under the assumption that illicit burning or dumping cannot be taxed directly and conclude that first best can be achieved even in the presence of illegal disposal. The authors conclude that the optimal fee structure is a deposit-refund system: a tax on all output plus a rebate on proper disposal through either recycling or garbage collection. Choe and Fraser [5] explicitly introduce monitoring cost into their model and identify the second-best optimal policy, whereas Shinkuma [23] also accounts for transaction costs in determining second best optimal instrument.

We also connect to the literature on the economics of organized crime. In particular, our modeling framework borrows from Grossman [12] and Garoupa [10]. In the first paper, organized crime is modelled as a competitor of the State in the provision of public services. As a result, the existence of organized crime constraints the government's behavior. A similar trade off is likely to arise in waste disposal choices. In Garoupa [10], the criminal organization is modelled as a vertical structure extracting some rents from the agents through extortion. Under such assumptions, Garoupa [10] concludes that, as long as extortion is a costless transfer from individuals to the criminal organization, the criminal group can even be social welfare improving.

Finally, our modeling strategy follows the literature on officers' corruption in order to evade regulation. Such literature started from the article of Becker and Stigler [1], but our work could be viewed as a simplified version of the model presented in Mookherjee and Png [19], where the focus is on pollution regulation³. We extend the literature by accounting both for corruption and for the presence of organized crime in waste management; also we provide a first attempt to model how waste policy design might affect the incentives of criminal organizations to enter the market.

³More recent contributions include the survey by Polinsky and Shavell [20] and the paper by Fahad *et al.*[8].

The paper is organized as follows: Section 2 introduces the features of the model while Section 3 analyses the economic agent's problem. Section 4 derives results in the absence of mafia and Section 5 those in the presence of organized crime. Section 6 performs comparisons and, finally, Section 7 concludes.

2 The model

We model the interaction between an economic agent performing an economic activity, a bureaucrat, a criminal organization (when present) and an environmental authority. In the last stage, the economic agent chooses whether to perform waste disposal legally or illegally and the level of activity (consumption or production), subject to a tax on legal disposal and a payment on illegal disposal which depends on the presence of the criminal organization. Moving backwards, we can have two cases:

- if organized crime is not present, the game features three stage. In the second one, the bureaucrats chooses how much it is willing to accept from the agent in terms of bribes to allow illegal disposal. In such a case both the agent and the bureaucrat are subject to enforcement and the expected payment by the agent for illegal disposal amounts to the bribe plus the expected fine.
- if organized crime is present, the game features four stages. In the third one the mafia chooses the extortion rate to be charged to the agent and is subject to enforcement in place of the agent itself; in the second stage, the bureaucrats chooses how much it is willing to accept from the mafia in terms of bribes to allow illegal disposal. Also in this case, the bureaucrat is subject to enforcement.

In the first stage of the game, under both scenarios, an environmental authority chooses the tax rate on legal disposal and the level of enforcement. We compare two possible settings: one where the tax rate is chosen to cover waste management expenses with one where the tax is set optimally. The game structures that might arise are clarified in Figures 1a and 1b.

(Figures 1a and 1b about here)

3 The economic agent's problem

In the last stage of the game, a representative economic agent performs an economic activity y . Such an economic activity generates waste that might be disposed of legally (label the corresponding quantity as g) or illegally (labelled as b). The firm maximizes concave benefits from the economic activity, minus private disposal costs, minus taxes on legal disposal minus a payment on illegal

disposal depending on whether organized crime is present or not. We label p the unit payment whose shape depends on the presence of the mafia. More specifically:

- when organized crime is not present, then the agent is subject to enforcement and it has to pay, on each unit of illegal disposal, an expected fine, labelled as V , which depends on the enforcement effort performed by the government. Also, to perform illegal disposal, the firm has to bribe a bureaucrat in charge of waste disposal, the corresponding amount being labelled as m . In this case $p = V + m$.
- when organized crime is present, then the agent has to pay an extortion rate to the mafia (labelled as x) and is not subject to enforcement, as in such a case we assume that enforcement is only devoted to the criminal organization, while the agent obtains from the latter a seemingly lawful documentation. In this case $p = x$.

The economic agent's problem can therefore be rewritten as:

$$\max_{g,b} \alpha (g + b) - \frac{(g + b)^2}{2} - \mu \frac{g^2}{2} - tg - pb$$

FOCs are therefore⁴:

$$\begin{aligned} (-\mu - 1)g + (\alpha - t - b) &= 0 \\ (\alpha - p - g) - b &= 0 \end{aligned}$$

$$g = \frac{1}{\mu} (p - t) \tag{1}$$

$$b = \frac{1}{\mu} (t - p(1 + \mu) + \alpha\mu) \tag{2}$$

Notice that any choice increasing the payment from the agent to dispose of waste illegally implies an increase (decrease) in legal (illegal) disposal, while the opposite happens with respect to the tax rate. As a result, the choice of the government is likely to affect in several non straightforward ways the agent illegal and legal behavior.

4 The Game in the Absence of the Mafia

In such a case, $p = m + V$. The solutions to the agent's problem imply:

$$g = \frac{1}{\mu} (V + m - t)$$

⁴Notice that we rule out the uninteresting case where $b = 0$.

$$b = \frac{1}{\mu} (t + \alpha\mu - (\mu + 1)(V + m))$$

The bureaucrat gets a salary S , which is normalized to 0, and gets a unit bribe m from the agent. Also, the bureaucrat is subject to enforcement, so that on each unit of illegal disposal it has to pay a unit fine equal to V^5 , plus a bribe m . The bureaucrat solves therefore the following problem:

$$\max_m mb - Vb$$

FOCs wrt m are:

$$2 \left(-\frac{1}{\mu} (\mu + 1) \right) m + \left(\frac{V}{\mu} (\mu + 1) - \frac{1}{\mu} (V - t + V\mu - \alpha\mu) \right) = 0$$

that is:

$$m = \frac{1}{2} \frac{t + \alpha\mu}{\mu + 1}$$

Notice that the tax rate on legal disposal affects the bribe required from the bureaucrat. This is likely to constrain the available policy options for the government.

The government maximizes concave benefits from legal disposal $\delta \left(g - \frac{g^2}{2} \right)$, related for example to recycling, minus convex damages from illegal disposal $\gamma \frac{b^2}{2}$ minus enforcement costs θV , where we label θ as unit enforcement costs. Welfare is therefore:

$$W = \delta \left(g - \frac{g^2}{2} \right) - \theta V - \gamma \frac{b^2}{2}$$

We compare two cases: a situation where the tax rate is set to balance the legal disposal budget with one where the tax is optimally set.

4.1 Case 1: Budget Balancing tax rate

Budget balancing requires that the tax revenue equals total legal disposal cost, i.e. $tg = \varepsilon g$ where ε is the unit legal disposal cost parameter. Assume therefore that $t = \varepsilon$.

FOCs with respect to V imply that the equilibrium level of the expected fine is as follows:

$$V_1 = \frac{\mu^2 \left(\delta \left(\frac{1}{\mu} + \frac{1}{2\mu^2} \left(2\varepsilon - 2\frac{\varepsilon + \alpha\mu}{2\mu + 2} \right) \right) + \frac{\gamma}{\mu^2} (\mu + 1) \left(\varepsilon + \alpha\mu - \frac{\varepsilon + \alpha\mu}{2\mu + 2} - \mu \frac{\varepsilon + \alpha\mu}{2\mu + 2} \right) - \theta \right)}{\gamma + \delta + 2\gamma\mu + \gamma\mu^2}$$

As a result, the equilibrium bribe, legal and illegal disposal are:

$$m_1 = \frac{1}{2} \frac{\varepsilon + \alpha\mu}{\mu + 1}$$

⁵We assume that the unit fine is the same with respect to the agent, i.e. if caught, the bureaucrat and the agent gets an identical sentence. Removal of this hypothesis is not likely, however, to influence our results substantially.

$$b_1 = \frac{1}{\gamma\mu^2 + 2\gamma\mu + \gamma + \delta} (\theta\mu - \delta + \alpha\delta - \mu\delta - \delta\varepsilon + \theta\mu^2)$$

$$g_1 = \frac{1}{\gamma\mu^2 + 2\gamma\mu + \gamma + \delta} (\delta - \theta\mu + \alpha\gamma - \gamma\varepsilon + \alpha\gamma\mu - \gamma\mu\varepsilon)$$

Finally, the economic activity level and the corresponding welfare are:

$$y_1 = g_1 + b_1$$

$$W_1 = \delta \left(g_1 - \frac{g_1^2}{2} \right) - \theta V_1 - \gamma \frac{b_1^2}{2}$$

4.2 Case 2: Optimal tax rate

In such a case, unit legal disposal costs are normalized to 0. The FOCs with respect to V and t imply respectively:

$$V_2 = \frac{2\alpha\gamma\delta - \theta\delta - 2\gamma\delta - \theta\gamma\mu^2 - 4\theta\mu^2\delta - 2\gamma\mu^2\delta - 2\theta\gamma\mu - 4\theta\mu\delta - \theta\gamma - 4\gamma\mu\delta + 2\alpha\gamma\mu^2\delta + 4\alpha\gamma\mu\delta}{4\gamma\delta(\mu + 1)^2}$$

$$t_2 = \frac{2\alpha\gamma\delta - \theta\delta - 2\gamma\delta - \theta\gamma\mu^2 - 2\gamma\mu^2\delta - 2\theta\gamma\mu - 2\theta\mu\delta - \theta\gamma - 4\gamma\mu\delta + 2\alpha\gamma\mu\delta}{2\gamma\delta(\mu + 1)}$$

The corresponding equilibrium bribe, legal and illegal disposal are:

$$m_2 = \frac{2\alpha\gamma\delta - \theta\delta - 2\gamma\delta - \theta\gamma\mu^2 - 2\gamma\mu^2\delta - 2\theta\gamma\mu - 2\theta\mu\delta - \theta\gamma - 4\gamma\mu\delta + 2\alpha\gamma\mu^2\delta + 4\alpha\gamma\mu\delta}{4\gamma\delta\mu^2 + 8\gamma\delta\mu + 4\gamma\delta}$$

$$g_2 = \frac{1}{2} \frac{\theta + 2\delta}{\delta}$$

$$b_2 = \frac{1}{2} \theta \frac{2\mu + 1}{\gamma(\mu + 1)}$$

The resulting levels of economic activity and social welfare are therefore:

$$y_2 = g_2 + b_2$$

and

$$W_2 = \delta \left(g_2 - \frac{g_2^2}{2} \right) - \theta V_2 - \gamma \frac{b_2^2}{2}$$

5 The Game in the Presence of the Mafia

In the presence of the criminal organization, the agent FOCs can be rewritten as follows:

$$(-\mu - 1)g + (\alpha - t - b) = 0$$

$$(\alpha - x - g) - b = 0$$

Implying the following values for legal and illegal disposal. Notice that, as the agent gets a formally lawful documentation in exchange of the extortion rate, enforcement does not play any direct role.

$$g = \frac{1}{\mu} (x - t)$$

$$b = \frac{1}{\mu} (t + \alpha\mu - x(\mu + 1))$$

The mafia maximizes net rent but pays a bribe proportional to illegal disposal to the bureaucrat. Also, the rent of the Mafia decreases with the expected fine payment, given by Vb ⁶:

$$R = (x - m - V)b$$

implying the following FOCs wrt to x :

$$2 \left(-\frac{1}{\mu} (\mu + 1) \right) x + \frac{1}{\mu} (t + (\mu + 1)(V + m) + \alpha\mu) = 0$$

The extortion rate is therefore:

$$x = \frac{1}{2(\mu + 1)} (t + (\mu + 1)(V + m) + \alpha\mu)$$

The mafia imposes and extortion rate which is increasing with the tax on legal disposal; also, a larger "price" for illegal disposal set by the bureaucrat (the bribe m) and a larger expected fine (for example determined by a larger probability to be caught due to a larger enforcement) imply a larger extortion rate.

The Bureaucrat gets a salary S , which is normalized to 0, and gets a unit bribe m from the criminal organization. Also, the bureaucrat is subject to enforcement, so that on each unit of illegal disposal it has to pay a unit fine equal to V . The unit bribe is therefore chosen in order to maximize the net rent:

$$\max_m mb - Vb$$

FOCs wrt m are:

$$2 \left(-\frac{1}{\mu} \frac{(\mu + 1)^2}{2\mu + 2} \right) m + \left(\frac{1}{\mu} \left(t + \alpha\mu - \frac{\mu + 1}{2\mu + 2} (t + \alpha\mu + V(\mu + 1)) \right) + \frac{V(\mu + 1)^2}{\mu(2\mu + 2)} \right) = 0$$

that is:

$$m = \frac{t + \alpha\mu}{2(\mu + 1)}$$

Notice that for a given tax rate the bribe is the same as in the absence of the mafia. However, as we will show, the equilibrium tax rate is different, under

⁶We keep the assumption that the unit expected fine is the same, if caught, for the mafia and for the bureaucrat.

certain condition, and the same holds, therefore, with respect to the equilibrium bribe.

As in the case without the mafia, we compare two cases: a situation where the tax rate is set to balance the legal disposal budget with one where the tax is optimally set. Recall that social welfare is given by the following expression:

$$W = \delta \left(g - \frac{g^2}{2} \right) - \theta V - \gamma \frac{b^2}{2}$$

5.1 Case 3. Budget Balancing tax rate

Budget balancing requires that the tax revenue equals total legal disposal cost, i.e. $tg = \varepsilon g$ where ε is the unit legal disposal cost parameter. Assume therefore that $t = \varepsilon$.

The corresponding equilibrium level for the enforcement level is as follows:

$$V_3 = \frac{4\mu\delta + \gamma\varepsilon + \delta\varepsilon - 8\theta\mu^2 - 8\theta\mu^3 + 4\mu^2\delta + 2\alpha\gamma\mu^2 + \alpha\gamma\mu^3 + \gamma\mu^2\varepsilon + \alpha\gamma\mu - 3\alpha\mu\delta + 2\gamma\mu\varepsilon + 4\mu\delta\varepsilon}{2\gamma + 2\delta + 6\gamma\mu + 2\mu\delta + 6\gamma\mu^2 + 2\gamma\mu^3}$$

As a result, the equilibrium bribe, legal and illegal disposal are:

$$m_3 = \frac{\varepsilon + \alpha\mu}{2(\mu + 1)2}$$

$$b_3 = \frac{1}{\gamma\mu^2 + 2\gamma\mu + \gamma + \delta} (2\theta\mu - \delta + \alpha\delta - \mu\delta - \delta\varepsilon + 2\theta\mu^2)$$

$$g_3 = \frac{1}{\gamma\mu^2 + 2\gamma\mu + \gamma + \delta} (\delta - 2\theta\mu + \alpha\gamma - \gamma\varepsilon + \alpha\gamma\mu - \gamma\mu\varepsilon)$$

The resulting level of economic activity and welfare are:

$$y_3 = g_3 + b_3$$

$$W_3 = \delta \left(g_3 - \frac{g_3^2}{2} \right) - \theta V_3 - \gamma \frac{b_3^2}{2}$$

5.2 Case 4. Optimal tax rate

In such a case, unit legal disposal costs are a net social transfer. The FOCs with respect to V and t imply, respectively:

$$V_4 = \frac{2\alpha\gamma\delta - \theta\delta - 2\gamma\delta - \theta\gamma\mu^2 - 16\theta\mu^2\delta - 2\gamma\mu^2\delta - 2\theta\gamma\mu - 8\theta\mu\delta - \theta\gamma - 4\gamma\mu\delta + 2\alpha\gamma\mu^2\delta + 4\alpha\gamma\mu\delta}{4\gamma\delta + 4\gamma\mu^2\delta + 8\gamma\mu\delta}$$

$$t_4 = \frac{2\alpha\gamma\delta - \theta\delta - 2\gamma\delta - \theta\gamma\mu^2 - 2\gamma\mu^2\delta - 2\theta\gamma\mu - 4\theta\mu\delta - \theta\gamma - 4\gamma\mu\delta + 2\alpha\gamma\mu\delta}{2\gamma\delta + 2\gamma\mu\delta}$$

The equilibrium bribe, legal and illegal disposal are:

$$m_4 = \frac{2\alpha\gamma\delta - \theta\delta - 2\gamma\delta - \theta\gamma\mu^2 - 2\gamma\mu^2\delta - 2\theta\gamma\mu - 4\theta\mu\delta - \theta\gamma - 4\gamma\mu\delta + 2\alpha\gamma\mu^2\delta + 4\alpha\gamma\mu\delta}{4\gamma\delta\mu^2 + 8\gamma\delta\mu + 4\gamma\delta}$$

$$g_4 = \frac{1}{2\delta}(\theta + 2\delta)$$

$$b_4 = \frac{\theta + 4\theta\mu}{2\gamma + 2\gamma\mu}$$

while the economic activity and welfare are given, respectively, by:

$$y_4 = g_4 + b_4$$

$$W_4 = \delta \left(g_4 - \frac{g_4^2}{2} \right) - \theta V_4 - \gamma \frac{b_4^2}{2}$$

6 Comparisons

The aim of this section is to compare the different results obtained in the preceding section. We first compare the no mafia and the mafia case under each assumption concerning the way in which the tax on legal disposal is chosen. Then we will compare the budget balancing and optimal tax case in the presence of the mafia, with a specific focus on the incentives for the criminal organization to enter the "market".

6.1 Budget balancing tax rate

Using result obtained under cases 1 and 3, we can easily get the following inequalities:

$$\begin{aligned} m_3 - m_1 &= 0 \\ b_3 - b_1 &= \theta\mu \frac{\mu + 1}{\gamma\mu^2 + 2\gamma\mu + \gamma + \delta} > 0 \\ g_3 - g_1 &= -\theta \frac{\mu}{\gamma + \delta + 2\gamma\mu + \gamma\mu^2} < 0 \\ y_3 - y_1 &= \theta \frac{\mu^2}{\gamma + \delta + 2\gamma\mu + \gamma\mu^2} > 0 \end{aligned}$$

Proposition 1 *When the tax on legal disposal is set in such a way to achieve budget balancing then:*

- *the bribe is the same with or without the mafia*
- *illegal disposal is larger and legal disposal smaller in the presence of the mafia*
- *the level of economic activity is larger under the mafia*

Turning to enforcement effort and social welfare:

$$V_3 - V_1 = \frac{\mu}{(\mu + 1)(\gamma\mu^2 + 2\gamma\mu + \gamma + \delta)} ((1 - \alpha + \mu + \varepsilon)\delta - 3\theta\mu(\mu + 1))$$

which is positive if $\theta < \frac{1}{3\mu} \frac{\delta}{\mu + 1} (1 - \alpha + \mu + \varepsilon) = \theta_V$, that is, if enforcement costs are sufficiently low.

$$W_3 - W_1 = -\frac{1}{2} \theta \frac{\mu}{(\mu + 1)(\gamma\mu^2 + 2\gamma\mu + \gamma + \delta)} (2\delta - 3\theta\mu - 2\alpha\delta + 2\mu\delta + 2\delta\varepsilon - 3\theta\mu^2)$$

Welfare turns out to be higher under the mafia when $\theta > \frac{2}{3\mu} \frac{\delta}{\mu + 1} (-\alpha + \mu + \varepsilon + 1) = \theta_W$.

Proposition 2 *Enforcement and social welfare might be larger or smaller under the mafia, depending on enforcement costs.*

In order to achieve a better understanding of the driving forces of our results, we normalize a few parameters. More specifically, we assume $\alpha = 1$. We can easily conclude that

$$\theta_W - \theta_V = \frac{1}{3\mu} \frac{\delta}{\mu + 1} (\mu + \varepsilon) > 0$$

Under these specific circumstances, therefore, a sufficiently large θ (i.e. larger than θ_W), implies a larger welfare under organized crime, as in such a case enforcement effort, as measured by the expected fine, is lower in the presence of the mafia and, if enforcement is very costly, this is likely to more than compensate the foregone benefits from legal disposal as well as the larger damages from illegal disposal arising under the mafia.

6.2 Optimal tax rate

Turning to the optimal tax case, we can use result obtained under cases 2 and 4, to get:

$$m_4 - m_2 = -\frac{1}{2} \frac{\theta}{\gamma} \frac{\mu}{(\mu + 1)^2} < 0$$

$$b_4 - b_2 = \theta \frac{\mu}{\gamma(\mu + 1)} > 0$$

$$g_4 - g_2 = 0$$

$$y_4 - y_2 = \theta \frac{\mu}{\gamma(\mu + 1)} > 0$$

The above inequalities can be summed up as follows.

Proposition 3 *When the tax on legal disposal is optimally set then:*

- *the bribe is smaller under the mafia*
- *illegal disposal is larger in the presence of the mafia, while the presence of a criminal organization does not affect the level of legal disposal.*
- *the level of economic activity is larger under the mafia*

Turning to the enforcement level, the tax rate and social welfare, we get:

$$V_4 - V_2 = -\frac{\theta\mu + 3\theta\mu^2}{\gamma + 2\gamma\mu + \gamma\mu^2} < 0$$

$$t_4 - t_2 = -\theta\frac{\mu}{\gamma + \gamma\mu} < 0$$

$$W_4 - W_2 = \frac{1}{2}\frac{\theta^2}{\gamma}\frac{\mu}{(\mu + 1)^2}(3\mu + 1) > 0$$

Proposition 4 *Enforcement and the tax on legal disposal are smaller under the mafia, while social welfare is larger.*

The surprising result in Proposition 4 is again related to the prevalence of gains in terms of enforcement costs over damages from illegal disposal.

6.3 Entry Incentives

The extortion rate under the budget balancing and the optimal tax are, respectively:

$$x_3 = \frac{1}{2(\mu + 1)}(\varepsilon + (\mu + 1)(V_3 + m_3) + \alpha\mu)$$

$$x_4 = \frac{1}{2(\mu + 1)}(t_4 + (\mu + 1)(V_4 + m_4) + \alpha\mu)$$

We can also obtain the gross rent differential under the two tax regimes. Under budget balancing the rent is:

$$R_3 = (x_3 - m_3 - V_3)b_3$$

while the corresponding rent under the optimal tax is:

$$R_4 = (x_4 - m_4 - V_4)b_4$$

We can identify the incentives of the criminal organization in the waste cycle, for any given fixed entry costs, by comparing the rents arising under the two waste tax regimes, a larger rent implying larger entry incentives. Unfortunately, the comparisons are not straightforward in this case. We need, to get readable insights, to normalize parameter values⁷.

We get, under this respect, the following results:

⁷More specifically, we assume: $\alpha = 100$, $\mu = 10$, $\delta = .1$, $\gamma = .01$, $\varepsilon = .1$, $1.4304 \times 10^{-29} < \theta < 0.10847$ and recall that $t_3 = \varepsilon$. Though such assumptions imply strictly positive values for all variables, the related losses in terms of generality will be subject to investigation in our future research.

Proposition 5 *Entry incentives and the extortion rate can be larger or smaller under the optimal tax as compared to the budget balancing case. However, it might indeed be the case that the mafia has stronger incentive to enter the market when the environmental authority sets a budget balancing tax rate on legal disposal.*

Indeed, comparing the two extortion rates we get:

$$x_4 - x_3 = 25.616 - 38.692\theta$$

which is always negative in the assumed parameters range. Turning to the mafia rent under case 3 and case 4, we get.

$$R_4 - R_3 = 5933.7\theta^2 - 3980.7\theta - 118.99$$

As the above expression is negative in the assumed parameter range, we can conclude that, at least in our example, the entry incentives are strictly larger under a budget balancing waste tax.

7 Concluding remarks

This paper is a first attempt in providing a complete analysis of the impact of bribery to corrupt official(s) and criminal organizations in waste management. Using a simple sequential game we provide some insights on how the presence of criminal organizations might affect illegal disposal and enforcement effort. Also, we get preliminary insights on how the chosen waste tax regime might affect the incentives of the criminal organizations to enter the market.

Additional analysis is of course needed to check for the robustness and to clarify the driving forces of our conclusions. On the other hand, what has been obtained so far looks promising both in theoretical terms and for its (though preliminary) policy implications. Additional effort will also be needed in order to generalize our analysis to less specific functional forms and to model corruption and extortion in a less simplified way.

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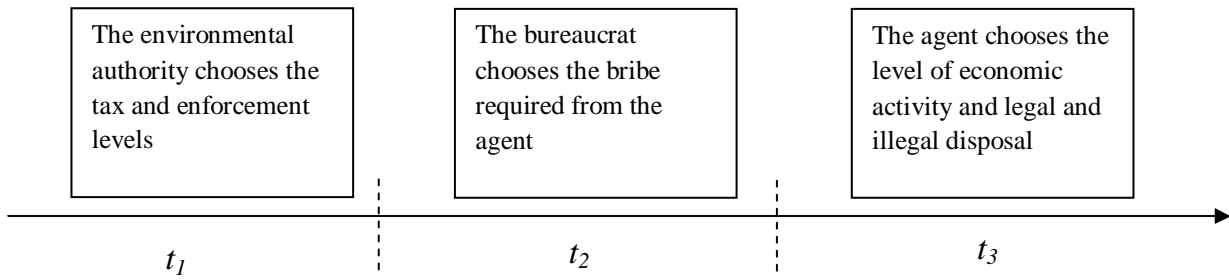


Figure 1a. The game without the mafia

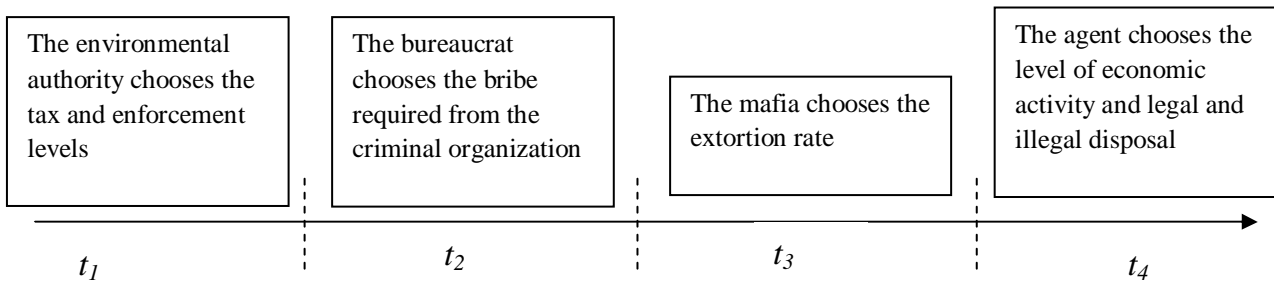


Figure 1b. The game with the mafia