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# Interjurisdictional Competition with Adverse Selection

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**Abstract**

In this paper, we study the welfare consequences of imposing alternative regimes of competition between two local governments that compete for mobile firms which have private information on their degree of mobility.

Competition among jurisdictions raises the firms' rents to higher levels than if jurisdictions were to cooperate. Therefore, from the perspective of a utilitarian federation, constitutional constraints on the competition process may be desirable.

We find that imposing a system of coarser policy instruments improves welfare relative to competition with discretionary instruments, because it reduces the socially costly rents that are granted to firms in equilibrium.

We also find that the gains from resorting to constitutional constraints are maximal when communities are identical, but decline if the extent of asymmetry between locations (in terms of local market size or technological complementarities) increases.

JEL Codes: D82; H20; H32; H73; R38; R50.
Keywords: Interjurisdictional competition; asymmetric information; constitutional constraints; fiscal policy.

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# 1 Introduction

Competition among states and local governments to attract business is widespread in the United States. Almost every state and local government operates development agencies tasked with designing incentive programs to attract and retain business. Recently, the New York Times compiled a detailed database of these incentives awarded by local and state governments (Story et al., 2013). The pattern that emerges is that incentives are large and prevalent among the states. Since the early 2000s, total state incentives ranged from $27.8 million in South Dakota to $19.1 billion in Texas. Missouri, for example, granted General Motors $306 million from 2002 to 2011 in various programs that included corporate income tax credits, rebates, or reductions, as well as free services, to support its Wentzille plant. Similarly, Ford received $207 million in grants from 2007 to 2010 to support its plant in Louisville, Kentucky. In Texas, Amazon received $277 million in property tax abatements, sales tax refunds, and other tax discounts or exemptions from 2005 to 2012.

The public opinion recognizes that local governments use their discretionary powers of taxation to discriminate in favor of (usually) more productive firms. The concern is that that any potential benefits from competition among local governments might be outweighed by the distortions induced by the taxation regimes that underlie the generous incentives being offered. As a result, various economists as well as policy-makers have recommended that the use of preferential or discretionary incentive programs should be discouraged by the federal government. For example, Burstein and Rolnick (1994) argued that competition through uniform taxation and spending policies may lead to a more efficient allocation of resources for the provision of public and private goods. Their proposal generated a great deal of discussion and eventually led a U.S. Representative to sponsor a bill outlining the banning of discretionary incentives, but the bill did not become law.[1]

Inspired by these concerns, in this paper we analyze the welfare properties of banning the use of discretionary incentives in the competition among local governments for mobile firms. Relative to the existing literature, our main contribution is to introduce private information regarding the degree of mobility of the firms. This contribution is novel because previous studies that compare banning preferential regimes do not consider private information. In our analysis we show that the presence of private information represents an important source of distortions that, to the best of our knowledge, has not previously been analyzed when comparing the welfare properties of alternative regimes of decentralized competition between

[1] Bill H.R.1060 was referred to as the "Distorting Subsidies Limitation Act of 1999" and proposed to limit the discretionary application of benefits. It was submitted to the US Congress on March 1999 by Rep. David Minge [MN-2].

local governments.

The public concern about the magnitude and popularity of discretionary incentives is not a recent phenomenon. Over the past three decades there has been a very active empirical literature on the effectiveness of these incentives at promoting local economic development, with mixed results. Newman and Sullivan (1988) and Bartik (1991) compiled earlier works on the effectiveness of incentives assessing the effect of various incentives on measures of local development, such as employment or wages. Gorin (2008) notes that many of the early studies featured imprecise measures of incentives, presumably because state and local governments did not regularly published detail reports of their expenditures. Subsequently, Fisher and Peters (1997) not only categorized various types of incentives and identified several non-tax incentives, but also identified various ways to better assess their costs. They also brought attention to various types of incentives offered by local governments. Today, although most local governments regularly publish information on the costs of incentives, they still fail to also keep detailed measures of the benefits generated by the firms they manage to attract. Gorin (2008) suggests that the challenge going forward is to maintain better information on the social benefits from incentives and make policy-makers accountable based on this evidence.

Similar concerns have been discussed in the international arena regarding competition among countries for the location of multinational firms. In this case, there has been a concern especially about the potentially harmful effects (in terms of eroding national tax revenues) of using preferential tax regimes to offer advantageous treatment to non-resident firms. The use of preferential regimes in the competition among countries for internationally mobile firms also has consequences for transfer pricing, profit shifting, and the existence of tax havens. When subsidiaries of a multinational firm are located in countries with different tax rates, firms have an incentive to set lower-than-market transfer prices (used to value the exchange of assets or services among their subsidiaries) to shift profits to lower-tax countries (Gresik and Osmundsen, 2008).

Similarly to the incentives offered in the United States, the differential incentives offered across countries appear to be economically important. Bartelsman and Beetsma (2003), among others, provide ample empirical evidence of profit shifting among OECD countries. The authors calculate that revenue losses because firms under-report profits by claiming lower-than-market transfer prices in countries with relatively high taxes may be substantial. More recently, Devereux et al. (2008) also provide empirical evidence of strategic interaction among OECD countries, linking the fall in statutory corporate tax rates in the 1980s and 1990s to intense international competition in tax rates. Also similar to the proposals in the United States, both the Organization for Economic Co-operation and Development (OECD,

1998) and the European Union (EU, 1998) have adopted standards for good behavior in international taxation to mitigate these incentives in an effort to prevent the erosion of national tax revenues. But also similarly to the proposals in the United States, these efforts have had limited success because of the difficulty among nations of agreeing on what constitutes a harmful tax system. Instead the efforts have focused on encouraging countries to exchange information to enforce their own tax systems (Keen and Konrad, 2013).

The literature that has analyzed the welfare effects of bans on preferential tax regimes, such as the those proposed by Burstein and Rolnick (1994) or the (OECD, 1998), has not reached definitive results. Often equating welfare with national tax revenues, various works have found that bans on preferential tax regimes can decrease or increase domestic tax revenues. Keen (2001), argued for example, that preferential tax regimes may be socially desirable because they limit the negative effects of tax competition.[2] In his model, two countries compete for two imperfectly mobile tax bases that differ in the degree of international mobility, but are fixed in the aggregate. He finds that preferential regimes help confine the most intense competition on the more mobile bases, limiting distortions on the more immobile bases, and a ban on preferential regimes cannot improve revenues. On the other hand, Janeba and Peters (1999) studied a situation with two governments that levy taxes on a domestic an immobile base and on a base that is perfectly mobile between two countries. They find that a uniform tax regime is preferred to tax discrimination because this regime allows governments to exploit the mobile tax base and raise revenues, whereas a discretionary regime induces more tax evasion. Janeba and Smart (2003) appear to reconcile both approaches arguing that the desirability of preferential regimes depends on the elasticities of the aggregate tax bases. They find that tax discrimination is preferable when elasticities are sufficiently low. In another example, Haupt and Peters (2005) extend Keen's (2001) model assuming that tax bases exhibit regional preferences, or home bias, and also conclude that preferential regimes make tax competition more harmful.[3] Relative to the above studies, which analyze the taxation of firms (or mobile or immobile tax bases), our model portrays the competition of governments that offer incentive programs to attract firms to their location, and firms respond optimally making location choices. Our framework, therefore, directly relates to the anecdotal stories described earlier.

The above studies on the effects of the mobility of tax bases on tax revenues do not con-

[2] In the traditional tax competition literature, governments compete over capital tax rates (Zodrow and Mieszkowski, 1986; Wilson, 1986) and the negative effects of competition among local governments are associated with the fiscal externalities that result because the tax bases are mobile, resulting in equilibrium tax rates that are too low (for excellent surveys see Wilson, 1999; Wilson and Wildasin, 2004).

[3] While many studies, including ours, compare the welfare properties of alternative competition regimes, Gaigné and Wooton (2011) have recently analyzed the impact on national tax revenues of extending the competition game between countries to the endogenous choice of discriminatory or uniform tax regimes.

sider private information. The analysis on information issues can be found in the literature on transfer pricing and the taxation of multinational firms. (See for example Gresik, 2001) The early approaches in the analysis of multinationals with private information were similar to the principal–agent approach found in the industrial organization literature regarding the regulation of a monopolist with unknown costs, as in Baron and Myerson (1982). This analysis however ignored issues of competition between governments to represent taxation by both host and home countries. Osmundsen et al. (1998) is an example of this approach. The authors examine the case of a multinational considering to locate capital investment in a host country. The host country is unable to observe the firm's degree of mobility, which represents the benefits of host investment. Bond and Gresik (1996) first modeled the analysis of a multinational subject to regulation by both the home and host countries. They modeled competition between governments as a common agency game between two principals, applying the techniques of the literature on mechanism design. (Laffont and Tirole, 1991; Martimort, 1992; Martimort and Stole, 2002) In their model, the multinational firm produces an intermediate good at home that is shipped to a subsidiary in a host country where the firm transforms it into a final good that it sells to consumers as a monopolist. In this environment, both the home and host governments set tax policies on the intermediate and final good, respectively, and the firm has private information on its production cost.

Our paper builds on the spirit of these early works to analyze the role of private information on the mobility of the firms in the comparison of the welfare properties of two alternative regimes of competition between local governments: a preferential or discretionary regime and a uniform or non-discretionary regime. As in Osmundsen et al. (1998), we assume that firms possess private information on their degree of mobility. As in Haupt and Peters (2005), we introduce the assumption that firms exhibit locational attachment or home bias. We then equate this attachment with the degree of mobility. This provides an intuitive ordering of firms along a spatial dimension, but we show that it is the presence of private information that constitutes the main distortion in our environment. As in Bond and Gresik (1996), we model the interaction between two governments as competition between principals for the exclusive services of mobile agents. While Bond and Gresik (1996), and more recently Morelli et al. (2012), also analyze the welfare properties of taxation regimes when local governments compete, these studies only compare the non-cooperative regime with a unified tax system under collusion. Our paper, in contrast, compares the welfare properties of two decentralized, non-cooperative, regimes which provide different policy instruments to the competing governments.[4]

[4]Recently, Gresik (2010) also evaluates two alternative competition regimes for taxing multinational firms with private information. The regimes compared, however, represent different accounting formulas (*formula*

Our main result is that imposing constitutional bans on the use of discretionary incentives improves aggregate welfare, supporting the views of earlier proposals, such as Burstein and Rolnick (1994). We assume that it is socially costly to provide incentives, and from an aggregate welfare perspective, competition generate excessive firms' rents in equilibrium, compared with a cooperative solution. In the regime where local governments compete with discretionary policy instruments, local governments induce further distortions in the output of the firms, as they need to generate information rents for the firms to induce them to reveal their true mobility. Therefore, competition with a system of coarser, non-discretionary, instruments improves welfare because it reduces rents that are granted to firms in equilibrium. We evaluate the merits of bans on discretionary incentives considering also asymmetries between locations in terms of local market size or location-specific technological advantages.

The exercise described in our paper is an extension of a similar comparison of alternative policy regimes by Boyer and Laffont (1999) to the case of competition between governments. Boyer and Laffont analyze the option of restricting the use of discretionary policy instruments in an model where a single regulator designs environmental policies for a polluting monopolist. The authors find that constraints that force the regulator to use coarser policy instruments may be desirable because they limit the regulator's ability to redistribute rents. Our results on the welfare ranking of alternative regimes are consistent with their findings.

The study by Biglaiser and Mezzetti (1993) is also related to ours, although they do not examine the question of instruments availability. In their model, the authors characterize the incentive contracts of principals competing for an agent under adverse selection and moral hazard. As in their model, we also rely on the techniques of mechanism design mentioned earlier. Our approach is also similar to the analysis of price discrimination with nonlinear pricing of Stole (1995) and Spulber (1989). The common methodology across our analyses is in the spirit of the standard model of horizontal spatial differentiation of Hotelling (1929).

The choice of policy instruments to regulate interjurisdictional competition within a federation has also been analyzed from the perspective of optimal taxation. Holmes (1995), in particular, analyzed formally the Burstein and Rolnick (1994) proposal and found that banning discretionary taxation to attract firms improves welfare, because it prevents governments from applying differentiated tax rates to agents, which are essentially of the same type, but originate from different locations. Holmes did not consider private information. Similarly, Becker and Mulligan (2003) have found that when government policy responds to the actions of interest groups, welfare can be improved by an apparently suboptimal tax

*apportionment* and *separate accounting*) as opposed to different sets of policy instruments, and the tax policies do not allow the governments to infer the firms' private information.

system of less sophisticated instruments, because it reduces the overall inefficiency of the public sector and creates pressures to suppress the size of governments. In our environment, competition drives the behavior of local governments that may need to be restrained to prevent welfare losses.

To a lesser degree, our analysis is also related to the classic literature on industrial organization and international economics, such as Brander and Spencer (1985), where a domestic government commits to provide export subsidies to domestic firms, essentially changing the rules of competition between the domestic and foreign firms to improve national welfare. In our environment, a supranational federation chooses the rules of competition, but in contrast with Brander and Spencer (1985), it is concerned with aggregate welfare.

The outline of our paper is as follows. In section 2 we describe the details of the model. In sections 3 and 4 we characterize the two alternative regimes of incentive programs we consider and characterize the equilibrium under each regime. In section 5 we present the welfare comparison of the alternative regimes. In section 6, we summarize our results and conclude. Finally, we relegate proofs and additional derivations to the appendix.

# 2 The model

In our model, two local governments compete for the exclusive services of a group of mobile firms by offering incentive programs. The environment can represent the competition among states within a federation to attract mobile firms, or the competition among countries to attract internationally mobile firms. In either case, we assume there is an overarching authority that can enforce limits on the incentive programs that can be used in the decentralized competition. The exercise we undertake consists of describing two alternative regimes of competition based on the set of instruments available to the local governments and evaluating the welfare properties of each regime. The decentralized competition between governments takes the form of a two-stage game. In the first stage, local governments announce incentive programs simultaneously, and in the second stage, firms make location decisions. The equilibrium in each case is the Nash equilibrium of the game. For simplicity we consider pure strategies and interior solutions only. Below we describe the characteristics of the local governments, the set of mobile firms, and the payoff functions of both.

## 2.1 Locations

There are two locations hosting immobile local residents who derive benefits from the output produced by the mobile firms. We assume that in a first stage, local governments in location $i = 1, 2$ offer incentive programs in the form of transfers and required output, $\{t_i, q_i\}$, and in a second stage, the mobile firms choose to locate in only one of the locations. That is, we assume that firms provide exclusive services to the local governments. We will analyze the competition between the local governments and therefore we assume that the mobile firms consider only the incentives of each government in their location decisions and do not interact strategically with other firms.

We define the surplus generated to local consumers and the rents to a firm choosing to locate in jurisdiction $i$ as follows:

$$CS^i = S^i - (1+\lambda)t_i \tag{2.1}$$

$$U^i = t_i - c^i. \tag{2.2}$$

We also assume that transfers to the firms $t_i$ are socially costly and $\lambda > 0$ represents the social cost of public funds (which assumes that in the background public funds are generated with distortionary taxes on local residents). We assume that $\lambda$ is the same across locations. This assumption is reasonable if the underlying tax systems across locations are similarly efficient (at raising public funds). This might be the case for different states within the same country, or for similar countries within the same supranational federation.[5] A similar formulation has been used, among others, by Laffont (1996), Martimort (1996), Osmundsen et al. (1998), and especially Boyer and Laffont (1999).

The quasilinear setup, which is analogous to assuming interpersonal transferability of utility (expressed in money) among individuals, is a natural choice for the welfare analysis we undertake, and as usual, it is justifiable if the sector represented by the firms is small relative to other sectors of the local economies combined, as it abstains from considering income effects. The separability of preferences also has implications for the analysis with private information, especially from the perspective of the firms which are able to evaluate the incentives offered by each local government separately and are not affected by potential externalities between the programs they are offered.[6]

## 2.2 Home bias

We assume that a continuum of atomistic firms are located along a horizontal line $[0, \Delta]$ and we identify the two locations as the extremes of this interval. We denote the location to

[5] It is possible to allow for different $\lambda$s to account for differences in the local governments' ability at raising public funds, but in that case, closed-formed results are limited. The case, however, can be analyzed numerically.

[6] For more on the implications of separable preference in common agency problems with private information or hidden actions, see Attar et al. (2008).

the left as location 1. Firms are indexed by a cost parameter $\theta \in [0, \Delta]$. This parameter is private information, and its distribution is given by a publicly known cumulative distribution function, $F(\theta)$, with continuous density $f(\theta)$.

We assume that firms exhibit horizontal attachment to locations in the sense that costs of production are directly related to the distance to each location from position $\theta$: for a firm of type $\theta \in [0, \Delta]$, we denote by $\theta_1 = \theta$ the cost parameter it obtains in location 1 and by $\theta_2 = \Delta - \theta_1$, the cost parameter the firm obtains in location 2. The distributions of $\theta_1$ and $\theta_2$ are given by $f^1(\theta_1) = f(\theta_1)$ and $f^2(\theta_2) = f(\Delta - \theta_2)$. Clearly, $F^1(\theta_1) = F(\theta_1)$ and $F^2(\theta_2) = 1 - F(\Delta - \theta_2)$.

In the classic model of a duopoly on a linear city (Hotelling, 1929) where consumers are the agents ordered along the line segment, the horizontal attachment to the extremes of the line can intuitively be associated with a notion of distance from the firms' location, and the corresponding transportation cost involved in gaining access to the market goods. In the present model where the extremes of the line correspond to locations, we provide the intuition for the horizontal attachment of the mobile firms in terms of their production cost, which represents their degree of mobility.

This locational attachment reflects, in a subnational context, the notion that the technology of production depends on the complementarity of the firms' characteristics and the characteristics of the locations where they choose to locate (such as access to local geophysical resources or the skill level of the local workforce).

Mezzetti (1997), for example, uses a similar structure in a model of common agency where the agent has different abilities at performing the tasks required by two different principals. Similarly, Boyer and Laffont (1999) identifies the firms' location parameters as a cost parameter.

In an international context, this attachment to the home location is referred to as *home bias* and is a well-established empirical regularity (see, for example Haupt and Peters, 2005, and other references therein). Home bias also reflects in this environment the higher information and transaction costs involved in investing abroad implied by differences in legal and taxation institutions across countries. As in the subnational environment, the locational attachment also represents the degree of mobility of the firms.

The horizontal attachment naturally translates into the single-crossing property.

**Assumption 1** *(Single-crossing)*
*Production costs are given by $c^i(q, \theta_i)$, which satisfies*

$$c_q > 0, c_\theta > 0, \text{ and } c_{\theta q} > 0.$$

Thus, both costs and marginal costs increase with the distance from locations.

The single-crossing assumption is standard in models of horizontal price competition and especially in models of adverse selection. It is a natural approach in our environment for indexing the set of high and low cost firms which are atomistic and only interact strategically with the local governments but not with each other.

Interpreted as the degree of mobility, it is reasonable to assume that home bias is private information, as in Osmundsen et al. (1998), and represents situations in which firms are better informed about their true mobility than the local governments that are competing to attract them. When we interpret home bias as the complementarity of the firms' technologies with the characteristics of the locations, although it is reasonable to think that local governments would be well informed about the latter, it remains reasonable to assume that firms are better informed about the former.

## 2.3 Parametrization

In the rest of this paper we assume the following functional forms.

$$\begin{aligned} S^i(q) &= \alpha_i q_i - \frac{1}{2} q_i^2 \\ c^i(q,\theta) &= (\delta_i + \theta_i) q_i \\ \Delta &= 1 \\ F(\theta) &= \theta, \text{ thus } f(\theta) = 1. \end{aligned} \tag{2.3}$$

The subscripts $i$ in the benefit and cost function parameters $(\alpha_i, \delta_i)$ allow for differences across locations. The parameter $\alpha_i$ represents attractiveness of the good provided by the mobile firms to the local consumers and can be interpreted as the local (maximum) willingness to pay for the firms' services, or as an indicator of local market size as in Haufler and Stähler (2013). The parameter $\delta_i$ allows for technological differences across locations, representing, for example, geophysical constraints, such access to rivers, roads, or terrain constraints which affect distribution channels.

This parametrization is a simplification that allows for closed-form solutions, but it is also provides for an intuitive interpretation of the reduced number of parameters at play. More general functions, with concave local benefits $S$, convex costs $c$, and well-behaved distributions $F$, would yield similar results regarding the existence of equilibria under each alternative regime we considered. But we have not analyzed the welfare implications with more general functional forms. We conjecture, however, that the cross-regional externalities that drive the results in our case (regional attachment) as well as the distortions induced by private information, would remain the driving mechanisms with more general functions. (The welfare comparisons could be carried out numerically.) The quasilinear structure, in any case, would remain an appealing feature to be used for the welfare analysis, as we have mentioned earlier.

The choice of $\Delta = 1$ is a normalization and is analogous to fixing the number of firms in the aggregate. Under this normalization, the marginal firm $\overline{\theta}_1$ represents the share of firms that choose location 1. We abstain from comparative statics regarding the number of firms to focus on the choices of the local governments and the welfare properties of the equilibria under alternative regimes of competition. Nevertheless, the horizontal structure of the model suggests that a lower $\Delta$ would mitigate the distortions from private information because the firms would be more similar and the rents that would have to be provided to induce self-selection might be lower. On the other hand, firms become more mobile because the cost differences between locations are also reduced, and therefore competition might be intensified inducing higher rents. Conversely, a higher $\Delta$ would increase the distortions from information issues, and it would be more costly to induce self-selection. So that relative to competition forces (as firms become less mobile) it might not be possible to sustain positive rents for the marginal firm in equilibrium. This case would eventually result in the two locations acting in isolation as the moving costs for the firms would be prohibitively high.

The normalization of $\Delta = 1$ also helps to characterize the closed-form expressions of various objects, via $q_i^F(\theta_i)$, the maximizing choice of a utilitarian local social planner in isolation under perfect information. For example, we obtain the following characterization of the output produced by the most and least efficient firms in terms of the local social cost of public funds: $q_i^F(0) - q_i^F(1) = (1 + \lambda)$, for all $i$.

Finally, the firms' value of no participation, $U_0$, is normalized to zero.

## 2.4 Objective of local governments

In what follows we will refer to each local government indistinctly as a *local social planner*. We assume that the objective of each local social planner is to maximize a utilitarian measure of the residents' welfare in their location, which includes the rents of the firms that choose that location. That is, local governments maximize a weighted sum of the resident consumers' surplus and the firms' rents. For simplicity, we assume that the welfare weights for local consumers and firms are the same. (Note that this assumption is analogous to assuming that local residents are able to share in the entirety of the rents of the firms that locate in that jurisdiction.)

The objective function of the local government is thus

$$\max_{q_i,t_i} \int_0^{\overline{\theta}_i} \{CS^i + U^i\} d\theta_i, \tag{2.4}$$

where $\overline{\theta}_i$ denotes the marginal type that delimits the segment of firms that location $i$ is attempting to attract: $\theta_i \leq \overline{\theta}_i$.

We will show that in equilibrium, the set of firms that choose location 1 is of the form $[0, \overline{\theta}_1]$ and the set of those which choose location 2 is of the form $[\overline{\theta}_2, 1]$ because $U^1(\theta) > U^2(\theta)$ for all $\theta \in [0, \overline{\theta}_1]$ and $U^2(\theta) > U^1(\theta)$ for all $\theta \in [\overline{\theta}_2, 1]$.

We will also focus the analysis on the interior equilibrium where the local social planners are in competition and $\overline{\theta}_1 = 1 - \overline{\theta}_2$ to provide a meaningful welfare comparison of the alternative incentive regimes.

Expanding the objective function we can re-express it as:

$$\begin{aligned}
\int_0^{\overline{\theta}_i} \{CS^i + U^i\} d\theta_i &= \int_0^{\overline{\theta}_i} \{S^i - (1+\lambda)t_i + U^i\} d\theta_i \\
&= \int_0^{\overline{\theta}_i} \{S^i - (1+\lambda)(c^i + U^i) + U^i\} d\theta_i \\
&= \int_0^{\overline{\theta}_i} \{S^i - (1+\lambda)c^i - \lambda U^i\} d\theta_i.
\end{aligned} \tag{2.5}$$

A similar structure is presented, for example in Boyer and Laffont (1999). The common feature with our approach is that the information rents, which are socially costly because $\lambda > 0$, are partially nullified in the local government's objective relative to the situation where local governments maximize only the local consumers' surplus because in our case, the local social planner values the firms' profits.[7]

Depending on the motivation behind the objective function, an intuitive constraint on the local social planner's problem would then be to require that $\int CS^i \geq 0$ and $U^i(\overline{\theta}_i) \geq U_0$, or simply $\int_0^{\overline{\theta}_i} \{CS^i + U^i\} d\theta_i \geq 0$ and $U^i(\overline{\theta}_i) \geq U_0$. The non-negativity constraints put an upper-bound on the information rents that local governments can offer to the firms in their location and could be triggered for the location that is least able to generate local surplus. In the rest of the analysis we will focus on the interior case where these constraints are not binding. Focusing on interior equilibria allows us to simplify the comparison of the two alternative regimes, but it does not undermine the intuition of the mechanism driving the

[7] This partial offset of the firms' rents is larger than under a situation in which only a portion $\sigma < 1$ of local residents shared in the firms' rents: $1 + \lambda - \sigma \geq \lambda$. This case was considered with similar results in a previous version of this paper.

results.

## 2.5 Welfare benchmark

To evaluate the welfare properties of alternative competition regimes, we need to make an assumption on an aggregate welfare criterion used to evaluate the combined welfare of the equilibrium outcome under each alternative regime.

We assume that a global planner, perhaps in the form of an overarching authority, such as a supranational federation, is utilitarian and has the following welfare function:

$$W = W_1 + W_2 = \int_0^{\bar{\theta}_1} [CS^1 + U^1] d\theta_1 + \int_0^{\bar{\theta}_2} [CS^2 + U^2] d\theta_2. \tag{2.6}$$

Note that this criterion assumes that even a global planner would be limited by the local distortionary taxation systems underlying the local social cost of public funds in each location. This is consistent with an environment where tax revenues are raised locally and local governments have tax authorities that are independent of those in other countries.

To compare alternative competition regimes, we simply calculate the consumers' surplus and the firms' rents implied by the choice of instruments available in each regime in each location and evaluate them according to this welfare measure. It is important to note that the powers of the overarching authority are limited to imposing the rules of competition between local governments. Allocations will remain the outcome of decentralized competition between the local social planners. Thus it makes no sense to derive the incentive programs that would be designed by a global social planner. Clearly, under private information, this planner would eliminate the rents granted to the marginal firms, and would impose the same fully nonlinear direct revelation incentive-compatible mechanisms that will be offered in the decentralized game with discretionary incentives sans the marginal rents resulting from competition. (That this the solution is apparent because all the other incentives we consider in the decentralized competition environments would be part of the choice set of the global planner. Furthermore, with a single global planner, the standard revelation principle applies, and the optimal mechanism is given by the optimal direct mechanism.)

It should be apparent also that, in general, competition outcomes will not be efficient, even under full information, because competition will likely result in positive rents for the marginal firm, and rents are socially costly. A global planner choosing allocations across all firms and locations could impose zero rents for all firms.

It is also true that according to the global planner's welfare criterion, the outcome of competition under any regime—discretionary or non-discretionary—is inferior to the outcome of collusion between local governments. This results because collusion would also allow the local social planners to set costly information rents of the marginal types equal to zero. In general, however, collusion outcomes will not be sustainable as Nash equilibria of the competition games. (Under collusion, the standard revelation principle also applies, and the solution would coincide with the solution of a global planner.)

## 2.6 Full information and isolated locations

To establish an efficiency benchmark in the required output levels, it is useful to characterize the choices a local social planner under full information in isolation, assuming that there is no competition with a rival local government.

Letting the superscript $F$ stand for full information and under full discretion in the choice of incentive programs, after substituting $t_i(\theta_i) = U^i(\theta_i) + c^i(q_i(\theta_i), \theta_i)$, the problem of the local government in isolation is:

$$\max_{q_i^F(\theta_i), \overline{\theta}_i^F} \int_0^{\overline{\theta}_i^F} \{[S^i(q_i^F(\theta_i) - (1+\lambda)c^i(q_i^F(\theta_i), \theta_i)] - \lambda U^i(\theta_i)\} d\theta_i. \tag{2.7}$$

We refer to the first term in square brackets as the local social surplus. We can see that $\lambda > 0$ implies that in the solution, rents $U(\theta)$ will be zero for all firms. This is also because the relevant individual rationality constraint is $U^i(\theta_i) \geq U_0 = 0$. The solution $q_i^F(\theta_i)$ is characterized by the point-wise first order condition:

$$S_q^i(q_i^F(\theta_i)) = (1+\lambda)c_q^i(q_i^F(\theta_i), \theta_i) \ \forall \theta_i, \tag{2.8}$$

which yields:

$$q_i^F(\theta) = \alpha_i - (1+\lambda)(\delta_i + \theta). \tag{2.9}$$

The marginal type of firms $\overline{\theta}_i^F$, is determined in turn from:

$$S^i(q_i^F(\overline{\theta}_i^F)) = (1+\lambda)c^i(q_i^F(\overline{\theta}_i^F), \overline{\theta}_i^F), \text{ if } \overline{\theta}_i^F < 1 \text{ exists, and } \overline{\theta}_i^F = 1 \text{ otherwise.} \tag{2.10}$$

Output levels are constrained-efficient—in the sense that they maximize the local social surplus subject to using distortionary taxation to generate public funds. The marginal type is determined so that its contribution to the social surplus vanishes.

Lastly, to avoid aberrant situations in the analysis of the competition equilibria, we impose the following assumption to guarantee that for any given location it is socially more efficient for the firm with the strongest attachment ($\theta_i = 0$) to locate there than at the competitor's location ($\theta_{-i} = 1$).

**Assumption 2** *(Heterogeneity)*
*We restrict the extent of heterogeneity across locations as follows: for each location $i = 1, 2$ and rival location $-i \neq i$,*

$$\max_q \{S^i(q) - (1+\lambda)c^i(q,0)\} > \max_q \{S^{-i}(q) - (1+\lambda)c^{-i}(q,1)\} > 0.$$

Given the functional forms in our parametrization, this condition is equivalent to $q_i^F(0) > q_{-i}^F(1) > 0$. This assumption helps ensure the existence of an interior equilibrium which is necessary for the meaningful comparison of the welfare properties of each competition regime. It also helps to characterize various objects in terms of the quantities, $q_i^F(0)$ and $q_i^F(1)$.

## 2.7 Alternative competition regimes

The goal is to analyze the implications of imposing constitutional constraints on the set of available policy instruments used by the local governments when they compete and evaluate the merits of banning the discretionary regime. In what follows, we describe each alternative competition regime in terms of the incentives that can be offered by the local governments (the local social planners). Given the available instruments imposed by the federation (the global social planner), and the atomistic nature of the firms, it is enough to characterize the Nash equilibrium of each environment as the policy programs for each location $\{t_i, q_i\}$, the marginal types $\{\overline{\theta}_1,\overline{\theta}_2\}$, and the rents for the marginal types $\{U^1(\overline{\theta}_1), U^2(\overline{\theta}_2)\}$, such that the incentive programs $\{t_i, q_i\}$ are the solution to the optimization problem of each local planner given the programs offered by the rival local government. To compare across regimes, we will focus on identifying interior equilibria where local governments compete and $\overline{\theta}_1 = 1 - \overline{\theta}_2$ and $U^1(\overline{\theta}_1) = U^2(\overline{\theta}_2) = \underline{U} \geq 0$.

# 3 Sophisticated contracts

Our model with sophisticated contracts builds upon Spulber's (1989) and section 3.1 of Stole (1995), extending the objective function of the local social planner to account for the firms' rents. As in Bond and Gresik (1996) and especially Boyer and Laffont (1999), we use the tools of mechanism design to analyze this case. In this regime, we assume that local social planners use direct revelation mechanisms to compete. Direct mechanisms are attractive because of their simplicity. In a direct mechanism, the mechanism designer, i.e., the local planner, offers incentives that depend only on the firms' report of their private information or type (the cost parameter). In our environment, direct mechanisms comprise a transfer $t$ and a required output level $q$ as functions of each firm's report of cost parameter $\hat{\theta} : \{t(\hat{\theta}), q(\hat{\theta})\}$.

According to the taxation principle (Rochet, 1986) the equilibrium with truth-telling direct revelation mechanisms, $\{t_i(\theta), q_i(\theta)\}$ can be expressed as menu of choices given by a fully nonlinear tariff, $\{T(q)\}$, by inverting the output function, $q_i(\theta)$, $T(q) \equiv t(\theta_i^{-1}(q))$, so that firms instead of making a report on their type, select the output level to produce. This contracting scheme may be more realistic in some applications. In our environment, the incentive programs in the form of transfers in exchange for a required output level seem to be commonly used in cases where the firms are tasked with producing a public project.

Because the firms have private information, local governments would like to design incentives to induce firms to reveal their private information, while minimizing the cost of providing these incentives. The natural approach in a situation with a single local government is to model incentives as in the standard principal–agent problem (for example, in the case of a government regulating a monopolistic firm, as in Baron and Myerson, 1982 and Boyer and Laffont, 1999). In that case, the revelation principle (e.g. Myerson, 1979, 1982) guarantees that there is no loss of generality assuming that the local social planner offers direct revelation mechanisms that induce truth-telling.[8]

In a situation with multiple principals, restricting principals to compete with direct mechanisms is not without loss of generality.[9] Addressing this issue is beyond the scope of the current application, and for simplicity, we focus on incentive-compatible direct revelation mechanisms to characterize the discretionary regime. However, we offer the following discussion of the relevant literature, which encouragingly suggests that the use of direct mechanism may be justified in our case.

## 3.1 Failure of the revelation principle

The main reason for the failure of the revelation principle in a multi-principal environment is that not all outcomes that can be sustained as equilibria of a game with general mechanisms can be sustained as equilibria of the game with direct mechanisms. The problem arises because the principals are aware of the possibility that the agent or agents may communicate with other principals about the incentive programs being offered. Direct mechanisms are too

[8]The revelation principle states that the maximum payoff that the principal can obtain with general, or indirect, mechanisms can also be obtained in the optimization problem in which the principal uses direct mechanisms.

[9]Martimort and Stole (2002) describe three basic reasons why the standard revelation principle fails in an environment with multiple principals and a single common agent.

simple for the principals to profit from the extra information held by agent, and any principal might improve his payoff by offering indirect incentives that depend not only on the agent's private information but also on the market information (the incentives offered by other principals) (Attar et al., 2008).

The literature on these issues has been very active in recent years because the multi-principals environment is very appealing for various applications. Until recently, the literature had offered two alternatives to tackle this problem (Attar et al., 2008). One approach consists of expanding the set of the agent's private information to include also market information such that a version of the revelation principle for this expanded space is still valid. This is the approach of Epstein and Peters (1999) and Pavan and Calzolari (2010). However, characterizing these general solutions has proved too complex for most applications.

The second approach consists of shifting the focus from the equilibrium outcomes under direct or indirect mechanism to consider instead alternative strategies for the principals so that the equilibrium payoffs supported under indirect mechanisms can also be supported in equilibria of the games where principals offer simpler menus of choices that do not require the agent to strategically report any information. This is the approach of Peters (2001) and Martimort and Stole (2002) who employ an extension of the taxation principle (Rochet, 1986) to substitute a potentially complex set of mechanisms with a simpler one where the agent does not need to strategically reveal his private information. This approach essentially sidesteps the revelation principle.

Recently, a third approach identifies circumstances (restrictions on the agent's preferences or restrictions on the equilibria under indirect mechanisms) for which the revelation principle does hold. The analysis by Attar et al. (2014), for example, provides a rationale for restricting competing principals to use direct revelation mechanism in an environment where the agent negotiates under an *exclusivity clause*. That is, the agent chooses to provide services for only one of the principals. The authors analyze a restriction on the set of equilibria under indirect mechanisms that can also be supported with direct mechanisms. This restricted equilibria (referred to as *strongly robust* in the sense of Peters, 2001 and Han, 2007) eliminate situations in which the agent might be indifferent between lying or telling the truth, after receiving the offers from the principals.[10]The results on exclusivity, however, do not extend to the case with multiple agents that can interact strategically.

[10] Direct revelation mechanisms that are incentive compatible by construction cannot characterize equilibria in which the agent lies. According to Attar et al. (2014), in a strongly robust equilibrium in the sense of Peters (2001), and Han (2007), the agent's beliefs at equilibrium are restricted so that any principal can break the agent's indifference between telling the truth or lying in the most favorable way for him both on and off the equilibrium path. In other words, equilibria that fail to be strongly robust induce outcomes that cannot be supported by direct revelation mechanisms.

The failure of the multi-agent case results because any principal can create coordination between agents by appropriately choosing his mechanisms, hence it may be profitable for a principal to propose indirect mechanisms rather than direct ones. In our model, the agents (the firms) are atomistic and do not interact strategically with each other. Therefore, we conjecture that the problems in the multi-agent case identified by (Attar et al., 2014) do not arise in our case. However, in order to apply the results about the validity of the revelation principle under exclusivity, we would have to investigate whether equilibria in the general mechanism game are strongly robust. This is beyond the scope of the current application.

## 3.2 Information rents

We assume then that local governments offer direct revelation contracts $\{t_i(\hat{\theta}_i), q_i(\hat{\theta}_i)\}$ in terms of the firm's report on its type $\hat{\theta}_i$. We denote the information rents obtained by firm of type $\theta_i$ in location $i$ from making a report $\hat{\theta}_i$ by $V^i(\hat{\theta}_i, \theta_i) \equiv t_i(\hat{\theta}_i) - c^i(q_i(\hat{\theta}_i), \theta_i)$, and we let $U^i(\theta_i) \equiv V^i(\theta_i, \theta_i)$ be the payoff from truthful revelation. Incentive compatibility (henceforth **IC**) and individual rationality (henceforth **IR**) constraints for types $\theta_i$ are given by

$$(\mathbf{IC}) \quad U^i(\theta_i) \geq V^i(\hat{\theta}_i, \theta_i) \tag{3.1}$$

$$(\mathbf{IR}) \quad U^i(\theta_i) \geq \max[U^{-i}(1-\theta_i), 0]. \tag{3.2}$$

As in Lemma 1 in Stole (1995), we show in the next lemma that it is convenient to express the firm's rent, $U^i(\theta_i)$, in its integral form. Intuitively, the incentive compatibility constraint imposes an internal optimization on the choice of the firm's report. The integral form of the rents subsumes this optimization. Incentive compatibility implies that both $U^i$ and $q_i$ are strictly decreasing in the position parameter. Furthermore, the monotonicity of $U^i$ implies that the individual rationality constraint binds only for the marginal type, which, in equilibrium, will be indifferent between either location. Thus, in the equilibrium with direct mechanisms, **IC** and **IR** are only relevant for types which actually choose the location in question.

**Lemma 1** *Given the rival location's contract, $\{t_{-i}(\theta_{-i}), q_{-i}(\theta_{-i})\}$, a firm $\theta_i \leq \overline{\theta}_i$ chooses location $i = 1, 2$, and reports its type truthfully iff:*

$$\textbf{\textit{IC(i)}} \quad U^i(\theta_i) = U^i(\overline{\theta}_i) + \int_{\theta_i}^{\overline{\theta}_i} q_i(s)ds, \tag{3.3}$$

$$\textbf{\textit{IC(ii)}} \quad q_i(\theta_i) \textit{ is nonincreasing in } \theta_i. \tag{3.4}$$

*The individual rationality constraint in equation (3.2) can be replaced by*

$$\boldsymbol{IR}(iii) \quad U^i(\overline{\theta}_i) \geq \max[U^{-i}(1-\overline{\theta}_i), 0]. \tag{3.5}$$

*The marginal type,* $\overline{\theta}_i$*, in location* $i$*, is such that types* $\theta_i > \overline{\theta}_i$ *either choose location* $-i$ *or do not participate.*

### 3.3 Virtual surplus

A standard technique in problems of mechanism design is to restate the optimization problem of the principal in terms of a *virtual surplus* function that satisfies certain regularity conditions (see Myerson, 1979). The problem of principal $i$ can be then restated as choosing a required output level and the marginal type:

$$\max_{q_i, \overline{\theta}_i} \int_0^{\overline{\theta}_i} \left\{\Phi^i(q_i(\theta_i), \theta_i) - \lambda \max[U^{-i}(1-\overline{\theta}_i), 0]\right\} d\theta_i, \tag{3.6}$$

where,

$$\begin{aligned} \Phi^i(q_i, \theta_i) \equiv & \{S^i(q_i) - (1+\lambda)c^i(q_i, \theta_i)\} - \lambda c^i_\theta(q_i, \theta), \\ = & [\alpha_i q_i - \frac{1}{2}q_i^2 - (1+\lambda)(\delta_i + \theta_i)q_i] - \lambda q_i \theta_i; \end{aligned} \tag{3.7}$$

The virtual surplus function $\Phi^i$ accounts for the distortions in the local social surplus of each location induced by the firms' private information. As in the standard problem with only one principal, we will see that in order to provide information rents to induce truthful revelation, local governments have to require underproduction from all firm types with respect to the full-information case, except from the most efficient one.

Notice that in the optimization problem stated above local governments take into account the choices of the rival location by including the participation constraint on the marginal type. In equilibrium, individual choices of the marginal types, $\overline{\theta}_i$, have to be consistent with this endogenously determined participation constraint.

Although a standard approach in the literature is to impose regularity conditions on the function $\Phi^i$, we note that these conditions can be obtained from the properties of the fundamentals of the model, such as the concavity of the local benefits function $S^i$ and the convexity of the cost function $c^i$, as well as the monotone hazard ratio of the distribution of types $F$, which are easily verified with our parametrization. Thus the virtual surplus function, $\Phi$, is well-behaved. In particular, for all $(q, \theta)$ and $i$, $\Phi$ is strictly concave and has a unique interior maximizer in $q$. Furthermore, it satisfies the single-crossing property

$\Phi_{q\theta} < 0$, and reflects the assumption of home-bias, representing regional preferences, $\Phi_\theta < 0$.

We now outline the timing of the game between the principals. In a first stage they announce simultaneously incentive programs to the firms. In a second stage, firms choose incentive programs and decide where to locate. Finally, firms report their type truthfully in the location they have chosen and payoffs are realized.

## 3.4 Equilibrium

Eliminating the transfers from the problem using the integral representation of the firms rents and optimizing only in terms of required output and marginal types, $\{q_i, \overline{\theta}_i\}$, the following result states that there is a unique Nash equilibrium. We describe only the relevant interior case in which local governments compete.

Intuitively, the characterization of the equilibrium takes advantage of the indexing of firms along the horizontal line segment dividing the two locations. The ordering of firms along the line is an effective device to represent the heterogeneity of these agents and is a natural choice to model the problem of private information. It also provides an intuitive representation of the firms along a geographic or spatial dimension, which is appealing for the analysis of cross-regional externalities and competition between rival local governments.

**Proposition 1** *Under assumption 2, there exists a Nash equilibrium in the competition game with contracts $\{t_i(\theta_i), q_i(\theta_i)\}$ for $i = 1, 2$, characterized as follows.*
*(i) Letting superscript $S$ stand for sophisticated contracts, for $\theta_i \leq \overline{\theta}_i^S$, the required output function $q_i^S(\theta_i)$ is obtained from the first order condition $\Phi_q^i(q_i^S(\theta_i), \theta_i) = 0$ as:*

$$q_i^S(\theta_i) = \alpha_i - (1+\lambda)(\delta_i + \theta_i) - \lambda\theta_i. \tag{3.8}$$

*(ii) Marginal types $\{\overline{\theta}_1^S, \overline{\theta}_2^S\}$ and rents for the marginal type $\underline{U}^S$, such that $U^1(\overline{\theta}_1^S) = U^2(\overline{\theta}_2^S) = \underline{U}^S \geq 0$, are jointly determined from the following system of equations,*

$$[\Phi^i(q_i^S(\overline{\theta}_i^S), \overline{\theta}_i^S) - \lambda \underline{U}^S] - \lambda \overline{\theta}_i^S q_{-i}^S(\overline{\theta}_{-i}^S) = 0, \text{ for } i = 1, 2, \text{ and} \tag{3.9}$$

$$\overline{\theta}_1^S + \overline{\theta}_2^S = 1. \tag{3.10}$$

*(iii) The rents and transfers for all firms can be recovered from the following*

$$U^i(\theta_i) = U^i(\overline{\theta}_i) + \int_{\theta_i}^{\overline{\theta}_i^S} q_i^S(s)ds, \text{ and} \tag{3.11a}$$

$$t_i^S(\theta_i) = U^i(\theta_i) + c^i(q_i^S(\theta_i), \theta_i). \tag{3.11b}$$

This function $q_i(\theta_i)$ is the point-wise maximum of the virtual surplus function, $\Phi$, which represents the local social surplus accounting for the cost of inducing incentive-compatibility, which is verified because $q_i(\theta_i)$ is decreasing in firm types: $\frac{d}{d\theta} q_i^S(\theta_i) = -(1+2\lambda) < 0$. Furthermore, at an interior solution, the marginal type is given by:

$$\overline{\theta}_1^S = \frac{1}{2} + \frac{1}{2} \frac{q_1^F(0)q_1^F(1) - q_2^F(0)q_2^F(1)}{(1+3\lambda)(q_1^F(0)+q_2^F(0)) - (1+2\lambda)^2}. \tag{3.12}$$

Some intuition regarding the marginal types: $q_1^F(0)q_1^F(1) - q_2^F(0)q_2^F(1)$ measures the relative difference in the productive capabilities of jurisdictions. The segment of firm types is $[0,1]$. Therefore, since the denominator in the second term is positive, $q_1^F(0)q_1^F(1) > q_2^F(0)q_2^F(1)$ implies that location 1 has greater capacity of generating surplus—and thus transfers—and attracts a larger set of firms.[11]

In the competition environment, the local governments' choice of marginal types conflict with one another; competition imposes upward pressure on the rents of the marginal firm and therefore on the information rents that are provided to more efficient firms to induce truthful revelation. Thus, since transfers are socially costly, a constitutional regime where local governments are not allowed to discriminate among firm types may have welfare-improving consequences, because although competition will still boost the rents of marginal firms, higher rents to more efficient ones will not be necessary.

Clearly, production is inefficient with respect to the full information solution because of the cost of providing information rents to the firms: $q_i^S(\theta_i) = q_i^F(\theta_i) - \lambda\theta_i$.

# 4 Uniform contracts

In the second regime, local social planners are constrained to using *uniform* contracts: they have to offer the same transfer and require the same output from all firm types.[12] Intuitively, the proposals to ban discretionary regimes are aimed at preventing local governments from distinguishing among firms. In our environment, the motivation is that in the restricted regime local governments are prevented from eliciting the productivity information. The goal of this constraint is to limit the rents that are granted to marginal types and therefore to more efficient types. If we considered only one principal, an analogous situation would be to subject a regulated monopoly to set uniform prices, as opposed to using second-degree price

[11] We can verify that $(1+3\lambda)(q_1^F(0)+q_2^F(0)) - (1+2\lambda)^2 = (2\lambda+1)\big[q_1^F(1)+q_2^F(1)+1\big] + \lambda\big[q_1^F(0)+q_2^F(0)\big]$, which is positive by assumption 2: $q_i^F(0),\, q_i^F(1) > 0$.

[12] Because the equilibrium sophisticated contracts $\{t_i(\theta), q_i(\theta)\}$ can be expressed as a fully nonlinear tariff, $\{T(q)\}$, by inverting the output function, $q_i(\theta)$, $T(q) \equiv t(\theta_i^{-1}(q))$, a less restrictive constraint would be to impose a linear tariff, $T(q) = A + Bq$. We did not explore this case.

discrimination. Boyer and Laffont (1999) also impose a similar constitutional constraint on the set of instruments available to a single regulator of a polluting monopolist. The uniform regime in that case is characterized by requiring a constant pollution abatement level from all the firm types.

Therefore, contracts offered by locations in uniform regime are of the form $\{t_i, q_i\}$. With uniform contracts, the next lemma shows that the individual rationality constraint binds only for the marginal type, as in the previous regime.

**Lemma 2** *Given the rival location's contract,* ***IR*** *in equation (3.2) binds only at the marginal type in location i,* $\overline{\theta}_i$*, and can be replaced by*

$$U^i(\overline{\theta}_i) \geq \max[U^{-i}(1-\overline{\theta}_i), 0].$$

## 4.1 Objective function

In the case of uniform contracts, local governments are not concerned with providing incentives to extract the firms' private information; that is, they do not face an incentive-compatibility constraint, and their problem can be reduced to choosing a required level of output, $q_i$. They continue to face, however, the endogenous individual rationality constraint. Using the analogous integral representation of $U^i(\theta_i)$, as in equation (3.3), we can also restate the local governments' problem using the virtual surplus function, defined previously. The problem of the local governments is now

$$\max_{q_i, \overline{\theta}_i} \varphi^i(q_i; \overline{\theta}_i), \tag{4.1}$$

where

$$\varphi^i(q_i; \overline{\theta}_i) \equiv \int_0^{\overline{\theta}_i} \{\Phi^i(q_i, \theta_i) - \lambda \max[U^{-i}(1-\overline{\theta}_i), 0]\} f^i(\theta_i) d\theta_i. \tag{4.2}$$

## 4.2 Equilibrium

Eliminating the transfers from the problem using the integral representation of the firms rents and optimizing only in terms of required output and marginal types, $\{q_i, \overline{\theta}_i\}$, the following result states that there also exists a unique Nash equilibrium. Again, we describe only the relevant interior case in which local governments compete.

**Proposition 2** *Under assumption 2, there is a Nash equilibrium in the competition game, with contracts* $\{t_i, q_i\}$ *for* $i = 1, 2$*, characterized as follows:*

*(i) Letting superscript $U$ stand for uniform contracts, the required output level can be obtained from the first order condition:*

$$\int_0^{\overline{\theta}_i^U} \Phi_q^i(q_i^U, \theta_i)d\theta_i = [\alpha_i - q_i^U - (1+\lambda)\delta_i]\overline{\theta}_i^U - [(1+\lambda)+\lambda]\frac{(\overline{\theta}_i^U)^2}{2} = 0. \tag{4.3}$$

*Although output is constant for all firm types, it helps to think of $q_i^U$ as a function of the marginal type, $\overline{\theta}_i^U$:*

$$q_i^U = \alpha_i - (1+\lambda)(\delta_i + \overline{\theta}_i^U) + \frac{1}{2}\overline{\theta}_i^U. \tag{4.4}$$

*(ii) Marginal types $\{\overline{\theta}_1^U, \overline{\theta}_2^U\}$ and rents for the marginal type $\underline{U}^U$, such that $U^1(\overline{\theta}_1^U) = U^2(\overline{\theta}_2^U) = \underline{U}^U \geq 0$, are jointly determined from the following system of equations*

$$\begin{aligned} [\Phi^i(q_i^U, \overline{\theta}_i^U) - \lambda \underline{U}^U] - \lambda\overline{\theta}_i^U q_{-i}^U &= 0 \text{ for } i = 1,2 & (4.5)\\ \overline{\theta}_1^U + \overline{\theta}_2^U &= 1. & (4.6)\end{aligned}$$

*(iii) The rents and transfers for all firms can be recovered from*

$$\begin{aligned} U^i(\theta_i) &= U^i(\overline{\theta}_i^U) + q_i^U \int_{\theta_i}^{\overline{\theta}_i^U} ds, \text{ and} & (4.7)\\ t_i^U &= U^i(\overline{\theta}_i^U) + c^i(q_i, \overline{\theta}_i^U). & (4.8)\end{aligned}$$

## 4.3 Output levels

As in the case of sophisticated incentives, the output level prescribed under uniform contracts is also a decreasing function, when expressed as function of the marginal firm type:

$$\frac{d}{d\overline{\theta}_i^U} q_i^U(\overline{\theta}_i^U) = -(1+\lambda) + \frac{1}{2} = -\frac{(1+2\lambda)}{2} < 0.$$

As it turns out, $q_i^U$ requires overproduction from the marginal type, $\overline{\theta}_i^U$, compared with the output required for the firm with cost type $\overline{\theta}_i^U$ under sophisticated contracts: $q_i^U(\overline{\theta}_i^U) = q_i^S(\overline{\theta}_i^U) + (\frac{1}{2}+\lambda)\overline{\theta}_i^U$. Clearly, however, because under uniform contracts all firms produce the same level, there will be some low-cost firms for which output under sophisticated contracts exceeds the uniform level, $q_1^S(\theta) > q_1^U$. The output level under uniform programs, also exceeds what be required under full information from a firm of type $\overline{\theta}_i^U$. In fact, the following ordering results:

**Proposition 3** *Required output levels for the firm with cost parameter equal to the marginal under the uniform regime are ordered as follows:*

$$q_i^U \equiv q_i^U(\overline{\theta}_i^U) > q_i^F(\overline{\theta}_i^U) > q_i^S(\overline{\theta}_i^U).$$

In other words, the distortions in output levels induced by imposing the uniform regime on competition among local governments are very severe. This is evident when comparing with the level prescribed under the discretionary regime or with the full information levels for the marginal type. As all firms under the non-discretionary regime produce the same level, the distortions are compounded by restricting all firms to produce identical output levels. Remarkably, despite the severity of the distortions induced by the uniform regime, there are welfare gains from imposing this regime, as we will show in the next section.

## 4.4 Comparing marginal types

To characterize the marginal type at an interior solution when local government compete we use the output levels found in the previous proposition $q_1^U(\overline{\theta}_1^U)$, $q_2^U(\overline{\theta}_2^U)$. We also let $\overline{\theta}_2^U = 1 - \overline{\theta}_1^U$, and we substitute these quantities in the first order conditions for each local government. We can verify that after some manipulations:

$$\overline{\theta}_1^U = \frac{1}{2} + \frac{1}{2}\frac{q_1^F(0)q_1^F(1) - q_2^F(0)q_2^F(1)}{(1+3\lambda)(q_1^F(0) + q_2^F(0)) - \frac{3}{4}(1+2\lambda)^2}. \tag{4.9}$$

The same intuition discussed for the marginal type under sophisticated contracts applies here. The numerator in the second term of the above expression, $q_1^F(0)q_1^F(1) - q_2^F(0)q_2^F(1)$, represents the difference in productive capabilities between locations. Notice that for a situation in which $q_1^F(0)q_1^F(1) - q_2^F(0)q_2^F(1) > 0$, it follows that $\overline{\theta}_1^S > \overline{\theta}_1^U$, as the denominator in the second term is also positive, and therefore:

**Proposition 4** *The use of discretionary incentives allows the more productive location to attract a larger segment of firms than in the case of competition with non-discretionary instruments,* $\overline{\theta}_1^S > \overline{\theta}_1^U$.

The reason is that local social planners in the sophisticated regime can tailor incentives in a more efficient manner: requiring more production from lower-cost firms. Clearly this result only applies for asymmetric locations. If locations are identical, then obviously $\overline{\theta}_1^S = \overline{\theta}_1^U = \frac{1}{2}$.

# 5 Differences in welfare

We identify next the conditions that in our framework call for different kinds of incentive policy regimes, from the perspective of a utilitarian overarching authority, such as a supranational federation, whose social preferences are given by the aggregate version of the social preferences of the local governments.

When we examine competition between locations with identical productive capabilities, we find that the uniform regime unambiguously improves aggregate welfare relative to the discretionary regime, because it reduces the rents that are granted to firms in the equilibrium.

When we examine competition between heterogeneous locations, we find that the gains from imposing a ban on discretionary incentives depend on the extent of the asymmetry between locations. Namely, the advantages of the uniform regime are a concave function on the extent of asymmetry. Intuitively, the welfare gains are positive and maximal if locations are identical, but if locations differ in productive capabilities, although there is social waste because of information rents in the discretionary regime, the constant structure of production in the uniform regime may prevent society from acquiring more of the surplus it is capable of generating, and the gains from restricting the use of discretionary incentives diminish.

To evaluate the welfare properties of each regime, we substitute the equilibrium outcomes under each type of incentives in the welfare criterion of equation 2.6, we described earlier.

## 5.1 Identical locations

We will see that when locations are symmetric and have identical productive capabilities, $\alpha_1 = \alpha_2$ and $\delta_1 = \delta_2$, the expression for the difference in welfare depends only on the local social cost of public funds $\lambda$. Intuitively, at an equilibrium with identical locations, local governments split evenly the set of firms, and marginal types are $\overline{\theta}_1^S = \overline{\theta}_1^U = \frac{1}{2}$. Similarly, as we saw earlier, the non-discretionary regime requires overproduction for the marginal type relative to the level required for the marginal type in the discretionary regime, and the differences in production levels for the marginal types depend only on $\lambda$ :

$$
\begin{aligned}
q_1^S(\frac{1}{2}) &= \alpha - (1+\lambda)(\delta + \frac{1}{2}) - (\lambda)\frac{1}{2} \\
q_1^U(\frac{1}{2}) &= \alpha - (1+\lambda)(\delta + \frac{1}{2}) + (\frac{1}{2})\frac{1}{2},
\end{aligned} \tag{5.1}
$$

and therefore

$$
q_1^U(\frac{1}{2}) - q_1^S(\frac{1}{2}) = \frac{1}{2}(\frac{1}{2} + \lambda) > 0. \tag{5.2}
$$

Again, since under the uniform regime all firms produce the same level, there will be some low cost firms for which $q_1^S(\theta) > q_1^U$.

We now state our main result.

**Proposition 5** *Switching from a discretionary regime to using uniform incentives programs is welfare improving. Letting $W^U = W_1^U + W_2^U$ and $W^S = W_1^S + W_2^S$, we have*

$$dW = W^U - W^S = \frac{2(1+2\lambda)(8\lambda+1)}{96} > 0. \tag{5.3}$$

Notice that the gains from banning discretionary regimes are positive, even if the social cost of public funds, $\lambda$, were zero. Intuitively, the combination of the intensity of competition driving up the rents for the marginal type $\underline{U}$, compounded with the need to provide information rents to induce firms' self-selection in the discretionary regime, results in excessive distortions that warrant restricting the use of discretionary incentives.

The horizontal structure of the firm types implies that the intensity of competition can be reduced to one parameter: the rents of the marginal type, $\underline{U}$. It turns out that with identical locations, we can also sign the expression for the difference in information rents for the marginal type unambiguously.

**Proposition 6** *Competitive pressures in the discretionary regime increase rents for the marginal type $\underline{U}^S$ above the rents provided in the uniform regime, $\underline{U}^U$:*

$$dU = \underline{U}^U - \underline{U}^S = -\frac{1}{32}\frac{(2\lambda+1)(6\lambda+1)}{\lambda} < 0. \tag{5.4}$$

## 5.2 Heterogeneous locations

The question in this situation is whether constitutional bans on discretionary incentives, aimed at reducing the distortions from competition under private information, are justified when locations differ, either in terms of local market size (as represented by the parameter $\alpha$), of in terms of technological advantages that may impact productivity (as represented by the parameter $\delta$).

When we examine differences across locations we obtain the following result.

**Proposition 7** *Letting $\alpha_1 = \phi\alpha_2$ and $\delta_1 = \eta\delta_2$, then the welfare gain implied by the uniform regime is a concave function of the extent of asymmetry between locations. Furthermore, the welfare gain reaches a local maximum when locations are identical. That is,*
*(i) for $\phi$ close to 1, $\frac{\partial(dW)}{\partial\phi} = 0$, and $\frac{\partial^2(dW)}{\partial\phi^2} < 0$;*
*(ii) for $\eta$ close to 1, $\frac{\partial(dW)}{\partial\eta} = 0$, and $\frac{\partial^2(dW)}{\partial\eta^2} < 0$.*

Resorting to a system of uniform contracts generates welfare gains because it reduces the distortions induced by competitive pressures on the rents of the marginal types. A regime of coarser instruments thus reduces one important source of distortions at the cost of interfering with other margins, namely output choices.

The concavity result implies that the potential welfare-improving properties of constitutional bans on incentive programs are limited if asymmetries between locations are important. For example if $\alpha_1 > \alpha_2$ or $\delta_1 < \delta_2$, attempting to attenuate one unfavorable aspect of competition—socially costly rents for more productive firms—may have limited effects if it prevents the more productive location from attracting those types which would be more efficient in it, since, in that case, more firms would choose the first location under discretionary incentives: $\overline{\theta}_1^S > \overline{\theta}_1^U$.[13]

In other words, intervention by an overarching authority restricting the rules of competition among independent states may have limited effects (or not be warranted) if the rival states are too dissimilar in terms of, for example, local market size or productivity-relevant amenities (such as geophysical features or underlying institutions that affect the cost of doing business). If rival locations are very similar along these dimensions, however, imposing constitutional bans on incentive programs will have welfare-improving merits whenever private information and locational attachment are important.

# 6 Conclusion

In this paper we develop a model of competition among local governments for mobile firms in an environment where the firms exhibit private information and locational attachment, and we study the welfare consequences of imposing constitutional bans that determine alternative regimes of competition.

We show that private information represents an important source of distortions that, to the best of our knowledge, has not been previously analyzed in a comparison of alternative competition regimes.

Local governments are concerned with attracting firms to generate local surplus. Firms have private information on their degree mobility (representing home bias or the degree of complementarity of their technology with the location's specific amenities) and under a regime with discretionary incentives, local governments have to provide information rents, which are socially costly.

We summarize the extent of the distortions resulting from the competition process with

[13]Numerical simulations indicate that, for some parameter configurations with heterogeneous locations, it is possible to find $dW < 0$, so that the discretionary regime with sophisticated programs might be superior.

the rents that are provided to the marginal firm in equilibrium. These rents are positive in equilibrium, and represent another important source of distortions. Given a horizontal structure of firms' attachment to locations, the intermediate marginal firm types are among the least efficient for each location and would receive zero rents if the rival locations colluded.

For identical locations, we find that competition under non-discretionary incentives improves welfare unambiguously with respect to the regime with discretionary incentives, because the system of coarser instruments eliminates the need to provide information rents that are granted to the firms in the discretionary regime to induce truthful revelation.

When locations are heterogeneous (in market size or technological advantages), we find that the welfare gains of resorting to constitutional constraints on the choice of instruments are concave in the extent of the asymmetry between locations. For very similar locations, the non-discretionary regime is superior. For sufficiently different locations, however, the welfare gains of banning discretionary incentives may be reduced because the system of competition with discretionary instruments allows local governments to attract a larger number of firms that are more productive in that location and generate a larger local surplus.

In our model, the basic inefficiency under the regime with discretionary instruments is given by the costly rents that are provided to firms in equilibrium. This inefficiency is the result of private information. Intuitively, these inefficiencies would be reduced if the number of competing locations were to increase, since the variability of firm types attached to each location would decline because the segment of firms attached to each location would shrink. Therefore, the gains from resorting to the non-discretionary system would also decrease. Similarly, increasing the number of firms in the economy in our model is akin to reducing the degree of mobility, and in the extreme, there would be no reason for imposing constraints, as firms would be essentially immobile and there would be no competition between governments. In that case, any regime of incentives other than the fully discretionary ones, would reduce local social welfare unambiguously.

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# A Proofs and other derivations

**Proof of Lemma 1.** In the typical principal-agent problem with only one principal, **IR** would be $U(\theta) \geq U_0 \equiv 0$ for all $\theta$, and the marginal type $\overline{\theta}$ would be a choice variable determined by setting $U(\overline{\theta}) = 0$ because transfers are costly. In the typical problem, the proof that **IC** is equivalent to conditions (i)-(ii) is standard, and (i) then guarantees that $U(\theta)$ is strictly decreasing in $\theta$, so that **IR** binds only for the marginal type $\overline{\theta}$. In the case of competition between two principals, taking the marginal types as given, the equivalence of **IC** and (i)-(ii) follows again from standard techniques, and (i) then implies that $U^i(\theta_i)$ is strictly decreasing in $\theta_i$, whereas $U^{-i}(\Delta - \theta_i)$ is strictly increasing in $\theta_i$, and thus **IR** binds only for the marginal type $\overline{\theta}_i$, which is determined in equilibrium. ■

**Remark 1 (Derivation of the virtual surplus $\Phi$)** *We take the objective function in equation (2.4):*

$$\max_{q_i,t_i} \int_0^{\overline{\theta}_i} \left\{ [S^i(q_i(\theta_i)) - (1+\lambda)t_i(\theta_i)] + U^i(\theta_i) \right\} d\theta_i,$$

*and we use the integral form of $U^i$ from **IC**(i) in equation (3.3) to substitute transfers $t_i$ out of the problem:*

$$t_i(\theta_i) = U^i(\overline{\theta}_i) + \int_{\theta_i}^{\overline{\theta}_i} q_i(s)ds + c^i(q_i(\theta_i), \theta_i).$$

*The objective function is now:*

$$\max_{q_i,\overline{\theta}_i} \int_0^{\overline{\theta}_i} \left\{ S^i(q_i(\theta_i)) - (1+\lambda)c^i(q_i(\theta_i), \theta_i) - \lambda \int_{\theta_i}^{\overline{\theta}_i} q_i(s)ds - \lambda \max\{U^{-i}(1-\overline{\theta}_i), 0\} \right\} d\theta_i,$$

*where we have used that **IR** in equation (3.5) binds for the marginal type $\overline{\theta}_i$. After integration by parts, we have:*

$$\max_{q_i,\overline{\theta}_i} \int_0^{\overline{\theta}_i} \left\{ S^i(q_i(\theta_i)) - (1+\lambda)c^i(q_i(\theta_i), \theta_i) - \lambda q_i(\theta_i)\theta_i - \lambda \max\{U^{-i}(1-\overline{\theta}_i), 0\} \right\} d\theta_i.$$

**Proof of Proposition 1.** Suppose that each location attracts types $\theta_i \le \overline{\theta}_i$. In the optimization problem in (3.6), the unique point-wise maximum of $\Phi^i$ is given by $\Phi^i_q = 0$; $\Phi^i_{q\theta} < 0$ implies that the solution $q_i$ is non-increasing in $\theta_i$, and therefore the program $\{t_i(\theta_i), q_i(\theta_i)\}$ is **IC** for types $\theta_i \le \overline{\theta}_i$.

Because of the structure of horizontal attachment of firms to locations in terms of costs, it is not necessarily true that local governments wish to attract *all* types of firms, and thus the marginal type is a choice variable. We focus on the case in which locations compete for intermediate types, and the individual rationality constraints in the problem of each local government depend upon the policies offered by the other location as in equation (3.5). We have seen before that **IC** implies that **IR** will bind only for the marginal type, and in this case we have that the type region will be split between locations, i.e., the set of firms in $[0, \overline{\theta}_1]$ will choose location 1, and those in $[\overline{\theta}_1, 1]$ will join location 2. The relevant reservation value is now $U^1(\overline{\theta}_1) = U^2(\overline{\theta}_2) = \underline{U} \geq U_0 \equiv 0$, and is determined endogenously, as is $\overline{\theta}_1$.

We subtract the conditions in equation (3.9) for $i = 1, 2$, substitute $\theta_2 = 1 - \theta_1$, and define:

$$\xi(\theta_1) \equiv \Phi^1(q_1(\theta_1), \theta_1) - \lambda\theta_1 q_2(\Delta - \theta_1) - \Phi^2(q_2(1-\theta_1), 1-\theta_1) + \lambda(1-\theta_1)q_1(\theta_1).$$

Simplifying, we obtain:

$$\begin{aligned}\xi(\theta_1) \equiv\ & \{[S^1(q_1(\theta_1)) - (1+\lambda)c^1(q_1(\theta_1), \theta_1)] - [S^2(q_2(1-\theta_1)) - (1+\lambda)c^2(q_2(1-\theta_1), 1-\theta_1)]\} \\ & -\lambda\left\{\theta_1 - (1-\theta_1)\right\}\left\{q_1(\theta_1) + q_2(1-\theta_1)\right\}.\end{aligned}$$

From assumption 2, we have:

$$\begin{aligned}\xi(0) \equiv\ & \{[S^1(q_1(0)) - (1+\lambda)c^1(q_1(0), 0)] - [S^2(q_2(1)) - (1+\lambda)c^2(q_2(1), 1)]\} \\ & +\lambda\left\{q_1(0) + q_2(1)\right\} > 0. \\ \xi(1) \equiv\ & \{[S^1(q_1(1)) - (1+\lambda)c^1(q_1(1), 1)] - [S^2(q_2(0)) - (1+\lambda)c^2(q_2(0), 0)]\} \\ & -\lambda\left\{(q_1(1) + q_2(0)\right\} < 0.\end{aligned}$$

With these conditions in hand, we can guarantee that the Nash equilibrium exists since $\xi$ is continuous. Uniqueness follows as long as $\xi$ is *strictly* decreasing in $\theta_1$. The expression for $\xi'$ is given by

$$\xi' = \Phi^1_\theta + \Phi^1_q q_1' + \Phi^2_\theta + \Phi^2_q q_2' - \lambda q_2 - \lambda q_1 + \lambda\theta_1 q_2' + \lambda(1-\theta 1)q_1'.$$

Since $\Phi^i_\theta < 0$, $\Phi^i_q = 0$, and $q_i' < 0$, we have $\xi' < 0$, and $\overline{\theta}_1$ is defined by the unique solution to $\xi(\overline{\theta}_1) = 0$. ■

**Proof of Lemma 2.** With uniform contracts we have $U^i(\theta_i) = t_i - c^i(q_i, \theta_i)$, thus $U^i(\theta_i)$ is strictly decreasing in $\theta_i$ and $U^{-i}(1-\theta_i)$ is strictly increasing in $\theta_i$; the result then follows. ■

**Proof of Proposition 2.** Suppose that the marginal types are $\overline{\theta}_i$, then the problem for government $i$ is given by:

$$\max_{q_i, t_i} \int_0^{\overline{\theta}_i} \left[\{S^i(q_i) - (1+\lambda)t_i\} + U^i(\theta_i)\right] d\theta_i$$

subject to the individual rationality constraint. Now, substituting $t_i$ out of the problem and after integration by parts we can express the problem as:

$$\max_{q_i} \varphi^i(q_i; \overline{\theta}_i),$$

where, $\varphi^i(q_i;\overline{\theta}_i) \equiv \int_0^{\overline{\theta}_i}\{\Phi^i(q_i,\theta_i) - \lambda \max[U^{-i}(1-\overline{\theta}_i),0]\}d\theta_i$.

The first and second order conditions for $q_i$, are respectively:

$$\begin{aligned}
\varphi_q^i(q_i;\overline{\theta}_i) &= \int_0^{\overline{\theta}_i} \Phi_q^i(q_i,\theta_i)d\theta_i = 0 \\
\varphi_{qq}^i(q_i;\overline{\theta}_i) &= \int_0^{\overline{\theta}_i} \Phi_{qq}^i(q_i,\theta_i)d\theta_i < 0.
\end{aligned}$$

We notice that because $\Phi_{qq}^i < 0$ it follows that $\varphi_{qq}^i(q_i;\overline{\theta}_i) < 0$.

In order to check that the marginal types are chosen optimally, we focus on the case of competition and $\{q_1, q_2, \overline{\theta}_1, \overline{\theta}_2, \underline{U}\}$ are jointly determined as the solution to:

$$\begin{aligned}
\int_0^{\overline{\theta}_i} \Phi_q^i(q_i,\theta_i)d\theta_i = 0 \text{ for } i = 1,2 \\
[\Phi^i(q_i,\overline{\theta}_i) - \lambda\underline{U}] - \lambda\overline{\theta}_i q_{-i} = 0 \text{ for } i = 1,2 \\
\overline{\theta}_1 + \overline{\theta}_2 = 1.
\end{aligned}$$

In order to establish existence and uniqueness of the equilibrium, notice that from $\varphi_q^i = 0$, we can uniquely define $q_i$ as a function of $\overline{\theta}_i$, $\widehat{q}_i(\overline{\theta}_i)$, then we substitute in the first order condition for each location $i$, subtract, and replace $\overline{\theta}_2 = 1 - \overline{\theta}_1$ to form the expression:

$$\xi(\overline{\theta}_1) \equiv [\Phi^1(\widehat{q}_1(\overline{\theta}_1),\overline{\theta}_1) - \Phi^1(\widehat{q}_2(1-\overline{\theta}_1), 1-\overline{\theta}_1)] - \lambda\overline{\theta}_1\widehat{q}_2(1-\overline{\theta}_1) + \lambda(1-\overline{\theta}_1)\widehat{q}_1(\overline{\theta}_1).$$

We have to check that $\breve{\theta}$, such that $\xi(\breve{\theta}) = 0$, exists and is uniquely defined.

Existence of $\breve{\theta}$ is guaranteed since $\xi$ is continuous and we can verify that $\xi(0) > 0$, and $\xi(1) < 0$, from assumption 2. As in the proof of Proposition 1, uniqueness follows from $\xi' < 0$. The expression for $\xi'$ is given by

$$\xi' = \Phi_\theta^1 + \Phi_q^1\widehat{q}_1' + \Phi_\theta^2 + \Phi_q^2\widehat{q}_2' - \lambda\widehat{q}_2 - \lambda\widehat{q}_1 + \lambda\overline{\theta}_1\widehat{q}_2' + \lambda(1-\overline{\theta}_1)\widehat{q}_1',$$

After substitutions, it is easy to see that

$$\xi' = -\left[(3\lambda+1)(q_1^F(0) + q_2^F(0)) - \frac{3}{4}(2\lambda+1)^2\right] < 0,$$

as the term in brackets is positive, as shown in footnote 11; thus the equilibrium is unique. ■

# B Expressions for rents of marginal type and welfare

Algebraic manipulation of the first order conditions allows us to express the rents of the marginal type in terms of output requirements and the expression for the marginal type derived in equations (3.8) and (3.12). In order to obtain the expression for welfare in location 2, we also use $\overline{\theta}_2 = 1 - \overline{\theta}_1$.

## B.1 Sophisticated contracts

Substituting in the first order condition of either location, we have the following expression for the rents for the marginal type

$$\begin{aligned}
\underline{U}^S &= \frac{\Phi^1(q_1^S(\overline{\theta}_1^S))}{\lambda} - \overline{\theta}_1 q_2^S(1 - \overline{\theta}_1^S) \\
&= \frac{[q_1^S(\overline{\theta}_1^S)]^2}{2\lambda} - \overline{\theta}_1 q_2^S(1 - \overline{\theta}_1^S) \\
&= \frac{[q_2^S(1 - \overline{\theta}_1^S)]^2}{2\lambda} - (1 - \overline{\theta}_1^S) q_1^S(\overline{\theta}_1^S).
\end{aligned}$$

Similarly, manipulating the expression for welfare in location 1, we obtain

$$\begin{aligned}
W_1^S &= \int_0^{\overline{\theta}_1^S} \left\{ S^1(q_1^S(\theta_1)) - (1+\lambda)t_1^S(\theta_1) + U^1(\theta_1) \right\} d\theta_1 \\
&= \int_0^{\overline{\theta}_1^S} \left\{ \frac{[q_1^S(\theta_1)]^2}{2} - \lambda \underline{U}^S \right\} d\theta_1 \\
&= \left\{ \frac{[q_1^S(0)]^3 - [q_1^S(\overline{\theta}_1)]^3}{6(1+2\lambda)} - \lambda \overline{\theta}_1^S \underline{U}^S \right\}.
\end{aligned}$$

## B.2 Uniform contracts

In this case, we can also substitute in the first order conditions of either location and obtain the rents for the marginal type:

$$\begin{aligned}
\underline{U}^U &= \frac{1}{\lambda}\Phi^1(q_1^U, \overline{\theta}_1^U) - \overline{\theta}_1^U q_2^U \\
&= \frac{1}{\lambda} q_1^U \left[ \frac{1}{2} q_1^U - \overline{\theta}_1^U (\lambda + \frac{1}{2}) \right] - \overline{\theta}_1^U q_2^U \\
&= \frac{1}{\lambda} q_2^U \left[ \frac{1}{2} q_2^U - (1 - \overline{\theta}_1^U)(\lambda + \frac{1}{2}) \right] - (1 - \overline{\theta}_1^U) q_1^U.
\end{aligned}$$

Similar simplifications yield the following expression for welfare in location 1,

$$\begin{aligned} W_1^U &= \int_0^{\bar{\theta}_1^U} \left\{ S^1(q_1^U) - (1+\lambda)t_1(\theta_1) + U^1(\theta_1) \right\} d\theta_1 \\ &= \int_0^{\bar{\theta}_1^U} \left\{ \frac{[q_1^U]^2}{2} + (\overline{\theta}_1^U - \theta_1)q_1^U - \frac{1}{2}\overline{\theta}_1^U q_1^U - \lambda \underline{U}^U \right\} d\theta_1 \\ &= \left\{ \frac{[q_1^U]^2}{2}\overline{\theta}_1^U - \lambda\overline{\theta}_1^U \underline{U}^U \right\}. \end{aligned}$$

## B.3 Differences in welfare for heterogenous location

**Sketch of Proof of Proposition 7.** Assumption 2 implies

$$\max_q S^i(q) - (1+\lambda)c^i(q,1) > 0 \ \forall i,$$

which is equivalent to

$$\lambda < \lambda^* \equiv \min_i \{ \frac{\alpha_i - (1+\delta_i)}{(1+\delta_i)} \}.$$

We can then express $\lambda = \pi\lambda^*$, where $\pi \in (0,1)$ parameterizes the range $\lambda \in (0, \lambda^*)$, and substitute in the expression for $dW$. When we obtain the corresponding derivatives with respect to either $\phi$ or $\eta$, we then evaluate the expression at either $\phi = 1$ or $\eta = 1$. Factorization in terms of $\lambda^*$ leaves polynomials in $\pi$, which can be easily signed. ■