Construction of facilities under asymmetric information: do constitutional constraints matter?*

Martin Besfamille†  Jean-Marie Lozachmeur‡

December 31, 2002

Abstract
This paper studies construction of facilities in a federal state under asymmetric information. A country consists of two regions, each ruled by a local authority. The federal government plans to construct a facility in one of the regions. The facility generates a local value in the host region and has spillover effects in the other region. The federal government does not observe the local value because it is the local authority's private information. So the federal government designs an incentive-compatible mechanism, specifying if the facility should be constructed and a balanced scheme of interregional transfers to finance its cost. The federal government is constitutionally constrained to respect a given level of each region's welfare. We show that depending upon the facility's local value and the spillover effect, the government faces different incentive problems. Moreover, their existence depends crucially on how stringent constitutional constraints are. Therefore, the optimal mechanism will also depend upon these three features of the model.

Keywords: Fiscal federalism - Constitutional constraints - Facilities - Intergovernmental transfers - Asymmetric information

JEL Codes: D82 - H77

†We thank S. Blomquist, V. Chari, J. Hendricks, H. Hopenhayn, J.-J. Laffont, P. Legros, M. Marchand, D. Martimort, R. Myerson, S. Nanda, P. Pestieau, J. Pouyet, P. Rey, I. Werning, S. Wilkie for helpful comments and seminar participants at IIPF (Linz, 2001), LAMES (Sao Paulo, 2002), LACEA (Madrid, 2002), Université de Liège, Universidad de San Andrés, UNLP, Banco Central del Uruguay and Universidad Torcuato Di Tella. We thank financial support from the Communauté française de Belgique ARC 98/03-221. M. Besfamille also acknowledges financial support from FNRS, grant V 6/5/6-MJ 3232.

‡Universidad Torcuato Di Tella, Argentina. E-mail: mbesfamille@utdt.edu

§CORE, Université Catholique de Louvain and CREPP, Université de Liège, Belgium. E-mail: jmlozachmeur@ulg.ac.be
1 Introduction

Federal governments intervene in regions, states or localities, even in countries where decentralization prevails, like in the USA. For example, federal governments construct national public goods or facilities like prisons, waste disposals, airports or dams. In order to decide whether to construct such facilities and the best way to finance them, federal governments need to know their impact on the welfare of the different regions, specially in the host region. But, as it has long been recognized [e.g. Oates (1972)], local authorities know some of their constituency’s characteristics better than federal governments. So federal governments have to rely on reports made by local authorities. Hence local authorities may be tempted to use their private information opportunistically, in order to induce the federal government to adopt a decision that will favor its constituency.¹ This paper deals precisely with incentive problems that emerge in institutional contexts where federal decisions about construction of facilities are taken under asymmetric information.

As Tresch (1981) stated, such problems have to be analyzed in second-best asymmetrical information environments. The public economics literature that adopted such approach has studied two different issues. The first issue is the problem of siting noxious facilities. Whereas such facilities are supposed to benefit the majority of the population, the community designated as the host often views the project’s impact to be negative and thus try to oppose its construction.² Among others, Goetz (1982), Kleindorfer and Kunreuther (1986) and Easterling and Kunreuther (1992, 1996) have analyzed different mechanisms (auctions, monetary compensations, insurance) designed to obtain the acceptance of host localities. The second issue analyzed by the public economics literature concerns the design of intergovernmental transfers to finance a national public good (or a local public good with externalities) under asymmetric information. Cremer et al. (1996) and Bordignon et al. (2001) have studied the impact of incentive problems on the design of interjurisdictional transfers and on the level of public goods.

These articles suffer from an important drawback: they do explicitly consider neither prerogatives that federal governments have nor constitutional constraints they face. On the one hand, articles that analyze mechanisms to obtain the acceptance of noxious facilities in a given region assumed that the

¹Concerning noxious facilities, Goetz (1982) points that, in host localities, expressed fears of risk are regarded as exaggerated and perhaps strategically motivated.

²Opposition to facility siting is commonly designated by the acronym NIMBY (not-in-my-backyard).

federal government is obliged to respect the local status quo (i.e. the level of welfare that the host region has when the facility is not constructed). For example, Easterling and Kunreuther (1992) points that “For a benefits package to produce a positive outcome, the stakeholders with veto power must receive benefits that leave them better off with the facility than under the status quo”. But federal governments can implement policies that do not respect everybody’s status quo, provided they are compelling national interests do so.³ On the other hand, articles that deal with intergovernmental transfers under asymmetric information implicitly assume that federal governments, because of their pre-eminence, are not constrained towards local authorities. Bordignon et al. (2001) state that “Given the coercitive powers of the federal government, it is natural to assume that both regions are forced to play this game and thus we do not impose any participation constraint”. But federal governments seldom are completely free, specially if national projects yield negative values for some regions. In fact, federal governments are constitutionally constrained to respect lower levels of government.⁴ The purpose of this paper is precisely to add these two features to the existing literature.⁵ Our goal is to characterize, in a fiscal federal setting under asymmetric information, the optimal system of interregional transfers to finance a facility when the federal government is constitutionally constrained to respect a given level of each region’s welfare, but not necessarily their status quo.⁶

⁴In some countries, when local authorities consider that federal decisions are arbitrary, they can resist them judicially. In 1985, the U.S. Congress enacted the Low Level Radioactive Waste Policy Amendments Act. Among other things, this law imposes upon States the obligation to provide for the disposal of waste generated within their borders. The act contained three types of incentives to encourage the States to comply with that obligation. The State of New York and two of its counties filed a suit against the United States, seeking a declaratory judgement that the mentioned incentives were unconstitutional. The U.S. Supreme Court declared that effectively one of the incentive schemes proposed by the Congress were unconstitutional. See New York vs. United States 505 U.S. 144 (1992).
⁵These aforementioned considerations also apply to the theoretical literature that deals with revelation of preferences for public goods. On the one hand, it is well known that Clarke-Groves mechanisms may not respect participation constraints. On the other hand, both static mechanisms [Green and Laffont (1979)] or dynamic procedures [Drèze and De la Vallée Poussin (1971)] ensure each agent with the status quo.
⁶In a discrete public good setting, Green and Laffont (1979) introduced the notion of an intertemporal status quo. They generalized the idea of individual rationality by imposing the mechanism to result in welfare improvement on average, for all individuals, over many repeated applications. Therefore they enable the mechanism to set, in one given application, levels of utility lower than the status quo. But, for that particular
We present a simple model of a country consisting of two non-overlapping and equally wealthy regions, each ruled by a local authority. Following an utilitarian objective, the federal government plans to construct a facility in one region. If it is undertaken, the facility generates a value in the host region and also has spillover effects in the other. Both the local value and the spillover effect can be positive or negative. The federal government should decide whether to construct the facility and, if so, how to finance it. When it adopts both decisions, the federal government is constitutionally constrained to maintain each region's welfare above a certain level. But this level of welfare is not necessarily the status quo. In fact, we consider different cases of constitutional constraints. We also assume that the federal government does not observe the level of the facility's value in the host region (which can be high or low) because it is the local authority's private information. To deal with this informational gap, the federal government designs an incentive-compatible mechanism, specifying if the facility will be constructed and a balanced scheme of interregional transfers. The shape of the optimal mechanism will depend upon the local value, the spillover level and how the constitutional constraint is stringent.

The most important results of the paper are the following. First, under full-information, the traditional rule that equalizes marginal utilities of private consumption does not always apply when the project is undertaken. Indeed, it may be optimal to undertake a project when the constitutional constraint of one region binds. In that case, this region will be compensated, with respect to the case where marginal utilities are equalized.

Second, we prove that under asymmetric information, the federal government faces two different incentive problems. Depending upon the facility's value in the host region and the spillover effect, the host region may want to upward or downward misreport. Moreover, the existence of these incentive problems also depend upon how stringent the constitutional constraints are. When the federal government has to ensure the status quo level of welfare, it faces a unique type of local misbehavior, namely the understatement of the.

application of the mechanism, they did not analyze the impact of constraining minimal levels of utility on the optimal allocations. Gradstein (1994) and Makowski and Mezzetti (1994) are closer to our analysis. Gradstein (1994) finds an efficient allocation mechanism when the outside option is different from the zero-utility status quo. But his setting is different from ours because the private information concerns the cost. Moreover, he also assumes that it is always optimal to provide the public good whereas we endogenize this decision. In a paper that investigates efficient mechanisms with voluntary participation, Makowski and Mezzetti (1994) consider the possibility of weakening ex-post individual rationality constraints. But, as they impose ex-ante budget balancing (whereas we impose ex-post budget balancing), they find results that go in an opposite direction than ours.
facility's value. This problem occurs when the facility has a low value for the host region. When constitutional constraints are less stringent, another type of local misbehavior appears, namely the exaggeration of the facility's value. This second problem occurs when the facility has a high value for the host region. Therefore, we are able to show why both branches of the public economics literature mentioned above cannot deal with all potential incentive problems that emerge in general models of construction of facilities. Introducing the pertinent constitutional constraints indeed matters in those settings.

Third, we completely characterize the optimal mechanisms. In order to attenuate stakes for misreport, the federal government distorts constructions decisions and transfers upwardly and downwardly. For each constitutional constraint, we identify facilities that are nevertheless constructed, even if their benefits are low and others that are optimally shutdown, whereas they should have been undertaken under full-information.

In the next section we present the model and we analyze the full-information case. Then we study the problem when the federal government faces asymmetric information. In particular, we will give a special attention to extreme values of the constitutional constraints. Finally, we conclude. All proofs are in the Appendix.

2 The model

The country is composed by two regions \(i = L, R\), each ruled by a local authority. Due to high communication or transaction costs, we rule out the possibility of agreements between regions.\(^7\) The federal government has to decide whether to construct, in region \(L\), a facility of a given size.\(^8\) We formalize this decision as an index variable \(\delta\), where \(\delta = 1\) if the facility is constructed and 0 otherwise.

The facility We assume that, if the facility is constructed, it generates a value \(v_L\) in the host region \(L\) and has a spillover effect \(v_R\), in the other region \(R\). To be more specific, \(v_L\) can attain two levels \(\bar{v}_L\) and \(\underline{v}_L\), where \(\underline{v}_L < \bar{v}_L\). But we restrict neither the sign nor the numerical value of \(v_L\) and

---

\(^7\)Relaxing this assumption is left for future research.

\(^8\)Our paper does not deal with the facility's localization. Although this is a crucial problem for some kind of facilities (e.g. prisons), there are many others for which their localization is not an issue (e.g. nuclear waste disposals, dams). For such facilities, often there exists only one locality that has the appropriate hydrological and geological characteristics to become the host.
\(v_R\). Our goal is precisely to build up a general model that encompasses all interesting cases of facilities, which can be the following:

- \(v_L \geq 0\) and \(v_R \geq 0\): the facility is beneficial for both regions (e.g. a transportation project that improves traffic in \(L\) and \(R\)).

- \(v_L \geq 0\) and \(v_R < 0\): the facility is beneficial for region \(L\) but generates a negative externality in region \(R\) (e.g. an upstream dam in \(L\) that creates an artificial lake in \(R\), flooding completely some small towns).

- \(v_L < 0\) and \(v_R \geq 0\): a noxious facility that is beneficial for region \(R\) but to the detriment of the host region (e.g. a nuclear waste disposal in \(L\)).

The facility costs \(c\), which is common knowledge. If it is undertaken, the federal government bears this cost.

**Regions** The local authority is the representative agent of each region. For the sake of simplicity, we assume that both regions have same endowment \(y_i\), so \(y_L = y_R = y\). With this endowment \(y\), region \(i\) can consume a private good in quantity \(q_i\). Each region derives the same utility from the consumption of this good. This utility is formalized as a strictly increasing and concave function \(u(q)\), with \(u(0) = 0\).

In order to ensure the facility’s financing, the federal government designs a scheme of intergovernmental transfers \(t_i\). When \(t_i \geq 0\), the region \(i\) is taxed whereas when \(t_i < 0\), the region \(i\) is subsidized by the federal government. Taking into account each region’s budget constraint \(q_i = y - t_i\), utilities are thus \(U_L = u(y - t_L) + \delta v_L\) and \(U_R = u(y - t_R) + \delta v_R\). Utilities are separable between the private and the public good. Moreover, given the discrete approach adopted in the paper, utilities end out to be quasi-linear in the facility’s value. But, due to the non-linearity of the function \(u\), utility is non-transferable.

**The federal government** Its goal is to set an allocation \((\delta, t_L, t_R)\) in order to maximize an utilitarian social welfare \(W(v_R, v_L) = U_L + U_R\) subject to \(t_L + t_R = c\), which is the federal budget constraint denoted by \(B\).

The federal government controls the construction decision \(\delta\). On the one hand, it can impose the facility’s construction, even if \(v_L\) (or \(v_R\)) is

---

9 This rules out inter-regional redistribution from the model.

10 For the sake of simplicity, we rule out the possibility of having transfers \(t_i \neq 0\) when \(\delta = 0\). In Section 4 we discuss the consequences of relaxing this assumption.

11 For the moment, we allow negative consumption of the private good. In Section 4 we will consider the implications of bounding this consumption from below.
negative. On the other hand, it can reject the facility, even if \( v_L \) (or \( v_R \)) is so high that region \( L \) (or \( R \)) desires its construction. Although this seems to be a "command-and-control" economy, the country's constitution imposes to the federal government another constraint on allocations \((\delta, t_L, t_R)\). This restriction, denoted by \( CC_i \), has the following form:

\[
u(y - t_i) + \delta v_i \geq k
\]

The federal government has to leave to both regions the same minimal level of utility \( k \in (-\infty, u(y)] \).\(^{12}\) The upper bound \( u(y) \) is the status quo level of local welfare (i.e. the utility when the facility is not constructed) and ensures only Pareto improving construction of facilities. In that case, the constitution prohibits the federal government to benefit a region, at the detriment of the other. When \( k \in (-\infty, u(y)) \), we can interpret \( k \) as a measure of the (limited) veto power of each region. Although the federal government can construct a facility that yields a negative value \( v_i \) for region \( i \), the facility can not be too detrimental to exploit this region. If this indeed happens, region \( i \) can obtain the facility's shutdown. Therefore, the federal government has to be aware of that possibility. The lowest bound \(-\infty\) corresponds to the case of a non-constrained government, where every project that has a high value for the country as a whole \((v_L + v_R)\) will be undertaken. As we mentioned in the introduction, one of the objectives of this paper is to characterize the optimal allocations for different constitutional constraints, or equivalently, for different levels of the minimal utility \( k \). Next we analyze the full-information benchmark.

\(^{12}\) Although it may seem odd to assume the same level of minimal utility for both regions, this clearly simplifies the analysis and does not alter qualitatively the main results of the paper.

\(^{13}\) We could have considered, as Lockwood (1999) did, secession-proof constitutional constraints like

\[
u(y - t_i) + \delta v_i \geq \max\{u(y), u(y - c) + v_i\}
\]

But we believe that federal governments seldom face a secession as a consequence of the construction of a facility. Moreover, adopting such constraints yields trivial results.
2.1 Full-information

Assume that the federal government observes \( v_L \) and \( v_R \). It maximizes the social welfare by solving the following program, denoted by \( q^3 \):

\[
\begin{align*}
\max_{\delta_{L,R}} & \quad u(y - t_L) + u(y - t_R) + \delta (v_L + v_R) \\
\text{subject to} & \quad u(y - t_L) + \delta v_L \geq k & C_{CL} \\
& \quad u(y - t_R) + \delta v_R \geq k & C_{CR} \\
& \quad t_L + t_R = c & B
\end{align*}
\]

For a given value of \( k \), optimal full-information allocations \( (\delta^*(k), t^*_L(k), t^*_R(k)) \) clearly depend upon different values of \( v_L \) and \( v_R \). Recalling that the facility is undertaken provided that

\[
\sum_{i=L,R} u(y - t^*_i(k)) + v_i \geq 2u(y)
\]

the following proposition completely characterizes optimal full-information allocations \( (\delta^*(k), t^*_L(k), t^*_R(k)) \).

**Proposition 1** The construction decision \( \delta^*(k) = 1 \) in the following cases

- **Case A**
  \( v_R \geq k - u(y - \frac{k}{2}), v_L \geq k - u(y - \frac{k}{2}) \) and \( v_L \geq 2 \left[u(y) - u(y - \frac{k}{2})\right] - v_R \)
  In this case, transfers are \( t^*_R(k) = t^*_L(k) = \frac{k}{2} \).

- **Case B**
  \( v_R \geq 2u(y) - k - u(2y - c - u^{-1}(k - v_L)) \) and \( v_L \leq k - u(y - \frac{k}{2}) \)
  In this case, transfers are \( t^*_R(k) = c - y + u^{-1}(k - v_L) > \frac{k}{2} \) and \( t^*_L(k) = y - u^{-1}(k - v_L) < \frac{k}{2} \).

- **Case C**
  \( v_R \leq k - u(y - \frac{k}{2}) \) and \( v_L \geq 2u(y) - k - u(2y - c - u^{-1}(k - v_R)) \)
  In this case, transfers are \( t^*_R(k) = y - u^{-1}(k - v_R) < \frac{k}{2} \) and \( t^*_L(k) = c - y + u^{-1}(k - v_R) > \frac{k}{2} \).
Case A describes the parametric area where no constitutional constraint \( CC_i \) binds. As the optimum is interior, marginal utilities of consumption are equalized between both regions, i.e. \( u'(y - t_L) = u'(y - t_R) \). Using the federal budget constraint \( B \), this implies that \( t^*_L(k) = t^*_R(k) = \frac{k}{2} \). Both regions share equally the cost of the facility. Given these optimal taxes, this case applies as long as \( v_i \geq k - u(y - \frac{k}{2}) \).

Cases B and C describe two parametric areas for which the facility is undertaken when the constitutional constraint of one region \( i \) is binding. When this happens, the transfer \( t^*_i(k) \) is simply given by \( u(y - t_i) + v_i = k \), and \( t^*_j(k) (j \neq i) \), by the federal budget constraint \( B \). The region \( i \) will pay less than \( \frac{k}{2} \). Moreover, if \( v_i < 0 \), the region \( i \) can be compensated by \( t^*_i(k) < 0 \). These transfers have the following property

**Lemma 1** When the constitutional constraint \( CC_i \) binds, the transfer \( t^*_i(k) \) increases when the value of \( v_i \) increases.

The higher the value of the facility in region \( i \) is, the more this region participates in the financing of the cost. For further use, we denote by \( v^*_L(v_R, k) \) the value of \( v_L \) (as a function of \( v_R \) and \( k \)) above which a facility is optimally constructed under full-information. Straightforward use of Proposition 1 leads to:

\[
v^*_L(v_R, k) = \begin{cases} 
2u(y) - k - u(2y - c - u^{-1}(k - v_R)) & \text{if } v_R < k - u(y - \frac{k}{2}) \\
2 [u(y) - u(y - \frac{k}{2})] - v_R & \text{if } k - u(y - \frac{k}{2}) \leq v_R \leq 2u(y) - k - u(y - \frac{k}{2}) \\
k - u (2y - c - u^{-1}(2u(y) - k - v_R)) & \text{if } 2u(y) - k - u(y - \frac{k}{2}) < v_R
\end{cases}
\]

Full-information allocations can be seen in the following figure, where each pair \((v_R, v_L)\) represents a facility.

Insert Figure 1 here

The bold curve depicts the function \( v^*_L(k, v_R) \).\(^{14}\) Below this curve, no facility is constructed, in which case each region has a utility \( u(y) \). We can easily show that this frontier is decreasing and convex in \( v_R \). In the parametric area denoted by \( A \), the facility is constructed and financed following the equalization of marginal utilities. Note that, in this area, if \( v_i \leq u(y) - u(y - \frac{k}{2}) \), the utility \( U_i \) of region \( i \) verifies \( k \leq U_i \leq u(y) \). In other words, the federal government constructs a facility that is not Pareto improving for

\(^{14}\)This figure has been drawn for a value of \( k < u(y) \).
region \(i\). In area \(B\), the constitutional constraint \(CC_L\) binds and \(U_L = k\) whereas, in area \(C\), \(CC_R\) binds and \(U_R = k\).

In the next figure, we can see how full-information allocations vary with \(k\), in the \((v_R,v_L)\) space.

When \(k \to -\infty\), equalization of marginal utilities of consumption always applies, so cases \(B\) and \(C\) described in Proposition 1 vanish. The bold curve becomes a straight line above which each facility is constructed and each region shares equally the cost \(c\). When \(k = u(y)\), the curve is strictly convex. Obviously, the less stringent constitutional constraints \(CC_i\) are, the more facilities will be constructed.

3 Asymmetric information on \(v_L\)

Now we assume that the federal government observes \(v_R\) but not \(v_L\). Although the region \(L\)'s local authority knows it's type, the federal government is unable to observe whether the level of \(v_L\) is in fact high (\(\bar{v}_L\)) or low (\(v_L\)). The federal government has only some beliefs about these two states of nature, denoted by 
\[ \mu = \Pr[v_L = \bar{v}_L] \quad \text{and} \quad 1 - \mu = \Pr[v_L = v_L]. \]

Next we completely characterize optimal allocations under asymmetric information on \(v_L\).

It is convenient to solve this problem adopting a mechanism-design approach. The region \(L\) announces its type \(\bar{v}_L\) and the federal government commits to implement the allocation \((\delta(\bar{v}_L), t_L(\bar{v}_L), t_R(v_R))\). In this setting, the Revelation Principle applies. So the federal government can set incentive-compatible allocations \((\delta, t_L, t_R)\) that are conditional on both possible levels of \(v_L\). We denote these allocations by \((\delta, t_L, t_R)\) when they concern a "high value" region \(L\) (i.e. when the type of region \(L\) is \(v_L\) and \(1 - \mu = \Pr[v_L = v_L]\).}

---

15In spite of that, the value of \(v_R\) will have an important role to fulfill in the implementation game.

16For example, the federal government may want to construct an airport in region \(L\). A federal agency with technical expertise, like the U.S. Federal Aviation Administration, knows the value of the improvement in air traffic. But only \(L\)'s local authority is able to observe how damaging, in terms of increase in noise within its jurisdiction, the installation of the airport is.

17There is an extensive mechanism-design literature that deals with public provision of discrete public goods, among others Green and Laffont (1979), Gradstein (1994) and Ledyard and Palfrey (1994). But all of them assumed utilities that are quasi-linear in the consumption of the private good. Here we study implementation of a discrete public good but in a non-transferable utility framework.
by \((\delta, \ell_L, \ell_R)\) in the other case. Now, in order to maximize the social welfare, the federal government solves the new program \(\mathcal{P}'\)

\[
\begin{align*}
\max_{\delta, \ell_L, \ell_R} & \quad \mu \left[ u(y - \ell_L) + u(y - \ell_R) + \delta (\bar{v}_L + v_R) \right] \\
\text{s.t.} & \quad (1 - \mu) \left[ u(y - \ell_L) + u(y - \ell_R) + \delta (\bar{v}_L + v_R) \right] \\
& \quad u(y - \ell_L) + \delta v_L \geq k \quad \mathcal{CC}_L \\
& \quad u(y - \ell_R) + \delta v_R \geq k \quad \mathcal{CC}_R \\
& \quad \ell_L + \ell_R = c \quad \mathcal{B} \\
& \quad u(y - \ell_L) + \delta v_L \geq u(y - \ell_L) + \delta \bar{v}_L \quad \mathcal{IC} \\
& \quad u(y - \ell_R) + \delta v_R \geq u(y - \ell_R) + \delta \bar{v}_L \quad \mathcal{IC}
\end{align*}
\]

subject to

where \(\mathcal{IC}\) and \(\mathcal{IC}\) represent incentive-compatibility constraints, for region \(L\) with type \(\bar{v}_L\) and \(\bar{v}_L\) respectively.

As in the full-information program \(\mathcal{P}\), only constitutional constraints vary with \(k\). Thus, for a given facility (defined by a triplet \((v_R, v_L, \bar{v}_L)\)), an optimal allocation under asymmetric information obtained for a level of \(k\) is also feasible\(^{18}\) for a lower level \(k' < k\). It implies, as under full information, that more facilities will be undertaken as \(k\) decreases. However, as we will show below, facilities for which full-information allocations are not incentive compatible are not the same for different values of \(k\). Put differently, for a given \(k\), it may be that a facility is undertaken with full-information allocations while it is not for another value of \(k\).

\(\triangleright\) From now on, we call the pair of construction decisions \((\delta, \ell)\) a "configuration". It is straightforward to realize that an incentive-compatible mechanism must set \(\delta \leq \delta\). This monotonicity result, fairly common in agency theory, is due to incentive-compatibility and to the fact that local authority’s utility function \(U_L\) verifies a discrete version of the single-crossing property. This result implies that, for a given facility, there may be at most 3 configurations under asymmetric information. They are the following:

\(^{18}\)The allocation that solves the program \(\mathcal{P}'\) for \(k\) respects all the constraints defined in \(\mathcal{P}'\) for a lower value \(k' < k\).
• Configuration I: regardless of the level of $v_L$, the facility is undertaken (i.e. $\bar{\delta} = \delta = 1$)

• Configuration II: the facility is constructed provided it has a high level $\bar{v}_L$ (i.e. $\bar{\delta} = 0$ but $\delta = 1$)

• Configuration III: regardless of the level of $v_L$, the facility is abandoned (i.e. $\hat{\delta} = \delta = 0$).

3.1 When full-information allocations are not implementable

For some triplets $(v_R, \underline{v}_L, \bar{v}_L)$, full-information allocations are incentive-compatible even under asymmetric information regardless of the value of $k$. As we can see in the following example, this comes from the region $L$'s utility function $U_L$ being quasi-linear in the facility’s value $v_L$. For values of $v_R, \underline{v}_L$ and $\bar{v}_L$ above $u(y) - u(y - \frac{y}{2})$, the optimal full-information decision is $\delta^* = 1$, in each state of nature. Moreover, full-information transfers verify $t^*_L = \frac{s}{2}$ in both states of nature. Therefore, these allocations are incentive-compatible because region $L$ enjoys the facility and also the same level of private consumption $y - \frac{y}{2}$.

But this is not always the case. The following lemmas describe, in the $(v_R, \underline{v}_L, \bar{v}_L)$ space, parametric areas where full-information allocations are not incentive-compatible. To clarify the exposition, we first present the case when the project has a low value for region $R$ (i.e. when $v_R < u(y) - u(y - \frac{y}{2})$). Then we turn to the case where the project has a high value for region $R$ (i.e. when $v_R \geq u(y) - u(y - \frac{y}{2})$).

Lemma 2 When $v_R < u(y) - u(y - \frac{y}{2})$, full-information allocations are not implementable if and only if the triplet $(v_R, \underline{v}_L, \bar{v}_L)$ belongs to the parametric area defined by (a) or (b):

(a) \[
\begin{align*}
&v_R \leq k - u(y - \frac{y}{2}) \\
&\underline{v}_L(v_R, k) + k - u(y) \leq \underline{v}_L \leq \underline{v}_L(v_R, k) \leq \bar{v}_L
\end{align*}
\]

(b) \[
\begin{align*}
&k - u(y - \frac{y}{2}) < v_R < u(y) - u(y - \frac{y}{2}) \\
&u(y) - u(y - \frac{y}{2}) \leq \underline{v}_L \leq \underline{v}_L(v_R, k) \leq \bar{v}_L
\end{align*}
\]

The intuition is the following. Suppose that, for a given value of $k$, the federal government offers a menu that sets, in each state of nature $\underline{v}_L$ and $\bar{v}_L$, the optimal full-information allocation $(\delta^*, t^*_L, t^*_R)$ and $(\bar{\delta}^*, \underline{v}^*_L, \bar{v}^*_R)$
respectively. Given that \( v_L \leq v_R^*(v_R, k) \leq \bar{v}_L \), the full-information configuration should have been \( \Pi^* \) (i.e. \( \delta^* = 1 \) and \( \delta^* = 0 \)).\textsuperscript{19} If facing this menu region \( L \) truthfully reports its type, utilities are
\[
U_L(t^*_L) = u(y)
\]
in state \( y_L \) and
\[
\bar{U}_L(\bar{t}^*_L) = u(y - \bar{t}^*_L) + \bar{v}_L
\]
in state \( \bar{y}_L \). But, as the facility generates a low value for region \( R \), we know that
\[
\bar{U}_R(\bar{t}^*_R) = u(y)
\]
and
\[
k \leq \bar{U}_R(\bar{t}^*_R) \leq u(y)
\]
Recall that, in order to construct the facility in state \( \bar{y}_L \),
\[
\bar{U}_L(\bar{t}^*_L) + \bar{U}_R(\bar{t}^*_R) \geq 2u(y)
\]
must hold. Therefore, to be undertaken, the facility must be more than Pareto improving in the high value region \( L \), i.e. \( \bar{U}_L(\bar{t}^*_L) = u(y - \bar{t}^*_L) + \bar{v}_L \geq 2u(y) - k \geq u(y) \). Thus, even if the value of \( v_L \) is below \( v_R^*(v_R, k) \), if this value is not “too low” so that
\[
U_L(t^*_L) = u(y) < U_L(\bar{t}^*_L) = u(y - \bar{t}^*_L) + \bar{v}_L
\]
holds, the low value region \( L \) prefers to obtain the construction of the facility. If this happens, and although it has to pay the transfer \( \bar{t}^*_L \), the low value region \( L \) gets a net utility gain up to \( u(y) - k \). Therefore, in the parametric area described in Lemma 2, the federal government faces one kind of misbehavior, namely the low value region \( L \) overstating \( v_L \).

It is also interesting to realize that this result does not hold for all values of \( k \). The parametric area described in Lemma 2 vanishes when \( k \rightarrow u(y) \). Precisely, in this extreme case where the federal government has to respect the status-quo, a facility is abandoned if and only if the utility of a region is below \( u(y) \). Therefore, in this particular case, the low value region \( L \) has no incentives to mimic the high value region because it will never obtain a Pareto improvement.

**Corollary 1** The parametric areas described in cases (a) and (b) vanish when \( k = u(y) \).

\textsuperscript{19}Thus, in state of nature \( y_L \), transfers should have been \( \delta^*_L = \delta^*_R = 0 \).
We now turn to the study of facilities that generate a high value \( v_R \) for the region \( R \).

**Lemma 3** When \( v_R \geq u(y) - u(y - \frac{a}{2}) \), full-information allocations are not implementable if and only the triplet \((v_R, \overline{V}_L, \overline{V}_L)\) belongs to the parametric area defined by (c) or (d):

\[
\begin{align*}
\text{(c)} & \quad \begin{cases} 
    u(y) - u(y - \frac{a}{2}) \leq v_R \\
    \overline{V}_L \leq v^*_L(v_R, k) \leq \overline{V}_L \leq u(y) - u(y - \frac{a}{2})
\end{cases} \\
\text{(d)} & \quad \begin{cases} 
    2u(y) - k - u(y - \frac{a}{2}) \leq v_R \\
    v^*_L(v_R, k) \leq \overline{V}_L \leq k - u(y - \frac{a}{2})
\end{cases}
\end{align*}
\]

Again, to understand this result, suppose that, for a given value of \( k \), the federal government offers a menu that sets, in each state of nature \( \overline{V}_L \) and \( \overline{V}_L \), the optimal full-information allocation \((\delta^*, t^*_L, t^*_R)\) and \((\delta^*, \overline{t}_L, \overline{t}_R)\) respectively. Now, in parametric areas characterized by Lemma 3, the federal government faces another kind of misbehavior: the high value region \( L \) tries to mimic the low value region by understating \( \overline{V}_L \).

Indeed, when (c) holds, \( \overline{V}_L \leq v^*_L(v_R, k) \leq \overline{V}_L \). So the full-information configuration should have been \( II^* \) (i.e. \( \delta^* = 1 \) and \( \delta^* = 0 \)). Given that, in state of nature \( \overline{V}_L \), the facility generates an important value in \( R \) but not in \( I \), the federal government sets full-information transfers such that \( k \leq \overline{U}_L(\overline{t}_L) \leq u(y) \). Thus, the high value region \( L \) prefers to mimic the low value region \( L \) in order to obtain the rejection of the facility and a net utility gain up to \( u(y) - k \). This is precisely the kind of misbehavior analyzed by the NIMBY literature. But it does not emerge for all values of \( k \). Again, when \( k = u(y) \), the government only constructs Pareto improving facilities so that the high value region has no incentives to understate its local value.

**Corollary 2** In case (c), full-information allocations are implementable if and only if \( k = u(y) \).

If (d) holds, the full-information configuration should have been \( I^* \) (i.e. \( \delta^* = \delta^* = 1 \)) where \( \overline{C}_L \) binds. Under this circumstance, the full-information transfers \( t^*_L \) increase with \( \overline{V}_L \), \( t^*_L < t^*_L \) (see Lemma 1). So the region \( L \) with type \( \overline{V}_L \) would like to pretend to be \( \overline{V}_L \), in order to contribute less to the facility’s financing. In the extreme case where \( k \rightarrow -\infty \), there is no such problem of downward mimicking since both high and low value regions pay the same cost \( \frac{a}{2} \).
Corollary 3  The parametric area described in case (d) vanishes when $k \to -\infty$.

To sum up, when the facility has a low value for $R$, we observe (for some parameters $\psi_R, \psi_L$ and $\psi_L$) upward mimicking. When the facility is beneficial for $R$, we observe (for other parameters $\psi_R, \psi_L$ and $\psi_L$) downward mimicking. In the extreme case $k = u(y)$, upward mimicking of the low value region seeking to obtain the facility's construction vanishes. By the same way, downward mimicking of the high value region seeking to obtain the facility's rejection vanishes. In the opposite case $k \to -\infty$, downward mimicking of the high value region seeking to obtain a lower contribution for the facility’s financing vanishes. We gather these results in the following table, where an arrow denotes that type $i$ wishes to misreport as type $i' \neq i$.

Insert Table 1 here

It is clear from this table that, because of their extreme assumptions concerning the minimal level of utility $k$, the two branches of the public finance literature mentioned in the Introduction cannot deal with all incentive problems that emerge in our more general framework. Moreover, our results call for a revision of some of their results. To be more specific, consider the NIMBY literature, whose goal is to design mechanisms to obtain the revelation of the true local willingness to accept a noxious facility. Such mechanisms were designed to satisfy a ‘participation’ constraint like $U_i \geq u(y)$. But we have just shown that if $k = u(y)$ downward mimicking to cause the facility's shutdown cannot emerge. This kind of misreport is only a threat for the federal government when $k < u(y)$. Hence, to be optimal, the mechanisms analyzed by the NIMBY literature should have considered a less stringent ‘participation’ constraint.

3.2 Optimal allocations under asymmetric information

Now we characterize the optimal allocations when, for specific values of parameters $\psi_R, \psi_L$ and $\psi_L$, full-information allocations are not incentive-compatible. For such facilities, the federal government can decide to implement the same configuration as under full-information but with distorted transfers in order to deal with the corresponding incentive problem. However this is not the unique way to deal with misreporting. If welfare costs associated with the aforementioned distorted transfers are too high, the federal government can use its last degree of freedom, namely to distort the configuration $(\delta, \delta)$, with respect to the full-information one $(\delta^*, \delta^*)$. 

15
In what follows, we first characterize the cost-minimizing mechanism that implements each configuration, for each triplet \((v_R, \underline{y}_L, \bar{y}_L)\). We denote by
\[
\bar{y}_i^j \quad \{i = L, R; j = I, II, III\}
\]
the transfer paid by region \(i\), in configuration of projects \(j\), when the state of nature is \(\bar{y}_L\) (\(\underline{y}_L\)). These cost-minimizing mechanisms yield to a level of expected welfare. Next we compare such levels of welfare in order to find the optimal configuration. This permits the characterization of the parametric areas where a particular configuration is preferred to the others.\(^{20}\)

3.2.1 Facilities that generate a low value in region \(R\)

Let’s assume that \(v_R \leq u(y) - u(y - \frac{\delta}{2})\) and the pair \((\underline{y}_L, \bar{y}_L)\) verifies (\(a\)) and (\(b\)) in Lemma 2. Under these circumstances, the federal government has to prevent upward mimicking. If it plans to implement the same configuration \(II\) as under full-information, the incentive-compatibility constraint \(IC_L\) binds at the optimum. Transfers are thus given by
\[
\begin{cases}
\tilde{t}_L^{II} = y - u^{-1}(u(y) - \bar{y}_L) \\
\tilde{t}_L^{II} = 0
\end{cases}
\]

It is straightforward to verify that \(\tilde{t}_L^{II} > \tilde{t}_L^I\). In order to prevent a low value region \(L\) to pretend to be a high value one, the federal government distorts upwardly the transfer paid by the latter. These allocations yield to a level of expected welfare denoted by \(W^{II}(v_R, \underline{y}_L, \bar{y}_L)\).

If the federal government plans to implement the configuration \(I\), incentive-compatibility implies that
\[
u(y - \tilde{t}_L) = u(y - \tilde{t}_L)
\]
so \(\tilde{t}_L = \tilde{t}_L^I\). In other words, both a low and a high value region \(L\) pays the same transfer \(\tilde{t}_L^I\) that would be optimal under full-information. Formally, these transfers should be
\[
\tilde{t}_L^I = \tilde{t}_L = \begin{cases} 
\frac{c - y + u^{-1}(k - v_R)}{2} & \text{in case } (a) \\
\frac{\delta}{2} & \text{in case } (b)
\end{cases}
\]

because, in case (\(a\)), the constitutional constraint \(CC_R\) binds. If implemented, configuration \(I\) represents an upward distortion of \(\delta^*\) with respect\(^{20}\)The complete characterization of the frontiers of these parametric areas can be found in Besfamille and Lozachmeur (2002).
to configuration $II^*$. These allocations yield to a level of expected welfare $W_I(v_R, u_L, \bar{u}_L)$. Finally, if the federal government decides to shutdown the facility in both states of nature, which is a downward distortion of $\delta^*$, transfers are $t_L^{III} = t_L^{II} = 0$ and the expected welfare is $W_{III}(v_R, u_L, \bar{u}_L)$.

The next figure represents, in the $(u_L, \bar{u}_L)$ space, the parametric areas where each configuration is optimal.21

Insert Figure 3 here

Now, for a given value of $v_R$, a pair $(u_L, \bar{u}_L)$ represents a facility, from the federal government's point of view. In parametric areas denoted by $I^*, II^*$ and $III^*$, the federal government implements the same allocations than under full-information. In the parametric area $II$, the federal government implements the same configuration than under full-information but with distorted transfers $t_L^{II} > t_L$. Moreover, as $t_L^{II}$ increases with $u_L$, the cost of implementing configuration $II$ (measured by the difference $W_{II}(v_R, u_L, \bar{u}_L) - W_{II}(v_R, u_L, \bar{u}_L)$), increases. Thus, above a threshold value of $u_L$, the federal government prefers to distort upwardly the configuration and to implement configuration $I$ making the low value region pay the tax that, under full information, is optimal for the high value region $L$. Finally, for low values of $u_L$, implementation costs dominate the social value of the facility in state of nature $\bar{u}_L$. Therefore, in the parametric area $III$, the facility is optimally shutdown, even in state of nature $\bar{u}_L$. As we mentioned above, this is a downward distortion in the decision $\delta^*$.

3.2.2 Facilities that generate a high value in region $R$

Now let's assume that $v_R > u(y) - u(y - \frac{\delta}{2})$ and the pair $(u_L, \bar{u}_L)$ verifies (c) and (d) in Lemma 3. Under these circumstances, the federal government has to prevent downward mimicking. If it plans to implement the configuration $I$, incentive-compatibility yields to $t_L^I = t_L^I$. Moreover, for $k - u(y - \frac{\delta}{2}) \geq u_L$, the constitutional constraint $CC_L$ also binds so

$$t_L^I = t_L^I = \begin{cases} \frac{\delta}{2} & \text{if } u_L \geq k - u(y - \frac{\delta}{2}) \\ y - u^{-1}(k - u_L) & \text{if } u_L < k - u(y - \frac{\delta}{2}) \end{cases}$$

where $t_L^I < t_L^I$. In order to prevent a high value region $L$ to pretend to be a low one (and thus to contribute less to the facility's financing), the

21We have considered only case (a) because case (b) implies similar distortions in the construction decisions.
federal government distorts downwardly the transfer $t_{L}$ in case (d). In case (c), if configuration I is implemented, it represents an upward distortion of $g^*$. These allocations yield to a level of expected welfare denoted by $W_I(v_R, v_{L}, v_{L})$.

If the federal government plans to implement configuration II, the incentive-compatibility constraint $IC_L$ binds only when $v_{L} < u(y) - u(y - \frac{k}{2})$, so that transfers are given by:

$$
\begin{align*}
\tilde{t}_{L}^{II} &= \begin{cases} 
\quad y - u^{-1}(u(y) - v_{L}) & \text{if } v_{L} < u(y) - u(y - \frac{k}{2}) \\
\quad \frac{y}{2} & \text{if } v_{L} \geq u(y) - u(y - \frac{k}{2})
\end{cases}, \\
\tilde{t}_{L}^{II} &= 0
\end{align*}
$$

where $\tilde{t}_{L}^{II} < \tilde{t}_{L}^{*}$. In order to prevent a high value region L (which participates in the financing of a facility even if $v_{L}$ is low) to pretend to be a low value region (and thus to obtain the facility’s shutdown), the federal government distorts downwardly the transfer paid by the high value region $L$. Therefore, if implemented, configuration II represents a downward distortion of the transfer $t_{L}$ in case (c). In case (d), configuration II yields to a downward distortion in $g^*$, combined with a downward distortion of $\tilde{t}_{L}^{*}$ when $v_{L} < u(y) - u(y - \frac{k}{2})$. The reason for this second distortion is the following one. If, in case (d) when $v_{L} < u(y) - u(y - \frac{k}{2})$ the federal government wants to implement configuration II in order to attenuate implementation costs, it puts itself in the situation described by case (c). Therefore, the federal government has also to prevent a high value region $L$ pretending to be a low value one, to cause the facility’s shutdown.

Figure 4 illustrates the optimal configurations in cases (c) and (d).

Insert Figure 4 here

In parametric areas denoted by $I^*$, $II^*$ and $III^*$, the federal government implements the same allocations than under full-information. But in all others, this is not possible. When $v_{L} \leq v_{L}^{*}(v_R, k)$ and $v_{L}^{*}(v_R, k) \leq v_{L} \leq u(y) - u(y - \frac{k}{2})$, the federal government faces the incentive problem described in case (c).

In the parametric area denoted by $II$, the federal government implements the same configuration than under full-information, but with distorted transfers $\tilde{t}_{L}^{II} < \tilde{t}_{L}^{*}$. Moreover, as $\tilde{t}_{L}^{II}$ increases with $v_{L}$, the cost of implementing II (measured by the difference $W_{II}(v_R, v_{L}, v_{L}) - W_{III}(v_R, v_{L}, v_{L})$) decreases with $v_{L}$. Therefore, for lower values of $v_{L}$ and $v_{L}$, the federal government

---

22In order to draw this figure, we consider $v_R \geq 2u(y) - k - u(y - \frac{k}{2})$. This enables us to analyze, in the same figure, both cases (c) and (d).
prefers to implement configuration III. As we mentioned above, this is a downward distortion in \( \delta^* \). For higher values of \( y_L \), when \( \overline{v}_L \) decreases, the federal government prefers to implement configuration I, which is an upward distortion in \( \delta^* \).

When \( v^*_L(v_R, k) \leq v_L \leq k - u(y - \frac{y}{2}) \), the federal government faces the incentive-problem described in case (d). In the parametric area denoted by I, the federal government implements the same configuration than under full-information, but with distorted transfers \( t^*_L < \overline{t}^*_L \). The welfare cost of such distortion increases as \( y_L \) decreases. In the area II, there is a downward distortion in \( \delta^* \) with a downward distorted transfer \( \overline{t}^*_L \), when \( \overline{v}_L < u(y) - u(y - \overline{y}) \). The cost of this last distortion is higher the lower is \( \overline{v}_L \). Therefore, when \( \overline{v}_L \geq u(y) - u(y - \overline{y}) \), configuration II is preferred below a threshold value \( y_L \). When \( \overline{v}_L < u(y) - u(y - \overline{y}) \), configuration II is preferred for low \( y_L \) and for high \( \overline{v}_L \).

3.3 Discussion

We have shown that when \( k \) changes, the area of facilities (represented by a triplet \((v_R, y_L, \overline{v}_L)\)) for which full-information allocations are not implementable also changes. But one should note that full-information allocations also change with \( k \). The important point is that allowing \( k \) to decrease (resp. increase) makes a wider range of facilities become non implementable with full information allocations in case (a), (b) and (c) (resp. case (d)). Put differently, as \( k \) changes, optimal full-information allocations open more or less room for certain types of misbehavior. Nevertheless, the resulting optimal allocation under asymmetric information for a given facility implies less distortions when \( k \) decreases since the constitutional constraints are less stringent as \( k \) decreases.

Last, we want to stress the robustness of our results regarding the existence of different kinds of misreporting and distortions in construction decisions \( \delta \).

First, because we assume that utility is separable between private consumption and public good and that the level of the public good is discrete, the analysis has been done with a regional quasi-linear utility function. With a more general utility like \( u(q, t, v) \), the main message of this paper would be unchanged. With this more general utility, the equalization of marginal utilities does not imply equalization in private consumptions. Therefore, the only difference with our analysis is that configuration I* would never be incentive compatible, the high region pretending to be the low one, whatever
the level of $k$. Distortions in this case would be similar to the ones observed in case (d).

Second, we ruled out positive compensations for rejected projects from the model. Although our formalization precludes redistribution, such compensations could help to relax incentive-compatibility constraints, specially when the configuration II implemented with full-information transfers is not incentive-compatible. Giving a subsidy to the low value region $L$ may be beneficial in cases (a) and (b), but the main results of the paper would remain qualitatively unchanged.

Third, one may think that our results depend heavily on the federal government only using deterministic mechanisms, where $\delta \in \{0, 1\}$. In fact, this is not completely true. Under full-information, random mechanisms are worthless. Under asymmetric information on the value $v_L$, although such kind of mechanisms help relax incentive-compatibility constraints and thus improve expected welfare, it can be shown that transfers $t$ should always be deterministic. Only construction decisions may be optimally random, with upward or downward distortions in construction decisions $\delta$: e.g. $\hat{\delta} > 0 = \delta^* \text{ or } \hat{\delta} < 1 = \delta^*$. But even under this circumstance, these distortions are equivalent to those that we found using deterministic mechanisms.

Finally, we did not put non-negativity restrictions on private consumption. Indeed, with limited liability constraints like $y - t_i \geq 0$, some transfers characterized in the paper are not feasible any more. Therefore the parametric areas where such transfers are optimal shrinks. In spite of that, the main results (specially Table 1, Figure 3 and Figure 4) remain qualitatively unchanged.

4 Conclusion

We have formalized a country consisting of two non-overlapping regions, each ruled by a local authority. The federal government has planned to construct a public facility in one region. If it is undertaken, this facility generates a social value in the host region and has spillover effects in the other. Both the local value and the external effect can be positive or negative.

The federal government should decide whether to undertake the work and how to finance it. But it does not observe the local value (which can be high or low) because it is in fact the local authority's private information. To deal with this informational gap, the federal government designs an incentive-compatible mechanism, specifying if the project should be undertaken and a balanced scheme of interregional transfers. In its choice,
federal government is constitutionally constrained to respect a given level of each regions' welfare.

In this very simple model, we have completely characterized the optimal allocations under asymmetric information. We have also shown the impact of different constitutional constraints on these allocations, specially the distortions that appear in the decision about which project to undertake. The most important result is the emergence of different patterns of misbehavior according to different constitutional rules.

This model enables us to pursue this research in different directions. First of all, we can extend the informational asymmetries to consider the case where both the local value and the spillover effects are unknown to the federal government. In that case, we can analyze localization of the facility. A second direction could be to consider more general expressions for the constitutional constraints, with different levels of minimal utility for both regions. This could be a first step towards the endogenization of the constitutional setting. We could obtain some insights concerning constitutional design for rising federations, which could serve in political discussion, for example at the European level.
Appendix

A Proof of Proposition 1

For $\delta = 1$, substituting the budget constraint $(B)$, the Lagrangian of the problem can be written as:

$$L(t_R, t_L, \alpha_1, \alpha_2, \beta_1, \beta_2) = u(y - t_L) + u(y - c + t_L) + v_R + v_L +$$
$$+ \beta_1 [u(y - t_L) + v_L - k]$$
$$+ \beta_2 [u(y - c + t_L) + v_R - k]$$

where $\beta_i$ are the Lagrangian multipliers associated with constraints $CC_i$. First-order conditions with respect to $t_L, \beta_1, \beta_2$ are respectively:

$$-u'(y - t_L) + u'(y - c + t_L) - \alpha_1 +$$
$$-u'(y - t_L) + u'(y - c + t_L) - \alpha_1 +$$
$$-\beta_1 u'(y - t_L) + \beta_2 u'(y - c + t_L) = 0$$

(1)

$$\beta_1 [u(y - t_L) + v_L - k] = 0$$

(2)

$$\beta_2 [u(y - c + t_L) + v_R - k] = 0$$

(3)

$$\beta_1, \beta_2 \geq 0$$

(4)

Note that the project will be undertaken if (1) to (4) are fulfilled, together with $W(1, t_L, t_R) \geq W(0, 0, 0) = 2u(y)$. We prove point (i) to point (iii) of proposition 1 successively:

(i) Suppose that $\beta_1 = \beta_2 = 0$. Then $t_L = t_R = \frac{y}{2}$. In this case, $\beta_1 = \beta_2 = 0$ if and only if $v_L \geq k - u(y - \frac{k}{2})$ and $v_R \geq k - u(y - \frac{k}{2})$ by $CC_L$ and $CC_R$. Moreover, the project will be done if and only if

$$W(1, \frac{y}{2}, \frac{y}{2}) \geq W(0, 0, 0)$$

$$\Leftrightarrow 2u(y - \frac{k}{2}) + v_L + v_R \geq 2u(y)$$

$$\Leftrightarrow v_L \geq 2 [u(y) - u(y - \frac{k}{2})] - v_R$$

(ii) Suppose that $\beta_1 = 0$ and $\beta_2 > 0$ then $u(y - c + t_L) + v_R = k$. With point (i), we know that $\beta_2 > 0$ if $v_R < k - u(y - \frac{k}{2})$. Moreover, for the project to be undertaken, we need further

$$W(1, t_L, t_R) \geq W(0, 0, 0)$$

$$\Leftrightarrow u(y - t_L) + v_L + k \geq 2u(y)$$

$$\Leftrightarrow v_L \geq 2u(y) - k - u(2y - c - u^{-1}(k - v_R))$$
(iii) Symmetric argument

B Proof of Lemma 1

Recall that, in case $B$ (or $C$), transfer $t_i^*(k)$ for the region where the constitutional constraint $CC_i$ binds is given by $t_i^*(k) = k - u^{-1}(-v_i)$. Therefore, it is immediate to compute $\frac{dt_i^*(k)}{dv_i} = (u^{-1})'(-v_i) > 0$.

C Proof of Lemma 2

Consider that conditions (a) or (b) are fulfilled. Then

- In case (a):
  \[
  U_L(t_L^*, \delta^*) = u(y) \\
  U_L(t_L^*, \delta^*) = u(2y - c - u^{-1}(k - v_R)) + v_L
  \]
  where $U_L(t_L^*, \delta^*)$ denotes the utility of a low value region $L$ that truthfully reports its type and $U_L(t_L^*, \delta^*)$, the utility of a low value region $L$ that misreports. One thus have
  \[
  U_L(t_L^*, \delta^*) - U_L(t_L^*, \delta^*) = v_L + u(2y - c - u^{-1}(k - v_R)) - u(y) \\
  = v_L + u(y) - k - v_L^*(k, v_R) \geq 0
  \]
  given that $v_L \geq v_L^*(v_R) + k - u(y)$.

- In case (b):
  \[
  U_L(t_L^*, \delta^*) = u(y) \\
  U_L(t_L^*, \delta^*) = u(y - \frac{c}{2}) + v_L
  \]
  One thus have
  \[
  U_L(t_L^*, \delta^*) - U_L(t_L^*, \delta^*) = v_L + u(y - \frac{c}{2}) - u(y) \geq 0
  \]
  given that $v_L \geq u(y) - u(y - \frac{c}{2})$. It follows that the low local region wants to mimic the high local value region in case (a) and (b).

We have just proved sufficiency. To prove necessity, it is straightforward to show that, if a triplet $(v_R, v_L, \bar{v}_L)$ does not belong to the parametric area defined by conditions (a) and (b), full-information allocations are incentive-compatible. We omit these computations from the paper.
D Proof of Lemma 3

Consider that conditions (c) or (d) are fulfilled. Then

- In case (c):

\[
U_L(t^*_L, \hat{\delta}^*) = \begin{cases} 
  u(y - \frac{k}{2}) + \overline{v}_L & \text{if } \overline{v}_L \geq k - u(y - \frac{k}{2}) \\
  k & \text{otherwise}
\end{cases}
\]

\[
\overline{U}_L(t^*_L, \hat{\delta}^*) = u(y)
\]

where \( \overline{U}_L(t^*_L, \hat{\delta}^*) \) denotes the utility of a high value region \( L \) that truthful reports and \( \overline{U}_L(t^*_L, \hat{\delta}^*) \), the utility of a high value region \( L \) that misreports. One thus have

\[
\overline{U}_L(t^*_L, \hat{\delta}^*) - \overline{U}_L(t^*_L, \hat{\delta}^*) = \begin{cases} 
  u(y) - u(y - \frac{k}{2}) - \overline{v}_L & \text{if } \overline{v}_L \geq k - u(y - \frac{k}{2}) \\
  u(y) - k & \text{otherwise}
\end{cases} \geq 0
\]

given that \( \overline{v}_L \leq u(y) - u(y - \frac{k}{2}) \) and \( k \leq u(y) \).

- In case (d):

\[
U_L(t^*_L, \hat{\delta}^*) = \begin{cases} 
  u(y - \frac{k}{2}) + \overline{v}_L & \text{if } \overline{v}_L \geq k - u(y - \frac{k}{2}) \\
  k & \text{otherwise}
\end{cases}
\]

\[
\overline{U}_L(t^*_L, \hat{\delta}^*) = k + \overline{v}_L - \overline{v}_L
\]

One thus have

\[
\overline{U}_L(t^*_L, \hat{\delta}^*) - \overline{U}_L(t^*_L, \hat{\delta}^*) = \begin{cases} 
  -\overline{v}_L - u(y - \frac{k}{2}) & \text{if } \overline{v}_L \geq k - u(y - \frac{k}{2}) \\
  \overline{v}_L - \overline{v}_L & \text{otherwise}
\end{cases} \geq 0
\]

given that \( \overline{v}_L \leq -u(y - \frac{k}{2}) \) and \( \overline{v}_L \leq \overline{v}_L \). It follows that the high value region \( L \) wants to mimic the low value region in cases (c) and (d).

We have just proved sufficiency. To prove necessity, it is straightforward to show that, if a triplet \((\overline{v}_R, \overline{v}_L, \overline{v}_L)\) does not belong to the parametric area defined by conditions (c) and (d), full-information allocations are incentive-compatible. We omit these computations from the paper. \[\blacksquare\]
References


Figure 1

\[ C \]

\[ v_L \]

\[ v_R \]

\[ A \]

\[ B \]

\[ v^*_L(v_R, k) \]
Figure 2
Table 1: How incentive problems vary with $k$

<table>
<thead>
<tr>
<th>$k = u(y)$</th>
<th>(a) and (b)</th>
<th>(c)</th>
<th>(d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>$v_L \rightarrow \bar{v}_L$</td>
<td>$v_L \rightarrow \bar{v}_L$</td>
<td>$v_L \rightarrow \bar{v}_L$</td>
</tr>
<tr>
<td>$k \in ]u(y),-\infty[$</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>$k \rightarrow -\infty$</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>$(\delta_L = 0) \rightarrow (\bar{\delta}_L = 1)$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(\bar{\delta}_L = 1) \rightarrow (\delta_L = 0)$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(\bar{\delta}_L = 1) \rightarrow (\delta_L = 1)$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 3