# Tax differentials and agglomeration economies in intraregional firm location

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ABSTRACT: This paper analyzes empirically how differences in local taxes affect the intraregional location of new manufacturing plants. These effects are explored within the random profit maximization framework while accounting for the presence of different types of agglomeration economies (localization/ urbanization/ Jacobs' economies) at the municipal level. We look at the location decision among more than 400 municipalities of more than 10,000 establishments in the period 1996-2003. Controlling for agglomeration economies and restricting the choice set to the local labor market becomes crucial to identify the effects of taxes on the location of new establishments.

*Key words*: local taxes, agglomeration economies, firm location.

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**1.-Introduction.**

The effect of taxation on the location of economic activities is a topic that has interested scholars, politicians and policy makers alike. Knowing how much do firms respond to tax differentials is an issue of major concern for tax setting governments. In particular, governments may want to foresee the outflow of firms following a tax increase in order to asses, correctly, how tax revenues are affected by tax rate changes. Since the inflow of firms received by other jurisdictions is not taken into account by the tax setting government, a positive externality arises resulting in tax rates which are lower than those efficiency goals would dictate, yielding an under provision of local public goods (Zodrow and Mierzkowski, 1986). Hence, how sensitive firms are to taxes also carries along welfare implications.

Although the first attempts to empirically quantify the role of taxes on the location of economic activities date back to some decades ago the question is far to be solved. The studies carried out during the sixties and the seventies, mainly for the U.S. case, had come to the conclusion that regional and local tax bills did not play any relevant role in the firm location problem. It was argued that these taxes were too small and hence, tax differentials were offset by other location factors. Yet, during the eighties some studies, again based on the U.S. case, succeeded at finding a significant role played by taxes on the location of economic activities[1]. This type of analysis has not flourished in the European context to a comparable extent. For Spain, the only published piece of work we are aware of is the paper by Solé-Ollé and Viladecans-Marsal (2003). In their study, these authors focus on local employment growth within the metropolitan area of Barcelona, finding and elasticity around -0.5 for both the local business and the property tax rates, the main local taxes in Spain.

To tackle empirically how taxes do weight in the location decision of firms is a difficult question given the variety of factors that underlie this particular decision. Moreover, there are good reasons to think that governments may choose their tax rates by looking at the same local attributes that firms take into consideration at the time to locate. Hence, this opens the possibility of obtaining biased estimates of the taxes' effects.

[1] This literature is reviewed in Bartik (1991a) and Herzog and Schlottmann (1991).

The tax competition literature has looked at how governments should set their tax rates if they are to maximize welfare while taking into account strategic behaviours of governments and the mobility of tax bases[2]. Two related arguments that stand out from this literature are worth considering when adapted to the municipal level. In the first place, larger municipalities should set higher tax rates all else being equal. When a large municipality raises its tax rate, the outflow of firms induced by this change may drive up the rents of buildings elsewhere in its surroundings. In contrast, this last effect may be negligible if it is a small jurisdiction the one that is raising taxes since the amount of firms moving out will be a phenomenon of a very limited size (Hoyt, 1992). This implies that large jurisdictions face a less severe outflow of firms in relative terms setting tax rates which are higher than those chosen by smaller jurisdictions. In the second place, those jurisdictions that are well endowed with attributes which are valued by firms will set higher tax rates, ceteris paribus. In order to gain access to these attributes firms will be willing to pay a higher tax bill. This allows governments to tax the "agglomeration rent" without experiencing a significant loss in its tax base (Ludema and Wooton, 2000).

Given that large urban agglomerations are also preferred locations by firms, the two arguments predict that large municipalities enjoying factors attracting firms will tend to set higher taxes than small municipalities lacking elements that firms value. This implies that there may be a positive correlation between tax rates and agglomeration economies. Hence, unless one is able to measure the attributes which firms put a value on appropriately, the estimates obtained may underestimate the effects of taxes on the location of economic activities. Fortunately enough, there is a broad literature that has focused its attention on the determinants of the location of economic activity. This literature has made clear which the determinants in terms of location are although no consensus has been reached regarding the relative importance of these factors (Guimares *et al.* 2004). At the intraregional level, the list of relevant determinants is formed by the wage and land rent levels, taxes, transportation facilities, the local business climate and agglomeration economies.

[2] See Wilson (1999) for an early review of this literature.

When reviewing the role played by taxes on the location of economic activity, Bartik (1991a) points out that empirical studies tend to come to different conclusions depending on whether the analysis are focused at the intrametropolitan or the intermetropolitan level. If the first class of studies has tended to find that tax increases discourage firms to move in, the studies analyzing the intermetropolitan location of firms have failed to produce a stylized result regarding how taxes affect location. This may not be independent of the difficulties these studies are faced with at trying to measure interregional variation in important location factors such as wage levels, business climate or transportation facilities. By looking at the location of economic activities among nearby municipalities, we do away with this problem since these variables can be assumed to show little variation between neighboring locations. Between very close municipalities, location decisions are assumed to be driven by differences in buildings rents, taxes and agglomeration economies. The Spanish municipal level is an especially adequate setting to study the effects of taxes on the location of economic activities in the presence of agglomeration economies. This is due to the fact that there is a close equivalence between the size of the tax setting jurisdiction and the scope of agglomeration economies, whose effects seem to die out at very short distances (Rosenthal and Strange, 2003; and Duranton and Overman, 2005)[3].

Most studies concerning the role of taxes on the location of economic activities have looked at either employment levels or employment growth. However, as pointed out by Bartik (1991b), it may be preferable to study a particular location decision to model employment levels or changes. By looking at a particular decision rather than modelling the aggregate result of creation, closure, expansion and contraction of plants processes, it is possible to impose more structure to the analysis yielding more precise estimates of the effects of interest. In the spirit of Erickson and Wasylenko (1980), Carlton (1983), Charney (1983) and Bartik (1985) or a series of more recent papers by Guimaraes and coauthors, 2000, 2002 and 2004, we look at the location of new and relocating establishments. This empirical strategy presents at least two advantages. First, Schmenner's (1982) study reveals that managers first decide whether to start-up a new establishment or not and then choose the location that best suits their needs. This allows us to focus on the locating decision of firms abstracting from any consideration with

[3] Spanish municipalities are rather small. In 2000, their average size in terms of urban area was 1,13 $Km^2$.

regards to the process driving the decision to start-up an establishment. Second, it enables the researcher to consider the explanatory variables as pre-determined avoiding endogeneity considerations of the regressors (Rosenthal and Strange, 2003). In this paper we focus on manufactures. Looking at the location of manufacturing firms has the additional advantage that demand remains unchanged within the region given that manufactured outputs are targeted at national or supranational markets (Erickson and Wasylenko, 1980; and Charney, 1983). Hence, this enables us to abstract from any local demand consideration that may affect the location decision of firms.

This paper is organized in the following manner. After this introduction, in section 2 we present a model that sets up the problem of the firm location in the spirit of Carlton (1983). Then, an empirical application follows. First, we describe the dataset and variables in section 3.1. After, we introduce and explain the econometric specification in Section 3.2. In Section 3.3, we discuss the results obtained to finally end with a section summarizing the main conclusions of this paper (Section 4).

## 2-The Model.

The aim of a competitive firm that belongs to industry *s* is to choose simultaneously a location and the level of inputs that yield the highest level of profits. There are *J* jurisdictions each firm can choose to locate in and, conditional on locating in *j,* the problem of the firm *i* is to choose the level of machinery (*K*), labor (*L*) and buildings (*N*) that maximize the following profit function:

$$\overline{P}\cdot Y-w_l\cdot L-\overline{r}\cdot K-R_j\cdot N-T_j^{prop}(N)-T_{sj}^{bus}(L,K,N) \qquad [1]$$

The price of manufactures ( $\overline{P}$ ) are supposed to be common for all firms in the region. The prices of the three inputs used by firms are expected to vary at different geographic levels due to different degrees of mobility. The rental price of machinery ( $\overline{r}$ ) is assumed to show no variation within the region. Wages are assumed to vary by local labor markets ($w_l$), whereas the rent of industrial buildings ($R_j$) may differ from one location to another. The local tax system consists of a business tax ( $T_{sj}^{bus}$ ) and a property tax ($T_j^{prop}$). $Y$ denotes output which is assumed to be obtained by the following decreasing returns to scale homogeneous production function of the Cobb-Douglass form:

$$Y_{ij} = A_{sj} \cdot (L^{\alpha_1} \cdot K^{\alpha_2} \cdot N^{\alpha_3}) \cdot \exp(\mu_i) \cdot (\exp(\varepsilon_{ij}))^{\delta} \qquad [2]$$

where $k \equiv \alpha_1 + \alpha_2 + \alpha_3 < 1$ denotes the returns to scale of the production function; $A_{sj}$ is a hicks neutral productivity shifter capturing the agglomeration economies of site *j* for firms whose activity falls into industry *s*; $\mu_i$ pins down the managerial ability of the firm in the terms defined in Mundlak (1978); $\varepsilon_{ij}$ stands for an identically and independently distributed (*iid*) zero mean Weibull random variable that changes over firms and locations; and $\delta$ is a positive constant.

The simultaneous problem of choosing a location and the optimal level of inputs can be reduced through the restricted profit function into one in which firms choose the location where the level of profits is the highest when inputs are chosen optimally. This is equivalent to choose the location where the log of the restricted profit function, scaled by $(1-k)/\delta$, takes its highest value:

$$\begin{aligned} \ln \Pi_{isj} \cdot (1-k)/\delta \equiv \pi_{isj} = \varphi_0 + 1/\delta \cdot \ln \overline{P} + 1/\delta \cdot \ln A_{sj} \\ + \alpha_1/\delta \cdot \ln(w_l + t_{sj}^{bus,L}) + \alpha_2/\delta \cdot \ln(\bar{r} + t_{sj}^{bus,K}) + \alpha_3/\delta \cdot \ln(R_j + t_{sj}^{bus,N} + t_j^{prop}) \\ + 1/\delta \cdot \mu_i + \varepsilon_{ij} \end{aligned} \qquad [3]$$

where $\Pi$ is the restricted profit functions and $\varphi_0$ stands for a constant term. $t_{sj}^{bus,L} \equiv dT^{bus}/dL$ denotes the increase in the business tax liability that follows an increase in the hired level of labor for a firm found in location *j* of the $s^{th}$ industry (the same applies for *N* and *K*). Analogously, $t_j^{prop}$ accounts for how the property tax bill increases in municipality *j* when a firm increases the usage of buildings in one unit. To accommodate expression [3] into the conditional logit framework the following normalizations are done. Notice that the units of capital can be set in such a way that its price is unity (i.e., $\bar{r} = 1$). Given that $\ln(1+\lambda) \approx \lambda$ for low values of $\lambda$, it has to be the case that for low values of tax rates ($t$), as it happens to be the case here, $\ln(\bar{r}+t_j^{bus,K})$ approaches $t_j^{bus,K}$ if $K$ is set at the appropriate scale. We assume that within a region, wages do show variation but within bounds. Hence, by choosing the appropriate scale for the units of labor, the wage can be redefined as one plus a wage premium ($w_l = 1+\tilde{w}_l$). The same reasoning can be applied to the rents of buildings ($R_j = 1+\tilde{R}_j$). After these normalizations, expression [3] turns out to be:

$$\begin{aligned}\pi_{isj} &= \varphi_1 + 1/\delta \cdot \ln \bar{P} + 1/\delta \cdot \ln A_{sj} \\ &+ \alpha_1/\delta \cdot t_{sj}^{bus,L} + \alpha_2/\delta \cdot t_{sj}^{bus,K} + \alpha_3/\delta \cdot t_{sj}^{bus,N} + \alpha_3/\delta \cdot t_j^{prop} \\ &+ \alpha_2/\delta \cdot w_l + \alpha_3/\delta \cdot R_j + 1/\delta \cdot \mu_i + \varepsilon_{ij}\end{aligned} \quad [4]$$

where $\varphi_1 = \varphi_0 - 2$[4]. Expression [4] is a conditional logit model whose parameters can be estimated, up to a $1/\delta$ scale, by maximum likelihood. As Bartik (1985) points out, it makes sense that the estimates are up to some scale given that doubling the profits at all sites leaves the selection probabilities unchanged. McFadden (1974) shows that given the assumption put on $\varepsilon_{ij}$, the probability that firm *i* locates in *j* is given by:

$$p_{ij} = \frac{\exp(\pi_{isj} - \varepsilon_{isj})}{\sum_j \exp(\pi_{isj} - \varepsilon_{isj})} \quad [5]$$

where the variables that do not show variation across locations (i.e. $\varphi_1, \bar{P}, \mu_i$) drop out of the analysis.

## 3.-Empirical exercise

### 3.1.-Data and variables.

The empirical analysis is carried out using a rich dataset containing information on the new and relocating manufacturing establishments settling down in Catalonia, a Spanish

[4] In the empirical analysis we will not be able to identify the effects of $\alpha_1/\delta \cdot t_{sj}^{bus,L}$ from the ones of $\alpha_2/\delta \cdot t_{sj}^{bus,K}$ or $\alpha_3/\delta \cdot t_{sj}^{bus,N}$. Instead, we will be able to estimate an aggregate business tax rate effect. This is explained in detail in Setion 3.1.

region, between 1996 and 2003[5]. This dataset, the Industrial Establishments Registry, contains information on the establishments created including employment, location and activity (2 digit industry classification). In Table 1, we report the number of establishments' entries and the number of municipalities for which data are available. Roughly speaking, these are municipalities with more than 1,000 inhabitants that host some amount of industrial activity[6]. The municipal data sources, variable definitions and summary statistics are provided in Table 2.

[Insert Table 1]

[Insert Table 2]

**A.-Local taxes**

Local governments have a moderate size in Spain (its expenditure just exceeds the 10% of the total public expenditure). However, local taxes accrue for substantial shares of municipal budgets (over 30%). Although the list of taxes municipalities can make use of is not short, only two local taxes, the local business tax (*Impuesto sobre Actividades Económicas*) and the property tax (*Impuesto sobre la Propiedad Immueble*), are quantitatively relevant for business activities[7]. The former taxes the mere exercise of any business or professional activity whereas the latter is levied on properties' owners.

The local business tax liability of each firm ($T^{bus}$) is based on a presumed level of profits that is established in accordance to the observed level of input usages and the economic sector of each firm. This presumed level of profits is determined by national tax laws that do not make any distinction with regards to location. This level of tax liability ($\phi_s^L \cdot L_i + \phi_s^K \cdot K_i + \phi_s^N \cdot N_i$), which is the same for two identical firms in different locations, is then modified at the municipal level at being multiplied by a coefficient which is set by local governments which cannot vary across firms within a municipality

[5]Catalonia is a region found in north-east Spain. In 1999, there are 6.2 million inhabitants sorted in 946 municipalities whose surface adds to 32 thousand square Km.

[6] In 2000, 2001 and 2002 there is a substantial increase in the number of municipalities for which data are available. This is due to the fact that business tax rates are only available for those municipalities exceeding 1,000 inhabitants for the previous years.

[7] Summed up, these two taxes account for roughly 70% of the local tax revenue.

($\tau_j^{bus}$). Hence, the tax bill for a firm *i* belonging to industry *s* in municipality *j* is given by $T_{isj}^{bus} \equiv \tau_j^{bus} \cdot (\phi_s^L \cdot L_i + \phi_s^K \cdot K_i + \phi_s^N \cdot N_i)$ where $\phi_s^L$ , $\phi_s^K$ and $\phi_s^N$ measure the way national tax laws assess how profits in industry *s* increase differently with an extra unit of labor, machinery and buildings, respectively. Hence, it is possible to decompose $\alpha_1 / \delta \cdot t_{sj}^{bus} + \alpha_2 / \delta \cdot t_{sj}^{bus} + \alpha_3 / \delta \cdot t_{sj}^{bus}$ into two terms, an industry-specific constant (i.e. $\alpha_1 / \delta \cdot \phi_s^L + \alpha_2 / \delta \cdot \phi_s^K + \alpha_3 / \delta \cdot \phi_s^N$) times the municipal business tax rate $\tau_j^{bus}$. Moreover, this constant captures in which percentage the profits squeeze when the municipal business tax rate increases by one unit. If this share has to be similar across sectors (after all, the business tax is levied on a presumed level of profits for all industries), then one can expect this coefficient being roughly the same for all sectors.

The local business tax was reformed by a law passed on 2002. From 2003 onwards, all self-employed and very small firms (with sales below 1 million €) are tax exempt. At the same time, the tax burden is partly shifted towards larger firms. Hence, we expect the business tax rate to have a markedly differentiated effect between small and large firms in the post-reform sub-sample. This reform was a cornerstone of the electoral campaign of the conservative party that eventually won the elections by a wide margin in 2002. Hence, if anticipated, the reform could have had an effect on the location of establishments prior to 2003.

The other main local tax, the property tax, is charged to the owners of land and buildings' structures and no difference is made between industrial and residential usages. The property tax bill ($T^{prop}$) results from the product between the nominal tax rate ($t^{prop,nom}$) and the ratable value of each building ($Ratv$), i.e. $T^{prop} = t^{prop,nom} \cdot Ratv$. We are interested in measuring how the property tax bill increases when we increase the usage of a representative building in one unit ($t^{prop} \equiv dT^{prop} / dN$) and, therefore, noting that the tax bill can be expressed as $t^{prop,nom} \cdot (Ratv / N) \cdot N$ enables us to write the property tax rate as the nominal tax rate times the ratable value of a representative unit of buildings in location *j*, i.e. $t_j^{prop} \equiv t_j^{prop,nom} \cdot (Ratv / N)_j$ [8]. Hence, we need a proxy of

[8] One can claim that the property tax belongs to the ad-valorem class. However, the revisions of the properties' values are not carried out simultaneously. Rather, different municipalities can

the ratable value of a representative unit of an industrial building. Unfortunately, this information is not available and, instead, we use the mean of the ratable value of all properties found in location *j*.

It is important to assess whether these two taxes and theirs differences across municipalities are large enough to drive the location decisions of establishments. Municipal governments are given remarkable tax autonomy to choose both business and property tax rates. The business tax rate can range from 0.8 to 1.9. Differences within this interval lead to non negligible changes in firms' profitability. In particular, an increase from the lower to the upper bound may produce a reduction above 1.5% in the after tax level of profits. There exists substantial cross-section variation in this variable. In 1999, half of the municipalities have set a tax rate that is either below 1.1 or above 1.4. Regarding the property tax, governments are free to choose a nominal tax rate between 0.4 and 1.1%. That is, property owners are asked to pay a share (between 0.4 and 1.1%) of the ratable value of theirs properties. Given a ratable value of a property, a tax increase from 0.4 to 1.1 can increase the after tax rent bill by 6%. The property tax rate exhibits a great deal of heterogeneity across locations although low tax rates are generally preferred. For instance in 1999, a quarter of municipal governments set a property tax rate below 0.45 whereas another quarter ends up choosing a tax rate above 0.7. Differences in the average ratable value of properties across municipalities are very large and further enlarge property tax bill differentials (See Table II for descriptive statistics).

**B.-Agglomeration economies**

The term agglomeration economies' denotes the productivity gains a firm may obtain from the economic scale of its location. This is to say that agglomeration economies emerge as a consequence of summing up individual external effects stemming from the interaction of firms located in the same geographical environment. Agglomeration economies, $A_{sj}$, are expected to be summarized by the following expression:

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have been revised at very distant points in time. In particular in 2002, 75% of the municipalities had not been revised since 1990.

$$A_{sj} \equiv K_0 \cdot OME_{sj}^{\psi_1} \cdot ME_{sj}^{\psi_2} \cdot NME_j^{\psi_3} \cdot DIV_j^{\psi_4} \qquad [6]$$

where $K_0$ stands for a constant. $OME_{sj}$ denotes the $s^{th}$ manufacture employment in location *j* whereas $ME_{sj}$ captures the remaining manufacturing employment found in municipality *j*. This distinction is made in order to take into account that the benefits for two firms to co-localize in space may be larger between same industry firms than between two firms that belong to distant activities. The non-manufacturing employment level, $NME_{sj}$, is introduced in order to capture the advantages manufacturing firms enjoy from locally provided services. The productivity gains derived from own manufacturing employment levels ($OME_{sj}$) are known in the literature as localization economies. The benefits stemming from the remaining levels of employment ($ME_{sj} + NME_{sj}$) are often called urbanization economies in a distinction that dates back to Hoover (1934). Jacobs (1969) sustains that diverse economic environments favour the productivity of firms through the cross-fertilization of ideas. To test this last hypothesis we introduce the variable $DIV_j$, that accounts for how diverse the productive environment is and it amounts to the inverse of a Hirschman-Herfindahl index which is defined as follows:

$$DIV_j = 1/\sum_s sh_{sj}^2 \qquad [7]$$

where $sh_{sj}$ denotes the share of the overall employment in location $j$ that is devoted to activity $s$ (including both manufacturing and non-manufacturing activities). The larger the value of the index, the more diverse the described economic environment is.

**C.-The rent of buildings**

Data on the rent of industrial buildings are not available for Spanish municipalities[9]. The omission of this variable may bias the estimates of the effects of taxes on the location of firms. This is due to the fact that the equilibrium rent occurs where demand meets

[9]Neither the ratable value of the property tax can be used as a proxy given that revisions are not carried out simultaneously.

supply and none of these two is likely to be uncorrelated to the rest of variables present in our analysis. We circumvent this problem by looking at how pre-established firms use labor in relation to buildings.

Since wages are assumed to be constant across a local labor market, the aggregate ratio of buildings with respect to labor should provide us with information regarding the rent of buildings' distribution. However, we need to take into account that different aggregate ratios of labor to square meters of buildings may not only be the result of differences in relative prices but also respond to variation in the sectoral composition of municipalities[10]. If we would measure the rent of buildings with the aggregate ratio of labor to buildings (in square meters) we would tend to overstate its variation within a local labor market. The reason is that firms that need particularly large buildings will tend to gather in locations where buildings are relatively cheap. Therefore, we need to account for the aggregate ratio of labor to buildings while controlling for the sectoral composition of municipalities. That is:

$$R_j = \frac{1}{N_j} \cdot (\sum_s \kappa_s \cdot L_{sj}) \qquad [9]$$

where $N_j$ is the surface occupied by industry in municipality *j*, $L_{sj}$ is employment of the $s^{th}$ industry in *j* and the $\kappa_s$'s are constants to be estimated. These should be high for sectors using large buildings intensively (high $\alpha_3 / \alpha_1$ ratios) and low for sectors that have lower space requirements (low $\alpha_3 / \alpha_1$ ratios). This can be seen at a more formal level in Annex [1].

### 3.2.-Economteric specification

Up to now, we have not mentioned how we capture wage differentials between local labor markets. As a matter of fact, there is no information on wage levels at this geographical scale. The way we proceed consists of conditioning the choice set to be the

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[10] This is to recognize the point stressed by Gyourko (1987) at analyzing the between cities variation of the aggregate ratio of labor to capital between cities. This author decomposes the variation into two phenomena: economic sector composition of the city and within industry factor intensity variation.

local labor market in which we finally observe the establishment is being settled. The local labor markets we consider have been built on the basis of labor mobility considerations[11]. Thus, they reflect groups of municipalities which show high levels of interaction among theirs municipalities at a variety of levels. Hence, by looking at the location of establishments within a local labor market we are not only controlling for wage differentials but also for unobserved location attributes that may show up at precisely this geographical level. This attributes may include the business climate, transportation facilities or the access to markets.

The dataset we use gathers information on firms that belong to different manufactures entering the market at different points in time. We are interested in looking at how an establishment manager belonging to industry *s*, decides in which municipality to settle down in period *t*, conditionally on investing in a particular local labor market. Hence we need to condition the choice of jurisdiction *j* on the sector, time period and local labor market we eventually observe the investment is taking place. Following Rosenthal and Strange (2003), we assume that there is a one year time lag between a new establishment decides where to locate and we observe the establishment being settled. Hence, we are interested in location probabilities of the following type:

$$p_{ij/s,t+1,j\in l} = \frac{\exp(\beta_1 OME_{sjt} + \beta_2 ME_{sjt} + \beta_3 NME_{jt} + \beta_4 DIV_{jt} + \beta_5 \tau_{jt}^{bus} + \beta_6 \tau_{jt}^{prop} + \sum_s \beta_s (L_{sjt} / N_{jt}))}{\sum_{j=1}^{J_l} \exp(\beta_1 OME_{sjt} + \beta_2 ME_{sjt} + \beta_3 NME_{jt} + \beta_4 DIV_{jt} + \beta_5 \tau_{jt}^{bus} + \beta_6 \tau_{jt}^{prop} + \sum_s \beta_s (L_{sjt} / N_{jt}))}$$

[10]

where

$$\beta_k \equiv 1/\delta \cdot \psi_k \text{, for k} = 1, 2, 3 \text{ and } 4.$$

$$\beta_5 \equiv \alpha_1 / \delta \cdot \phi_s^L + \alpha_2 / \delta \cdot \phi_s^K + \alpha_3 / \delta \cdot \phi_s^N$$

$$\beta_6 \equiv \alpha_3 / \delta \cdot \phi_s^N$$

$$\beta_s \equiv \alpha_3 / \delta \cdot \kappa_s \text{, for } s = 1,...,19.$$

[11] The local labor markets we consider have been computed by Roca and Moix (2004) following a very similar methodology to the one that is used to construct the British local labor markets. We consider the 945 municipalities to conform 41 local labour markets.

This resembles a nested logit model which is often seen as a conditional logit where decisions are made sequentially. In this particular case, firm managers would choose in which labor local market to locate in the first place and then would choose the municipality they like better within the local labor market. It turns out that the estimates to be obtained by the estimation of expression [10] are precisely the ones that would arise by estimating a nested logit model. At this moment, it is worth making two comments in this respect. First, the approach we take allows us to control for the "birth potential" of an area in the words of Carlton (1983). That is, people is tight to particular areas and, hence, when an entrepreneur is looking where to locate a start-up, some additional advantages offered by a far municipality may be offset by a personal preference for locations that might be placed more nearby. Put in another way, not all jurisdictions may be equally substitutes one for each other. Given the fact that there are more entrepreneurs in large cities that show both more agglomeration and higher tax rates, this statistical control may be important. In the second place, it may happen that for large and very mobile firms (e.g. foreign direct investment) the choice set considered does not correspond to the actual choice set. Even if this is true, the consistency of our estimates does not rely on assuming that we are specifying the choice set correctly. This is due to the fact that in order to obtain consistent estimates of the parameters of interest all it is required is that the independence of irrelevant alternatives assumption holds between each pair of alternatives we are considering in our estimation.

The log-likelihood of the model is given by:

$$\sum_t \sum_s \sum_l \sum_{j=1}^{J_l} n_{s,t+1,j} \ln p_{j/s,t+1,j\in l} \quad [11]$$

Guimaraes (2004) shows that this log-likelihood function differs in a constant from the log-likelihood function of a Poisson model with exponential mean function whose mean and variance are given by the following expression:

$$E(n_{s,t+1,j}) = Var(n_{s,t+1,j}) = \exp(\alpha_{stl} + \beta_1 OME_j + \beta_2 ME_j + \beta_3 NME_j + \beta_4 DIV_j + \beta_5 \tau_j^{bus} + \beta_6 \tau_j^{prop} + \sum_s \beta_s (L_{sj} / N_j)) \quad [12]$$

where $n_{s,t+1,j}$ accounts for the number of firms of the $s^{th}$ industry that locate in jurisdiction $j$ during period $t+1$ and $\alpha_{stl}$ denotes a time-sectoral-Local Labor Market specific constant term[12]. The exponential mean Poisson regression model does not suffer from the incidental parameters problem that generally affects non-linear models (Cameron and Trivedi, 1998). This implies that the consistency of the slope parameters does not hinge on the number of constant terms that needs to be fitted.

### 3.3.-Results

The maximum likelihood Poisson estimates of the location determinants of new and relocating establishments are presented in Table III. In the first column of Table III, we present the preferred specification that corresponds to the location of manufacturing establishments specification outlined in expressions [11] and [12]. Auxiliary results are provided in specifications 2 and 3.

[Insert Table III]

The high number of statistically significant variables reported in specification (1) suggests that the model fits the data satisfactorily. Although not reported, a likelihood ratio test has been computed indicating that the model is statistical globally significant at any reasonable level. Moreover, the variables take the sign that theory predicts. That is, local taxes and the proxies used to capture the rent of buildings seem to discourage the arrival of firms whereas agglomeration economies are an attribute that firms value at the time they look for a location[13].

The two local taxes, the local business tax and the property tax seem to be a relevant determinant of the location of new manufacturing establishments. Both the business tax

[12] $\alpha_{stl}$ can not be computed if, for industry $s$ in time period $t+1$, there are no firms locating in any location within local labor market $l$. Hence, the number of observations changes over the runned regressions.

[13] The coefficients associated with the variables that proxy the rent of buildings have been omitted to save space. The normalizations made regarding the units of labor and buildings make the evaluation of these variables hard to interpret since the coefficients obtained are up to two unknown constants.

and the property tax rate coefficients are negative and statistically significant at the 1% level ($\beta_5$ , $\beta_6 < 0$). Given that these variables do not enter the model in logs, the estimated coefficients do not tell us much regarding the size these effects have[14]. Hence, the average elasticity for these two taxes has been computed. The estimated elasticity of the business tax rate is -0.52 whereas the one obtained for the property tax rate is -0.13. As mentioned, the list of papers we can compare our results with is extremely short. Since the paper by Solé-Ollé and Viladecans-Marsal (2003) is focused on employment growth, it is hard to assess to which degree are these results strictly comparable. Our elasticities are in general smaller than the ones they find, especially for the property tax. Nevertheless, the results we report are in the range these authors handle. In particular, the elasticity we have obtained for the business tax rate is close to the one they report for the overall employment growth equation (-0.5) whereas we find an elasticity for the property tax rate that is close to the one they provide for the services employment growth (-0.18). These elasticities are also small in comparison to the average result found in the U.S. context which Bartik (1991a) quantifies in -2. However, our results resemble the ones found in U.S. studies of the conditional logit type like Bartik (1985) or Guimaraes *et al.* (2004). These studies report negative elasticities that do not exceed -0.5 in general. If, in addition, we take into account the size of the taxes considered in this analysis, we deem our elasticities plausible.

The results also suggest that agglomeration economies play an important role as firm location determinants since all the coefficients of the agglomeration economies' variables turn out to be positive and statistically significant at the 1% level[15]. Since all agglomeration economies' variables are measured in logs, the coefficients have an elasticity interpretation. The variable pinning down the localization economies (*OME*), seem to exert an important role in the firm location decision being its elasticity around 0.40. The variables capturing the urbanization economies (*ME* and *NME*) have elasticities of 0.25 and 0.12, respectively. This suggests that localization economies

[14] When a coefficient is interpreted in terms of its impact on the expected number of firms settling down ($n_{s,t+1,j}$), it is directly the elasticity if the associated variable ($x$) is measured in logs. If not, the average elasticity can be obtained by multiplying the coefficient by the sample mean of the regressor, $\beta \cdot \bar{x}_{jst}$ .

[15] In unreported estimates, we have also considered the industrial characteristics of neighbouring municipalities. The spatial lags of the agglomeration economies' variables have turned out to be statistically insignificant. Moreover, the estimates of the parameters of interest do not experience important changes.

outweigh the advantages stemming from the presence of employment from distant economic activities. The diversity of the economic environment also shifts the productivity of firms becoming a valuable attribute for firms in search of a location. The elasticity lies around 0.22 supporting the hypothesis associated with Jacobs. The results obtained regarding the relative importance of these location determinants are in line with the results found in the literature[16]. We have also computed the averaged marginal effects which are implicit in our agglomeration estimates in order to better contextualize our results with the literature[17]. Our localization economies' estimate implies that an extra worker of a particular industry increases the expected number of start-ups of the same industry in 9.68E-04. Regarding the urbanization economies, a worker increase outside the industry has an effect of 4.01E-05 births if it is a manufacturing worker and 6.89E-06, otherwise. These estimates are in the upper bound of the results found by Rosenthal and Strange (2003). One possible explanation is that, unlike these authors, we are holding rents and taxes fixed.

In the second column of Table III, we report the results obtained when we do not restrict the choice set to the local labor market level. Although not drastically, when the choice set is considered to be the entire region of Catalonia, some coefficient estimates change substantially. In particular, the coefficients (and the elasticities) of the business tax rate and the property tax rate drop by a 55% and 22 %, respectively. This suggests that the IIA assumption does not hold at the regional level. This can also be tested statistically. The second row from the bottom in Table III reports the log-likelihood functions of the different specifications. Since specification (2) arises by restricting the sector-year-local labor market dummy variables to be equal regardless of the local-labor market of the municipality, a likelihood ratio test can be performed. The value this test takes is over 2000 which clearly exceed the critical value of a Chi-Square distribution with 1378 degrees of freedom at the 1% level. Hence, the data point in the direction that there are relevant location factors that show up at the local labor market or/and, for some entrepreneurs, not all municipalities are equally substitutes one for each other. This supports our empirical strategy to restrict the choice set to nearby locations.

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[16] See Rosenthal and Strange (2004) for a review of this literature.

[17] If the variable x is expressed in logs, the averaged marginal effect can be obtained as $\beta_k \cdot (\overline{n}_{jst} / \overline{x}_{jst})$ where $\overline{n}_{jst}$ is the sample mean of the dependent variable.

In Figure I (Graphics 1-6) the partial correlations between tax rates and different agglomeration proxies are depicted. We consider three different measures of agglomeration (manufacturing employment, overall employment and the diversity index). Since we focus on firm location within a local labour market we express both taxes and agglomeration proxies in deviations from the LLM means[18]. Tax rates and agglomeration proxies show remarkable positive correlations to be found in the 25-50% range. This yields some evidence supporting the prediction that municipalities that are well endowed with attributes firms value (including large towns) choose higher tax rates (Ludema and Wooton, 2000). Hence, in order to identify taxes' effects, accounting for how firms like particular locations is in order. Specification (3) whose results are reported in the third column omit the agglomeration economies' variables to illustrate this point. The business tax rate effect switches sign becoming positive (and statistically significant at the 1% level). Moreover, the implied elasticity is very large (exceeds 3). In contrast, the property tax estimate remains unchanged.

[Insert Figure 1]

*Robustness checks and additional results*

In this subsection we first comment on the robustness of our results. In particular, we explore if the estimates are too sensitive to the empirical strategy we use to control for the rent of buildings. After, the implications of omitting the level of some particular public expenditure programmes are also addressed. The analysis is then extended in two directions. First, we consider small and large firms, separately (Table IV). Finally, we explore the role of taxes on the location of service activities.

Since to the best of our knowledge there are no papers that control for the rent of buildings by looking at how pre-established firms use labor with respect to meters of buildings, we have estimated specification [1] using the density of the population as a proxy of the buildings' rent. This approach has been used in Bartik (1985) and Guimaraes *et al.* (2004), the rationale for this being that population and manufactures compete for the use of land. The density takes the correct sign if higher densities are to

[18] Manufacturing employment and overall employment are measured in logs.

pick up higher buildings' rents. Although some coefficient estimates experience some non-negligible changes, the sign and order of magnitude of the estimates remain unchanged, bringing consistency to our analysis.

Bartik (1991A) points out that controlling for the level of some local public expenditures can be relevant for identification purposes (i.e. higher tax bills may be financing better services which are valued by firms). Unfortunately, we lack data on current expenditures in which we can identify the programmes that firms may be particularly interested in. Hence, we are not able to address this question, empirically. However, we think that this is not a major issue in our analysis. Inter-municipal differences in per capita tax revenue do not stem so much from differences in municipal tax efforts. Rather, they arise from differences in fiscal capacity and in the volume of unconditional grants received from the central government[19]. As a robustness check, we have included the log of the overall public expenditure per capita in specification (1). Although the expenditure per capita coefficient is positive, its elasticity is very small and statistically insignificant and, moreover, produces no significant changes in the parameters of interest.

The objective of performing the analysis that accounts for firm size is not only to explore if small and large firms respond differently to tax differentials but also to assess the impact of the local business tax reform passed on 2002 whose effects should differ with firm size. We consider two subsets of firms that should be affected by the reform in a different manner. On the one hand, an establishment that is registered with 1, 2 or 3 employed is considered to be small. Likewise, an establishment with more than 5 workers is considered to be large. The amounts of entries falling into these two categories are reported in the second and third rows of Table 1. These subsets of firms are designed to reflect the differentiated effect that the business tax reform had on small *vs.* large firms[20]. We allow the business tax rate coefficient to have three different

[19] The correlation between the overall expenditure per capita and the tax rates is around 16% and 24% for the business and the property taxes, respectively.

[20] We consider that 5 workers or 1 million € pin down, approximately, the same firm size. For instance, European Institutions define as a micro firm a firm that either has less than 10 workers or that its sales do not exceed 2 million €. The firms being born with 4 or 5 workers are not considered in this particular analysis. The inclusion of these firms in any of the two groups decreases the precision of the estimates of interest. Our interpretation is that the effect of the reform may be very heterogeneous across firms within this size interval.

slopes. One is for firms entering the market in the time period spanning 1996 to 2000 when the pre-reform business tax law applied. Another coefficient is fitted for new establishments in search of a location in 2001 and 2002 when managers could have anticipated the effects of the reform. Finally, a third slope is considered for establishments settling down in 2003 when the effects of the new business tax law should be at work fully.

[Insert Table IV]

Before the reform of the local business tax in 2002-2003, the results suggest that small firms are more sensitive to business tax rate differentials than theirs larger counterparts. If the estimated elasticity for large firms approaches -0.28, the elasticity found for small firms lies around -0.78. In contrast, the elasticity of the property tax rate seems to be relatively similar between small and large firms, -0.13 *vs.* -0.16, respectively. As commented above, the reform of the local business tax partly consisted on shifting some of the tax burden from very small to larger firms. As expected, our results point into the direction that the reform increased the sensitivity of large firms to business tax differentials. The elasticity of interest rises remarkably, from -0.28 to -0.87. The opposite is found for the considered subset of small firms. In this case, the elasticity of interest decreases from -0.78 to -0.42. The estimates of the business tax for firms locating in 2001 and 2002 lye in between the pre and post reform period estimates for both small and large firms. This supports the idea that, during 2001 and 2002, the reform was partly anticipated. Notice that the analysis of this reform corroborates the nature of the effects of the business tax and, therefore, enhances the consistency of this analysis.

With regards to agglomeration economies, there are relevant differences in how small and large firms value the characteristics of the economic environment of locations. The most striking qualitative difference concerns the results obtained for the non-manufacture employment ($NME_j$) and the diversity of the economic environment ($DIV_j$). If small firms seem to put a large weight on these two attributes when locating (the elasticities are 0.24 and 0.34, respectively), large firms do not seem to care much about these (the coefficients are, respectively, 5 and 3 times smaller). One way to read these results is that large firms are less dependent on external services and tacit knowledge than small firms.

Despite this analysis has focused on manufactures for reasons explained above, we have also explored the role of taxes on the location of services for a variety of reasons. First, due to policy implications given that services account for more than half of the employment. Second, because a growing number of services do not need to be consumed locally and finally, because it enables us to better contextualize the results. To take into account that demand for services may show variation at the local level, we include the population and a measure of the local income level in the regression following Erickson and Wasylenko (1980). The estimated tax elasticities are of the same order of magnitude of the ones obtained for the manufactures although the business tax rate estimate turns out to be statistically insignificant. These elasticities are -0.28 and -0.18 for the business and the property tax, respectively. This is at odds with the results found by Solé-Ollé and Viladecans-Marsal (2003) which differed significantly between a very large impact of taxes on manufactures and a much more moderate effect on the services side of the economy. Higher levels of manufacturing and non-manufacturing employment as well as diversified economic environments seem to attract new service establishments. This is consistent with both an external economies and a local demand story. In contrast, the variables included to capture differences in demand at the municipal level (population and income) are statistically not different from zero. As recognized by Newman and Sullivan (1983), even though some activities may not export their output beyond the local level, mobility among nearby jurisdictions ensures that both demand and the cost of factors, aside from the rent of buildings, can be assumed to show little cross-section variation at this geographical level.

## 4.-Conclusions

In this study we have focused on the role of local taxes on the location of new manufacturing establishments among nearby municipalities while accounting for the presence of agglomeration economies. The empirical application we carry out, using Spanish municipalities' data, is especially adequate for two reasons. First, in light of the results of Rosenthal and Strange (2003) and Duranton and Overmans (2005), the Spanish case is a setting where there is probably a good match between the size of the tax setting jurisdiction and the geographic scope of agglomeration economies. Second, it sheds some extra light on a topic that has not focused too much attention in the European context.

The tax elasticity we have found for the business tax is close to -0.5. Significantly lower is our estimated elasticity for the property tax. In this case, we have found an elasticity that lies around -0.12. The size of these effects is in the lower bound of the results reported by Solé-Ollé and Viladecans-Marsal (2003) for Spain. Given the quantitative importance of these local taxes in Spain, we consider that our estimates are reasonable. A reform of the business tax that took place within the period we study shifted part of the tax burden from small to larger firms. Our results suggest that the reform decreased the sensitivity of small firms to tax differentials whereas the opposite is found for large firms. Hence, this enhances the consistency of our estimates.

Restricting the choice set to the local labor market and, especially, accounting for the presence of agglomeration economies is of paramount importance to identify the role of local taxes on the location of economic activities. In particular, the omission of the agglomeration economies' variables results in a severe underestimation of the negative effect of the business tax on the location of manufactures. This can be explained by large and positive correlations that exist between taxes and proxies of agglomeration economies. This set of results is consistent with the "agglomeration rent" prediction that states that governments of jurisdictions that are well endowed with attributes that firms value will set higher tax rates, all else held constant (Ludema and Wooton, 2000). Given that firms are fond of large cities, our finding is also consistent with the argument sustaining that large cities will set higher tax rates given its capacity to alter the return of buildings (Hoyt, 1992).

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**Table 1. Number of new establishments and municipalities by year.**

| Variable | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|
| # new establishments (all) | 1319 | 1664 | 1733 | 1065 | 1175 | 926 | 1127 | 1163 |
| # new establishments (small)[1] | 567 | 620 | 716 | 432 | 441 | 392 | 380 | 368 |
| # new establishments (large)[2] | 497 | 713 | 689 | 451 | 500 | 301 | 497 | 538 |
| # municipalities | 259 | 396 | 414 | 412 | 410 | 636 | 631 | 631 |

*Notes*: 1. Small (1-3 workers). 2. Large ($\geq 6$ workers).

**Table II. Definition of municipal variables. Data sources and descriptive statistics**

| Variable | Definition | Data sources | 1999 | |
|---|---|---|---|---|
| | | | mean | st. dev |
| Business tax rate; $\tau_j^{bus}$ | Municipal coefficient to be applied to a presumed firm-specific level of profits | Ministry of economics municipal yearbooks (1995-1999) & data-base (2000-2002) | 1.357 | 0.187 |
| Nominal property tax rate; $\tau_j^{prop,nom}$ | Nominal property tax rate | Property Assessment Office | 0.567 | 0.154 |
| Assessed value per unit of surface; $(Ratv/N)_j$ | Mean of the ratable value of buildings | Property Assessment office | 20.898 | 14.388 |
| Property tax rate; $\tau_j^{prop}$ | $\tau_j^{prop,nom} \cdot (Ratv/N)_j$ | Property Assessment office | 12.145 | 8.486 |
| Manufacturing employment; $ME_j$ | ln of workers employed in manufacturing activities | Social Security Register | 4.128 | 2.317 |
| Non-manufacturing employment; $NME_j$ | ln of workers employed in non-manufacturing activities | Social Security Register | 4.462 | 2.173 |
| Diversity index; $DIV_j$ | ln of the inverse of a *H-H* index of sectoral concentration | Social Security Register | 4.890 | 2.957 |
| Manufacturing ratio of labor to buildings surface; $L_j/N_j$ | Manufacturing workers over square meters of industrial buildings | Catalan Institute of Statistics & Social Security Register | 0.053 | 0.177 |

**Table I.-Location determinants. Poisson Maximum Likelihood estimates.**

| *Variable* | [1] | [2] | [3] |
|---|---|---|---|
| *(i) Local tax rates* | | | |
| $\tau_j^{bus}$ | -0.387<br>(-4.67)*** | -0.249<br>(-3.24)*** | 2.643<br>(36.39)*** |
| $\tau_j^{prop}$ | -0.011<br>(-4.90)*** | -0.009<br>-(2.55)*** | -0.012<br>(6.09)*** |
| *(i) Agglomeration economies* | | | |
| $OIE_j$ | 0.403<br>(34.89)*** | 0.416<br>(41.06)*** | -.-<br>-.- |
| $ME_j$ | 0.248<br>(12.04)*** | 0.190<br>(11.09)*** | -.-<br>-.- |
| $NME_j$ | 0.124<br>(7.29)*** | 0.135<br>(9.53)*** | -.-<br>-.- |
| $DIV_j$ | 0.224<br>(5.36)*** | 0.261<br>(6.67)*** | -.-<br>-.- |
| *Rent of buildings* $(L_{sj} / N_j, \forall s)$ | Yes | Yes | Yes |
| *Local Labor Market dummies* | Yes | No | Yes |
| *Log-likelihood* | -13,564 | -14,585 | -16,538 |
| *# Observations* | 21,914 | 21,914 | 21,914 |

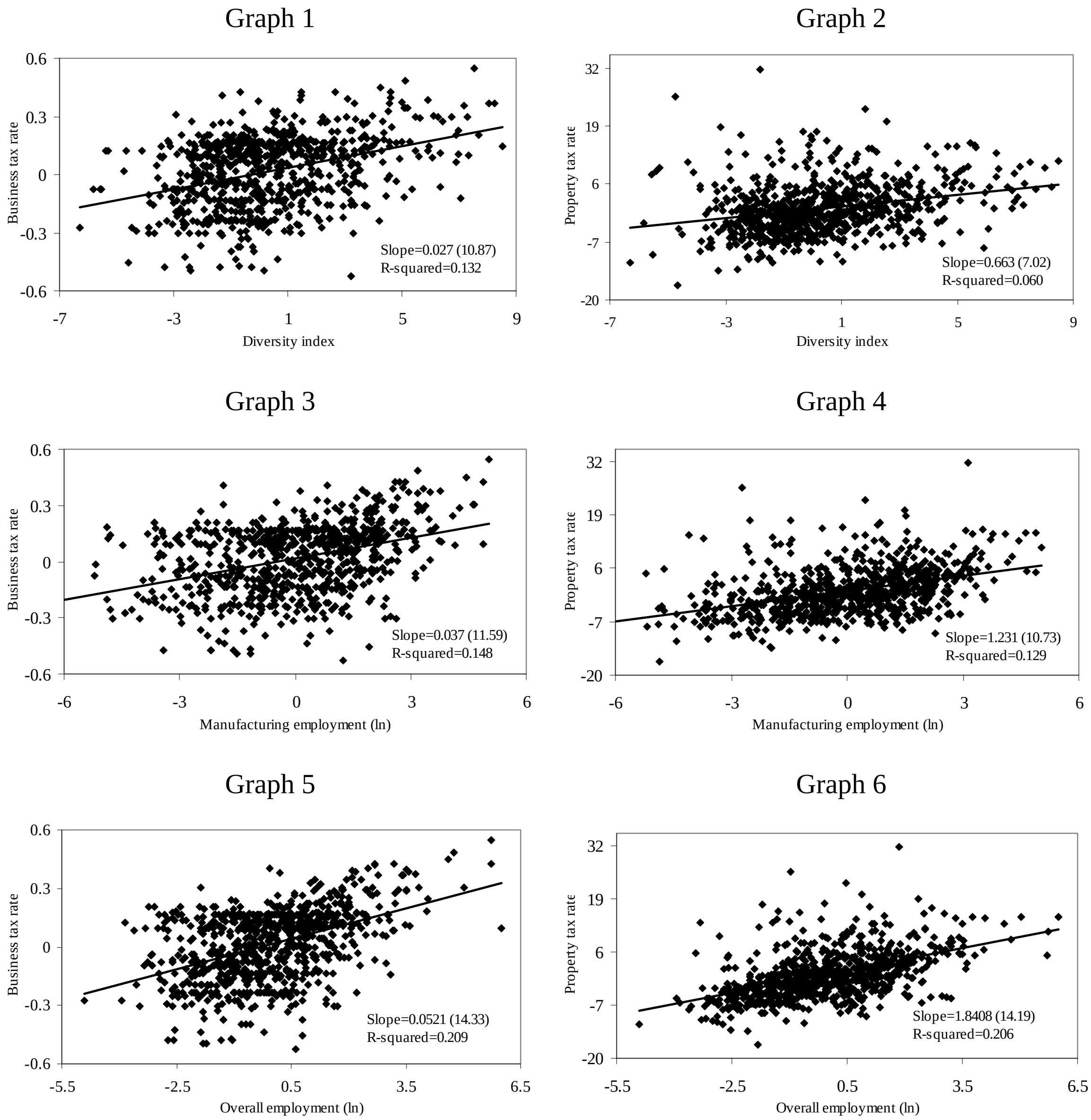
*Notes*: 1. Figures in parenthesis are *z*-statistics. 2. *, **, ***: statistically significant at the 90%, 95% and 99%, respectively.

**Table II.-Location determinants. Poisson Maximum Likelihood estimates for small and large firms.**

| *Variable* | *Small firms* | *Large firms* |
|---|---|---|
| *(i) Local tax rates* | | |
| $\tau_j^{bus,1996-2000}$ | -0.599<br>(-4.06)*** | -0.221<br>(-1.53) |
| $\tau_j^{bus,2001-2002}$ | -0.426<br>(-1.86)* | -0.463<br>(-2.05)** |
| $\tau_j^{bus,2003}$ | -0.329<br>(-1.01) | -0.675<br>(-2.64)*** |
| $\tau_j^{prop}$ | -0.011<br>(-3.10)*** | -0.014<br>(-3.94)*** |
| *(ii) Agglomeration economies* | | |
| $OIE_j$ | 0.342<br>(17.93)*** | 0.433<br>(24.52)*** |
| $ME_j$ | 0.146<br>(4.63)*** | 0.294<br>(8.88)*** |
| $NME_j$ | 0.244<br>(9.01)*** | 0.053<br>(1.96)** |
| $DIV_j$ | 0.340<br>(4.96)*** | 0.125<br>(1.95)* |
| *Rent of buildings* $(L_{sj}/N_j, \forall s)$ | Yes | Yes |
| *Local Labor Market dummies* | Yes | Yes |
| *Log-likelihood* | -6,898 | -7,405 |
| *Observations* | 18,010 | 17,594 |

*Notes*: 1. Figures in parenthesis are *z*-statistics. 2. *, **, ***: statistically significant at the 90%, 95% and 99%, respectively.

**Figure 1. Correlations between tax rates and agglomeration proxies.**



**Annex 1.**

Hotelling's lemma and equation [12] admit equating the following expressions for labor and buildings, respectively:

$$\frac{\partial \Pi_{ij} / \Pi_{ij}}{\partial R_j / R_j} = -\frac{\alpha_3}{(1-k)} \cdot \frac{R_j}{(R_j + dT^{bus}/dN + dT^{prop}/dN)} = \frac{-N_{ij} \cdot R_j}{\Pi_{ij}} \qquad [A.1]$$

$$\frac{\partial \Pi_{ij} / \Pi_{ij}}{\partial w_l / w_l} = -\frac{\alpha_3}{(1-k)} \cdot \frac{w_l}{(w_l + dT^{bus}/dN)} = \frac{-L_{ij} \cdot w_l}{\Pi_{ij}} \qquad [A.2]$$

These two expressions can be combined to yield an expression for the before tax buildings' bill. At this point, it is relevant to introduce the industry subscript to acknowledge inter-sectoral differences regarding wage levels, tax rates and elasticities of production of inputs (the $\alpha's$).

$$N_{ijs} \cdot R_j = L_{ijs} \cdot \left( \frac{\alpha_3}{\alpha_1} \cdot w_l \right)_s \cdot \left[ \frac{\dfrac{R_j}{(R_j + dT^{bus}/dN + dT^{prop}/dN)}}{\dfrac{w_l}{(w_l + dT^{bus}/dL)}} \right]_{js} \qquad [A.3]$$

If we sum up for all firms in location *j* that are devoted to activity *s* we obtain:

$$N_{js} \cdot R_j = L_{js} \cdot \left( \frac{\alpha_3}{\alpha_1} \cdot w_l \right)_s \cdot \left[ \frac{\dfrac{R_j}{(R_j + dT^{bus}/dN + dT^{prop}/dN)}}{\dfrac{w_l}{(w_l + dT^{bus}/dL)}} \right]_{js} \qquad [A.4]$$

If we add the tax bill for all industries, we find that the buildings' bill in location *j* is given by:

$$N_j \cdot R_j = \sum_s \kappa_s \cdot L_{js} \qquad [A.5]$$

where $\kappa_s = \varsigma \cdot \left( \frac{\alpha_3}{\alpha_1} \cdot w_l \right)_s \cdot \left[ \frac{\dfrac{R_j}{(R_j + dT^{bus}/dN + dT^{prop}/dN)}}{\dfrac{w_l}{(w_l + dT^{bus}/dL)}} \right]_s$.

$\varsigma$ is a constant term that needs to be introduced to take into account that *L* and *N* have been set at a particular scale. It is important to notice that this particular way to measure the rent of buildings relies on the fact that local taxes are not changing the relative prices of inputs across municipalities to a significant extent.