Public Good Provision: A Tale of Tax Evasion and Corruption

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Public Good Provision:
A Tale of Tax Evasion and Corruption*

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Abstract

We develop a model that links tax evasion, corruption, and public good provision. In our model, citizens pay or evade taxes into the public fund, which a corrupt governor redistributes. Each citizen forms expectations about the amount of public goods the governor should provide. After observing the actual level of public goods, a citizen punishes the governor if this level is below his expectations. We describe three types of equilibria: tax evasion, efficient public good provision, and symmetric mixed-strategy. We show that the highest expectations can lead to no free riding (tax evasion) and the efficient level of public good provision even with the corrupt governor and without punishment for tax evasion.

Keywords : Tax evasion, Audits, Embezzlement, Corruption, Sanctions, Public goods.

JEL Codes : H40, D83, D73

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1 Introduction

Tax is a mandatory financial charge levied upon the citizens to fund public expenditures including provision of public goods. A citizen's decision of whether or not to pay taxes not only depends on monetary reasons, but also on several non-monetary factors. These include social norms, peer pressure, trust in government and political corruption. In most societies, elected political leaders (mayors, governors, etc.) control the public funds and decide how to redistribute them. Empirical evidence shows that political corruption (such as embezzlement of public funds by governmental officials for private gain) exists both in developed and developing countries, see, for example, Costas-Pérez et al. (2012), Ferraz and Finan (2008), Reinikka and Svensson (2004). However, there is a surprising lack of study on the connections among tax evasion, political corruption, and public good provision.

In this paper, we develop a theoretical model to show how citizens' tax evasion and the governor's embezzlement affect public good provision. The main problem of public good provision is free riding. In our model, each citizen decides whether to evade taxes and free ride on public goods or not. The governor collects taxes in the public fund and decides how to allocate it. The governor is corrupt and behaves in her own self interests: she embezzles public funds if her benefits outweigh her costs. Even though the free rider problem is magnified by the corrupt governor in our model, we show that this governor in fact helps to obtain the efficient public good provision even without punishments for tax evasion.

There are two types of punishments in the model. First, each citizen can be punished for the tax evasion with a positive probability. Tax authorities can only monitor a certain fraction of citizens and this probability is typically less than one. Moreover, each citizen forms expectations about public good provision and if the actual provision is below these expectations, then the citizen punishes the governor. Empirical evidence shows that indeed citizens tend to punish by not re-electing corrupt politicians, see, for example Ferraz and Finan (2011), Welch and Hibbing (1997).

We obtain three main results in the model. First, the efficient public good provision equilibrium is characterized. We show that if the punishment for embezzlement of public funds is high enough, then there exists an equilibrium where all citizens pay taxes and expect the efficient public good provision from the governor. If this provision is not provided by the governor, then all citizens punish her. This leads to a situation where the governor either provides the efficient level of public goods if she collects enough funds or she embezzles all public funds because she is punished for all other levels of public good provision. In this situation each citizen is pivotal for public good provision and the efficient level of public good provision can be achieved without punishment for tax evasion.

Note that citizens' expectations of the public good provision are a measure of accountability for the elected politician (the governor in our model) which prevent embezzling of public funds. Accountability has been widely studied in political science and political economy literature (see, for example, Duggan and Martinelli (2017), Maskin and Tirole (2004), Persson et al. (1997)) with the emphasis on elections and organizational structures. Instead of focusing on political accountability, in this paper, we focus on social accountability. According to the World Bank, "while the concept of social accountability remains contested, it can broadly be understood as a range of actions and strategies beyond voting, that societal actors – namely the citizens – employ to hold the state to account" (O'Meally, 2013). Citizens could use a multitude of social accountability mechanisms to put pressure and hold public officials or/and elected politician accountable. When citizens perceive their rights to be violated and/or there are inadequate goods and services provided, they challenge the government. Some examples of social accountability measures include the monitoring and oversight of public sector performance, protesting, complaints and claim-making.[1] For example, India has a long history of the formal mechanism of complaint and claim-making called "grievance redress mechanism" (Auerbach & Kruks-Wisner, 2020; Post & Agarwal, 2011). The central idea of the mechanism is that in the case that the citizens' expectations for a certain level of public goods or services are not met, the citizens can complain to a government agency and hold the officials accountable. The officials concerned are required to respond to such a complaint. This further encourages citizens to make official complaints, which creates a positive feedback loop.

[1] See Fox (2015) for a meta-analysis on social accountability.

Second, as in any public good game, the tax evasion equilibrium is characterized. We show that if the punishment for tax evasion is relatively small, then all citizens can evade taxes and expect the minimal level of the public good provision from the governor, who in turn always provides the minimal level of public goods. Note that the citizens' expectations are always correct and self-enforced in this equilibrium.

Finally, we show that for any citizens' expectations, there always exists a (mixed-strategy) equilibrium, where the governor matches these expectations: she either provides exactly the expected level of public good if she collects enough funds or embezzles all public funds if she does not collect enough funds to match the expectations.

There is a lot of literature on tax evasion, embezzlement, and public goods. Each topic deserves its own special attention. Allingham and Sandmo (1972), in their seminal paper, analyze an individual taxpayer's decision. The individual decides how much of their income to declare to the tax authority with a given tax rate and a fixed probability of audit. Since then, the literature on tax evasion has expanded. See Slemrod (1985), Slemrod and Yitzhaki (2002), and Alm (2019) for a review of the tax evasion literature.

Corruption and embezzlement are extensively studied both by economists and political scientists. See, for example, Ades and Di Tella (1999), Brollo et al. (2013), Weitz-Shapiro and Winters (2017), Welch and Hibbing (1997), where corrupt behavior of a ruler is punished by individual population members via elections.

The literature on public goods started from Samuelson (1954). See also Chaudhuri (2011), Ledyard (1995) for reviews. The recent work is focused on improving the mechanism of redistributing public funds and decreasing the free rider problem. A peer punishment (i.e. decentralised or informal punishment), see Fehr and Gächter (2000, 2002), as well as, a central sanction mechanism, see Andreoni and Bergstrom (1996), Baldassarri and Grossman (2012), Markussen et al. (2014, 2016), have been used to tackle the free rider problem.

Even though the literature on tax evasion, corruption and public good provision is vast, only a handful of papers look into the interplay between them. Lambert-Mogiliansky (2015) links public good provision, corruption and social accountability by considering a model where a public official allocates a budget for public goods and services, and the official has to provide evidence that she deserves to be reappointed, or else she will be suspected of embezzlement. In our paper, we use citizens' complaints as a social accountability mechanism.[2] Another related work that connects public good provision, corruption and (political) accountability is Van Weelden (2013), where an infinitely repeated citizen-candidate model of political competition is used to study the corrupt behavior of the elected politician. The elected candidate chooses the policy to implement and how much to embezzle when in office. The voter decides which candidate to elect and, subsequently, whether the candidate should be retained. Our focus in this paper is on social accountability.

Litina and Palivos (2016) link embezzlement and tax evasion via a theoretical framework consisting of an overlapping generation of citizens and politicians, where a fraction of the population emerges as politicians through a random process. The model uses social stigma as a way to deter corrupt behaviour. In our model, citizens live for the entire game (i.e. no overlapping generation of citizens) and the governor is distinct from the citizens. More importantly, we focus on deterrence policies like the enforcement mechanisms for both citizens (penalty for tax evasion) and politicians (citizens' complaints).

The outline of the paper is as follows: Section 2 describes our model. Section 3 presents the analysis of the model that includes the main results, a discussion of these results. We conclude in Section 4. The proofs of all the results have been relegated to Appendix A.

2 MODEL

We consider a four-stage sequential-move game involving $N = \{1, 2, 3, .., n\}$ citizens and a governor, G. First, citizens decide whether or not to pay taxes. Then, Nature - an independent tax agency, like IRS in the USA or HMRC in UK, which acts as a non-strategic player of the game - selects $k \leq n$ citizens to audit at random. If the audited citizen did not pay tax, then he has to pay it and is also penalized. The total tax col-

[2] See Bobonis et al. (2016), Avis et al. (2018), Campante and Do (2014), Ortner and Chassang (2018) for some recent literature on various other accountability mechanisms for reducing corruption.

lected goes into a public fund which the governor re-distributes in the form of public goods. The governor keeps (embezzles) whatever is left in the public fund after the redistribution. Finally, citizens voice their opinion about the governor by punishing the latter in the case of lower provision of public goods than what they expected. We will formally describe the game now.

STAGE 1

Each citizen $i \in N$ simultaneously chooses an action t_i, where $t_i = 0\ (=1)$ implies tax evasion (tax payment). We assume that the tax is 1 unit for each citizen and the total tax collected goes towards the public fund.

STAGE 2

Nature randomly selects k (out of n) citizens to audit, and we assume

$$Pr(\text{citizen } i \text{ is audited}) = \frac{k}{n}.$$

If a non-tax paying citizen is audited, he will need to pay 1 unit of tax and a penalty for tax evasion, z, where $z \geq 0$. Taxes and penalties go to the 'Consolidated Fund Account', out of which total penalty pays for supply services, i.e. payments issued to government departments, like IRS and HMRC, to finance their expenditure, and taxes go towards the public fund.[3]

STAGE 3

The governor receives total public funds $X \in \{k, k+1, ..., n\}$. If all citizens evade taxes, the governor receives $X = k$ units of the public fund, while the maximum amount of the public fund available to the governor is $X = n$ (for example if all citizens pay taxes). The governor can choose to redistribute any amount, $g \leq X$, from the public fund. In this case, each citizen receives ag and the governor gets $ag + (X - g)$, where $0 < a < 1$

[3] See, for example, page 2 of Treasury (2018).

is the marginal per capita return from the public good. We assume that the governor also benefits from the public good provision.

Stage 4

In the final stage of the game, we model a proxy for voting, where each citizen i forms expectations, $\tau_i \in \{k, k+1, ..., n\}$, of the total public fund X available to the governor. Citizens observe the level of public good, g, being provided by the governor, and in the case $g < \tau_i$, citizen i punishes the governor by $b \geq 0$ for not meeting his expectations, in other words, the governor loses the confidence of her citizens. We assume that citizens care about having the right expectations and putting across their opinion in the case when their expectations are not met. We assume that a citizen i gets some disutility if $\tau_i > g$ and he does not complain. This assumption means that each citizen has a dominant action at stage 4. Our results also hold if we assume that only a particular share of citizens behave that way. Figure 1 summarizes the four stages of the game.

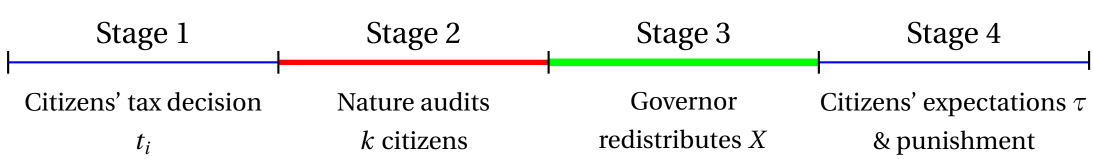

Figure 1: Timeline

We can describe the payoffs of all players after stage 4 now. Citizen i receives

$$u_i((1, \tau_i), ...; g) = ag - 1,$$

where the citizen paid tax, the governor provided g units of public goods, and citizen

i expected τ_i units of public goods from the governor. Analogously, citizen i receives

$$u_i((0,\tau_i),...;g) = \begin{cases} ag, & \text{if } i \text{ was not audited,} \\ ag - 1 - z, & \text{if } i \text{ was audited,} \end{cases}$$

where the citizen evaded tax, the governor provided g units of public goods, and citizen i expected τ_i units of public goods from the governor.

Utility for the governor is

$$u_G((1,\tau_1),...,(0,\tau_n);g) = X - g + ag - [\#\text{complaints}]b,$$

where the total public fund is X, the governor provided g units of public goods, citizen i expected τ_i units of public goods from the governor, and [#complaints] is the number of citizens whose public good expectations are above g.

3 Analysis

Citizens and the governor have many pure strategies in the model. However, it is enough to consider only particular strategies to obtain our main results. So, we will restrict our attention to symmetric pure strategies for citizens and cut-off strategies for the governor.

Symmetric pure strategies $(1,\tau)$ and $(0,\tau)$ specify whether citizens pay taxes, 1, or not, 0, and τ describes their public good provision expectations. Since citizens have the dominant action at stage 4, they complain if $\tau > g$ and they do not complain if $\tau \leq g$. We will also consider symmetric mixed strategies $\sigma = (p,\tau)$ where citizens randomize over the first stage actions, pay taxes with probability p, and expect τ units of public goods.

A cutoff strategy $\langle g \rangle$ means that the governor redistributes exactly $g \geq 0$ units if the total collected public fund is at or above this cutoff level, or $g \leq X$. Otherwise, no public good is produced. Note that the governor, who uses the cutoff strategy, embezzles public funds more often than not. For example, she plunders whatever is left in the public fund after the cutoff level is satisfied. It is even more striking that we obtain our results with a corrupt governor.

We will be looking for symmetric (pure and mixed) equilibria in this section. Our results take into account an important element of the model – citizens' expectations, τ. In the next Lemma 1, we characterize these expectations, assuming that citizens are rational.

LEMMA 1. *Suppose that there are n citizens and k of them are audited. If each citizen pays 1 unit tax with probability p at stage 1, then the expected number of units, τ, that the governor collects is*

$$\tau = k + p(n - k). \tag{1}$$

Next, we analyze three situations. First, we consider *efficient public good provision*, where each citizen pays the tax, $p = 1$, and expects, from Lemma 1, $\tau = n$ units of public goods from the governor, who provides exactly n units in the equilibrium. The second situation we look at is a *tax evasion equilibrium*, where each citizen does not pay the tax, $p = 0$, and expects, from Lemma 1, $\tau = k$ units of public good from the governor, who indeed provides k units in the equilibrium. In order to give a flavor of these results, we consider an example describing these two extreme cases in the next subsection 3.1.

Finally, we analyze a situation when each citizen pays the tax with probability p and expects, from Lemma 1, τ units of public goods from the governor, who provides either τ units, if she collects enough taxes, or 0 units, if she receives less than τ units in taxes. We illustrate this result in subsection 3.4.

Our results depend on the four parameters of the model: marginal per capita return a, punishment for embezzlement b, penalty for tax evasion z, and citizens' expectations about the public fund, τ.

3.1 An example

In this section, we present an example that illustrates our two main findings. Suppose that there are $n = 3$ citizens and one of them is audited at random, $k = 1$. We also assume that $a = \frac{3}{4}$, $b = \frac{1}{2}$, and $z = 1$.

3.1.1 Efficient public good provision

Consider a situation when each citizen pays $t = 1$ unit tax, or $p = 1$, and expects, from Lemma 1, $\tau = 3$ units of public good from the governor, or plays strategy $(p, \tau) = (1, 3)$. Suppose that the governor redistributes g units, using a cutoff strategy

$$g = \langle 3 \rangle = \begin{cases} 0, & \text{if } X < 3, \\ 3, & \text{if } X = 3, \end{cases}$$

where the total collected public fund is X, and if it is at the cutoff level, 3, then the governor produces exactly 3 units of public goods. Otherwise, no public good is produced.

We claim that a symmetric strategy profile $((1,3),(1,3),(1,3);\langle 3 \rangle)$ is a Nash equilibrium. Let us verify that. Note that the expected utility of citizen i is

$$E\,u_i((1,3),(1,3),(1,3);\langle 3 \rangle) = 3a - 1 = \frac{5}{4},$$

and the expected governor's utility is

$$E\,u_G((1,3),(1,3),(1,3);\langle 3 \rangle) = 3a = \frac{9}{4}.$$

For the strategy profile $((1,3),(1,3),(1,3);\langle 3 \rangle)$ to be a pure strategy Nash equilibrium, it should be mutual best responses for the players to play the strategy prescribed in the profile. The best possible deviation for the governor is to embezzle all units from the public fund, which gives the following expected utility:

$$E\,u_G((1,3),(1,3),(1,3);\langle 0\rangle) = 3-3b = \frac{3}{2} < E\,u_G((1,3),(1,3),(1,3);\langle 3\rangle).$$

The best possible deviation for citizen $i=1$ is to evade taxes, and the corresponding expected utility is

$$E\,u_i((0,3),(1,3),(1,3);\langle 3\rangle) = \frac{1}{3}(3a-z-1)+\frac{2}{3}(0) = \frac{1}{12} < E\,u_1((1,3),(1,3),(1,3);\langle 3\rangle).$$

Note that if citizen $i=1$ evades the tax and is not audited, the governor gets only 2 units in taxes and, therefore, embezzles these 2 units, because she will be punished for not providing 3 units of the public good by two other citizens who expect three units of public goods. Thus, given our parameter values, the strategy profile $((1,3),(1,3),(1,3);\langle 3\rangle)$ is a Nash equilibrium. We generalize this result in Theorem 1 (see subsection 3.2).

3.1.2 Tax evasion

Consider a situation when each citizen evades taxes, or $p=0$, and expects, from Lemma 1, $\tau = k = 1$ units of public good from the governor, or plays strategy $(p,\tau) = (0,1)$. Suppose that the governor redistributes $g=1$ unit, which is always possible because $k=1$. Then, a symmetric strategy profile $((0,1),(0,1),(0,1);\langle 1\rangle)$ is a Nash equilibrium. Let us verify that.

Note that the expected utility of citizen i is

$$E\,u_i((0,1),(0,1),(0,1);\langle 1\rangle) = \frac{1}{3}(a-z-1)+\frac{2}{3}a = \frac{1}{12},$$

and the expected utility of the governor is

$$E\,u_G((0,1),(0,1),(0,1);\langle 1\rangle) = a = \frac{3}{4}.$$

For the strategy profile $((0,1),(0,1),(0,1);\langle 1\rangle)$ to be a Nash equilibrium, it should be mutual best responses for citizens and the governor to play the strategies prescribed in this profile. The only possible deviation for the governor is to embezzle 1 unit, i.e. play strategy $g = \langle 0 \rangle$, and her expected utility in this case is

$$E\, u_G((0,1),(0,1),(0,1);\langle 0 \rangle) = 1 - 3b = -\frac{1}{2} < E\, u_G((0,1),(0,1),(0,1);\langle 1 \rangle).$$

The best possible deviation for citizen $i = 1$ is to pay the tax, and the corresponding expected utility is

$$E\, u_1((1,1),(0,1),(0,1);\langle 1 \rangle) = \frac{1}{3}(a-1) + \frac{2}{3}(a-1) = -\frac{1}{4} < E\, u_1((0,1),(0,1),(0,1);\langle 1 \rangle).$$

Thus, given our parameter values, the strategy profile $((0,1),(0,1),(0,1);\langle 1 \rangle)$ is a Nash equilibrium. We generalize this result in subsection 3.3.

3.2 Efficient Public Good Provision

In the previous subsection, we had an *efficient public good provision* example where all three citizens pay taxes and expect three units of public goods from the governor, and the governor redistributes three units in the equilibrium. Our next result generalizes this example and provides conditions for the efficient public good provision.

Theorem 1. *If the public good provision is efficient,*

$$an \geq 1,$$

and the punishment for embezzlement is high enough,

$$b \geq 1 - a,$$

then there exists an efficient public good provision equilibrium where all citizens pay taxes and expect $\tau = n$ units of public goods from the governor, and the governor redis-

tributes g units using the following cutoff strategy:

$$g = \langle n \rangle = \begin{cases} 0, & \text{if } X < n, \\ n, & \text{if } X = n. \end{cases}$$

The public good literature has long been looking for the efficient public good provision mechanisms. The most tractable solution is, probably, the public good provision with punishments. See for example Fehr and Gächter (2000, 2002). Theorem 1 demonstrates that the efficient public good provision can be achieved with a corrupt governor and without punishment for tax evasion if each citizen is pivotal in the following sense. Each citizen pays taxes and expects provision of all n units from the governor. If the governor does not provide exactly n units, then each citizen punishes her. The punishment is severe and the governor prefers to avoid it. This means that the governor will only consider two options: either provide all n units of public goods or embezzle the whole public fund. Therefore, each citizen is pivotal for the efficient public good provision: he expects that his deviation (tax evasion) leads to no public good provision (most likely, unless he is audited). The governor – the institution – executes the punishment and the reward here. Hence, surprisingly, we do not need to impose any punishment for the individual tax evasion. It is interesting to emphasize that the governor is corrupt and tries to embezzle public funds in the "right" situation, but, even in this case, she does not want to embezzle funds in the equilibrium.

Our finding has a similar flavor to that of Gallice and Monzón (2019), who consider a one-shot sequential public goods game with position uncertainty and with partial history of immediate predecessors. They find that there is an equilibrium where everyone contributes without the need of punishment.

3.3 Tax Evasion

In the example, we have already seen a *tax evasion* equilibrium where all three citizens evade taxes and expect the governor to redistribute just one unit of the public fund, which the governor always obliges. We generalize this result in the next theorem.

THEOREM 2. *If the punishment for tax evasion is relatively small*

$$z \leq \frac{(n-k)}{k},$$

and the punishment for embezzlement is high enough

$$b \geq \frac{k}{n}(1-a),$$

there exists a tax evasion equilibrium, where all citizens evade taxes and expect $\tau = k$ *units of public good, and the governor always provides exactly* $g = k$ *units.*

There are several important points to note from Theorem 2. First, if the punishment for tax evasion is relatively small, then all citizens can evade taxes and expect the minimal level of public good provision, k units, from the governor, who in turn does not have any incentives to produce more than k units of public goods. These citizens' expectations are self-enforced in the equilibrium.

Second, punishment conditions for the tax evasion equilibrium depend on the population size, n, and the number of audited citizens, k. If the population size, n, and the punishment for tax evasion, z, are fixed, then increasing the audit level, k, makes it more difficult to sustain the equilibrium. Similarly, if the audit level, k, and the punishment for tax evasion, z, are fixed, then increasing the population size, n, makes it easier to sustain the tax evasion equilibrium.

Finally, a tax audit experiment conducted in Denmark (Kleven et al., 2011) finds that for self-reported income, the empirical results are consistent with our theoretical prediction: tax evasion is widespread and is negatively related to an increase in penalties.

3.4 SYMMETRIC MIXED STRATEGY EQUILIBRIUM

So far we have considered two extreme cases: in the efficient equilibrium, all citizens pay taxes and the governor redistributes the entire public fund (Theorem 1); in the tax evasion equilibrium, all citizens evade taxes and the governor redistributes the minimal amount (Theorem 2). The following result generalizes Theorems 1 and 2.

THEOREM 3. *For any citizens' expectations,* $\tau \in \{k, k+1, ..., n\}$*, there exists a symmetric mixed strategy equilibrium* $((p,\tau), ...(p,\tau); \langle\tau\rangle)$*, where*

- *all citizens pay taxes with probability* $p = \frac{\tau-k}{n-k}$ *and expect* τ *units of public goods;*
- *the governor uses the cutoff strategy,* $\langle\tau\rangle$*, for public good provision, where*

$$\langle\tau\rangle = \begin{cases} 0, & \text{if } X < \tau, \\ \tau, & \text{if } X \geq \tau. \end{cases}$$

In the equilibrium, the penalty for the tax evasion, $z^* = z(p,a)$ *is uniquely determined, and the penalty for the embezzlement,* $b \geq b^*$*, has to be above the threshold level,* $b^* = b(\tau, a)$.

We provide an example for Theorem 3 in Appendix B. Theorem 3 gives conditions when it is optimal for the governor to match the citizens' expectations. For example, if the governor gets $\tau + m$ units in the public fund, then she will embezzle m units. At the same time, if she receives less than τ units, then the governor will embezzle everything.

Theorem 3 covers also two extreme cases. In the efficient equilibrium, citizens expect n units, i.e. $\tau = n$, and each citizen pays the tax with probability 1. In the tax evasion equilibrium, citizens expect k units, i.e. $\tau = k$, and every citizen evades the tax with probability 1. We get the following two corollaries from Theorem 3.

COROLLARY 1. *If* $\tau = n$*, then* $p = 1$ *and we have the efficient public good provision equilibrium.*

COROLLARY 2. *If* $\tau = k$*, then* $p = 0$ *and we have the tax evasion equilibrium.*

Theorem 3 shows the importance of citizens' expectations. Higher expectations lead to a higher level of tax payments and higher public good provision by the governor. In other words, higher citizens' expectations encourage a corrupt governor to embezzle less. At the same time, if the governor cannot meet the expectations, she embezzles everything. Citizens expect that and pay more taxes to give the governor a chance to produce more public goods. These driving equilibrium forces are self-fulfilled in the equilibrium.

4 Conclusion

We develop a model of tax evasion, corruption, and public good provision. In the model, citizens create public funds which the governor redistributes. The governor can embezzle some or all public funds. Here are some recent examples:

- Malaysia's ex-Prime Minister, Najib Razak, was arrested in 2018 for one of the world's biggest corruption scandals, where according to the US justice department, more than $4.5 billion funds were stolen from the 1Malaysia Development Berhad (1MDB). 1MDB is a Malaysian state fund set up in 2009 to promote development through foreign investments and partnerships, and then PM, Najib Razak, was the Chairman (Ellis-Peterson, 25 October 2018).

- A recent news article in Telegraph (Chazan, 5 June 2019) reports that financial prosecutors suspect that about £442,000 in public money may have been embezzled by Gerard Collomb, the Mayor of Lyon, France.

- Russian Legal Information Agency (RAPSI-News, 15 July 2019) reports that the Ex-Finance Minister of the Moscow Region, Alexey Kuznetsov, is charged with embezzling nearly $200 million.

In our model, we introduce social accountability as a part of an equilibrium strategy: citizens form their expectations about the public good provision. If these expectations are not met, then citizens punish the governor. A recent event illustrates this punishment: more than 12,000 Czechs gathered in Prague in a protest to demand the resignation of Prime Minister Andrej Babis over alleged misuse of EU Funds (Tait, 4 June 2019). With social accountability, we show that each citizen is pivotal and it is indeed possible to achieve the efficient public good provision with the right level of expectations.

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APPENDIX A PROOFS

Proof of Lemma 1. Let j denote the number of citizens paying tax. Let k_s denote the number of successful audits. Let K be a random variable whose outcome is k_s. Here K follows a hyper-geometric distribution whose probability mass function (p.m.f) is given by

$$Pr(K = k_s) = \frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}} \tag{2}$$

Let τ represent the expected number of units that the governor has.

$$\begin{aligned}
\tau &= \sum_{j=0}^{n}\sum_{k_s=0}^{k}(j+k_s)\binom{n}{j}p^j(1-p)^{n-j}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}} \\
&= \sum_{j=0}^{n}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=0}^{k}(j+k_s)\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}\right) \\
&= \sum_{j=0}^{n}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=0}^{k}j\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}} + \sum_{k_s=0}^{k}k_s\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}\right)
\end{aligned} \tag{3}$$

We apply *absorption identity* (Graham et al., 1994, p. 157) on the last term of (3) and we get the following

$$\tau = \sum_{j=0}^{n}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=0}^{k}j\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}} + \sum_{k_s=1}^{k}(n-j)\frac{\binom{j}{k-k_s}\binom{n-j-1}{k_s-1}}{\binom{n}{k}}\right) \tag{4}$$

Then we use *Vandermonde's identity* on the last two terms in (4)

$$\begin{aligned}
\tau &= \sum_{j=0}^{n}\binom{n}{j}p^j(1-p)^{n-j}\left(j\frac{\binom{n}{k}}{\binom{n}{k}} + (n-j)\frac{\binom{n-1}{k-1}}{\binom{n}{k}}\right) \\
&= \sum_{j=0}^{n}\binom{n}{j}p^j(1-p)^{n-j}\left(j+(n-j)(\frac{k}{n})\right) \\
&= \sum_{j=0}^{n}(j)\binom{n}{j}p^j(1-p)^{n-j} + k\sum_{j=0}^{n}\binom{n}{j}p^j(1-p)^{n-j} - \frac{k}{n}\sum_{j=0}^{n}(j)\binom{n}{j}p^j(1-p)^{n-j} \\
&= \sum_{j=1}^{n}(n)\binom{n-1}{j-1}p^j(1-p)^{n-j} + k(1) - \frac{k}{n}\sum_{j=1}^{n}(n)\binom{n-1}{j-1}p^j(1-p)^{n-j} \\
&= \sum_{j=1}^{n}(np)\binom{n-1}{j-1}p^{j-1}(1-p)^{n-j} + k(1) - \frac{k}{n}\sum_{j=1}^{n}(np)\binom{n-1}{j-1}p^{j-1}(1-p)^{n-j} \\
&= np + k - kp \\
&= k + p(n-k)
\end{aligned} \tag{5}$$

□

Proof of Theorem 1. Consider a strategy profile $((1,n),...,(1,n);\langle n\rangle)$, where each citizen pays tax and expects n units of public good, and the Governor redistributes n units of public good, whenever possible. Thus, the expected utility of citizen i is

$$Eu_i((1,n),...,(1,n);\langle n\rangle) = -1 + an,$$

and the expected utility of the Governor is

$$Eu_G((1,n),...,(1,n);\langle n\rangle) = na.$$

For the strategy profile $((1,n),...,(1,n);\langle n\rangle)$ to be a Nash equilibrium, it should be a mutual best response for the players to play the strategy prescribed in the profile. Below we consider the best possible deviations for the Governor and citizens.

The best possible deviation for the Governor is to embezzle everything, $\langle 0\rangle$, i.e. provide 0 units of public goods. In this case, the expected payoff for the Governor is:

$$Eu_G((1,n),...,(1,n);\langle 0\rangle) = n - nb.$$

In the equilibrium, it has to be

$$Eu_G((1,n),...,(1,n);\langle n\rangle) \geq Eu_G((1,n),...,(1,n);\langle 0\rangle),$$

or

$$b \geq 1 - a. \tag{6}$$

The best possible deviation for citizen 1 is to evade the tax, $(0,n)$, which leads to the following expected utility for him

$$Eu_1((0,n),(1,n),...,(1,n);\langle n\rangle)) = \frac{k}{n}(-1 - z + na). \tag{7}$$

Note that when citizen 1 evades the tax and is not audited, Governor does not have enough public funds to provide n units of the public good and therefore embezzles all public funds.

In the equilibrium, it has to be

$$Eu_1((1,n),...,(1,n);\langle n\rangle) \geq Eu_1((0,n),(1,n),...,(1,n);\langle n\rangle),$$
$$z \geq \frac{(n-k)(1-an)}{k}.$$

Since the efficiency condition requires $an \geq 1$, the last inequality holds for any $z \geq 0$. Therefore, (6) gives us the condition for the efficient PG provision. □

Proof of Theorem 2. Consider a strategy profile $((0,k),(0,k),...,(0,k);\langle k\rangle)$, where each citizen i evades the tax and expects k units of public goods, and the Governor redistributes k units of public goods by means of a cut-off strategy, $\langle k\rangle$. Thus, the expected utility of citizen i is

$$Eu_i((0,k),(0,k),...,(0,k);\langle k\rangle) = \frac{k}{n}(-1 - z + ka) + \left(1 - \frac{k}{n}\right)(ka),$$

and the expected utility of the Governor is given by

$$Eu_G((0,k),(0,k),...,(0,k);\langle k\rangle) = ka.$$

For the strategy profile $((0,k),(0,k),...,(0,k);\langle k\rangle)$ to be an equilibrium, it should be a mutual best response for the players to play the strategy prescribed in the profile. Below we consider the best possible deviations for the Governor and citizens.

The best possible deviation for the Governor is to embezzle everything, i.e. provide zero units of public goods. The expected payoff for the Governor in this case is

$$Eu_G((0,k),(0,k),...,(0,k);\langle 0\rangle) = k - nb.$$

In the equilibrium, it must be

$$Eu_G((0,k),(0,k),...,(0,k);\langle k\rangle) \geq EU_G((0,k),(0,k),...,(0,k);\langle 0\rangle),$$

or

$$b \geq \frac{k(1-a)}{n}. \tag{8}$$

The best possible deviation for citizen 1 is to pay the tax, $(1,k)$. The expected utility for citizen 1 in this case is

$$Eu_1((1,k),(0,k),...,(0,k);\langle k\rangle) = -1 + ak \tag{9}$$

In the equilibrium, it has to be

$$Eu_1((0,k),(0,k),...,(0,k);\langle k\rangle) \geq Eu_1((1,k),(0,k),...,(0,k);\langle k\rangle), or$$

$$z \leq \frac{(n-k)}{k}. \tag{10}$$

Thus, (8) and (10) provide conditions for the tax evasion equilibrium. □

Proof of Theorem 3. Consider a mixed strategy $\sigma_{-i} = (p,\tau)$ where citizens $-i$ randomise between paying or evading taxes and expect τ units to be provided by the Governor, and let us assume that the Governor plays a cut-off strategy, $\langle\tau\rangle$, for public good provision, where

$$\langle\tau\rangle = \begin{cases} 0, & \text{if } X < \tau, \\ \tau, & \text{if } X \geq \tau. \end{cases}$$

The expected utility of citizen i when paying tax is given by:

$$
\begin{aligned}
Eu_i((1,\tau),\sigma_{-i};\langle\tau\rangle) = \frac{k}{n}\Bigg[& \sum_{j=\tau-1}^{n-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1+\tau a) \\
& + \sum_{j=\tau-k}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k-1}\frac{\binom{j}{k-1-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k-1}}\Bigg)(-1+\tau a) \\
& + \sum_{j=\tau-k}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=0}^{\tau-2-j}\frac{\binom{j}{k-1-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k-1}}\Bigg)(-1) \\
& + \sum_{j=0}^{\tau-k-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1)\Bigg] \\
& + (1-\frac{k}{n})\Bigg[\sum_{j=\tau-1}^{n-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1+\tau a) \\
& + \sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(-1+\tau a) \\
& + \sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=0}^{\tau-2-j}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(-1) \\
& + \sum_{j=0}^{\tau-k-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1)\Bigg].
\end{aligned} \tag{11}
$$

Similarly, the expected utility of citizen i by evading tax is given by:

$$
\begin{aligned}
Eu_i((0,\tau),\sigma_{-i};\langle\tau\rangle) = \frac{k}{n}\Bigg[& \sum_{j=\tau-1}^{n-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1+\tau a-z) \\
& + \sum_{j=\tau-k}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k-1}\frac{\binom{j}{k-1-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k-1}}\Bigg)(-1+\tau a-z) \\
& + \sum_{j=\tau-k}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=0}^{\tau-2-j}\frac{\binom{j}{k-1-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k-1}}\Bigg)(-1-z) \\
& + \sum_{j=0}^{\tau-k-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1-z)\Bigg] \\
& + (1-\frac{k}{n})\Bigg[\sum_{j=\tau}^{n-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(\tau a) \\
& + \sum_{j=\tau-k}^{\tau-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(\tau a) \\
& + \sum_{j=\tau-k}^{\tau-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=0}^{\tau-1-j}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(0) \\
& + \sum_{j=0}^{\tau-k-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(0)\Bigg].
\end{aligned} \tag{12}
$$

By re-writing the sums, using distributive law, inside the second square brackets of (11), we get

$$
\begin{aligned}
Eu_i((1,\tau),\sigma_{-i};\langle\tau\rangle) = \frac{k}{n}\Bigg[&\sum_{j=\tau-1}^{n-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1+\tau a)\\
&+\sum_{j=\tau-k}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k-1}\frac{\binom{j}{k-1-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k-1}}\Bigg)(-1+\tau a)\\
&+\sum_{j=\tau-k}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=0}^{\tau-2-j}\frac{\binom{j}{k-1-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k-1}}\Bigg)(-1)\\
&+\sum_{j=0}^{\tau-k-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1)\Bigg]\\
&+(1-\frac{k}{n})\Bigg[\sum_{j=\tau-1}^{n-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1)\\
&+\sum_{j=\tau-1}^{n-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(\tau a)\\
&+\sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(-1)\\
&+\sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(\tau a)\\
&+\sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=0}^{\tau-2-j}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(-1)\\
&+\sum_{j=0}^{\tau-k-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1)\Bigg] \qquad (13)
\end{aligned}
$$

Further simplifying (13) gives us,

$$
\begin{aligned}
Eu_i((1,\tau),\sigma_{-i};\langle\tau\rangle) = \frac{k}{n}\Bigg[&\sum_{j=\tau-1}^{n-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1+\tau a)\\
&+\sum_{j=\tau-k}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k-1}\frac{\binom{j}{k-1-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k-1}}\Bigg)(-1+\tau a)\\
&+\sum_{j=\tau-k}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=0}^{\tau-2-j}\frac{\binom{j}{k-1-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k-1}}\Bigg)(-1)\\
&+\sum_{j=0}^{\tau-k-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(-1)\Bigg]\\
&+(1-\frac{k}{n})\Bigg[(-1)+\sum_{j=\tau-1}^{n-1}\binom{n-1}{j}p^j(1-p)^{n-1-j}(\tau a)\\
&+\sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^j(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(\tau a)\Bigg] \qquad (14)
\end{aligned}
$$

Citizen i will be indifferent if $Eu_i((1,\tau),\sigma_{-i},\langle\tau\rangle) = Eu_i(0,\tau);\sigma_{-i};\langle\tau\rangle)$. Therefore, equating (12) and (14) and simplifying we get,

$$\begin{aligned}
\frac{k}{n}(-z) = (1-\frac{k}{n})\Bigg[(-1) + \sum_{j=\tau-1}^{n-1}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}(\tau a)\\
+\sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(\tau a)\\
-\sum_{j=\tau}^{n-1}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}(\tau a)\\
-\sum_{j=\tau-k}^{\tau-1}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(\tau a)\Bigg]\\
=(1-\frac{k}{n})\Bigg[(-1)+\binom{n-1}{\tau-1}p^{\tau-1}(1-p)^{n-\tau}(\tau a)\\
+\sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(\tau a)\\
-\sum_{j=\tau-k}^{\tau-1}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(\tau a)\Bigg].
\end{aligned}$$

Solving for z we get,

$$\begin{aligned}
z = \left(\frac{k-n}{k}\right)\Bigg[(-1)+\binom{n-1}{\tau-1}p^{\tau-1}(1-p)^{n-\tau}(\tau a)\\
+\sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(\tau a)\\
-\sum_{j=\tau-k}^{\tau-1}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)(\tau a)\Bigg]
\end{aligned} \tag{15}$$

Rewriting equation (15):

$$z = \left(\frac{n-k}{k}\right)\Big[(1) - A\tau a - B\tau a + C\tau a\Big],$$

where,

$$\begin{aligned}
A &= \binom{n-1}{\tau-1}p^{\tau-1}(1-p)^{n-\tau}\\
B &= \sum_{j=\tau-k-1}^{\tau-2}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-1-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)\\
C &= \sum_{j=\tau-k}^{\tau-1}\binom{n-1}{j}p^{j}(1-p)^{n-1-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-1-j}{k_s}}{\binom{n-1}{k}}\Bigg)
\end{aligned}$$

For z to be non-negative we need:

$$\begin{aligned}
1 - A\tau a - B\tau a + C\tau a \geq 0\\
a \leq \frac{1}{\tau\big(A+B-C\big)}
\end{aligned} \tag{16}$$

From Lemma 1 we have,

$$k + p(n-k) = \tau$$
$$p = \frac{\tau - k}{n-k} \tag{17}$$

Fixing τ, k, n we have p uniquely determined. Plugging this p in equation (15) we get a unique value of z.

Assuming the citizens pay taxes with probability p, for the profile $(\sigma;\sigma_{-i};\langle\tau\rangle)$ to be a symmetric MSNE, we want the Governor's best response to be his cut-off strategy, $\langle\tau\rangle$, i.e.,

$$E\,u_G(\sigma_i,\sigma_{-i};\langle\tau\rangle) \geq E\,u_G(\sigma_i,\sigma_{-i};0) \tag{18}$$

where the left hand side of the inequality (18) is

$$\begin{aligned} E\,u_G(\sigma_i;\sigma_{-i};\langle\tau\rangle) = &\sum_{j=\tau}^{n}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=0}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(\tau a + j + k_s - \tau)\right)\\ &+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(\tau a + j + k_s - \tau)\right)\\ &+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=0}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(j + k_s - nb)\right) \end{aligned} \tag{19}$$

Using absorption identity on the second expression and simplifying the first expression of (19) we get,

$$\begin{aligned} E\,u_G(\sigma_i;\sigma_{-i};\langle\tau\rangle) = &\sum_{j=\tau}^{n}\binom{n}{j}p^j(1-p)^{n-j}(\tau a - \tau + j + k - \frac{jk}{n})\\ &+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(\tau a - \tau + j) + \sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(k_s)\right)\\ &+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=0}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(j - nb) + \sum_{k_s=0}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j-1}{k_s-1}}{\binom{n}{k}}(n-j)\right) \end{aligned} \tag{20}$$

Using absorption identity on the second expression of (19) we get,

$$\begin{aligned} E\,u_G(\sigma_i;\sigma_{-i};\langle\tau\rangle) = &\sum_{j=\tau}^{n}\binom{n}{j}p^j(1-p)^{n-j}(\tau a - \tau + j + k - \frac{jk}{n})\\ &+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(\tau a - \tau + j) + \sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j-1}{k_s-1}}{\binom{n}{k}}(n-j)\right)\\ &+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\left(\sum_{k_s=0}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(j - nb)\sum_{k_s=1}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j-1}{k_s-1}}{\binom{n}{k}}(n-j)\right) \end{aligned} \tag{21}$$

Manipulating the second and the third expression of (21) we get

$$
\begin{aligned}
E\,u_G(\sigma_i,\sigma_{-i};\langle\tau\rangle) = &\sum_{j=\tau}^{n}\binom{n}{j}p^j(1-p)^{n-j}(\tau a-\tau a+j+k-\frac{jk}{n}) \\
&+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(\tau a-\tau)+\sum_{k_s=0}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(-nb)+\sum_{k_s=1}^{k}\frac{\binom{j}{k-k_s}\binom{n-j-1}{k_s-1}}{\binom{n}{k}}(n-j)\Bigg)
\end{aligned}
\tag{22}
$$

Next we apply Vandermonde's identity on the last expression of (22)

$$
\begin{aligned}
E\,u_G(\sigma_i,\sigma_{-i};\langle\tau\rangle) = &\sum_{j=\tau}^{n}\binom{n}{j}p^j(1-p)^{n-j}(\tau a-\tau+j+k-\frac{jk}{n}) \\
&+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(\tau a-\tau)+\sum_{k_s=0}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(-nb)+(j+k-\frac{jk}{n})\Bigg) \\
E\,u_G(\sigma_i,\sigma_{-i};\langle\tau\rangle) = &\ k+(n-k)p+\sum_{j=\tau}^{n}\binom{n}{j}p^j(1-p)^{n-j}(\tau a-\tau) \\
&+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(\tau a-\tau)+\sum_{k_s=0}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(-nb)\Bigg)
\end{aligned}
\tag{23}
$$

The right had side of the inequality (18) is

$$
E\,u_G(\sigma_i,\sigma_{-i};0) = k+p(n-k)-nb \tag{24}
$$

The proof for (24) is analogous to the proof of Lemma 1.

Using expressions (23) and (24) in (18) we have

$$
\begin{aligned}
&k+(n-k)p+\sum_{j=\tau}^{n}\binom{n}{j}p^j(1-p)^{n-j}(\tau a-\tau) \\
&+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(\tau a-\tau)+\sum_{k_s=0}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(-nb)\Bigg)\geq k+p(n-k)-nb
\end{aligned}
\tag{25}
$$

simplifying inequality (25)

$$
\begin{aligned}
&\sum_{j=\tau}^{n}\binom{n}{j}p^j(1-p)^{n-j}(\tau-\tau a) \\
&+\sum_{j=0}^{\tau-1}\binom{n}{j}p^j(1-p)^{n-j}\Bigg(\sum_{k_s=\tau-j}^{k}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(\tau-\tau a)+\sum_{k_s=0}^{\tau-j-1}\frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}}(nb)\Bigg)\leq nb
\end{aligned}
$$

and then solving for b

$$
b\geq\frac{(\tau-\tau a)(D+E)}{n(1-F)}
$$

where

$$D = \sum_{j=\tau}^{n} \binom{n}{j} p^j (1-p)^{n-j}$$
$$E = \sum_{j=0}^{\tau-1} \binom{n}{j} p^j (1-p)^{n-j} \left(\sum_{k_s=\tau-j}^{k} \frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}} \right)$$
$$F = \sum_{j=0}^{\tau-1} \binom{n}{j} p^j (1-p)^{n-j} \left(\sum_{k_s=0}^{\tau-j-1} \frac{\binom{j}{k-k_s}\binom{n-j}{k_s}}{\binom{n}{k}} \right)$$

□

Appendix B Example

Consider a game with $n = 3, \tau = 2$, and $k = 1$. If citizens 2 and 3 pay taxes with probability $p \geq 0$ and the governor uses a cut-off strategy to provides 2 units of public goods, citizen 1's expected utility from paying the tax is

$$Eu_1((1,2),(p,2),(p,2);\langle 2\rangle) = -\frac{2}{3}a\left(p^2 - 2p - 2\right) - 1 \tag{26}$$

Assuming citizen 2 and 3 pay taxes with probability p and the governor provides 2 units of public good, citizen 1's expected utility from evading tax is given by:

$$Eu_1((0,2),(p,2),(p,2);\langle 2\rangle) = \frac{1}{3}(-2a(p-4)p - z - 1) \tag{27}$$

Equating (26) and (27) and simplifying gives us a value of z which makes citizen 1 indifferent between paying or evading taxes, i.e.,

$$z = 2(2ap - 2a + 1) \tag{28}$$

Given (1), we have,

$$p = \frac{\tau - k}{n - k} = \frac{1}{2},$$

which gives us

$$z = 2 - 2a$$

from (28), and given $z \geq 0$, we have $a \leq 1$.

Assuming the citizens pay taxes with probability p, for the profile $((0,2),(p,2),(p,2);\langle 2\rangle)$ to be a symmetric MSNE, we want the Governor's best response to be his cut-off strategy, $\langle 2\rangle$, i.e.

$$Eu_G((p,2),(p,2),(p,2);\langle 2\rangle) \geq EU_G((p,2),(p,2),(p,2);0)$$

where

$$Eu_G((p,2),(p,2),(p,2);\langle 2\rangle) = 2p(-a(p-2) + p - 1) - 3b(p-1)^2 + 1$$

and

$$Eu_G((p,2),(p,2),(p,2);0) = 1 + 2p - 3b$$

Given $p = \frac{1}{2}$, we have

$$b \geq \frac{2}{3}(1-a)$$