

# Should victims of theft be compensated by the government?

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## Abstract

Should governments compensate the victim for items stolen by a thief if the latter cannot be apprehended? A four-stage model is presented where a thief contemplates whether to attempt theft or not. He may be discouraged if the king's investment in apprehending thieves or the potential victim's effort to thwart attempted theft are sufficiently large. A large compensation rate can be effective in making the king exert high policing efforts. However, the larger the compensation rate and the larger the policing effort, the smaller the effort undertaken by the potential victim to protect himself against theft.

## 1. Introduction

<sup>1</sup>In some of the oldest texts of mankind, kings are expected to compensate the victim for items stolen by a thief if the latter cannot be apprehended.

The Old Egyptian narrative “The voyage of Unamūn” dates from the second half of the second millennium BCE.<sup>2</sup> During his travels, Unamūn finds that

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<sup>1</sup>Valuable hints have been given by Maria Nāther and Alexander Schneider.

<sup>2</sup>For the dating, see Erman (1927, pp. xx-xxi).

[a] man from my ship ran away and stole in Gold: . . . Silver: . . .

On the same (?) morning I arose and went to where the prince was, and said unto him: “I have been robbed in thine harbour. Now thou art the prince of this land, and thou art its judge, so look for my money. . . .”

And he said to me: “Art thou aggrieved (?), or art thou friendly?<sup>3</sup> For behold, I understand nought of this matter that thou hast told me. Had it been a thief belonging to mine own country that went aboard thy ship and stole thy money, then would I have repaid it thee out of my treasury, until thy thief aforesaid had been apprehended. But the thief that hath robbed thee, he is thine, he belongeth to thy ship. So tarry a few days here with me, that I may seek for him.”<sup>4</sup>

Much later (perhaps 7. century CE)<sup>5</sup>, the Indian Law Code of Viṣṇu (Viṣṇu 3.65-67) stipulates:

He [i.e., the king, HW] should safeguard the property of children, of those without a protector, and of women. Recovering property stolen by thieves, he should give all of it to the owner, irrespective of the class he may belong to. If he is unable to recover, he should provide restitution from his own treasury.<sup>6</sup>

It is certainly interesting that in both cultures the local ruler is considered responsible for thefts happening in his realm (or to people under his jurisdiction, see the Egyptian source). First of all, he is to apprehend them and retribute the stolen items to the owners. Second, if or so long as he cannot catch the thief and the stolen items, he is to compensate the victim out of his treasury.

The aim of this paper is find the conditions under which such compensation is a good idea. Of course, compensation need not be 100%. The rate of compensation might be fixed on the constitutional level. Indeed, the Indian king for whom the Law Code of Viṣṇu is relevant, may not find it easy to change that law book’s contents or to claim the relevance of another law book that is more to his liking.

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<sup>3</sup>There is a closing quotation mark here after the question mark which seems to be a typing error.

<sup>4</sup>Erman (1927, p. 176).

<sup>5</sup>For the dating, see Olivelle (2009, pp. 14-15).

<sup>6</sup>Olivelle (2009, p. 54).

That is, we assume that the king cannot alter the compensation rate at his own will.

In order to find out how small or large compensation rates affect the agents' incentives, three game-theoretic models are build. In the first one, the focus is on the "king" and the "thief". The king invests in a police force that allows him to capture a thief should the latter have carried out a theft. The thief who hopes for a valuable item and fears punishment knows about the policing effort and decides on whether to attempt theft or not. The second model focuses on the subject and the thief. The subject can invest in protection measures against theft. If these protection measures thwart off attempted theft with a sufficiently high probability, the thief will desist from trying. The third model includes all three agents.

The paper's central parameter is the compensation rate  $\gamma$ . If the value of the stolen object is  $V > 0$  and the thief is not apprehended, the king pays  $\gamma V$  to the victim. Normally, one would assume  $\gamma \in [0, 1]$ . However,  $\gamma > 1$  can also be interpreted: the king would pay additional damages to the subject for failing to apprehend the thief. For example, the subject may not only be interested in having  $V$  refunded, but also harbours some revenge feelings. Inversely, a compensation rate  $\gamma < 0$  means that the king collects  $\gamma V$  from the victim who already suffers the loss of  $V$ . Perhaps, the king punishes the subject for insufficient protection measures?<sup>7</sup> From the texts above, it seems that the Egyptian and Indian sources had  $\gamma = 1$  in mind. For the Law Code of Viṣṇu, this clearly transpires from the seventeenth-century<sup>8</sup> commentator Nandapaṇḍita and from his Vyāsa citation.<sup>9</sup>

In a sense, our models lie at the crossroads of two different types of models. First, there is the crime-and-punishment literature championed by Becker (1968).<sup>10</sup> In these models, the incentives of offenders to commit crimes, of governments to apprehend and convict offenders, and of potential victims protect themselves against crimes covered and balanced. Second, the incentives of insured potential victims of theft and other damages to prevent theft are dealt with under the heading of moral hazard (for example, Shavell (1979)). In particular, the compensation by the government is similar to the compensation paid by the insurance company.<sup>11</sup> The models presented in the current paper yield these results:

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<sup>7</sup>One is reminded of Brecht's "helpless boy" in the stories of Mr. Keuner. See Brecht (2001, p. 16).

<sup>8</sup>For the dating, see Olivelle (2009, p. 30).

<sup>9</sup>See Krishnamacharya (1964, p. 52).

<sup>10</sup>See also chapter 7 in Posner (2007).

<sup>11</sup>The interested reader may also consult Cooter & Ulen (2008), in particular chapter 2 (on moral hazard) and chapter 8 (on tort law).

Attempted theft can be prevented with sufficiently large policing (by the king) and protecting (by the potential victim) measures. The larger the compensation rate, the larger the king's effort to prevent theft. The larger the compensation rate and the larger the policing effort, the smaller the protection effort.

## 2. King and thief

Apart from the compensation rate  $\gamma$  (fixed at the constitutional level), there are only two active players: the king  $K$  (the government in a jurisdiction) and the potential thief  $T$ . The potential victim or subject  $S$  does not play any active role in this first model. For simplicity's sake  $S$  is also called an agent. The game sequence is as follows:

1. The compensation rate  $\gamma$  can be any non-negative number.
2. The king  $K$  incurs the cost of  $c_K(\alpha) = \frac{a}{2}\alpha^2$  (with  $a > 0$ ) that allow him to apprehend a thief with probability  $\alpha$ .
3. The thief  $T$  attempts to steal from the subject. The attempt is successful and carries the costs of  $C_T > 0$ .

The value of the object is  $V$ . If the thief is apprehended, the king returns the stolen item to the subject, otherwise, the king pays  $\gamma V$  to the victim out of his treasury. The apprehended thief is punished (fine  $F > 0$ ). Therefore, welfare  $W$  and the agents' payoffs (the functions are denoted by  $W$ ,  $K$ ,  $S$ , and  $T$ , respectively) are determined as follows.

The thief's payoffs are given by

$$T = \begin{cases} 0, & \text{theft not carried out} \\ -C_T - F, & \text{theft carried out, but thief apprehended} \\ -C_T + V, & \text{theft carried out and thief not apprehended} \end{cases}$$

for the thief. The subject does not play any active role here and is just concerned with the loss that he may incur:

$$S(\gamma) = \begin{cases} 0, & \text{theft not carried out} \\ 0, & \text{theft carried out, but thief apprehended} \\ -(1 - \gamma)V & \text{theft carried out and thief not apprehended} \end{cases}$$

The king's payoff function reflects that agent's financial interests in a narrow sense:

$$K(\gamma, \alpha) = -c_K(\alpha) + \begin{cases} 0, & \text{theft not carried out} \\ 0, & \text{theft carried out, but thief apprehended} \\ -\gamma V, & \text{theft carried out and thief not apprehended} \end{cases}$$

In this paper, it is assumed that  $F$  is a fine that negatively enters the thief's payoff function. If the fine were monetary,  $+F$  should be a part of the king's payoff after apprehension. If the fine consisted of a prison sentence, the king might have expenditures for running the prison. In that case, the king's payoff would feature prison costs after apprehension. Arguably, one might leave  $F$  out of the king's payoff function by steering the middle ground between these two extremes. For example, if the convicted thief were whipped, the cost to the king were small.

There have been a lot of arguments whether the gain to an offender should be considered of social value.<sup>12</sup> Here, we disregard  $V$  from the thief's payoff function and thus obtain welfare as

$$W(\gamma, \alpha) = -c_K(\alpha) + \begin{cases} 0, & \text{theft not carried out} \\ -C_T - F, & \text{theft carried out, but thief apprehended} \\ -C_T - V, & \text{theft carried out and thief not apprehended} \end{cases}$$

The following assumptions are needed:

- $V > C_T$  (Otherwise the thief will not even find successful attempt attractive.)
- $a \geq \gamma V$  (This assumption ensures that the FOC apprehending probability is not larger than 1.)
- $\gamma \geq 0$  (This assumption ensures that the FOC apprehending probability is not negative.)

At the third stage, the payoff for a thief who has carried out theft is

$$T^{(3)} = -C_T + [\alpha(-F) + (1 - \alpha)V]$$

Thus, stealing is worthwhile if  $T^{(3)} > 0$  holds or, equivalently, if

$$\alpha < \frac{V - C_T}{V + F} =: \alpha_T$$

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<sup>12</sup>This is not the place to seriously enter into that discussion. See the major contenders Becker (1968), Stigler (1970), and Lewin & Trumbull (1990).

Inversely, by letting  $\alpha \geq \alpha_T$ , the king can prevent the thief from stealing.

At the second stage, the king's payoff is

$$K^{(2)}(\gamma) = \begin{cases} -c_K(\alpha), & \alpha \geq \alpha_T \\ -c_K(\alpha) - (1 - \alpha)\gamma V, & \alpha < \alpha_T \end{cases}$$

The FOC with respect to the second line is

$$\tilde{\alpha}(\gamma) = \frac{\gamma V}{a}.$$

This first-order condition can be rewritten as

$$\underbrace{a\tilde{\alpha}(\gamma)}_{\substack{\text{marginal cost} \\ \text{of increasing} \\ \text{apprehending probability}}} = \underbrace{\gamma V}_{\substack{\text{marginal benefit} \\ \text{of increasing} \\ \text{apprehending probability}}}$$

Note that the second-order condition is fulfilled and note  $0 \leq \tilde{\alpha}(\gamma) \leq 1$  by the second and third assumptions above. Note

$$\tilde{\alpha}(\gamma) < \alpha_T \text{ iff } \gamma < \frac{V - C_T}{V + F} \frac{a}{V} =: \gamma_K.$$

Thus,  $\gamma = \gamma_K$  is sufficiently large to deter theft because the king will then choose  $\alpha_T$ . Therefore, the king optimally chooses

$$\alpha^*(\gamma) = \begin{cases} \alpha_T = \frac{V - C_T}{V + F}, & \gamma \geq \gamma_K = \frac{V - C_T}{V + F} \frac{a}{V} \\ \tilde{\alpha}(\gamma) = \frac{\gamma V}{a}, & \gamma < \gamma_K = \frac{V - C_T}{V + F} \frac{a}{V} \end{cases}$$

Summarizing, the probabilities for theft (attempted and carried out) and for non-apprehension are given by

$$\begin{aligned} \text{prob}(\text{theft carried out}) &= \begin{cases} 0, & \gamma \geq \gamma_K \\ 1, & \gamma < \gamma_K \end{cases} \\ \text{prob}(\text{thief not apprehended} | \text{theft carried out}) &= 1 - \tilde{\alpha}(\gamma) \text{ in case of } \gamma < \gamma_K \end{aligned}$$

Turning to the first stage, expected welfare is given by

$$W^{(1)}(\gamma, \alpha^*(\gamma)) = \begin{cases} -c_K(\alpha_T), & \gamma \geq \gamma_K = \frac{V - C_T}{V + F} \frac{a}{V} \\ -c_K[\tilde{\alpha}(\gamma)] - C_T + \tilde{\alpha}(\gamma) \cdot (-F) + [1 - \tilde{\alpha}(\gamma)](-V), & \gamma < \gamma_K = \frac{V - C_T}{V + F} \frac{a}{V} \end{cases}$$

Since the derivative of the second line with respect to  $\gamma$  is positive if  $\gamma \leq \frac{V-F}{V}$ , one finds the welfare-maximal compensation rate<sup>13</sup>

$$\gamma^* \begin{cases} \in [\gamma_K, \infty), & a \leq \frac{V^2-F^2}{V-C_T} \\ = \frac{V-F}{V} & a > \frac{V^2-F^2}{V-C_T} \end{cases}$$

with

$$W^{(1)}(\gamma^*, \alpha^*(\gamma^*)) = \begin{cases} -\frac{a}{2} \left( \frac{V-C_T}{V+F} \right)^2, & a \leq \frac{V^2-F^2}{V-C_T} \\ -V + \frac{1}{2} \frac{(V-F)^2}{a} - C_T, & a > \frac{V^2-F^2}{V-C_T} \end{cases}$$

The main results are summarized in the following

**Theorem 2.1.** *In the king-thief model, for any compensation rate  $\gamma \geq 0$ , the king chooses*

$$\alpha^*(\gamma) = \begin{cases} \tilde{\alpha}(\gamma) = \frac{\gamma V}{a}, & \gamma < \gamma_K = \frac{V-C_T}{V+F} \frac{a}{V} \\ \alpha_T = \frac{V-C_T}{V+F}, & \gamma \geq \gamma_K = \frac{V-C_T}{V+F} \frac{a}{V} \end{cases}$$

*The thief carries out theft in case of  $\alpha^* = \tilde{\alpha}(\gamma)$ , but not in case of  $\alpha^* = \alpha_T$ . Taking the agent's payoff maximizing actions into account, the (or a) compensation rate*

$$\gamma^* \begin{cases} \in [\gamma_K, \infty), & a \leq \frac{V^2-F^2}{V-C_T} \\ = \frac{V-F}{V} & a > \frac{V^2-F^2}{V-C_T} \end{cases}$$

*maximizes welfare (maximum  $W^{(1)}(\gamma^*, \alpha^*(\gamma^*))$ ). In case of  $a \leq \frac{V^2-F^2}{V-C_T}$ , the thief does not carry out theft.*

Compare fig. 2.1. According to the theorem, theft can be prevented with a sufficiently large  $\gamma$  and with relatively small cost of policing. The assumptions on the parameters do not exclude  $\gamma_K > 1$ .<sup>14</sup>

<sup>13</sup>Note  $\gamma_K \leq \frac{V-F}{V}$  iff  $a \leq \frac{V^2-F^2}{V-C_T}$  holds.

<sup>14</sup>If  $\gamma \leq 1$  is to hold, it may be useful to distinguish between  $\gamma_K \leq 1$  and  $\gamma_K > 1$ . The former inequality is equivalent to  $a \leq \frac{V(V+F)}{V-C_T}$ . Note that the interval  $\gamma V < a \leq \frac{V(V+F)}{V-C_T}$  is nonempty. Thus, for  $\gamma \leq 1$ , the theorem can be rewritten as follows: In the king-thief model, the king chooses

$$\alpha^*(\gamma) = \begin{cases} \tilde{\alpha} = \frac{\gamma V}{a}, & a \leq \frac{V(V+F)}{V-C_T} \text{ and } \gamma < \gamma_K \\ \alpha_T = \frac{V-C_T}{V+F}, & a \leq \frac{V(V+F)}{V-C_T} \text{ and } \gamma \geq \gamma_K \\ \tilde{\alpha} = \frac{\gamma V}{a}, & a > \frac{V(V+F)}{V-C_T} \end{cases}$$

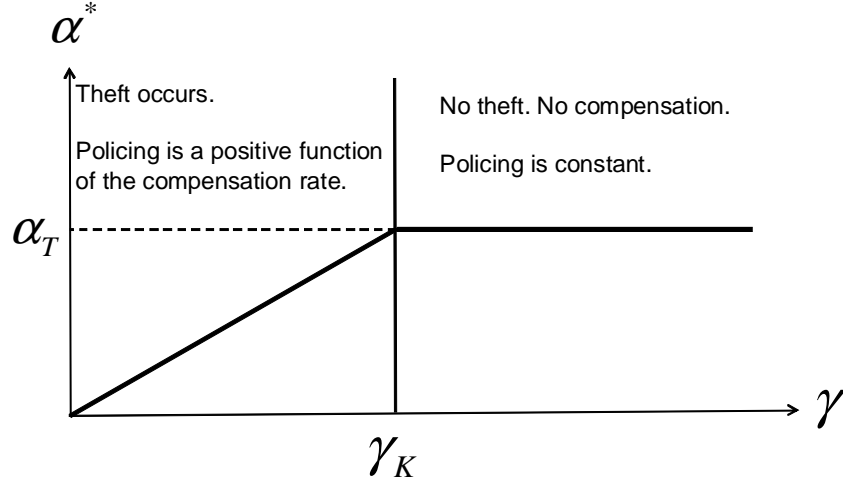


Figure 2.1: Outcomes of the king-thief model

Consider the condition ( $a \leq \frac{V^2 - F^2}{V - C_T}$ ). If apprehension is relatively cheap ( $a$  small) and carrying out theft costly ( $C_T$  large), the optimal compensation rate prevents the thief from trying theft. This condition is also met if the fine is small. This result is seemingly counterintuitive. Note, however, that a small fine  $F$  leads to a large  $\alpha_T$  (that is necessary to prevent theft).  $\alpha_T$  is smaller than  $\tilde{\alpha}(\gamma)$  (so that preventing theft is optimal for the king) if  $\gamma$  is sufficiently large, i.e., larger than  $\gamma_K$  which is large for small  $F$ . Thus, the thief is prevented from carrying out theft is the fine is small because a larger welfare-optimal compensation rate together with a larger apprehension rate makes theft unattractive for him.

### 3. Subject and thief

In the second model, there are two active players, the potential victim or subject  $S$  and the potential thief  $T$ . The king is not active and  $\alpha = 0$  is assumed. The model again proceeds in three stages:

1. The compensation rate  $\gamma$  can be any number not larger than 1.
2. The subject  $S$  invests in protection measures. He can thwart attempted theft with probability  $\theta$ , by incurring the costs of  $c_S(\theta) = \frac{d}{2}\theta^2$  (with  $d > 0$ ).



3. The thief  $T$  attempts to steal from the subject. With probability  $1 - \theta$ , this attempt fails. The attempt carries the costs of  $C_T > 0$ .

Welfare and the agents' payoffs are given by

$$T = \begin{cases} 0, & \text{theft not attempted} \\ -C_T, & \text{theft attempted, but not carried out} \\ -C_T + V, & \text{theft carried out and thief not apprehended} \end{cases}$$

for the thief,

$$S(\theta) = -c_S(\theta) + \begin{cases} 0, & \text{theft not attempted or not carried out} \\ -(1 - \gamma)V & \text{theft carried out} \end{cases}$$

for the subject,

$$K(\gamma) = \begin{cases} 0, & \text{theft not attempted or not carried out} \\ -\gamma V, & \text{theft carried out} \end{cases}$$

for the king, and welfare

$$W(\gamma, \theta) = -c_S(\theta) + \begin{cases} 0, & \text{theft not attempted} \\ -C_T, & \text{theft attempted, but not carried out} \\ -C_T - V, & \text{theft carried out and thief not apprehended} \end{cases}$$

The following assumptions are required to hold:

- $V > C_T$
- $d \geq (1 - \gamma)V$  (This assumption ensures that the FOC thwarting probability is not larger than 1.)
- $\gamma \leq 1$  (This assumption ensures that the FOC thwarting probability is not negative.)

At the third stage, the payoff for a thief who has carried out theft is

$$T^{(3)} = -C_T + \theta \cdot 0 + (1 - \theta)V.$$

Therefore, attempting to steal is worthwhile if  $T^{(3)} > 0$  holds or, equivalently, if

$$\theta < \frac{V - C_T}{V} =: \theta_T$$

At the second stage, the potential victim chooses the thwarting probability  $\theta$ . Within the interval  $[0, \theta_T)$  (where the thief attempts theft), the subject's payoff is

$$S^{(2)}(\theta) = -c_S(\theta) - (1 - \theta)(1 - \gamma)V$$

The FOC is

$$\tilde{\theta}(\gamma) = \frac{(1 - \gamma)V}{d}$$

This first-order condition can be rewritten as

$$\underbrace{d\tilde{\theta}(\gamma)}_{\substack{\text{marginal cost} \\ \text{of increasing} \\ \text{thwarting probability}}} = \underbrace{(1 - \gamma)V}_{\substack{\text{marginal benefit} \\ \text{of increasing} \\ \text{thwarting probability}}}$$

Note that the second-order condition is fulfilled and note  $\tilde{\theta}(\gamma) < 1$  by  $d > (1 - \gamma)V$ . Note  $\tilde{\theta}(\gamma) < \theta_T$  iff

$$\gamma > \frac{V^2 - d(V - C_T)}{V^2} =: \gamma_S.$$

Thus,  $\gamma = \gamma_S$  is sufficiently small to deter theft because the subject will then choose  $\theta_T$ . Therefore, the subject optimally chooses

$$\theta^*(\gamma) = \begin{cases} \tilde{\theta}(\gamma) = \frac{(1-\gamma)V}{d}, & \gamma > \gamma_S = \frac{V^2 - d(V - C_T)}{V^2} \\ \theta_T = \frac{V - C_T}{V}, & \gamma \leq \gamma_S = \frac{V^2 - d(V - C_T)}{V^2} \end{cases}$$

From these two stages, the probabilities for attempting and carrying out theft and for non-apprehension are given by

$$\begin{aligned} \text{prob}(\text{theft attempted}) &= \begin{cases} 0, & \gamma \leq \gamma_S \\ 1, & \gamma > \gamma_S \end{cases} \\ \text{prob}(\text{theft carried out} | \text{theft attempted}) &= 1 - \tilde{\theta}(\gamma) \text{ in case of } \gamma > \gamma_S \\ \text{prob}(\text{thief not apprehended} | \text{theft carried out}) &= 1 \text{ in case of } \gamma > \gamma_S \end{aligned}$$

Thus,  $\gamma = \gamma_S$  is sufficiently small to deter theft because the potential victim will then choose  $\theta_T$ .

Turning to the first stage, expected welfare is given by

$$W^1(\gamma, \theta^*(\gamma)) = \begin{cases} -c_S[\theta^*(\gamma)] - C_T + \tilde{\theta}(\gamma) \cdot 0 + [1 - \tilde{\theta}(\gamma)](-V), & \gamma > \gamma_S = \frac{V^2 - d(V - C_T)}{V^2} \\ -c_S(\theta_T), & \gamma \leq \gamma_S = \frac{V^2 - d(V - C_T)}{V^2} \end{cases}$$

Since the derivative of the first line with respect to  $\gamma$  is negative, the interval of welfare-optimal compensation rates  $\gamma^*$  is  $[0, \gamma_S]$  with  $W^1(\gamma^* \in [0, \gamma_S], \theta^*(\gamma^*)) = -c_S(\theta_T)$ .

Thus, the following theorem holds:

**Theorem 3.1.** *In the subject-thief model, for any compensation rate  $\gamma \leq 1$ , the subject chooses*

$$\theta^*(\gamma) = \begin{cases} \tilde{\theta}(\gamma) = \frac{(1-\gamma)V}{d}, & \gamma > \gamma_S = \frac{V^2 - d(V - C_T)}{V^2} \\ \theta_T = \frac{V - C_T}{V}, & \gamma \leq \gamma_S = \frac{V^2 - d(V - C_T)}{V^2} \end{cases}$$

*The thief attempts theft in case of  $\theta^*(\gamma) = \tilde{\theta}(\gamma)$ , but not in case of  $\theta^*(\gamma) = \theta_T$ . Taking the agent's payoff maximizing actions into account, the compensation rates  $\gamma^* \in [0, \gamma_S]$  maximize welfare (maximum  $-c_S(\theta_T)$ ).*

Compare fig. 3.1. According to the theorem, attempted theft is thwarted with probability  $\tilde{\theta}(\gamma) = \frac{(1-\gamma)V}{d}$ . That is, theft tends not to be carried out (after being attempted) if  $\gamma$  is small or if the subject's costs of theft prevention are relatively small. The assumptions on the parameters do not exclude  $\gamma_S < 0$ , for very large protection costs.<sup>15</sup> The optimal compensation rate lie left of  $\gamma_S$ . The potential vicim invests in protecting measures sufficient to make the thief abstain from attempting theft.

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<sup>15</sup>If  $\gamma \geq 0$  is to hold, it may be useful to distinguish between  $\gamma_S \geq 0$  and  $\gamma_S < 0$ . The former inequality is equivalent to  $d \leq \frac{V^2}{V - C_T}$ . Note that the interval  $V(1 - \gamma) < d \leq \frac{V^2}{V - C_T}$  is nonempty even for  $\gamma = 0$ . Thus, for  $\gamma \geq 0$ , the theorem can be rewritten as follows: In the subject-thief model, the subject chooses

$$\theta^*(\gamma) = \begin{cases} \tilde{\theta}(\gamma) = \frac{(1-\gamma)V}{d}, & d \leq \frac{V^2}{V - C_T} \text{ and } \gamma > \gamma_S \\ \theta_T = \frac{V - C_T}{V}, & d \leq \frac{V^2}{V - C_T} \text{ and } \gamma < \gamma_S \\ \tilde{\theta}(\gamma) = \frac{(1-\gamma)V}{d}, & d > \frac{V^2}{V - C_T} \end{cases}$$

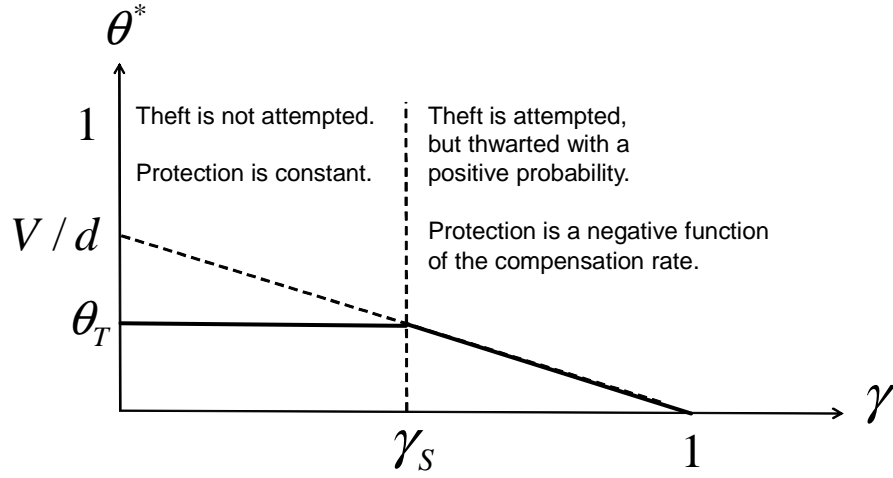


Figure 3.1: Outcomes of the subject-thief model

#### 4. King, subject, and thief

In the third model, all three agents are actively involved. The model cannot be solved in total, but resort to specific parameters turns out to be necessary. The assumptions  $a > 0$ ,  $d > 0$ ,  $V > C_T > 0$ ,  $F > 0$  continue to hold. The game sequence is:

1. Constitutionally,  $\gamma$  is determined.
2. The king  $K$  incurs the cost of  $c_K(\alpha) = \frac{a}{2}\alpha^2$  (with apprehension probability  $\alpha$ ).
3. The subject  $S$  incurs the costs of  $c_S(\theta) = \frac{d}{2}\theta^2$  (with thwarting probability  $\theta$ ).
4. The thief incurs the costs of  $C_T$  for attempting theft.

The agents' payoffs are

$$T = \begin{cases} 0, & \text{theft not attempted} \\ -C_T, & \text{theft attempted, but not carried out} \\ -C_T - F, & \text{theft carried out, but thief apprehended} \\ -C_T + V, & \text{theft carried out and thief not apprehended} \end{cases}$$

for the thief,

$$S(\theta) = -c_S(\theta) + \begin{cases} 0, & \text{theft not attempted or not carried out} \\ 0, & \text{theft carried out, but thief apprehended} \\ -(1-\gamma)V & \text{theft carried out and thief not apprehended} \end{cases}$$

for the subject,

$$K(\gamma, \alpha) = -c_K(\alpha) + \begin{cases} 0, & \text{theft not attempted or not carried out} \\ 0, & \text{theft carried out, but thief apprehended} \\ -\gamma V, & \text{theft carried out and thief not apprehended} \end{cases}$$

for the king, and welfare is given by

$$W(\gamma, \alpha, \theta) = -c_K(\alpha) - c_S(\theta) + \begin{cases} 0, & \text{theft not attempted} \\ -C_T, & \text{theft attempted, but not carried out} \\ -C_T - F, & \text{theft carried out, but thief apprehended} \\ -C_T + V, & \text{theft carried out and thief not apprehended} \end{cases}$$

Assume the special case of  $\gamma = 0$ . Then the king's payoff function is  $K(0, \alpha) = -c_K(\alpha)$  so that the king will choose  $\alpha^* = 0$ . Then, the subject-thief model ensues. If  $\gamma = 1$  holds (see the introduction), the subject's payoff is  $S(\theta) = -c_S(\theta)$  so that the subject will not incur any protection costs. Then, one obtains the king-thief model.

Turning to the general model (for any  $\gamma$ ), the assumptions  $a \geq \gamma V$  and  $d \geq 2V(1-\gamma)$  are required for FOC apprehending and thwarting probabilities within  $[0, 1]$ .

At the fourth stage, the payoff for a thief who attempts to steal is

$$T^{(4)} = -C_T + \theta \cdot 0 + (1-\theta)[\alpha(-F) + (1-\alpha)V]$$

Thus, attempting theft is worthwhile if  $T^{(4)} > 0$  holds or, equivalently, if  $\alpha(-F) + (1-\alpha)V > 0$  (i.e.,  $\alpha < \frac{V}{V+F} =: \alpha_T(0)$ ) and

$$\theta < 1 - \frac{C_T}{\alpha(-F) + (1-\alpha)V} =: \theta_T(\alpha)$$

hold. Note  $\theta_T(\alpha) \geq 0$  iff  $\alpha \leq \frac{V-C_T}{V+F} =: \alpha_T(C_T)$ . Thus,  $\alpha = \alpha_T(C_T)$  is sufficient to deter the potential thief even in case of  $\theta = 0$ .

**Lemma 4.1.**  $\frac{\partial \theta_T(\alpha)}{\partial \alpha} < 0$  holds.

Thus, if the king increases policing efforts, a smaller thwarting-probability threshold is sufficient to make the thief abstain.

Assume  $\alpha < \alpha_T(0)$ . Within the interval  $[0, \theta_T(\alpha)]$  (where the thief attempts theft), the subject's payoff is

$$S^{(3)}(\theta) = -c_S(\theta) + (1 - \theta) [\alpha \cdot 0 - (1 - \alpha)(1 - \gamma)V]$$

with first-order condition

$$\tilde{\theta}(\gamma, \alpha) = \frac{(1 - \alpha)(1 - \gamma)}{d}V.$$

Therefore, one finds:

**Lemma 4.2.** *If the thief is not deterred from attempting theft, the subject chooses a low protection if  $\alpha$  is large (i.e., the thief apprehended with a high probability) and/or if  $\gamma$  is large (i.e., the subject is refunded a large portion of the stolen property's value).*

We can rewrite this first-order condition as

$$\underbrace{d\tilde{\theta}(\gamma, \alpha)}_{\substack{\text{marginal cost} \\ \text{of increasing} \\ \text{thwarting probability}}} = \underbrace{(1 - \alpha)(1 - \gamma)V}_{\substack{\text{marginal benefit} \\ \text{of increasing} \\ \text{thwarting probability}}}$$

Note that the second order condition for a maximum is fulfilled by the assumptions on  $a$  and  $d$  above. Thus, the subject's choice of  $\theta$  is given by

$$\theta^*(\gamma, \alpha) = \begin{cases} 0, & \alpha \geq \alpha_T(C_T) \\ \min(\theta_T(\alpha), \tilde{\theta}(\gamma, \alpha)), & \alpha < \alpha_T(C_T) \end{cases}$$

At the second stage, the king's payoff is

$$K^{(2)}(\alpha) = \begin{cases} -c_K(\alpha), & \alpha \geq \alpha_T(C_T) \\ -c_K(\alpha), & \alpha < \alpha_T(C_T) \text{ and } \theta_T(\alpha) \leq \tilde{\theta}(\gamma, \alpha) \\ -c_K(\alpha) - (1 - \tilde{\theta}(\gamma, \alpha))(1 - \alpha)\gamma V, & \alpha < \alpha_T(C_T) \text{ and } \tilde{\theta}(\gamma, \alpha) < \theta_T(\alpha) \end{cases}$$

With respect to the third line, the FOC

$$\tilde{\alpha}(\gamma) = \frac{dV\gamma - 2V^2\gamma(1-\gamma)}{ad - 2V^2\gamma(1-\gamma)}$$

is obtained where the second-order conditions holds by the two assumptions on  $a$  and  $d$ . They also guarantee  $0 \leq \tilde{\alpha}(\gamma) \leq 1$ .

**Lemma 4.3.**  $\frac{\partial \tilde{\alpha}(\gamma)}{\partial \gamma} < 0$  holds.

Thus, if the constitutionally determined compensation rate  $\gamma$  is increased, the king increases his policing efforts.

Since the general model is too complicated, we now resort to a special case with parameters  $V = 1$ ,  $F = 2$ ,  $C_T = \frac{1}{3}$ ,  $a = d = 3$ . The proof (and the relevant formulae) are given in the appendix. There, it is shown that for low  $\gamma$  (in particular  $\gamma < \bar{\gamma} \approx 0.74$ )

- the king chooses an apprehension rate  $\tilde{\alpha}(\gamma)$
- that makes the subject choose a thwarting probability  $\tilde{\theta}(\gamma, \tilde{\alpha}(\gamma))$
- that makes the thief attempt theft.

In contrast, for relatively large  $\gamma$ , i.e.,  $\gamma > \bar{\gamma} \approx 0.74$ ,

- the king chooses

$$\alpha_S(\gamma) = \frac{1}{6(1-\gamma)} \left( \sqrt{4\gamma^2 + 40\gamma + 37} - 5 - 4\gamma \right)$$

- that is sufficient to make the subject choose a thwarting probability (namely  $\theta_T(\alpha_S)$ )
- that makes the thief abstain from trying theft.

For the special parameters given above, the probabilities for attempting and carrying out theft and for non-apprehension are given by

$$\begin{aligned} \text{prob}(\text{theft attempted}) &= \begin{cases} 0, & \gamma \geq \bar{\gamma} \\ 1, & \gamma < \bar{\gamma} \end{cases} \\ \text{prob}(\text{theft carried out} | \text{theft attempted}) &= 1 - \tilde{\theta}(\gamma, \tilde{\alpha}(\gamma)) \text{ in case of } \gamma < \bar{\gamma} \\ \text{prob}(\text{thief not apprehended} | \text{theft carried out}) &= 1 - \tilde{\alpha}(\gamma) \text{ in case of } \gamma < \bar{\gamma} \end{aligned}$$

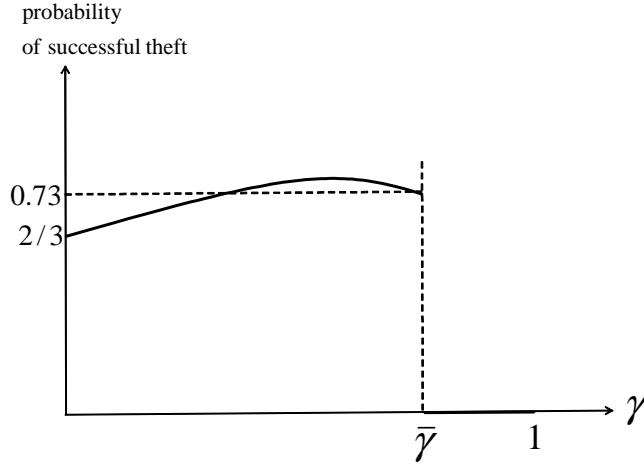


Figure 4.1: Probability of successful theft for small gamma

In case of  $\gamma < \bar{\gamma}$ , theft is attempted, carried out and left unpunished with probability<sup>16</sup>

$$\left(1 - \tilde{\theta}(\gamma, \tilde{\alpha}(\gamma))\right) (1 - \tilde{\alpha}(\gamma))$$

Consider fig. 4.1. A priori, it is unclear whether an increase in  $\gamma$  increases or decreases the probability of successful theft. While the increase of the compensation rate (in the region below  $\bar{\gamma}$ ) increases the apprehension rate, it decreases the thwarting probability. In fact, the latter is negatively influenced by two mechanisms. First, in a direct fashion,  $\tilde{\theta}(\gamma, \alpha) = \frac{(1-\alpha)(1-\gamma)}{d}V$  is reduced when  $\gamma$  is increased. Second, there is an indirect effect. A large  $\gamma$  increases  $\alpha^*(\gamma)$  and this also has a negative effect on  $\tilde{\theta}(\gamma, \alpha)$ . For the specific parameters chosen in the theorem, starting from  $\gamma = 0$ , the larger  $\gamma$ , the larger the probability of successful theft. For larger values of  $\gamma$ , but below  $\bar{\gamma}$ , the apprehension effect of increasing  $\gamma$  outweighs the thwarting effect.

Expected welfare is given by

$$\begin{aligned}
 & W(\gamma, \alpha^*, \theta^*) \\
 = & \begin{cases} -c_K[\alpha_S(\gamma)] - c_S(\theta_T[\alpha_S(\gamma)]), & \gamma \geq \bar{\gamma} \\ -c_K(\tilde{\alpha}(\gamma)) - c_S(\tilde{\theta}(\gamma, \tilde{\alpha}(\gamma))) + \tilde{\theta}(\gamma, \tilde{\alpha}(\gamma)) \cdot 0 & \gamma < \bar{\gamma} \\ + [1 - \tilde{\theta}(\gamma, \tilde{\alpha}(\gamma))] \tilde{\alpha}(\gamma)(-F) + [1 - \tilde{\theta}(\gamma, \tilde{\alpha}(\gamma))] [1 - \tilde{\alpha}(\gamma)](-V), & \gamma < \bar{\gamma} \end{cases}
 \end{aligned}$$

<sup>16</sup>For  $\gamma = 0$ , this probability is  $\frac{2}{3}$ , for  $\gamma = 0.546$ , it is about 0.7.



A plot of welfare and numerical calculations yield the welfare-optimal compensation rate  $\gamma^* \approx 0.9$ . It is clear that compensation rates  $\gamma$  just below the threshold  $\bar{\gamma}$  are particularly ill-advised. By increasing  $\gamma$  up to the threshold, theft is not even attempted.

**Theorem 4.4.** *In the king-subject-thief model with parameters  $V = 1$ ,  $F = 2$ ,  $C_T = \frac{1}{3}$ ,  $a = 3$ , and  $d = 3$ , and any compensation rate  $\gamma$  the king chooses*

$$\alpha^*(\gamma) = \begin{cases} \alpha_S(\gamma), & \gamma \geq \bar{\gamma} \\ \tilde{\alpha}(\gamma) = \frac{3\gamma - 2\gamma(1-\gamma)}{9 - 2\gamma(1-\gamma)}, & \gamma < \bar{\gamma} \end{cases}$$

with  $\frac{\partial \alpha_S}{\partial \gamma} > 0$ . The subject employs the protection rate

$$\theta^*(\gamma) = \begin{cases} \theta_T(\alpha_S), & \gamma \geq \bar{\gamma} \\ \tilde{\theta}(\gamma, \tilde{\alpha}(\gamma)), & \gamma < \bar{\gamma} \end{cases}$$

The thief attempts theft only in case of  $\gamma < \bar{\gamma}$ . The welfare-maximal compensation rate is  $\gamma^* \approx 0.9$  where the thief abstains from trying.

Consult the appendix for a proof. Compare fig. 4.2. In contrast to theorem 2.1 and fig. 2.1, the policing rate is a positive function of the compensation rate for large  $\gamma$ . In the former case (without protection organized by the subject), the king chooses the minimal deterring policing rate. In the present case (with protection by the subject), the thief is also deterred from attempting theft. However, with a larger compensation rate, the subject is less willing to invest in protection measures. Therefore, the king (who foresees this declining willingness) sends more policemen so that theft is deterred even after taking reduced protection measures into account. It turns out that a relatively large  $\gamma$  is welfare optimal. It prevents theft.

Note  $\alpha_S(\gamma^*) \approx 0.22$  and  $\tilde{\theta}(\gamma^*, \tilde{\alpha}(\gamma^*)) \approx 0.02$ . Since both cost functions are convex, one might surmise that a more even distribution of apprehension and thwarting probabilities should result. However, the subject only prevents attempted theft from being carried out. In contrast, the king not only takes  $V$  back, but also imposes a fine which is twice as large as  $V$  in the chosen example.

## 5. Conclusions

It seems that compensation for theft is unusual. For example, the German ‘‘Gesetz über die Entschädigung für Opfer von Gewalttaten (Opferentschädigungsgesetz -

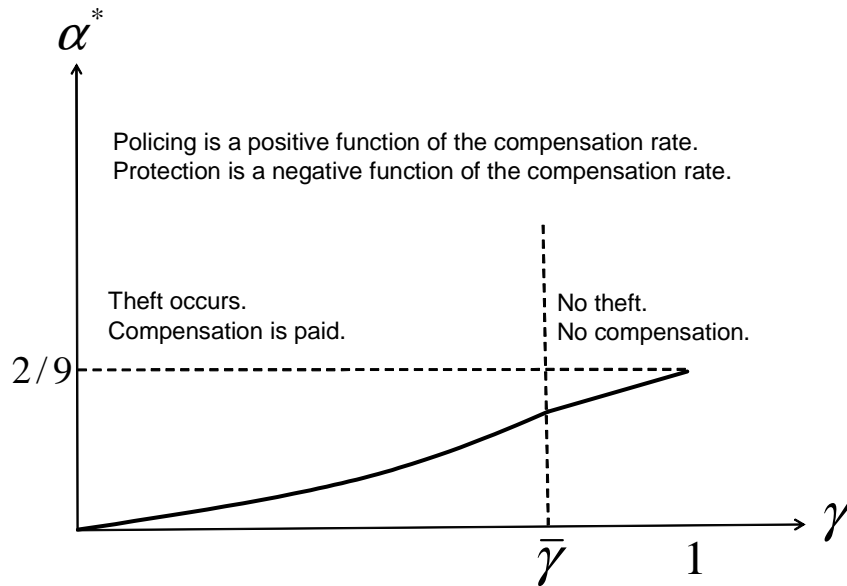


Figure 4.2: Outcomes of the king-subject-thief model

OEG)” promises compensation for “gesundheitliche Schädigung”, i.e., damage to health.<sup>17</sup> Similarly, the Canadian province of Manitoba stipulates: “The Compensation for Victims of Crime Program only covers physical or emotional injury. It does not cover damaged or stolen property or belongings.”<sup>18</sup> The reluctance to compensate theft in modern times, may be due to the fact that claims of theft are more difficult to confirm than claims of bodily harm.

The welfare-analysis of compensation gets even more complicated for several potential victims. One might suggest that a negative externality exists that one potential victim inflicts on the other one. By choosing a large thwarting probability, a subject may make the property of other subjects more liable to attempted theft. Also, externalities between different jurisdictions surely exist. If the compensation rate in country 1 is larger than in country 2, the subjects of country 1 tend to choose smaller protection rates than those of country 2 while policing efforts tend to be larger in country 1 than in country 2. It is unclear whether these two effects make country 1 more or less attractive for international robbers, for

<sup>17</sup>See the assessment of this law’s working by Bartsch, Brettel, Blauert & Hellmann (2014).

<sup>18</sup>website (consulted on May 5th, 2017): <https://www.gov.mb.ca/justice/victims/pubs/compensation.pdf>

example in the Europe of the Schengen agreement. However, attempted robberies are more often carried out in country 1 than in country 2, and carried-out robberies are more often punished in country 1 than in country 2. One might expect that newspapers in country 1 have more to tell about robberies and conviction of robbers.

## 6. Appendix: Proof of theorem 4.4

The parameters mentioned in the theorem fulfill the above assumptions. Note

$$\begin{aligned} & \tilde{\theta}(\gamma, \alpha) \geq \theta_T(\alpha) \\ \Leftrightarrow & \alpha^2 + \frac{-2(1-\gamma)V^2 - FV(1-\gamma) + Fd + Vd}{(1-\gamma)(F+V)V} \alpha + \frac{-d(V - C_T) + V^2(1-\gamma)}{(1-\gamma)(F+V)V} \geq 0 \end{aligned}$$

Substituting the parameters, this inequality reads  $\alpha^2 + \frac{1}{3} \frac{4\gamma+5}{1-\gamma} \alpha - \frac{1}{3} \frac{\gamma+1}{1-\gamma} \geq 0$ . The corresponding equality has two solutions:

$$\begin{aligned} \alpha_1 &= -\frac{1}{6(1-\gamma)} \left( 5 + 4\gamma + \sqrt{4\gamma^2 + 40\gamma + 37} \right) < 0 \text{ and} \\ \alpha_2 &= \frac{1}{6(1-\gamma)} \left( \sqrt{4\gamma^2 + 40\gamma + 37} - 5 - 4\gamma \right) \text{ with} \\ \alpha_2(\gamma = 1) &= \lim_{\gamma \rightarrow 1} \frac{1}{6(1-\gamma)} \left( \sqrt{4\gamma^2 + 40\gamma + 37} - 5 - 4\gamma \right) \\ &= \frac{2}{9} = 0.222 \end{aligned}$$

Simple algebraic manipulations show  $0 < \alpha_2 < 1$ . Define  $\alpha_S := \alpha_2$ .

Thus, one obtains

$$\begin{aligned}
\alpha_T(C_T) &= \frac{2}{9}, \\
\alpha_S(\gamma) &= \alpha_2 \text{ with } \frac{\partial \alpha_S}{\partial \gamma} > 0, \\
\tilde{\alpha}(\gamma) &= \frac{3\gamma - 2\gamma(1-\gamma)}{9 - 2\gamma(1-\gamma)} \text{ with } \frac{\partial \tilde{\alpha}(\gamma)}{\partial \gamma} > 0, \\
\theta_T(\alpha) &= 1 - \frac{1}{3 - 9\alpha} \text{ with } \frac{\partial \theta_T(\alpha)}{\partial \alpha} < 0, \\
\theta_T(\alpha_S(\gamma)) &= 1 - \frac{1}{3 - 9\frac{1}{6(1-\gamma)} \left( \sqrt{4\gamma^2 + 40\gamma + 37} - 5 - 4\gamma \right)}, \\
\tilde{\theta}(\gamma, \alpha) &= \frac{(1-\alpha)(1-\gamma)}{3} \text{ with } \frac{\partial \tilde{\theta}(\gamma, \alpha)}{\partial \gamma} < 0, \\
\tilde{\theta}(\gamma, \tilde{\alpha}(\gamma)) &= \frac{(1-\gamma)(3-\gamma)}{9 - 2\gamma + 2\gamma^2} \text{ with } \frac{\partial \tilde{\theta}(\gamma, \tilde{\alpha}(\gamma))}{\partial \gamma} < 0 \text{ for } \gamma \in [0, 1] \\
(1 - \tilde{\theta}(\gamma, \tilde{\alpha}(\gamma)))(1 - \tilde{\alpha}(\gamma)) &= 3 \frac{(2\gamma + \gamma^2 + 6)(3-\gamma)}{(9 - 2\gamma + 2\gamma^2)^2}
\end{aligned}$$

and

$$\begin{aligned}
\alpha_S &> \tilde{\alpha}(\gamma) \text{ iff } \gamma < \bar{\gamma} \approx 0.74, \\
\alpha_T(C_T) &> \tilde{\alpha}(\gamma) \text{ iff } \gamma \lesssim 0.76 \\
\alpha_S &< \alpha_T(C_T)
\end{aligned}$$

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