Why Me?
Siting a Locally Unwanted Public Good

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Abstract
The siting of public facilities, such as prisons, airports or incinerators for hazardous waste typically faces social rejection by local populations. These public goods exhibit a private bad aspect which creates a siting problem: all involved communities benefit from its existence, but only one (the host community) bears the local negative externality. We take the view that inequity perception is intrinsically part of the siting issue and focus on the redistributive aspects of the solution: the host should not be perceived as a "victim". To achieve this goal, we design a method to share the total cost (the disutility of the host plus the construction cost) in a way which overcomes the natural asymmetry of the problem. We also insist on a natural voluntary participation requirement which has strangely been overlooked in the literature on siting problems but which we claim is critical for the stability of any solution.

Keywords: Public good; Externalities; Allocative efficiency; Cost sharing.

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1 Introduction

"You can’t park here: it’s my retreat". The actor George Clooney has turned civic protester in an attempt to stop the building of parking lots that he says will ruin the peace and beauty of Lake Como (Italy)\textsuperscript{1}. Interestingly, the "peace and beauty" of his nearby lakeside villa is also mentioned. However, such self-interested behavior is not specific to well-known actors. The siting of a public facility, such as prisons, airports or nuclear waste disposses typically faces social rejection by local populations. These goods are socially necessary but come with local externalities (noise, pollution, noxious odors...) or bear a negative connotation. Different factors can be the cause of such rejection: the loss in the economic value of property, the perceived loss in quality of life or the fear of health effects. In economic terms, these public goods have a private bad aspect to them which creates a siting problem: all communities benefit from the public good, but only one—the host—bears the local disutility. This asymmetry typically leads to costly procedures or inefficient siting\textsuperscript{2}. Worse, for some difficult cases no host has yet been selected (e.g. a nuclear waste disposal in the United States, see the Environmental Protection Agency, 2002). In numerous practical situations, siting problems result in a stalemate.

Opposition from the public is identified by numerous studies as a major factor explaining siting difficulties (see Mitchell and Carson, 1986, the Environmental Protection Agency, 2002, Minehart and Neeman, 2002, or Marchetti, 2005, for comprehensive reviews). Recently, Vajjhala and Fishbeck (2006) quantify the difficulty of siting a locally unwanted public good (U.S Transmission line siting); combining different datasets based on state-level data from the United States, their empirical study concludes that public opposition is the main factor explaining siting difficulties (ahead of environmental and regulation factors).

The literature coins this public rejection phenomenon the NIMBY syndrome, for Not In My Back Yard. Without compensation it seems difficult for the host to accept a noxious facility. Thus, different procedures have been designed to overcome the issue (Kunreuther and Kleindorfer, 1986, Sullivan, 1992, O’Sullivan, 1993, Minehart and Neeman, 2002, etc). Their main objective is to design a procedure which is

\textsuperscript{1} The Times, June 22, 2007.

\textsuperscript{2} See Minehart and Neeman (2002) or Marchetti (2005).
decision-efficient: the chosen host should be the one which incurs the lowest hosting cost (consisting of the cost of construction and a disutility component) among all communities. The traditional approach in the economic literature focuses on the strategic properties of the procedures and are mainly aimed at eliciting truthful revelations of the hosting costs. The community with the lowest cost is then chosen and is compensated in a way which preserves the strategic properties of the method.

We question this exclusivity granted to strategic properties and take the view that redistribution is also an intrinsic part of the siting problem. Indeed, reviewing four cases of waste disposal facilities in the Canadian context, Khun and Ballard (1998) conclude that inequity perception and political dimensions (beyond the economic implications) were the main causes of the NIMBY effect. Similarly, Pol et al. (2006), adopting a social-psychological approach, review previous literature and point out that "the outcomes and lines of argument [reviewed] present the NIMBY issue in terms of distributive justice, inequity perception and risk attribution.". They analyze 47 environmental conflicts in Catalonia between 1988 and 2003 and find a perceived inequity in reluctant groups similar to that in Khun and Ballard (1998). They add that "arguing annoyances, risk, distrust in the technology or its management, and in the decision making of politicians are ways to express this perceived inequity".

Solving the siting problem requires understanding the parameters generating this self-defense behavior of sorts. Efficiency asks that only one site be chosen for the public good: constructing multiple airports, dumps or prison on a small area seems unjustified. It is precisely this inevitable asymmetry which generates the perceived inequity: "Why me?". However, while one cannot change the physical property of the problem, one can design a cost-sharing method (i.e. a redistribution scheme to spread the cost between all relevant communities) to overcome rejection by diminishing the inequity perception. Thus, we tackle the siting issue by defining desirable properties a cost sharing method should meet in this context and by characterizing a solution meeting these properties. The implementation problem (designing a procedure to handle the revelation issue) is treated in a companion paper (Laurent-Lucchetti and Leroux, 2007).

The relevant characteristics we consider to model the problem consist of two components: the benefit a community obtains from the existence of the public good ($b_i$ for community $i$) and the hosting cost (construction cost plus a disutility component),
community $i$ incurs if it is chosen to be the host of the facility. Up to now, studies on the siting issue have focused on the cost parameter to dictate the redistribution. We believe that adding a benefit component enhances the model in at least two ways. First, it determines explicitly whether the public good should be constructed or not (if the sum of the benefits exceeds the total cost). Second, and most importantly, it justifies a bound on the cost share each community will be asked to pay. Thus, ignoring the benefit component amounts to ignoring the voluntary participation of each community, which could be very problematic the stability of any solution.

We focus on the notion of responsibility to determine cost shares: communities should pay—or be compensated—solely for aspects for which they are responsible. We define natural properties of a cost sharing method designed to level the playing field between the participants: because all communities have the same responsibilities towards the public good ex ante (before the host is chosen) the host should not bear more responsibility ex post (after it is chosen). We believe that enforcing ex post equity, through the equalization of ex ante and ex post responsibilities, should help overcome the siting problem.

The first property we define addresses the fact that the host naturally bears a strong responsibility: its hosting cost determines the total cost to be shared among the set of communities. A standard solidarity requirement, in the classical cost-sharing literature, is that if the total cost were to increase, no one should pay less than before; hence, in our context, if the hosting cost increases, no community should have a lower cost share. Thus, in order to recover symmetry, we extend this responsibility to all communities and require that cost monotonicity applies to all hosting costs. We call this property extended cost monotonicity: if the hosting cost of any community were to increase no community should pay less than before.

The second property we ask of a sharing rule is related to the characteristics of the community related to the public facility\textsuperscript{3}. We model the characteristics of a community as the aggregation of those of its inhabitants and are thus subject to

\textsuperscript{3}We take the view that communities are responsible for these characteristics. We follow here a traditional economic treatment of responsibility and preferences (see, for example, Moulin, 2004) and other studies on the NIMBY issue: "faced with compensatory measures, acceptance and rejection of hazardous facilities will depend on the belief and value system of the affected community" (Pol et al., 2006).
change as a result of population movements. In practice, population movements are often observed after the announcement of a host and may thus be endogenous (a point raised by Sullivan (1990) and Baumol and Oates (1998)). Some agents (living in a non-host community) with very low disutility for the proximity of the facility may move near the facility because of lower housing prices, or because of other advantages brought by the compensation scheme (e.g. improved public infrastructures), while agents with high disutility may choose to move out of the host community. This, in turn, may affect the communities' characteristics and their resulting cost share.

To ensure *ex post* equity we address this issue explicitly and define the following property: if population movements occur between a subset of communities, and they collectively pay a higher cost share as a result, no community (outside of this subset) should pay a lower cost share. In other words, if the population distribution changes, no community should "suffer" while others benefit because this change cannot be linked to any community’s specific responsibility. We call this property *Zero Gain Under Endogenous Grouping*.

In addition to these properties, specific to the siting issue, we also require efficiency and voluntary participation. We show that there exists a unique efficient method which meets Extended Cost Monotonicity, Zero Gain Under Endogenous Grouping and Voluntary Participation. This method, which we call *Equal Responsibility Method* shares the total cost ($\min(c_i)$) proportionally to the benefits ($b_i$) each community obtains from the existence of the public good.

2 Related Literature

The siting problem has been widely studied in economics by considering the siting of a private bad: each community is identified by a hosting cost ($c_i$), then an auction-like procedure elicits a site (the community with the lowest hosting cost, for efficiency) and a compensation scheme is constructed to ensure incentive compatibility.

The first paper to study the problem of siting waste treatment facilities in this way is Kunreuther and Kleindorfer (1986). They propose a sealed-bid auction procedure to create an incentive for each community to truthfully reveal their costs (disutility plus technical cost of hosting the facility): each community pays its own bid. O’Sullivan (1993), Minehart and Neeman (2002), Perez-Castrillo and Wettstein
(2002) also propose auction mechanisms in the same vein, aiming for efficiency and truthful revelation. The traditional trade-off between efficiency, incentive compatibility and budget balance is central in these papers and they tackle the siting issue exclusively from a strategic viewpoint. However, they are silent with regards to redistribution.

By contrast, in a companion paper (Laurent-Lucchetti and Leroux, 2007) we design a simple mechanism to choose an efficient site which allows the implementation of any reasonable redistribution scheme. The unique subgame-perfect Nash equilibrium of our mechanism coincides with truth telling, is efficient, budget-balanced and is immune to coalitional deviations. Thus, it selects an efficient host and shares the cost in a predetermined way so as to achieve virtually any normative goal (such as the solution we propose here). Knowing that such a mechanism exists justifies further the need to examine carefully the siting problem from a redistributive viewpoint.

Taking a normative approach, Marchetti and Serra (2004) consider the siting problem as a cooperative game. They study the standard solutions of cooperative game theory (the Shapley value, the nucleolus and the core) with an asymmetric value function: the value of the cooperation changes when the host changes. They design an experiment and test which solution is the most appealing to participants. However, our modeling is quite distinct from theirs, as we wish to explicitly disentangle the public good aspect (the benefit component) and the private bad aspect (the hosting cost) of the siting problem.

Sakaï (2006) axiomatizes the properties of the proportional procedure used by Minehart and Neeman (2002). However, the model he uses is different from ours: he considers a waste disposal facility where the benefits that each community obtains from the facility are equal to the amount of waste generated by this community. By contrast, we consider a broader set-up where the benefits that each community obtains from the public good could be independent of the "intensity" of consumption of the good (e.g. a community could obtain a high benefit from the existence of a prison without sending any of its inhabitants in it).
3 The model and the desirable properties

Let $N = \{1, ..., n\}$ be the set of communities. Each community $i = 1, ..., n$ obtains a benefit, $b_i$, from the consumption of the public good and incurs a cost, $c_i$, if it is the host of the public good. Let $(b, c) = (b_i, c_i)_{i \in N}$ be the benefit-cost profile. We consider the cost parameter to be a combination of the physical construction cost and the disutility each community endures if it is the host of the public good.

Without loss of generality we rank communities from lowest to highest cost: $c_1 \leq c_2 \leq ... \leq c_n$. Efficient siting requires that the host be a lowest cost community: thus, we consider community 1 to be the host. Moreover, we assume $\sum_N b_i \geq c_1$ so that it is always efficient to build the facility. Hence, an efficient cost-sharing method assigns a vector of nonnegative cost-shares $x(b, c) \in \mathbb{R}^N_+$ such that $\sum_N x_i(b, c) = c_1$.

To overcome the natural asymmetry of the problem (one community bearing the cost for the benefits of all) we define a number of properties for the cost-sharing method which aim at leveling responsibilities among communities. The first properties are standard fare in the distributive justice literature. We then introduce two additional properties specific to the siting problem.

A basic incentives property is that of voluntary participation: communities should not pay more than the benefits they obtain from the existence of the public good. Surprisingly, this property seems to have been overlooked in previous works. The implicit assumption made there is that the outside option of each community is to host its own public facility and pay for its entire cost. By contrast, we explicitly consider that the outside option of each community is to build its own public facility only if the benefits it obtains are larger than its hosting cost. Therefore, if we want a solution to be stable (no community loses by participating to the procedure) we must require that no community pays more than the benefits it obtains from the existence of the public good:

**Voluntary Participation (VP):** For all $b, c, i$, $x_i(b, c) \leq b_i$.

The second property translates our statement that communities are responsible for their own characteristics. It states that if a community is in a profile in which it obtains higher benefits from the existence of the public good, all else equal, then it
should not have to pay a lower cost share:

**Monotonicity in benefits (b-MON):** For all $b, b'$ and $i, b_i \leq b'_i \Rightarrow x_i((b'_i, b_{-i}), c) \geq x_i(b, c)$.\(^4\)

The same argument holds for the hosting cost (if a community is in a profile in which it has a higher hosting cost, all else equal, then it should not have to pay a lower cost share), as implied by the following property which is more specific to the siting problem. The host naturally bears a strong responsibility: its hosting cost determines the total cost to be shared among the set of communities. A standard requirement, cost monotonicity, states that no community should pay less if the total cost (the cost to the host in our framework) were to increase. Because we wish the solution to not treat the host asymmetrically, **Extended Cost Monotonicity** extends the responsibility of the host community to the collective: it holds each community equally responsible for the total cost and subjects all communities to cost monotonicity:

**Extended Cost Monotonicity (ECM):** For all $i$ and $j$, $c_i \geq c'_i \Rightarrow x_j(b, (c'_i, c_{-i})) \geq x_j(b, c)$

A possible justification of ECM is the following: because *ex ante* —when the host is still unknown—the decision to build a facility is a collective one, all should be treated similarly. In other words, the host is not any more responsible for the total cost just because its own cost happens to be the lowest in the distribution. The sharing rule should reflect this fact.

Finally, our last property is one of solidarity between communities when population movements occur: if population movements occur between a subset of communities, and they collectively pay a higher cost share as a result, no community (outside of the subset) should pay a lower cost share:

\(^4\)Where $((b'_i, b_{-i})$ refers to the vector $b$ where $b_i$ has been replaced by $b'_i$
Zero Gain Under Endogenous Grouping (ZGUEG): For all benefit-cost
profile: \((b, c), (b', c')\) and \(S \subseteq N\)
\[
\begin{align*}
\sum_{j \in S} c'_j &= \sum_{j \in S} c_j \\
\sum_{j \in S} b'_j &= \sum_{j \in S} b_j \\
\min_{i \in S}(c_i) &= \min_{i \in S}(c'_i) \\
\sum_{j \in S} x_j((b'_S, b_{-S}), (c'_S, c_{-S})) &\geq \sum_{j \in S} x_j(b, c)
\end{align*}
\]

\[\implies x_i((b'_S, b_{-S}), (c'_S, c_{-S})) \geq x_i(b, c), \forall i \in N \setminus S.\]

This solidarity property reinforces our argument according to which no community is responsible for the distribution of characteristics. Indeed, if the population distribution changes, no community should "suffer" while others pay a lower cost share, because this change cannot be linked to anyone's specific responsibility.

4 The Equal Responsibility Method

We define the Equal Responsibility Method as follows:

\[x_i(b, c) = \frac{b_i}{\sum_{N} b_j} c_1\]  

(1)

This method simply shares the cost proportionally to the benefits each community obtains from the public good. In other words, it shares the hosting cost by applying a "flat rate", \(\frac{c_1}{\sum_{N} b_j}\), to each unit of benefit that a community obtains from the existence of the public facility.

**Theorem:** Given \(n \geq 3\), the Equal Responsibility Method is the unique efficient cost-sharing method meeting VP, ECM, and ZGUEG.

**Proof:** See Appendix.

The intuition for why this method meets ZGUEG is that if population movements occur between a subset of communities their aggregate cost share remains constant (as long as the sum of the benefits remain constant) because the method applies the same rate to each unit of benefit. Also, the solution satisfies ECM because it is
insensitive to the cost profile other than $c_1$. Finally, this method meets $VP$ because the ratio $\frac{c_i}{\sum_{j=1}^{N} b_j}$ is less than one by efficiency.

Other intuitive ways of splitting the hosting cost exist. For instance, the constrained egalitarian method (where the total cost is equally split among communities, up to the voluntary participation constraint) fails to satisfy $ZGUEG$. Indeed, when population movement occurs, it is possible for certain communities to benefit from a change in the population distribution while other communities suffer: a movement from an unconstrained community which "transfers" a higher benefits to a constrained community, everything else equal, will lead to an increase in their aggregate cost share and other communities will benefit. Also, sharing the hosting cost in proportion to each community hosting cost (the $c_i$'s) obviously fails $ECM$: a higher hosting cost (for a community other than the host) means it will pay a higher cost share and will benefit all other communities.

5 Conclusion

We have proposed a simple solution to solve the siting problem and share the hosting cost of a public good in a way which minimizes the chance of rejection. Our aim was to capture the specificity of the problem (one community bears the cost, benefits accrue to all) and overcome it by an appropriate method which focuses on redistributive properties: the host should no longer be perceived as a "victim". Thus, we designed a method which levels the playing field among communities by arguing that $ex\ ante$ all are equally responsible for the cost of the facility and equally non-responsive for the distribution of characteristics (preferences and costs). We defined natural properties to this argument and found that only one cost sharing method meets all of this property: the Equal Responsibility Method. We feel that the uniqueness and the simplicity of the solution are significant advantages for a concrete application.

In practice, the planner interested in the implementation of the Equal Responsibility Method must obtain information on $(b,c)$, the benefit-cost profile. In fact, in a companion paper (Laurent-Lucchetti and Leroux, 2007), we propose a procedure which elicits the benefit-cost profile and selects an efficient host while implementing any redistribution scheme.
References


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A Proof of Theorem

Let \( x \) be an efficient cost-sharing method which meets \( VP, ECM \) and \( ZGUEG \).

**Step 1:** Take a profile \((b, c)\). Let \( c' \) be such that \( c'_1 = c'_2 = \ldots = c'_n = c_1 \). Then, by \( ECM \) no cost share with this profile \((b, c')\) should be higher than with the profile \((b, c)\): 
\[
x_i(b, c) \geq x_i(b, c') \quad \forall i \in N.
\]
By budget balance the cost shares must be the same in the profile \((b, c)\) and \((b, c')\):
\[
x(b, c) = x(b, c') \quad \text{for all } b, c \text{ and } c' \text{ s.t. } c'_1 = c_1. \tag{2}
\]

The cost shares of each agent is only determined by the profile \( b \) and the total cost \( c_1 \). From now on we will slightly abuse notation and write \( x(b, c_1) \) instead of \( x(b, c) \).

**Step 2:** We now show that, by \( ZGUEG \) and budget balance, the cost share of an agent \( i \) is determined by \( b_i, \sum_{j \neq i} b_j \) and \( c_1 \). Consider the case of \( n \) communities:
\[
x_1(b, c_1) + \ldots + x_i(b, c_1) + \ldots + x_n(b, c_1) = c_1 \tag{3}
\]
Let \( i \in N \) and \( b' \) be such that \( b'_i = b_i \) and \( \sum_{N \setminus i} b'_j = \sum_{N \setminus i} b_j \). By \( ZGUEG \), agent \( i \) should not obtain a higher cost share than in the \((b, c)\) profile if \( \sum_{N \setminus i} x_j(b', c_1) \leq \sum_{N \setminus i} x_j(b, c_1) \) (or a lower cost share if the sum in the "prime" profile is higher than in the original profile). By budget balance \( \sum_{N \setminus i} x_j(b', c_1) = \sum_{N \setminus i} x_j(b, c_1) \), which implies \( x_i(b', c_1) = x_i(b, c_1) \). So, \( x_i(b, c_1) \) depends only upon \( b_i, \sum_{j \neq i} b_j \) and \( c_1 \) for all \( i \in N \).

**Step 3:** Following Step 2, expression (3) can be rewritten:
\[
x_1(b_1, b_N, c_1) + \ldots + x_i(b_i, b_N, c_1) + \ldots + x_n(b_n, b_N, c_1) = c_1 \tag{4}
\]
where \( b_N \) stands for \( \sum_N b_i \). Let \( i, j \in N \) and \( b' \) be such that \( b'_i = b_i + b_j, b'_j = 0 \) and \( b'_k = b_k \forall k \neq i, j \). By \( ZGUEG \) and budget balance, 
\[
x_i(b'_i, b_N, c_1) + x_j(b'_j, b_N, c_1) = x_i(b_i, b_N, c_1) + x_j(b_j, b_N, c_1). \]
By \( VP \), \( x_j(b'_j, b_N, c_1) = 0 \). Thus,
\[
x_i((b_i + b_j), b_N, c_1) = x_i(b_i, b_N, c_1) + x_j(b_j, b_N, c_1). \tag{5}
\]

Given \( c_1 \) and \( b_N \), the cost share of community \( i \) is only determined by \( b_i \). Again, we slightly abuse notations and rewrite equation \( (5) \):
\[ x_i((b_i + b_j)) = x_i(b_i) + x_j(b_j). \]  \hfill (6)

which holds for all \( b_i, b_j \) such that \( b_i, b_j \geq 0 \) and \( b_i + b_j \leq b_N \).

Similarly,

\[ x_j((b_i + b_j)) = x_i(b_i) + x_j(b_j). \]  \hfill (7)

holds for all \( b_i, b_j \) such that \( b_i, b_j \geq 0 \) and \( b_i + b_j \leq b_N \).

Thus,

\[ x_j \equiv x_i \text{ on } (0, b_N) \forall i, j. \]  \hfill (8)

By combining equations (5), equation (7) and equation (8) we obtain:

\[ x_i((b_i + b_j)) = x_i(b_i) + x_i(b_j). \]  \hfill (9)

for all \( b_i, b_j \) such that \( b_i, b_j \geq 0 \) and \( b_i + b_j \leq b_N \), which is a well-known Cauchy functional equation.

**Step 5:** Following a well-known result of functional equations theory (see Aczél, 1966), the general solution of such a functional equation is a linear function. Thus,

\[ x(b_i) = \lambda b_i \]  \hfill (10)

for all \( b_i \) in our domain.

**Step 6:** To conclude the proof we show that \( \lambda = \frac{c_1}{b_N} \), a result which follows immediately from combining expression (4) and (10). Therefore,

\[ x_i(b, c) = b_i \frac{c_1}{b_N} \]  \hfill (11)

which is precisely the Equal Responsibility Method.