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Mobile criminals, immobile crime: the efficiency of decentralized crime deterrence

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Abstract:
In this paper we examine a class of local crimes that involve perfectly mobile criminals, and perfectly immobile criminal opportunities. We focus on local non-rival crime deterrence that is more efficient against criminals pursuing domestic crimes than criminals pursuing crimes elsewhere. In a standard case of sincerely delegated politicians and zero transfers to other districts, we show that centralized deterrence unambiguously dominates the decentralized deterrence. With strategic delegation and voluntary in-kind transfers, the tradeoff is exactly the opposite: Decentralization achieves the social optimum, whereas cooperative centralization overprovides for enforcement. This is robust to various cost-sharing modes. We also examine the effects of the growing interdependence of districts, stemming from criminals' increasing opportunities to strategically displace. Contrary to the supposition in Oates's decentralization theorem, increasing interdependence makes centralization less desirable.

Keywords: crime mobility; crime deterrence; decentralization; strategic delegation; side payments

JEL: H41; H73; H76; R50

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1. Introduction

The mobility of criminals is an increasingly important determinant of optimal crime investigations and deterrence. Particularly in densely populated areas, criminals may swiftly cross district boundaries and keep organizing their activities across the districts, which establishes a strong rationale for enhanced cooperation between local authorities. More precisely, the lack of cooperation brings in uncompensated external effects of local enforcement efforts, both of a positive and negative form. Overall crime reduction is a chief positive externality of local spending, whereas crime diversion, resulting from the voluntary displacement of criminals into other districts, is a major negative externality. Combining the two opposing effects, a non-cooperative decentralized equilibrium may well feature either insufficient as well as excessive effort (Pinto, 2007).

Yet what if criminals are mobile, but criminal targets and victims of crimes are not? In that case, the spatial displacement of criminals is no longer equivalent to crime diversion. Criminals strategically relocate to districts with the lowest effective level of deterrence (weakest-link districts), yet they maintain the criminal business in the initial districts. Their relocation has zero effect on the new residential district. Thus, the inter-jurisdictional spillovers of local spending on crime deterrence are purely positive, and one should expect an unambiguous underprovision in decentralization. Given that most of law enforcement within metropolitan areas, particularly in the United States and Canada, is conducted by local police departments (Cheikbossian and Marceau, 2007), this class of crimes calls for a careful re-assessment of the pros and cons of decentralization.

In this paper, we aim to show that for a class of perfectly mobile criminals targeting immobile victims, the decentralization of local non-rival deterrence is likely to be welfare superior to centralization. This is as long as decentralization allows for voluntary transfers to the other districts, and if strategic delegation is available. Our study thereby shows that in the case of strategic adversaries, decentralization of crime deterrence does not require scale effects (Wheaton 2006) or majority-rule exploitation (Cheikbossian and Marceau 2007) to be superior to centralization.

The relation to the classic decentralization theorem deserves a special note here: By decentralization theorem, the welfare surplus of centralization increases (or, welfare loss decreases) in the level of spillovers. Notice that the level of spillovers intuitively represents the interdependence between the districts, hence the standard reading is that the interdependence of districts makes centralization relatively more desirable. In our case, however, if opportunities or incentives for the relocation of criminals increase, and the districts become more interdependent, the centralization is *less* likely to dominate decentralization, and not the other way around. In another context, Koethenbuerger (2008) also finds that the superiority of decentralization over centralization may increase in the level of spillovers.

The paper aims to contribute to the vast literature on the ebbs and flows of decentralization. The first generation of fiscal federalism perceived decentralization only as a safeguard against uniform policies for asymmetrical districts. In the second generation of fiscal federalism (Oates 2005), decentralization is endorsed because of additional benefits such as X-efficiency or accountability (Hindriks and Lockwood, 2009; Tommasi and Weinschelbaum, 2007). Besley and Coate (2003) prove that decentralization under standard assumptions is also delegation-proof, i.e. voters have no incentive for strategic delegation. Lockwood (2008) points out the benefits of decentralization under a skewed income distribution. Cheikbossian (2008) claims that the high elasticity of the influence functions of pressure groups eliminates a surplus in centralization, even for large spillovers. In the context of urban crime mobility, Bandyopadhyay, Pinto and Wheeler (2007) add that the tradeoff of underprovision and X-efficiency of decentralization crucially hangs on labor mobility.

Following Besley and Coate (2003), we assume a two-stage game with voters grouped in two districts and two delegates, one per district. Alternatively, we can consider local councils delegating police officials in charge of deterrence. In Stage 1, voters in each district simultaneously elect their policy-seeking delegate. In Stage 2, the delegates simultaneously decide on the local expenditures on deterrence. Taken from a production point of view, local public spending is spending on a district-specific input (local deterrence), and the inputs are complements to the production of district-specific outputs (protection against district-specific crimes). The production functions are district-specific in the sense that the domestic input enters perfectly and the foreign input enters imperfectly. We will specifically focus on the willingness to cover the costs of the production of the local input in the other district. In the electoral game of voters, we will further examine incentives to elect strategically; we will concentrate on whether voting for a less or more interested delegate will extract extra payments from the other district.

From the technical point of view, the main difference to the original setup is that local enforcement levels are not substitutes, but complements. Partial motivation for this extension has already been provided already by Besley and Coate (2003, fn. 15), who anticipated that their main result may not be robust when applied to different aggregations.

The remainder of the paper is organized as follows. Section 2 motivates the setup. Section 3 outlines the model and solves for the social optimum serving as the benchmark for welfare judgments. Section 4 solves for equilibria in decentralization both with and without transfers. It develops a key sufficient condition for decentralization with transfers to deliver the social optimum. Section 5 examines cooperative centralization under fixed cost-sharing rules and for Nash bargaining. Section 6 explicitly formulates the decentralization tradeoffs for all possibilities: transfer/no transfer, sincere/strategic delegation and fixed/Nash bargaining cost-sharing rules under centralization. Section 7 concludes.

2. Crime organization and deterrence

Our focus is on a special class of criminal activities and a special subset of police efforts. Traditionally, crime is thought to be an activity taking place completely within a single district. With improvements in communication technologies, crime can nevertheless be organized across several districts. As a result, the locations of crime targets may differ from the actual location of the criminal organization; activities damaging individuals in District 1 can be effectively organized in District 2. At the same time, the relocation of criminals from District 1 does not hurt District 2 as long as activities committed by these criminals are district-specific. The class of criminal activities relevant to our analysis is described by the following two conditions:

1. Immobile (district-targeted) crime. Nearly all victims or targets of criminals are concentrated within a single district. This is specifically the case whenever districts are heterogeneous, so crime is highly district-specific. For instance, car thefts are concentrated in residential areas of middle-income and high-income households. Drugs bring in a large social cost in districts with a high concentration of juveniles. We assume the perfect immobility of the victims, which is realistic at least in the short term.

2. Perfectly mobile criminals. A dominant portion of crime's "production process" is mobile: storing and reselling stolen goods, remodeling stolen cars, money laundering, setting meeting points and distribution points, or providing private rooms or hotel rooms for escort services. Thus, we have to distinguish between *target districts* and *residence districts*. The former are districts of the victims, and the latter are districts of the criminals.

Technology of crime deterrence is characterized as follows:

1. Deterrence is local and not crime-specific, with the property of a local public good. In other words, it targets all suspicious individuals, and all criminal activities in the district, not investigating or preventing individual cases. We may think of intelligence and operative activities:[1] monitoring flows of goods, identifying suspicious individuals, exploiting local informers, or penetrating re-sale networks. Non-rivalry implies that the number of criminals with a residence in a district is irrelevant for effective deterrence in the district. As we shall see below, since the Tiebout-sorting of criminals occurs in equilibrium, rivalry or synergy should not change anything substantial in the margins.

2. Asymmetrical productivity. The local police more likely deter criminals pursuing domestic crimes rather than criminals pursuing crimes elsewhere. Asymmetrical productivity might be related to the exploitation of information complementarities and tacit local knowledge. Tao (2004) suggests domestic interests: the police use resources and exert effort mainly to the purpose of identifying criminals relevant for their own district, not the other districts. Another point is that the productivity gap cannot be filled in by transferring resources, which might be again attributed to local knowledge or local autonomy: The police of District 1 might improve enforcement in District 2 only through intermediaries, or the voluntary transfer of homogenous (district-non-specific) assets.

Consider three examples: The first is drug sale targeting a special group (e.g., juveniles) residing in a single district. The only activity inevitably taking place within a target district is advertising, whereas storage and distribution may easily take place elsewhere. The second example is illegal prostitution via escort services, where, again, the only advertising may take place within a target district, as long as customers are willing to move. (This case also shows that victimless crimes likely satisfy the condition of a target district to be independent of a residence district.)

We can also consider car thefts, where the only activity within a target district is to get into the car; hiding, remodeling and reselling the car can be done anywhere else. Exactly the same holds for organized property crimes that aim chiefly at the resale of easily transportable valuables such as jewelry or paintings. For all these cases, the deterrence we model involves mostly

[1] For Sweden, Poutvaara and Priks (2009) find that the share of intelligence and operative activities in an average police unit is not less than 2/3 of total activities.

information, monitoring, and surveillance, that are all non-rival, and not crime-specific efforts.

3. Model

3.1 Assumptions

Assume two districts of unit size, $i = 1, 2$. (Extensions beyond the bilateral case are discussed in Section 6). In each district i, there is a continuum of citizens differing only in their preference for crime protection, $\lambda \in \mathbb{R}^+$, distributed by $F_i(\lambda)$. This may reflect an individual value of damage, probability of becoming a crime target, or wealth effect implying different levels of absolute risk aversion. Like Besley and Coate (2003), suppose that a mean is identical to a median, denoted λ^m, and they are the same in the two districts:[2] $\int_0^\infty \lambda F_i'(\lambda)d\lambda = \lambda^m$ and $F_i(\lambda^m) = 1/2$, $i \in \{1, 2\}$.

In each district i, the level of enforcement x_i is financed either by the district itself, at amount $g_i \geq 0$, or subsidized by the other district, at the amount $s_{-i} \geq 0$. Given the unit size of districts, all variables are expressed per capita. The enforcement applies to all criminal activities organized in the district, regardless of the target. The total level of enforcement is $x_i = g_i + s_{-i}$, and if voluntary transfers are not feasible (e.g., police is being completely autonomous, or in the presence of other administrative barriers to transfers of resources), then $s_1 = s_2 = 0$.

A key assumption is that criminals are specialized and district-oriented, so there are criminals targeting District 1 and criminals targeting District 2. The criminals are perfectly mobile and select the district for organization/residence to face the lowest enforcement (hitting the weakest-link of crime protection). As discussed in the introduction, assume that productivity of law enforcement drops by parameter $\kappa < 1$ if criminals targeting a district i reside in a district $-i$; this reflects that some local knowledge from the target district cannot be used perfectly by police in the other district. A rational criminal targeting district i thus resides in a district $k \in \{i, -i\}$ where $k = \arg\min_{i,-i}\{x_i, \kappa x_{-i}\}$, and the level of effective protection against

[2] Besley and Coate (2003) note that the distributions must be symmetric and identical. This is unnecessarily restrictive since the purpose of these restrictions is only to align objective of a median-type politician with the welfare of their district. In our setup, the social optimum can be written as the optimum of a (possibly hypothetical) individual with a mean of preference for the public good; whenever the median is equal to the mean, then this individual in fact represents the median voter. The consequences of mean differing from median, implying a biased median policy, are discussed in the (de)centralization framework by Lockwood (2008).

crime of the district i writes

$$G_i := \min\{x_i, \kappa x_{-i}\} = \min\{g_i + s_{-i}, \kappa(g_{-i} + s_i)\}.$$

Enforcement is financed through non-distortionary lump-sum district tax, $t_i \geq 0$. A unit of enforcement requires collecting per capita revenue $p > 0$ from each individual in either of the districts. (One may alternatively suppose fixed public funds with an opportunity cost of p.) In decentralization without transfers, each district can only pay expenditures for domestic enforcement, and the tax is $t_i = pg_i$. In decentralization with transfers, the tax is written as $t_i = p(g_i + s_i)$. In centralization, the tax is determined by the cost-sharing rule over total costs $p(x_1 + x_2)$.

We study fixed cost sharing and Nash bargaining. Cost sharing is defined by a pair (α, β), where $\alpha \in [0, 1]$ denotes the share of local enforcement in District 1 paid by District 1, and $\beta \in [0, 1]$ is the share of local enforcement in District 2 paid by District 2. Fixed cost sharing is equivalent to imposing the following restrictions: $(g_1, s_1) = (\alpha x_1, (1-\beta)x_2)$ and $(g_2, s_2) = (\beta x_2, (1-\alpha)x_1)$. Unlike fixed cost shares, Nash bargaining divides costs such that the product of the delegates' gains over their disagreement points, defined by decentralized production, is maximized.

An individual of type λ from district i has a utility function that is linear in the private (or alternative) consumption and concave in the effective crime protection,

$$u_i(\lambda, G_i, t_i) = \lambda q(G_i) + y - t_i.$$

Let $q(G)$ be an increasing and concave $\mathcal{C}^3$-function satisfying $q(0) = 0$, $\lim_{G \to 0^+} q'(G) = +\infty$, and $g'''(G) > 0$. We may interpret it as a probability of avoiding damage λ, capturing all interactions between deterrence expenditures and criminals' avoidance activities (see Langlais, 2008). Since individuals are risk-neutral in private consumption, sufficiently large income $y > 0$ is assumed only for the citizens to be able to meet any tax obligation. For convenience, let $u_i^m := u_i(\lambda^m, G_i, t_i)$. Notice that quasi-linearity immediately rules out cash-transfers, because the marginal rate of the substitution between private and public consumption is independent of the amount of private consumption. With quasi-linearity, neutrality of cash transfers goes entirely through private consumption, hence the only effect of a voluntary cash transfer would be the redistribution of private consumption from the donor to the recipient.

The timing is as follows: In Stage 1, both districts independently and simultaneously delegate two purely policy-seeking delegates, one each. The delegates characterized by parameters $(\lambda_1^d, \lambda_2^d)$ are the majority-preferred types. Like in Besley and Coate (2003), the pair of delegates is majority preferred if, in each district, a majority of citizens prefer the type of their representative to any other type, given the other district's representative type. Hence, the types are district's Condorcet winners. Later in the text, in order to obtain the majority-preferred types, we follow the logic that due to the quasiconcavity of preferences over the amount of effective crime enforcement, the equilibrium pair is identical as if the Stage 1 was reduced to a non-cooperative game of median voters from the two districts. Three types of best responses of the median voters may arise: sincere delegation where the median voter in district i promotes a candidate of identical type ($\lambda_i^d = \lambda^m$), strategic delegation of a person soft on crime ($\lambda_i^d < \lambda^m$), or strategic delegation of a hard law-enforcer ($\lambda_i^d > \lambda^m$). In line with the literature, we may call the preference for low public spending *conservative*, and preference for high public spending to be *progressive*.

In Stage 2, we distinguish between decentralization and centralization. For decentralization, each delegate non-cooperatively and simultaneously chooses their contribution to the domestic enforcement, $g_i \geq 0$, and voluntary transfer to the other district, $s_i \geq 0$, if allowed. In centralization, the elected policy makers select the allocation that is efficient from their joint perspective, and divide the costs either by shares (α, β) or by Nash bargaining. Thereby, we compare two polar arrangements: non-cooperative decentralization and cooperative centralization.

3.2 Social optimum

In this section, we will determine the socially optimal amounts of local enforcements (inputs) and, consequently, the levels of effective crime protection (outputs). Since utility is linear in private consumption, the distribution of costs is irrelevant from the Pareto-perspective. Thus, without a loss of generality, we impose $x_i = g_i$. By the linearity of utility in private consumption, the set of Pareto-efficient allocations must maximize the sum of utilities of all individuals in both districts,

$$(x_1^*, x_2^*) = \arg\max_{x_1, x_2} \left\{ \int_0^\infty F_1'(\lambda) u_1(\lambda) d\lambda + \int_0^\infty F_2'(\lambda) u_2(\lambda) d\lambda \right\}.$$

To identify the social optimum, notice that by the equality of the mean and median in both distributions,

$$\int_0^\infty F_i'(\lambda) u_i(\lambda) d\lambda = \left(\int_0^\infty \lambda F_i'(\lambda) d\lambda \right) q(G_i) + y - p x_i = \lambda^m q(G_i) + y - p x_i = u_i^m.$$

In other words, the social optimum is an argument maximizing the joint welfare of median voters,

$$u_1^m + u_2^m = \lambda^m q(\min\{x_1, \kappa x_2\}) + \lambda^m q(\min\{x_2, \kappa x_1\}) + 2y - p(x_1 + x_2). \quad (1)$$

We maximize the joint welfare in (1) first by identifying optimal shares of the fixed total costs, i.e. $dx_1 + dx_2 = 0$. Under this restriction, $dx_{-i}/dx_i = -1$. From the total differential, we focus only on the marginal benefits associated with an increase in x_i, and corresponding disutilities associated with a decrease in x_{-i}:

$$\begin{aligned}\frac{d(u_i^m + u_{-i}^m)}{dx_i}\,|_{dx_i+dx_{-i}=0} &= \frac{\partial u_i^m}{\partial x_i} + \frac{\partial u_i^m}{\partial x_{-i}}\frac{dx_{-i}}{dx_i} + \frac{\partial u_{-i}^m}{\partial x_i} + \frac{\partial u_{-i}^m}{\partial x_{-i}}\frac{dx_{-i}}{dx_i} \\ &= \frac{\partial u_i^m}{\partial x_i} - \frac{\partial u_i^m}{\partial x_{-i}} + \frac{\partial u_{-i}^m}{\partial x_i} - \frac{\partial u_{-i}^m}{\partial x_{-i}} \quad (2)\end{aligned}$$

We have three cases, $x_i < \kappa x_{-i}$, $x_i \in [\kappa x_{-i}, x_{-i}/\kappa]$, and $x_i > x_{-i}/\kappa$. The marginal benefits for each case are listed in Table 1.

Table 1: Marginal (dis)utilities of an increase in x_i under fixed total costs, $dx_i + dx_{-i} = 0$

	$x_i < \kappa x_{-i}$	$x_i \in [\kappa x_{-i}, x_{-i}/\kappa]$	$x_i > x_{-i}/\kappa$
$\partial u_i^m/\partial x_i$	$\lambda^m q'(x_i)$	0	0
$-\partial u_i^m/\partial x_{-i}$	0	$-\lambda^m \kappa q'(\kappa x_{-i})$	$-\lambda^m \kappa q'(\kappa x_{-i})$
$\partial u_{-i}^m/\partial x_i$	$\lambda^m \kappa q'(\kappa x_i)$	$\lambda^m \kappa q'(\kappa x_i)$	0
$-\partial u_{-i}^m/\partial x_{-i}$	0	0	$-\lambda^m q'(x_{-i})$
Marginal welfare	$+$	$+/-$	$-$

We insert terms from Table 1 into (2), to derive that under $dx_i + dx_{-i} = 0$,

$$\frac{du_i^m + u_{-i}^m}{dx_i} = \begin{cases} \lambda^m[q'(x_i) + \kappa q'(\kappa x_i)] > 0 & x_i < \kappa x_{-i}, \\ \lambda^m \kappa[q'(\kappa x_i) - q'(\kappa x_{-i})] \gtreqless 0 & x_i \in [\kappa x_{-i}, x_{-i}/\kappa], \\ -\lambda^m[q'(x_{-i}) + \kappa q'(\kappa x_{-i})] < 0 & x_i > x_{-i}/\kappa. \end{cases} \quad (3)$$

Clearly, if the share of x_i in total production is relatively low, the utilitarian criterion yields to increase the share, whereas if it is relatively high, it yields to decrease it. This is illustrated on Fig. 1, where arrows on cost-neutral line $dx_1 + dx_2 = 0$ indicate Pareto-dominant moves, which involve an increase in G_i with G_{-i} being constant.

The optimum lies in the intermediate part, where the interior first order condition is a candidate for the optimum, $\lambda^m \kappa[q'(\kappa x_1) - q'(\kappa x_2)] = 0$. Due to strict concavity of $q(\cdot)$, this implies symmetry, $x_1 = x_2$. Imposing symmetry into (1), the condition for the socially optimal enforcement spending, $x^* = x_1^* = x_2^*$, is as follows,

$$\lambda^m q'(\kappa x^*) = p/\kappa. \tag{4}$$

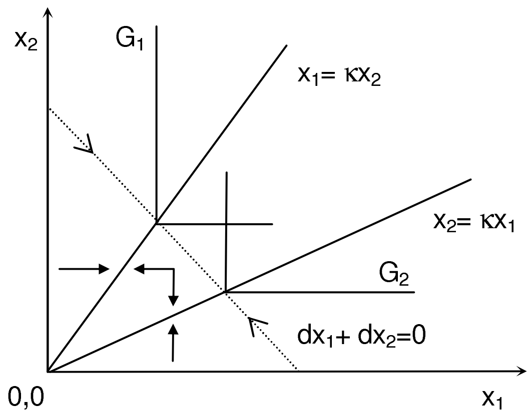

Figure 1: Mapping from inputs (x_1, x_2) to outputs (G_1, G_2)

4. Decentralization

4.1 No voluntary transfers

Besley and Coate (2003) found that if districts provide local public goods with spillovers, and the goods are pure substitutes, decentralization without transfers leads to sincere delegation, but also to underprovision. Dur and Roelfsema (2005) highlight that if the local public goods are strategic substitutes, decentralization in addition leads to strategic delegation of low-types. Underprovision is thus even stronger.

In this section, we show that these effects may also be sensitive to the assumption of zero voluntary transfers. Our case with criminals targeting the weakest-link district is particularly helpful: Without transfers, decentralization yields extreme underprovision; with transfers, it may even achieve the social optimum. Absent other effects, the introduction of a realistic possibility of voluntary transfers strikingly modifies the welfare properties of non-cooperative equilibria.

Proposition 1 *In decentralization without transfers, for any pair of delegates* $(\lambda_1^d, \lambda_2^d) \in \mathbb{R}^+$*, a unique Nash equilibrium is characterized by the zero provision,* $g_1 = g_2 = 0$*.*

The proposition is driven by the fact that for $\kappa < 1$, the delegates strategically undershoot each other level of deterrence, and their best responses intersect in zero, regardless of the preferences for enforcement. (Proofs of this as well as all subsequent propositions have been relegated to the Appendix.) This is illustrated by solid line arrows on Fig. 1. As a result, voters have no incentive to behave strategically, and the possibility to vote strategically in Stage 1 brings no change to the race to the ultimate bottom. The incentive to strategically undershoot can be remedied only if each delegate—at least on the margin—controlled the foreign level of enforcement, not the domestic level. This motivates to introduce voluntary transfers into the model.

4.2 Voluntary transfers

Transfers are typically considered an important instrument in the presence of spillovers (Bloch and Zenginobuz, 2007) and in cross-jurisdictional bargaining (Harstad 2007, 2008). In the context of weakest-link public goods, the opportunity to compensate another, less interested district has been highlighted by Vicary (1990), studied by Sandler and Vicary (2001), Vicary and Sandler (2002), and experimentally tested by Lei et al. (2007). Gregor (2008) shows that transfers give rise to strategic complementarities only for local spending being pure, not impure complements.

In our case, non-cooperative transfers solve the apparent problem that marginal rates of transformation of 'inputs' (local enforcement levels) are district-specific, which implies gains from specialization across districts. As we will see, each district is typically willing to contribute to the less productive foreign enforcement relatively more than to the more productive domestic enforcement, because relatively lower productivity makes the foreign district a more attractive option for criminals. For this purpose especially, we consider identical districts, i.e. we disregard motivation for transfers resulting from exogenous taste differences.

To start with, examine incentives in the policy-making sub-game of delegates (Stage 2). By the Slutsky duality, the necessary condition for the best response (and henceforth for a Nash equilibrium) is that each delegate minimizes costs for the given amount of the output. We use this rather trivial property of the equilibrium to deliver the following lemma.

Lemma 1 *In Nash equilibrium of the sub-game of delegates for decentralization with transfers, at least one of the districts contributes nothing to its own enforcement,* $g_1 = 0$ *or* $g_2 = 0$*.*

What is apparently unrealistic is that a district should fully specialize on providing resources in the other district. This is one of key findings of this setup, but it should be interpreted with caution. In reality, major part of spending on enforcement is pre-determined irrespective of the strategic considerations related to our class of crimes. It has extra use beyond reducing activities of strategically relocated criminals as envisioned here. Another plausible restriction is 'home bias' (cf. Sandler and Vicary, 2001), when a transfer is restricted not to exceed the level domestic spending, $s_i \leq g_i$. A careful reading of the model is that *ceteris paribus*, possibility to contribute to the foreign enforcement is key for the success of decentralized enforcement of this class of crimes.

To simplify our search for equilibrium, we introduce an extra notation: For any delegate i, let *S-strategy* be any strategy for which $g_i = 0$, and *T-strategy* be any strategy for which $g_i > 0$. Strategy profiles are, using this notation and ordering (Delegate 1, Delegate 2), classified into SS-, ST-, TS-, or TT-profiles. Through Lemma 1, the TT-profile is never in equilibrium.

Next, notice that any ST-profile implies $s_2 > 0$ (and TS-profile implies $s_1 > 0$). The proof is simple: If not and $s_2 = 0$, then $x_1 = g_1 + s_2 = 0$, $G_1 = \min\{0, \kappa(g_2 + s_1)\} = G_2 = \min\{g_2 + s_1, \kappa \cdot 0\} = 0$. Since $g_2 > 0$, this violates the cost-minimization at least for Delegate 2 (a decrease in $g_2 > 0$ will not affect G_2 and at the same time will decrease costs).

To summarize: The T-strategy of delegate i in equilibrium is always characterized by $g_i > 0$ and $s_i > 0$, while for the S-strategy, we have $g_i = 0$ and $s_i \geq 0$. The T-strategy thus can be re-interpreted as a strict *two-input strategy* (paying both domestic and foreign enforcement), whereas the S-strategy is a weak *single-input strategy* (paying only the foreign enforcement, if anything).

The useful property of quasi-linear preferences is that the marginal utility of public consumption is independent of the amount of private consumption, and the marginal utility of private consumption is constant. Therefore, we can define an optimal amount of output for each strategy type (S-strategy or T-strategy), purely as a function of λ. For S-strategy, we think of an interior optimum, that is a delegate i using the S-strategy is not bound by the insufficient amount of $x_i = s_{-i}$, so $x_i = s_{-i} > \kappa(g_{-i} + s_i) = \kappa x_{-i}$.

Precisely, let $G^S(\lambda)$ be the optimal amount of the local output that a citizen of type λ prefers to be provided if any additional output requires from their paying *only* extra foreign input. Let $G^T(\lambda)$ be the optimal amount of the local output preferred by a citizen of type λ if any extra output requires their paying *both* domestic and foreign input. For a delegate of type λ_i^d, we use for convenience G_i^S and G_i^T.

To express the optimal amount for the S-strategy, notice that the marginal cost of an extra unit of output is p/κ. This is from $dG_i = \kappa ds_i$, and the cost in terms of extra tax is $dt_i = pds_i = dG \cdot p/\kappa$. In the interior optimum, the marginal cost equals the marginal benefit of an extra unit of output, $\lambda_i^d q'(G)$, thus

$$\lambda_i^d q'(G_i^S) = p/\kappa. \tag{5}$$

For the T-strategies, the cost of an extra output unit is $p(1+1/\kappa)$. From $dG_i = \min\{dg_i, \kappa ds_i\}$, and the fact both inputs are increased effectively, $dG_i = dg_i = \kappa ds_i$, the extra tax is $dt_i = p(dg_i + ds_i) = p(dG_i + dG_i/\kappa) = dG_i \cdot p(1+1\kappa)$. In the interior optimum, the marginal cost equals the marginal benefit of a unit of extra output, thus

$$\lambda_i^d q'(G_i^T) = p(1+\kappa)/\kappa. \tag{6}$$

Since the marginal cost per extra output unit is $1+\kappa$-times higher under the T-strategy, $G^T(\lambda) < G^S(\lambda)$. From the implicit function theorem on (5) and (6), see also that optimal amounts increase in preference for crime protection,

$$\frac{\partial G^S(\lambda)}{\partial \lambda} = \frac{\partial G^T(\lambda)}{\partial \lambda} = -\frac{q'(G)}{\lambda q''(G)} > 0.$$

Most importantly, the values of these interior optimal outputs are *not* affected by the strategy of the other delegate, (g_{-i}, s_{-i}); later we will see that the delegate $-i$ only affects the feasibility of G_i^S and G_i^T.

For convenience, let $S(\lambda)$ be the total amount of the foreign inputs corresponding to $G^S(\lambda)$, $S(\lambda) := G^S(\lambda)/\kappa$. Similarly, let $T(\lambda)$ be the total amount of the foreign inputs x_{-i} corresponding to $G^T(\lambda)$, $T(\lambda) := G^T(\lambda)/\kappa$. For delegates and citizens of median types, introduce $S_i := S(\lambda_i^d)$, $T_i := T(\lambda_i^d)$, $S^m := S(\lambda^m)$ and $T^m := T(\lambda^m)$. By comparing (4) and (5), notice

$$x^* = S^m. \tag{7}$$

This means that if the median-type candidates ($\lambda_1^d = \lambda_2^d = \lambda^m$) expect an SS-profile, each of them prefers in their interior optimum $s_i = S^m$, which is also the socially optimal allocation. In Lemma 2 below, we show that this efficient SS-profile actually is a strict Nash equilibrium. Stability is preserved by the fact that since $\kappa s_i \leq s_{-i} = s_i$, we have $G_i = \min\{s_{-i}, \kappa s_i\} = \kappa s_i$, so the strategic situation of the delegate i resembles the consumption of a pure private good G_i for price p/κ, without any externality to consumption of the other delegate.

Lemma 2 proves that a pair of identical-type candidates deliver a symmetric SS-profile, not an ST- or TS-profile (recall TT-profile has been eliminated by Lemma 1).

Lemma 2 *For decentralization with transfers, within the subgame of symmetric delegates $\lambda_1^d = \lambda_2^d$, a unique Nash equilibrium is SS-profile with $s_1 = s_2 = S_1 = S_2$ and $g_1 = g_2 = 0$.*

We found that with in-kind transfers, identical-type delegates manage to install their joint optimum, even in a non-cooperative mode. By (1), this allocation is socially optimal, if the delegates are unbiased (median types). The next question is whether the median-type delegates are in equilibrium in delegation stage (Stage 1), where voters determine the optimal delegate for policy-making stage (Stage 2). The next Proposition 2 specifies a sufficient condition under which the median delegates are indeed in equilibrium in the delegation stage. This is also a sufficient condition for the social optimum to be immune to strategic delegation.

Proposition 2 *In decentralization with voluntary transfers, the delegation of median-type representatives, $\lambda_1^d = \lambda_2^d = \lambda^m$, is a sub-game perfect Nash equilibrium if*

$$\lambda^m q\left(\kappa^2 T^m\right) < \lambda^m q\left(\kappa S^m\right) - pS^m. \tag{8}$$

The condition in (8) has the following interpretation: The median voter, expecting sincere delegation, has only two options. Either sincere delegation, involving efficient SS-profile with symmetric cost-shares, or conservative delegation, involving inefficient ST-profile with asymmetric cost-shares. In the latter option, Delegate 1 fully free rides on Delegate 2. The condition says that the free-ride is not selected as long as loss from underprovision exceeds gain from free ride.

The condition is plotted in Fig. 2 as the positive difference between the utility at a symmetric efficient SS-profile, expressed by the maximum of u_2^S

(by symmetry, $\max u_1^S(\lambda^m) = \max u_2^S(\lambda^m)$), and the utility at a free-riding ST-profile, expressed by maximum of u_1^T, achieved when free ride is absolute, $g_1 = s_1^e = 0$. To derive the shape of the u_1^T schedule, it is sufficient to notice that (i) for all ST-profiles induced by Delegate 2, $(x_1, x_2) = (\kappa T_2, T_2)$, thus $du_1^T + du_2^T = 0$, and the profiles differ only in distribution of costs; and (ii) for $s_1 = \kappa T_2$, $u_1^T < u_2^T$, because by the definition of T_2, $u_1^T = \lambda^m q(\kappa^2 T_2) + y - p\kappa T_2 < \lambda^m q(\kappa T_2) + y - pT_2$.

Next, we show how the stability of the efficient SS-profile in decentralization is affected by a change in the interdependence between the districts. Interdependence can be understood as the relative importance of foreign to domestic enforcement. The importance grows when κ falls, because criminals gain an extra incentive to displace to a relatively less productive district.

In Proposition 3, we show that, non-intuitively, the more interdependent the districts are, the more likely it is that decentralization is socially optimal. In other words, the more attractive it is for criminals to reside elsewhere, the less attractive is free riding ST-profile to the efficient SS-profile.

Proposition 3 *Let $\kappa \in (2/3, 1)$. If (8) holds for $\kappa = \bar{\kappa}$, then it holds also for $\kappa < \bar{\kappa}$. If (8) does not hold for $\kappa = \bar{\kappa}$, then it does not hold for $\kappa > \bar{\kappa}$ either.*

5. Centralization

In cooperative centralization, delegates seize all of the benefits of cooperation. This makes centralization a seemingly very attractive mode. Yet even though delegates dispose of perfect cooperation devices under this type of centralization, social optimum is not guaranteed. The explanation lies in the incentive of non-cooperative rational voters to elect different than median-type delegates, and thereby affect the distribution of surplus in the sub-game of delegates. Strategic delegation is one of the key shortcomings of centralized arrangements, as well as a major obstacle to any bargaining.

Strategic delegation is a phenomenon with multiple applications in economics, e.g. in monetary policy (Chari *et a*l., 2004), industrial organization, tax competition (Brueckner, 2004) or environmental economics (Buchholz *et al.*, 2005). Conservative (low value of public spending) delegation is typically used to strategically decrease the breakdown allocation, and induce relatively larger compensations (Segendorff, 1998). In contrast, progressive (high value of public spending) delegation has an advantage in the case of fixed cost-sharing rules (Besley and Coate, 2003), and also if the proportion of shared costs is large (Dur and Roelfsema, 2005).

Strategic delegation in our case relates to a dichotomy in devices available in each stage: In electoral Stage 1, voters in one district play non-cooperatively with voters from the other district, whereas in the policy-making Stage 2, the delegates play cooperatively. Non-cooperative voters on one hand welcome the surplus from cooperation, but on the other hand try to improve their odds by effectively delegating someone with different preferences, at the cost of some distortion. In our case, we shall see that a burden of distortion may be fully born by the other district, which induces strict deviation from sincere delegation. Section 5.1 calculates the provision of goods for all pairs of delegates. In Section 5.2, we show that strategic delegation introduces welfare loss under all fixed cost shares (α, β), with only one exception. As a robustness check, Section 5.3 proves that if delegates split a positive surplus by Nash bargaining, the social optimum cannot be achieved either. Like fixed cost shares, Nash bargaining is not delegation-proof.

5.1 Cooperative allocation

The joint objective function of the two policy makers who cooperate in the provision of local enforcement is

$$u_1^d + u_2^d = \lambda_1^d q(\min\{x_1, \kappa x_2\}) + \lambda_2^d q(\min\{x_2, \kappa x_1\}) + 2y - p(x_1 + x_2). \quad (9)$$

Exactly like in Section 3.2, we maximize (9) by first optimizing under the fixed total costs, $dx_i + dx_{-i} = 0$. Under this restriction, we again focus only on the marginal benefits associated with an increase in x_i (and respective decrease in x_{-i}). Again, there are three cases, $x_i \leq \kappa x_{-i}$, $x_i \in [\kappa x_{-i}, x_{-i}/\kappa]$, and $x_i \geq x_{-i}/\kappa$. We can see, by analogy to (3), that under $dx_i + dx_{-i} = 0$,

$$\frac{du_i^d + u_{-i}^d}{dx_i} = \begin{cases} \lambda_i^d q'(x_i) + \lambda_{-i}^d \kappa q'(\kappa x_i) > 0 & x_i < \kappa x_{-i}, \\ \lambda_i^d \kappa q'(\kappa x_i) - \lambda_{-i}^d \kappa q'(\kappa x_{-i}) \gtreqless 0 & x_i \in [\kappa x_{-i}, x_{-i}/\kappa]\,, \\ -\lambda_i^d q'(x_{-i}) - \lambda_{-i}^d \kappa q'(\kappa x_{-i}) < 0 & x_i > x_{-i}/\kappa. \end{cases}$$

Like in the derivation of the social optimum, the optimum lies in the middle interval. To obtain it, we first derive the interior optimum for the marginal welfare in the middle interval, $(\hat{x}_i, \hat{x_{-i}})$. Using the FOC, it is implicitly characterized as follows:

$$\frac{\lambda_i^d}{\lambda_{-i}^d} = \frac{q'(\kappa \hat{x}_i)}{q'(\kappa \hat{x}_{-i})}$$

Unlike in the social optimum, it is not here guaranteed that this interior optimum lies in the middle interval, $\hat{x}_i \in [\kappa x_{-i}, x_{-i}/\kappa]$, if asymmetry of delegate types is large enough. The cooperative outcome, (x_1^C, x_2^C), may involve also corners $x_i^C \in \{\kappa x_{-i}^C, x_{-i}^C/\kappa\}$, hence satisfies for any i

$$x_i^C = \max\{\kappa x_{-i}^C, \min\left[\hat{x}_i, x_{-i}^C/\kappa\right]\}.$$

For sufficiently symmetric delegates with $(x_1^C, x_2^C) = (\hat{x}_1, \hat{x}_2)$, we may identify the interior values straightforwardly from the FOC imposed on (9),

$$\lambda_{-i}^d q'(\kappa \hat{x}_i) = p/\kappa.$$

By the definition of $S(\lambda)$,

$$\hat{x}_i = S(\lambda_{-i}^d). \tag{10}$$

Comparing (10) with (7), we can see that the social optimum is achieved if and only if both delegates are of median types, $\lambda_1^d = \lambda_2^d = \lambda^m$.

5.2 Fixed cost shares

It is an established fact that incentives for strategic delegation primarily depend on the structure of costs paid in cooperation (Dur and Roelfsema 2005), specifically on the amount of enforcement subsidized in the other district. Although the cost sharing itself does not affect the cooperation between delegates, it may introduce an element of conflict among the voters in the delegation stage. Recall now that a fixed cost sharing is defined by a pair of shares (α, β) of local enforcement paid within the districts, where $(g_1, s_1) = (\alpha x_1, (1-\beta)x_2)$ and $(g_2, s_2) = (\beta x_2, (1-\alpha)x_1)$. The contribution of this section is to examine if the conflict arises for reasons other than the often postulated equal-cost sharing (Besley and Coate 2003); equal-cost sharing is, in our notation, a special case of $(\alpha, \beta) = (1/2, 1/2)$.

We again use the fact that median voters are decisive in their districts. We will focus on their best responses in the non-cooperative game in delegation Stage 1. Since we are only interested in the stability of the socially optimal allocation, and this allocation by (10) can be achieved only via median-type delegates, this task is reduced to discerning whether median-type delegates are preserved in equilibrium.

Proposition 4 rejects this possibility for all but one case of cost sharing, to be called a *delegation-proof* cost sharing. With this exception, it proves that if a median voter expects a median-type delegate from the other district, they have an incentive to vote for a progressive delegate.

Proposition 4 *In centralization with strategic delegation and fixed cost shares (α, β), median-type delegates $\lambda_1^d = \lambda_2^d = \lambda^m$ are part of a sub-game perfect Nash equilibrium, if and only if $(\alpha, \beta) = (0, 0)$.*

5.3 Nash bargaining

Nash bargaining maximizes the product of the utility differences over the decentralized equilibrium (henceforth denoted by superscript D). The bargaining outcome apparently depends on the equilibrium in decentralization, where we distinguish between the case of the degenerated production (in the absence of transfers), the case of a specialization SS-profile, and the free-riding ST-profile. The following Propositions 5 and 6 show for all cases, there is always an incentive for strict deviation from the median-type delegation towards progressive delegation, as long as cooperation yields a non-zero surplus.

The cost paid by each individual in district i is t_i. Since Nash-bargaining yields an allocation efficient for the delegates, it must be for sufficiently symmetrical (e.g., median-type) delegates an SS-profile, where $G_1 = \min\{x_1, \kappa x_2\} = \kappa x_2 = \kappa S_1$, and by analogy $G_2 = \kappa S_2$. Total costs are $t_1 + t_2 = p(x_1 + x_2) = p(S_1 + S_2)$. The Nash bargaining outcome is characterized by the following cost-shares:

$$(t_i, t_{-i}) = \arg\max \left(\lambda_i^d q(\kappa S_i) + y - t_i - u_i^D\right) \left(\lambda_{-i}^d q(\kappa S_{-i}) + y - t_{-i} - u_{-i}^D\right)$$

Since utility is linear in transferable costs, and bargaining power is identical across delegates, the Nash bargaining equalizes the net surplus across the delegates,

$$\lambda_i^d q(\kappa S_i) + y - t_i - u_i^D = \lambda_{-i}^d q(\kappa S_{-i}) + y - t_{-i} - u_{-i}^D.$$

We will use this property of the derived cost shares in the analysis of the case when transfers are not allowed in decentralization.

Proposition 5 *In centralization with strategic delegation and Nash bargaining improving upon decentralization without transfers, the median-type delegates $\lambda_1^d = \lambda_2^d = \lambda^m$ are not in a sub-game perfect Nash equilibrium.*

With transfers, decentralization may deliver an efficient SS-profile, hence cooperation only preserves this allocation. As we will see, such an outcome is delegation-proof as long as the delegates are median types. In all remaining cases, cooperative centralization is not delegation-proof.

Proposition 6 *In centralization with strategic delegation and Nash bargaining improving upon decentralization with transfers, median-type delegates* $\lambda_1^d = \lambda_2^d = \lambda^m$ *are a part of a sub-game perfect equilibrium if and only if decentralization is socially efficient.*

6. Centralization tradeoff and extension to $n > 2$ regions

Table 2 summarizes the main findings by comparing welfare in decentralization (D) and centralization (C), under all possible institutional configurations and all levels of κ (a total of six cases). The Pareto-dominance of centralization over decentralization is denoted $C \succ D$, and Pareto-equivalence $C \sim D$. Social optimum is noted with G^* or just a star in the superscript, if equivalent to either of the arrangements.

Table 2: Centralization tradeoff

Transfers, delegation, κ	$(\alpha, \beta) \neq (0,0)$	$(\alpha, \beta) = (0,0)$	Nash bargain
1. no, sincere	$C^* \succ D$	$C^* \succ D$	$C^* \succ D$
2. no, strategic	$G^* \succ C$, $G^* \succ D$	$C^* \succ D$	$G^* \succ C$, $G^* \succ D$
3. yes, sincere, high	$C^* \succ D$	$C^* \succ D$	$C^* \succ D$
4. yes, sincere, low	$D^* \sim C^*$	$C^* \sim D^*$	$D^* \sim C^*$
5. yes, strategic, high	$G^* \succ C$, $G^* \succ D$	$C^* \succ D$	$G^* \succ C$, $G^* \succ D$
6. yes, strategic, low	$D^* \succ C$	$D^* \sim C^*$	$D^* \sim C^*$

The tradeoffs summarize Propositions 2, 4, 5, and 6. Non-cooperative decentralization is socially efficient (D^*), if transfers are feasible and interdependence is high, i.e. κ is low (Cases 4, 6); it is inefficient ($G^* \succ D$) either in the absence of transfers (Cases 1, 2), or for transfers but with interdependence (Cases 3, 5). Cooperative centralization is socially efficient (C^*) either if delegation is sincere (Cases 1, 3, 4), or if delegation is strategic but cost shares are delegation-proof (Column 2 in Cases 2, 5, 6). It is obviously also efficient if Nash bargaining only replicates the disagreement point (Column 3 in Cases 4,6). In the other cases, centralization is inefficient, $G^* \succ C$.

What is particularly interesting is to compare Cases 1 and 6 (Column 1). Case 1 represents a traditional setup in the literature on decentralization: no transfers, sincere delegates, and equal cost sharing. Case 6 is nothing but an extension of the setup by realistic assumptions of voluntary in-kind transfers and strategic delegation under sufficiently large interdependence. The extension itself completely reverts the centralization tradeoff; in Case

1, $C^* \succ D$, whereas in Case 6, $D^* \succ C$. It is a combination of two effects that switches the tradeoff: transfers weakly improve the performance of decentralization, and strategic delegation weakly worsens the efficiency of centralization.

To analyze a multilateral case, consider first a case when *all* districts are crime-targeted. Then, results are unchanged because in decentralization with transfers, each district again tends to specialize on controlling enforcement in one of the other, less productive districts. This establishes a multilateral version of a specialization SS-profile. The main result is also intact in the presence of non-targeted districts, if there is just a *single* targeted district. Then, the district provides nothing if transfers are not allowed, but with transfers, effectively funds enforcement in all non-targeted districts. This is socially efficient, because crime protection is consumed only in the targeted district.

The analysis complicates with non-targeted districts, in the presence of *several* targeted districts. Then, spending in the non-targeted districts has a collective good property. This obviously works against efficiency of decentralization, and the problem grows, the larger is the number of targeted districts. Note that the number of non-targeted districts is strategically irrelevant, since contributions to them, albeit featuring complementarities, are always strategic substitutes to contributions of other districts. For efficiency of decentralized crime deterrence, the existence of a few 'safe havens' in non-targeted districts is therefore more important than the existence of many targeted districts where criminals can relocate.

7. Conclusion

In this paper, we compare the efficiency of non-cooperative decentralization and cooperative centralization in the provision of local non-rival crime deterrence when criminals are mobile, and criminal opportunities are immobile. In the context of two symmetrical districts, we study to what extent voluntary in-kind transfers and strategic delegation affect the relative benefits of centralization *vis-a-vis* decentralization.

The transfers are found to enhance the efficiency of decentralization; non-cooperative decentralization with transfers may even reach the social optimum. Strategic delegation is found to worsen the efficiency of cooperative centralization, except for a special case of delegation-proof cost-sharing. As a result, the decentralization theorem for this class of criminal activities and deterrence efforts crucially depends on the feasibility of transfers and strategic delegation.

In a standard case with sincere delegates and the absence of transfers, centralization dominates decentralization. In contrast, with strategically nominated delegates who are allowed to provide in-kind transfers, decentralization dominates centralization at least for the sufficiently large asymmetry in local productivity. That is, if criminals relative more tend to strategically move to a less endangering district so as to avoid the use of local expertise, then the decentralization is more efficient. Perhaps surprisingly, the benefits of centralization are therefore *not* related to high interdependence among the districts, but rather to the lack of thereof.

Appendix

Proof of Proposition 1. If $g_i > \kappa g_{-i}$, a policy maker $i \in \{1,2\}$ can reduce g_i (less costs) and at the same time keep $G_i = \min(g_i, \kappa g_{-i}) = \kappa g_{-i}$ unchanged (constant benefits). A strict increase in utility u_i^d, implies that $g_i > \kappa g_{-i}$ cannot be the best response; the best response has to satisfy $g_i \leq \kappa g_{-i}$. If we apply this condition simultaneously to Delegate 1 and Delegate 2 ($g_1 \leq \kappa g_2$ and $g_2 \leq \kappa g_1$), it is satisfied for $\kappa < 1$ only as long as $g_1 = g_2 = 0$. □

Proof of Lemma 1. We partition the set of strategy profiles into the following four subsets: $s_1 = s_2 = 0$, $s_1 > 0, s_2 = 0$, $s_1 = 0, s_2 > 0$, and $s_1 > 0, s_2 > 0$. Incentives for deviation if $s_1 = s_2 = 0$ have been examined in Proposition 1, although on a restricted strategy set. Identical deviations however exist on the unrestricted set, hence the only candidate for equilibrium in this subset is $g_1 = g_2 = 0$.

If $s_1 > s_2 = 0$, we first show that Delegate 1 contributes to both inputs. Since $G_1 = \min\{g_1, \kappa(g_2 + s_1)\}$ and $s_1 > 0$, the delegate cannot tolerate waste in the input $x_2 = g_2 + s_1$, and $G_1 = \kappa(g_2 + s_1)$. A strictly positive subsidy $s_1 > 0$ implies also a strictly positive $g_1 > 0$, hence waste in the input $x_1 = g_1$ must not be tolerated either. Second, consider whether the Delegate 2 contributes to their own input. The output in District 2 is $G_2 = \min\{g_2 + s_1, \kappa g_1\}$. If Delegate 2 provides $g_2 > 0$, then $G_2 = g_2 + s_1 \leq \kappa g_1$ (otherwise he/she doesn't minimize costs). However, from Delegate 1's problem, we get $G_1/\kappa = g_2 + s_1 = g_1/\kappa > g_1$. This is inconsistent with $g_2 + s_1 \leq \kappa g_1$, hence Delegate 2 deviates to $g_2 = s_2 = 0$. If $s_2 > s_1 = 0$, the reasoning is analogical to $s_1 > s_2 = 0$, and $g_1 = s_1 = 0$.

If $s_1 > 0$ and $s_2 > 0$, the cost minimization for both delegates dictates $G_1 = g_1 + s_2 = \kappa(g_2 + s_1)$ and symmetrically $G_2 = g_2 + s_1 = \kappa(g_1 + s_2)$.

For $g_1 > 0$ and $g_2 > 0$, this implies $1 = \kappa^2$, which is false. Therefore, $g_1 = 0$ or $g_2 = 0$. To sum up, regardless of where the equilibrium profile appears, there always exists i, such that $g_i = 0$. □

Proof of Lemma 2. Using Lemma 1, impose $g_1 = 0$ without a loss of generality, hence we restrict ourselves to the ST and SS profiles. We proceed as follows—in the first part, we identify the best response of Delegate 2. In the second part, we check the best response of Delegate 1 to the best response of Delegate 2, to see when the equilibrium beliefs of Delegate 2 are correct beliefs.

- DELEGATE 2: Examine the best response of Delegate 2 (g_2, s_2) as a function of the expected s_1^e. This is possible because S-strategy of Delegate 1 is $(0, s_1)$, which is fully characterized by s_1. To recognize where Delegate 2 selects the S-strategy or T-strategy, we first find an optimal response of Delegate 2 limited to the set of SS profiles (denoted as $g_2^S(s_1^e), s_2^S(s_1^e)$), and an optimal response limited to the set of the ST profiles (denoted as $g_2^T(s_1^e), s_2^T(s_1^e)$); the response with maximum utility yields the true best response.

  i) SS-PROFILES: Consider the S-strategy. Here, $G_2 = \min\{s_1^e, \kappa s_2\}$. To provide $s_2 > s_1^e/\kappa$ is useless due to complementarity with the input $x_2 = s_1^e$. To provide $s_2 > S_2$ is also sub-optimal as it implies $G_2 > G^S(\lambda_2^d)$. The best among the S-strategies thus writes $s_2^S(s_1^e) = \min\{s_1^e/\kappa, S_2\}$ and $g_2^S(s_1^e) = 0$.

  ii) ST-PROFILES: Consider the T-strategy. Here, $G_2 = \min\{g_2 + s_1^e, \kappa s_2\}$. Delegate 2 can provide s_2 at any amount since the complementarity with input x_2 is not restrictive (he or she can raise g_2 to boost x_2). Therefore, the best among the T-strategies yields $G_2 = G_2^T(\lambda_2^d)$, which means $s_2^T(s_1^e) = T_2$ and $g_2^T(s_1^e) = \max\{0, \kappa T_2 - s_1^e\}$. Since by the definition of a T-strategy, $g_2 > 0$, the T-strategy is feasible to Delegate 2 only for $g_2^T(s_1^e) = \kappa T_2 - s_1^e > 0$, i.e. only for $s_1^e < \kappa T_2$.

  The payoffs for the best S-strategy and the best T-strategy are:

$$u_2^S(s_1^e) = \lambda_2^d q(\min\{s_1^e, \kappa S_2\}) + y - p\min\{s_1^e/\kappa, S_2\}, \tag{11}$$

$$u_2^T(s_1^e) = \lambda_2^d q(\kappa T_2) + y - p(1+\kappa)T_2 + p\min\{s_1^e, \kappa T_2\}. \tag{12}$$

  To identify the true best response, Fig. 2 depicts the utilities of Delegate 2 corresponding to both the best S-strategy, $u_2^S(s_1^e)$, and the best

T-strategy, $u_2^T(s_1^e)$. From (11), the function $u_2^S(s_1^e)$ grows on interval $s_1^e \in [0, \kappa S_2]$ (capturing the surplus over the marginal cost). From (12), the function $u_2^T(s_1^e)$ grows on the interval $s_1^e \in [0, \kappa T_2)$ (exploiting the fact that less is paid for input x_1). To help ourselves, evaluate the functions at $s_1^e = 0$:

$$u_2^S(0) = \lambda_2^d q(0) + y - 0 = 0 < \lambda_2^d q(\kappa T_2) + y - p(1+\kappa)T_2 = u_2^T(0) \quad (13)$$

Next, evaluate the functions at $s_1^e = \kappa T_2$. Since the T-strategy (and the ST-profile) is only available for $s_1^e < \kappa T_2$, we evaluate the limit value of the ST-profile in a supremum of the interval $[0, \kappa T_2)$:

$$\begin{aligned} u_2^S(\kappa T_2) = \lambda_2^d q(\kappa T_2) + y - pT_2 &= \lambda_2^d q(\kappa T_2) + y - p(1+\kappa)T_2 + p\kappa T_2 \\ &= \lim_{s_1^e \to \kappa T_2} u_2^T(s_1^e) \end{aligned}$$

To conclude, the best response of Delegate 2 is T-strategy for $s_1^e < \kappa T_2$ and S-strategy for $s_1^e \geq \kappa T_2$.

- DELEGATE 1: The next condition necessary to hold in equilibrium is that the best response of Delegate 1 to $g_2(s_1^e)$ and $s_2(s_1^e)$ must be $s_1 = s_1^e$ and $g_1 = 0$, hence the equilibrium beliefs are correct. First, we prove that for the pair of identical-type delegates, $\lambda_1^d = \lambda_2^d$, the ST-profile is never a Nash equilibrium. Second, we identify a unique equilibrium SS-profile.

  i) ST-PROFILES. We have found that the T-strategy is the true best response of Delegate 2, as long as $s_1^e < \kappa T_2$. The best response writes $(g_2, s_2) = (\kappa T_2 - s_1^e, T_2)$. The output for Delegate 1 on this best response is $G_1 = \min\{T_2, \kappa(\kappa T_2 - s_1^e + s_1)\}$. If this were an equilibrium, then $s_1 = s_1^e$ and $G_1 = \kappa^2 T_2 < T_2$. Notice that enforcement x_1 is excessive from the perspective of Delegate 1, hence the delegate can boost their output G_1 only by marginally increasing x_2. Delegate 1 is willing to do so (by increasing s_1, thereby increasing x_2), as long as $x_2 < S_1$. This is exactly the case here because for the *symmetrical* delegates, $x_2 = \kappa T_2 < \kappa S_2 = \kappa S_1 < S_1$. As a result, no ST-profile can be an equilibrium.

ii) SS-PROFILES. We have found that the S-strategy is the true best response of Delegate 2, as long as $s_1^e \geq \kappa T_2$. The best response is written $(g_2, s_2) = (0, \min\{s_1^e/\kappa, S_2\})$. Suppose there is an equilibrium, $s_1 = s_1^e$. We distinguish between two cases:

  * Low s_1^e: For $s_1^e \in [\kappa T_2, \kappa S_2]$, $G_1 = \min\{s_1^e/\kappa, \kappa s_1^e\} = \kappa s_1^e$. From the perspective of Delegate 1, enforcement x_1 is excessive, and to boost the output, only a marginal increase in x_2 is required. Delegate 1 is willing to do so, as long as $x_2 \leq S_1$. This is exactly the case here for the *symmetrical* delegates and this interval of s_1^e, $s_1^e \leq \kappa S_2 = \kappa S_1 < S_1$. Thus, low s_1^e cannot be in equilibrium.
  * High s_1^e: For $s_1^e > \kappa S_2$, the best S-strategy of Delegate 2 is $s_2 = S_2$. This yields to Delegate 1 $G_1 = \min\{S_2, \kappa s_1^e\}$. In the best response with S-strategy, Delegate 1 plays $s_1 \leq S_1$; if unconstrained, $s_1 = S_1$. Anticipating $s_2 = S_2$ doesn't constrain him, because $S_2 = S_1 > \kappa S_1 \geq \kappa s_1$. Thus $G_1 = \min\{S_2, \kappa s_1\} = \kappa s_1$, and Delegate 1 can play interior optimum $s_1 = S_1$, with $G_1 = G_1^S$. This is stable because—as we already know—Delegate 2 responds by $s_2 = S_2$ and $G_2 = G_2^S$.

Given that the only equilibrium strategy of Delegate 2 is S-strategy with $s_2 = S_2$, and the corresponding unique best response of Delegate 1 as $s_1 = S_1$, the equilibrium is unique, $(g_1, s_1, g_2, s_2) = (0, S_1, 0, S_2)$. □

Proof of Proposition 2. We seek a sufficient condition for median-type delegates to be Condorcet winners in elections in each district. It is sufficient to analyse only the incentives for unilateral deviation from the symmetric median-type delegation, which by Lemma 2 delivers the social efficient SS-profile with $(x_1, x_2) = (S^m, S^m)$, and $(G_1, G_2) = (\kappa S^m, \kappa S^m)$. When considering such deviations, we use the fact that the Condorcet winner in each district is identical to the optimal delegate for the median voter (to be proved in the last part of this proof). Thus, Stage 1 is equivalent to a bilateral non-cooperative game of a pair of median voters from different districts.

The median voter in District 1 expects that only the SS, ST, or TS-profiles emerge in the sub-game of delegates. First, if the SS-profile occurs in the sub-game of delegates, any strategic delegation that involves $s_1 \neq S^m$ is obviously dominated by $s_1 = S^m$, by the definition of the optimal $G^S(\lambda^m)$. Second, if the TS-profile occurs, the median voter in District 1 would lose

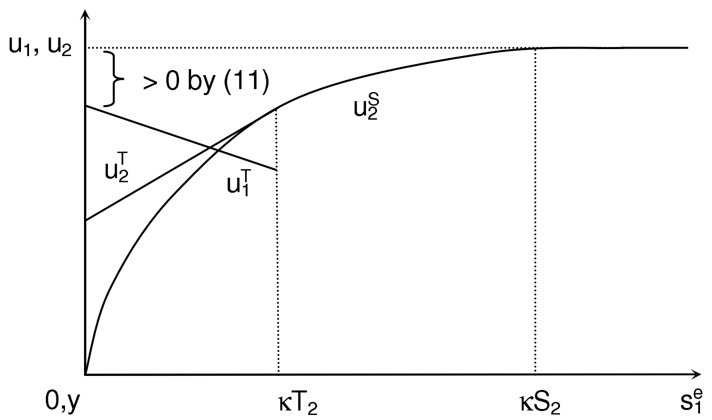

Figure 2: The utilities of the delegates for the best S-response and the best T-response of Delegate 2 to expected S-strategy of Delegate 1

in comparison to the social optimum, because its delegate would have to employ a more expensive two-input T-strategy (for any level of output). Thus, the only incentive for proper strategic delegation is to induce an ST-profile, and thereby a free ride on District 2, whose median-type delegate is willing to resort to the expensive two-input strategy.

To keep the ST-profile in an equilibrium of the delegates' sub-game, the T-strategy must be the best response of Delegate 2. From the proof in Lemma 2, the T-strategy is the best response, if $s_1^e < \kappa T_2$. The best response is $g_2 = \kappa T_2 - s_1^e$ and $s_2 = T_2$. Next, the output in District 1 is $G_1 = \min\{s_2 + g_1, \kappa(g_2 + s_1)\} = \min\{T_2, \kappa(\kappa T_2 - s_1^e + s_1)\}$. In this equilibrium, we require $s_1 = s_1^e$, thus $G_1 = \kappa^2 T_2$. We know the output and best response of Delegate 2, hence it remains to check best response of Delegate 1. Output for Delegate 1 is, considering possible deviations, $G_1 = \min\{T_2 + g_1, \kappa^2 T_2 - s_1^e + s_1\}$. If $S_1 > \kappa T_2$, Delegate 1 would deviate by increasing s_1 such that $x_2 = S_1$. Therefore, the stability of ST-profile in equilibrium requires $S_1 \leq \kappa T_2$. Notice that for such a pair of delegates, $\kappa T_1 < \kappa S_1 < S_1 \leq \kappa T_2$, i.e. $\kappa T_1 < \kappa T_2$ and Delegate 1 must be relatively more conservative than Delegate 2, $\lambda_1^d < \lambda_2^d$.

Next, for Delegate 1 who is exactly on the margin, $S_1 = \kappa T_2$, there are multiple equilibria in Stage 2, differing only in the distribution of $g_2 + s_1 = \kappa T_2$. For any slightly more conservative Delegate 1, characterized by $S_1 < \kappa T_2$, the best response is $s_1 = S_1 - g_2 = S_1 - \kappa T_2 + s_1^e < s_1^e$, and there is only a unique equilibrium with $s_1 = 0$, where the non-negativity constraint applies. Since both cases yield an identical G_1, delegating the indifferent delegate is—from the perspective of median voter in District 1—weakly dominated by delegating a sufficiently conservative delegate.

Finally, the payoff for the median voter in District 1 for this ST-profile is $\lambda^m q(\kappa^2 T^m)$. Since we check deviation from sincere delegation, we evaluate it for $T_2 = T^m$, and this is compared with the payoff for the symmetrically efficient SS-profile, $\lambda^m q(\kappa S^m) - pS^m$, which yields the condition in (8).

Now, we show that the existence of other-than-median voters brings no changes to the outcome. If an SS-profile is expected, voters within a district have single-peaked preferences over s_1, because $S(\underline{\lambda}) < S(\overline{\lambda})$ if and only if $\underline{\lambda} < \overline{\lambda}$. This means that within SS-profiles, Condorcet-winner-value of s_1 corresponds to $s_1 = S^m$. Within the ST-profiles, there is no conflict of interest within District 1, since the output $G_1 = \kappa^2 T_2$ is independent of type. As a result, each voter of type λ in District 1 compares his or her utilities of the two profiles and prefers SS-profile if

$$\lambda q(\kappa S(\lambda)) - \lambda q(\kappa^2 T^m) > pS^m. \tag{14}$$

The left-hand-side is clearly increasing in λ, and the right-hand-side is constant, hence if (8) holds, then (14) holds at least for the majority of voters of $\lambda \geq \lambda^m$ types. Hence, the median-type-preferred profile is also a majority-preferred profile, i.e. the Condorcet winner. This completes the proof. □

Proof of Proposition 3. Denote the utility difference as $V := \lambda^m q(\kappa G^T) - \lambda^m q(G^S) + pG^S/\kappa$. The Proposition aims to show that V grows in κ,

$$\frac{\partial V}{\partial \kappa} = \lambda^m q'(\kappa G^T)\left(G^T + \kappa \frac{\partial G^T}{\partial \kappa}\right) - \lambda^m q'(G^S)\frac{\partial G^S}{\partial \kappa} + p\frac{\partial S}{\partial \kappa} > 0.$$

Define the elasticities of the optimal outputs with respect to the level of κ: $\varepsilon^T = \varepsilon(G^T, \kappa) := \kappa(\partial G^T/\partial \kappa)/G^T$, $\varepsilon^S = \varepsilon(G^S, \kappa) := \kappa(\partial G^S/\partial \kappa)/G^S$. This allows us to write $G^T + \kappa(\partial G^T/\partial \kappa) = G^T + \varepsilon^T G^T = G^T(1 + \varepsilon^T)$, $\partial G^S/\partial \kappa = \varepsilon^S G^S/\kappa$, and

$$\frac{\partial S}{\partial \kappa} = \frac{\partial \frac{G^S}{\kappa}}{\partial \kappa} = \frac{G^S(\varepsilon^S - 1)}{\kappa^2}.$$

Imposing the second and third terms from $\partial V/\partial \kappa$, and using $q'(G^S) = p/(\lambda^m \kappa)$,

$$-\lambda^m q'(G^S)\frac{\partial G^S}{\partial \kappa} + p\frac{\partial S}{\partial \kappa} = \left[-\lambda^m \kappa \varepsilon^S q'(G^S) + p(\varepsilon^S - 1)\right]\frac{G^S}{\kappa^2} =$$

$$\left[p(\varepsilon^S - 1 - \varepsilon^S)\right]\frac{G^S}{\kappa^2} = -\frac{G^S p}{\kappa^2}.$$

From the concavity of $q(\cdot)$, $q'(\kappa G^T) > q'(G^T) = p(1+\kappa)/(\lambda^m \kappa)$. Hence, we may identify a sufficient condition for $\partial V/\partial \kappa > 0$:

$$\frac{G^T(1+\varepsilon^T)p(1+\kappa)}{\kappa} - \frac{G^S p}{\kappa^2} > 0 \implies V_\kappa > 0$$

After re-arranging,

$$\kappa(1+\kappa)(1+\varepsilon^T) > G^S/G^T. \tag{15}$$

Now, it is convenient to introduce the function $F(x) := q'^{-1}(x)$. From the concavity of $q(\cdot)$ and from $q'''(\cdot) > 0$, $F(\cdot)$ is decreasing and convex, $F'(x) = q''^{-1}(x) < 0$ and $F''(x) = q''^{-1}(x) > 0$. From this shape, we derive:

$$\frac{p}{\lambda^m \kappa} - \frac{p(1+\kappa)}{\lambda^m \kappa}F'\left(\frac{p}{\lambda^m \kappa}\right) > G^S - G^T.$$

Using $G^T < G^S$, an even more restrictive sufficient condition writes:

$$\frac{G^S}{G^T} < 1 - \frac{p}{\lambda^m G^T}F'\left(\frac{p}{\lambda^m \kappa}\right) < 1 - \frac{p}{\lambda^m G^S}F'\left(\frac{p}{\lambda^m \kappa}\right).$$

Now, from the definition of the elasticity ε^S, and by derivating G^S,

$$\frac{\partial G^S}{\partial \kappa} = F'\left(\frac{p}{\lambda^m \kappa}\right)\frac{-p}{\lambda^m \kappa^2},$$

we have $F'(p/\lambda\kappa)/G^S = -\varepsilon^S \lambda^m \kappa/p$. This allows us to write the final sufficient condition for (15) as $\kappa(1+\kappa)(1+\varepsilon^T) > 1 + \varepsilon^S \kappa$, or

$$[\kappa(1+\kappa) - 1] + \left[\kappa(\varepsilon^T - \varepsilon^S) + \kappa^2 \varepsilon^T\right] > 0.$$

It is easy to calculate that the first term is positive, as long as $\kappa > (\sqrt{5}-1)/2 > 2/3$. From the definition of elasticities and from the convexity of $F'(\cdot)$, we obtain the positivity of the second term,

$$\frac{\varepsilon^T}{\varepsilon^S} = \underbrace{\frac{F'(G^T)}{F'(G^S)}}_{>1}(1+\kappa)\underbrace{\frac{G^S}{G^T}}_{>1} > 1.$$

As a result, $\kappa > 2/3$ is a sufficient condition for $\partial V/\partial\kappa > 0$. □

Proof of Proposition 4. Consider the local deviation of median voter 1 from $\lambda_1^d = \lambda_2^d = \lambda^m$. For sufficiently symmetrical delegates, cooperation gives $G_1 = \kappa x_2$, so in the neighborhood of $\lambda_1^d \in (\lambda^m - \varepsilon, \lambda^m + \varepsilon)$, $dx_i/d\lambda_i^d = 0$. The median voter 1 uses that when maximizing $u_1^m = \lambda^m q(\kappa x_2) + y - p\alpha x_1 - p(1-\beta)x_2$, his or her FOC is written:

$$\frac{du_1^m}{d\lambda_1^d} = \left(\lambda^m \kappa q'(\kappa x_2) - (1-\beta)p\right)\frac{dx_2}{d\lambda_1^d} = 0. \tag{16}$$

We apply the implicit function theorem on (10), and derive:

$$\frac{dx_2}{d\lambda_1^d} = -\frac{q'(\kappa x_2)}{\kappa^2(\lambda_1^d)^2 q''(\kappa x_2)} > 0. \tag{17}$$

Plugging (17) into (16), we recognize that for $\lambda_1^d = \lambda^m$ to be an interior optimum of the median voter in District 1, we need x_2 (given by the cooperation of the delegates) to satisfy exactly $\lambda^m \kappa q'(\kappa x_2) = (1-\beta)p$. By inspecting (10), this is exactly when $\beta = 0$. For any $\beta > 0$, the FOC of the median voter yields a strategically progressive delegate, $\lambda_1^d > \lambda^m$. Analogously, $\lambda_2^d = \lambda^m$ if and only if $\alpha = 0$; otherwise $\lambda_2^d > \lambda^m$. □

Proof of Proposition 5. From Proposition 1, $u_1^D = u_2^D = y$. The Nash bargaining outcome equalizes net surplus, $\lambda_1^d q(\kappa S_1) + y - t_1 = \lambda_2^d q(\kappa S_2) + y - t_2$, hence

$$t_1 = \frac{1}{2}\left[\lambda_1^d q(\kappa S_1) - \lambda_2^d q(\kappa S_2) + p(S_1 + S_2)\right].$$

Evaluating the FOC on the utility of the median voter in District 1, $u_1^m = \lambda^m q(\kappa S_1) + y - t_1$, when delegate is also of median type, shows that utility is not maximized with this delegate:

$$\begin{aligned}\frac{du_1^m}{d\lambda_1^d}\Big|_{\lambda_1^d=\lambda^m} &= \frac{1}{2}\left\{\frac{\partial S_1}{\partial \lambda_1^d}\left[(2\lambda^m - \lambda_1^d)\kappa q'(\kappa S_1) - p\right] - q(\kappa S_1)\right\} \\ &= -\frac{q(\kappa S_1)}{2} < 0. \end{aligned}\tag{18}$$

We used that in the bargaining outcome for median-type delegates, $2\lambda^m - \lambda_1^d = \lambda^m$, and $\lambda_1^d \kappa q'(\kappa S_1) - p = 0$. The equation (18) shows that it pays off to strictly deviate from sincere to conservative delegation. □

Proof of Proposition 6. We have to distinguish between the SS-profile and ST-profile in decentralization.

i) SS-profile. For sufficiently symmetrical delegates, the SS-profile in decentralization satisfies $(x_1, x_2) = (S_2, S_1)$ and is efficient from the delegates' point of view. Hence, Nash bargaining delivers an identical allocation, and the total surplus is zero. Since the efficient outcome is also a disagreement point, the zero surplus cannot be divided in any other way but zero for each. As a result, there is no strict incentive for strategic delegation and the median-type delegates are in equilibrium.

ii) ST-profile. We have $G_1^D = \kappa^2 T_2, G_2^D = \kappa T_2$, $t_1^D = 0$, and $t_2^D = p(1+\kappa)T_2$. In the bargaining outcome, we have $G_1^C = \kappa S_1$, $G_2^C = \kappa S_2$. From the equality of net surpluses, $\lambda_1^d q(\kappa S_1) - \lambda_1^d q(\kappa^2 T_2) - t_1 = \lambda_2^d q(\kappa S_2) - \lambda_2^d q(\kappa T_2) + p(1+\kappa)T_2 - t_2$, we derive the division of costs as follows:

$$t_1 = \frac{1}{2}\left[\lambda_1^d q(\kappa S_1) - \lambda_1^d q(\kappa^2 T_2) - \lambda_2^d q(\kappa S_2) + \lambda_2^d q(\kappa T_2) + p(S_1 + S_2 - (1+\kappa)T_2)\right]$$

The utility of the median voter in District 1 is again, $u_1^m = \lambda^m q(\kappa S_1) + y - t_1$. Inserting t_1 into the FOC, evaluated for a median type delegate, shows that the median-type delegate does not maximize utility of the median voter:

$$\frac{du_1^m}{d\lambda_1^d}|_{\lambda_1^d=\lambda^m} = \frac{1}{2}\left\{\frac{\partial S_1}{\partial \lambda_d^1}\left[(2\lambda^m - \lambda_1^d)\kappa q'(\kappa S_1) - p\right] - q(\kappa S_1) + q(\kappa^2 T_2)\right\}$$
$$= \frac{q(\kappa^2 T_2) - q(\kappa S_1)}{2} < 0.$$

Again, we used this in the bargaining outcome for median-type delegates, $\lambda_1^d \kappa q'(\kappa S_1) - p = 0$, and moreover $S_1 > T_1 > \kappa T_1 = \kappa T_2$. Again, it pays off to deviate from sincere to conservative delegation. □

References

[1] Bandyopadhyay, S., Pinto, S.M., Wheeler, C.H., 2007. Urban crime and labor mobility. Working Paper 2007-046B. Federal Reserve Bank of St. Louis.

[2] Besley, T., Coate, S., 2003. Centralized versus Decentralized Provision of Local Public Goods: A Political Economy Analysis. Journal of Public Economics 87, 2611–37.

[3] Bloch, F., Zenginobuz, U., 2007. The effect of spillovers on the provision of local public goods. Review of Economic Design 11, 199–216.

[4] Brueckner, J.K., 2004. Fiscal decentralization with distortionary taxation: Tiebout vs tax competition. International Tax and Public Finance 11, 133–53.

[5] Buchholz, W., Haupt, P., Peters, W., 2005. International environmental agreements and strategic voting. Scandinavian Journal of Economics 107, 175–95.

[6] Chari, V.V., Jones, L., Marimon, R., 2004. Strategic Delegation in Monetary Unions. The Manchester School 72, 19–35.

[7] Cheikbossian, G., 2008. Rent-seeking, spillovers and the benefits of decentralization. Journal of Urban Economics 63, 217–228.

[8] Cheikbossian, G., Marceau, N., 2007. Why is Law Enforcement Decentralized? Working Paper 07-19, CIRPEE.

[9] Dur, R., Roelfsema, H., 2005. Why Does Centralization Fail to Internalize Policy Externalities? Public Choice 122, 395–416.

[10] Graziosi, G.R., 2009. On the Strategic Use of Representative Democracy in International Agreements. Journal of Public Economic Theory 11 (2), 281-296.

[11] Gregor, M., 2008. On the strategic non-complementarity of complements. Economics Bulletin 8(3), 1–7.

[12] Harstad, B., 2007. Harmonization and Side Payments in Political Cooperation. American Economic Review 97, 871–889.

[13] Harstad, B., 2008. Do Side Payments Help? Collective Decisions and Strategic Delegation. Journal of the European Economic Association 6 (2–3), 468–477.

[14] Hindriks, J., Lockwood, B., 2009. Decentralization and electoral accountability: Incentives, separation and voter welfare. European Journal of Political Economy, doi: 10.1016/j.ejpoleco.2009.01.004.

[15] Koethenbuerger, M., 2008. Revisiting the "Decentralization Theorem"—On the Role of Externalities. Journal of Urban Economics 64, 116–122.

[16] Langlais, E., 2008. Detection Avoidance and Deterrence: Some Paradoxical Arithmetic. Journal of Public Economic Theory 10 (3), 371-382.

[17] Lei, V., Tucker, S., Vesely, F., 2007. Foreign aid and weakest-link international public goods: An experimental study. European Economic Review 51, 599–624.

[18] Lockwood, B., 2008. Voting, Lobbying, and the Decentralization Theorem. Economics & Politics 20 (3), 416–31.

[19] Oates, W.E., 2005. Toward a Second Generation Theory of Fiscal Federalism. International Tax and Public Finance 12, 349–73.

[20] Pinto, S.M., 2007. Tax Competition in the Presence of Interjurisdictional Externalities: The Case of Crime Prevention. Journal of Regional Science 47 (5), 897–913.

[21] Poutvaara, P., Priks, M., 2009. The effect of police intelligence on group violence: Evidence from reassignments in Sweden. Journal of Public Economics 93, 403-411.

[22] Sandler, T., Vicary, S., 2001. Weakest-link public goods: giving in-kind or transferring money in a sequential game. Economics Letters 74, 71–5.

[23] Segendorff, B., 1998. Delegation and Threat in Bargaining. Games and Economic Behavior 23, 266–83.

[24] Tao, H., 2004. Property crime distribution and equal police deployment: an empirical study of Taiwan. Journal of Urban Economics 55, 165–178.

[25] Vicary, S., 1990. Transfers and the weakest-link: An extension of Hirshleifer's analysis, Journal of Public Economics 43, 375–94.

[26] Vicary, S., Sandler, T., 2002. Weakest-link public goods: giving in-kind or transferring money. European Economic Review 41, 1506–20.

[27] Wheaton, W.C., 2006. Metropolitan Fragmentation, Law Enforcement Effort and Urban Crime. Journal of Urban Economics 60, 1–14.

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