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Housing market prices: capitalisation of efficiency in local public service provision. An application with data on Italian urban transport related expenditures*

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Abstract

This paper investigates, from both a theoretical and an empirical point of view, the relationship between local government efficiency and the local housing market and, in particular, the possibility that councils' performance is capitalised in the price of housing. The theoretical analysis is developed within a classical "Tiebout framework" using a simple model of urban political economy, showing the mechanism through which local government efficiency is capitalised in the value of houses. The empirical analysis, based on data from Italian municipalities, provides robust evidence in support of the hypothesis of positive capitalisation.

JEL Code: R31, R32, R38, R48.
Keywords: house values, urban transport, efficiency, municipalities, capitalisation.

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1 Introduction

This paper studies, from both the theoretical and the empirical point of view, the relationship between local government efficiency and the housing market. In particular, we look at the possibility that councils' performance is capitalised in the value of properties.

From the analysis of the previous empirical and theoretical literature on capitalisation of local fiscal variables in the price of housing (Epple and Zelenitz 1981; Yinger 1982; Gyourko and Tracy 1989), it seems that at least three problems remain unsolved. First, to our knowledge, all the studies on capitalisation consider local taxes and local public benefits (expenditure) separately. Second, it is still not clear how to combine together inputs and outputs of councils' activity in order to evaluate the tax-public benefit package offered by local governments in a comprehensive way. Finally, local taxes and local public benefits are usually treated as exogenous variables when, in reality, they should be treated as endogenous.

Moving from these unsolved issues, the paper aims to address the capitalisation of local government efficiency in the price of housing inside a classical Tiebout framework. In particular, using a simple model of urban political economy, it has been possible to treat both local taxes and local expenditure as endogenous variables, differently from previous empirical literature.

Subsequently, the value of the tax-public benefit package has been measured in terms of local government technical efficiency combining together input and outputs of council activities in order to overcome the limitations of previous theoretical models where local taxes (inputs) and public benefits (outputs) are usually considered separately.

Finally, using a data-set of Italian municipalities (the lower level of government in Italy) over the period 2002-2007, a hedonic model has been estimated regressing the price of housing on technical efficiency, intergovernmental grants, and other features of the local context.

Efficiency is calculated in relation to urban transport related services since its wide spread use by both residents and non-residents makes it a good proxy for the overall perceived councils' efficiency, and thus performance. It is important to stress that these services include also street maintenance and public lighting, besides mobility services. This sector absorbs 25% of the total municipal capital expenditure and 10% of the total municipal current expenditure. The current expenditure on transport services is correlated at 70% with the total current expenditure (the highest among the 5 top areas of expenditure except general affairs). Moreover, the outcome of the urban transport services is measurable and highly visible. Finally, during electoral campaigns, issues related to the transport service are usually among the most debated.

The theoretical model shows that the mechanism through which local government efficiency is capitalised in the value of houses relies on the following crucial assumptions: free mobility of citizens among jurisdictions; housing supply with zero or positive elasticity (but not infinite!), which corresponds to the assumption of a jurisdiction with fixed boundaries; the private and public consumption must be weak complements; finally, in every period the local tax base must be greater than the housing consumption.

The empirical analysis, based on linear panel data models, provides two results: first, a measure of local government efficiency in the provision of the urban transport service by Italian municipalities; second, robust evidence in support of the hypothesis of positive capitalisation of local government efficiency in the price of housing.

The final estimates provide the following results: when the price of housing is measured in terms of monthly average rent per square metre registered in the city centre, the degree of capitalisation of efficiency varies from 4% in the case of offices to 28% in the case of residential properties; instead, when the price of housing is measured in terms of the monthly average rent per square metre registered in the suburban area, the degree of capitalisation of efficiency varies from 5% in the case of commercial properties to 33% in the case of properties used for production activities.

The remainder of the paper is organised as follows. Section 2 surveys the related literature. Section 3 sets up the theoretical framework and Section 4 describes the empirical strategy. Sections 5 and 6 give the baseline results and the outcome of the robustness checks. Finally, Section 7 provides concluding remarks. Most of the Tables are displayed in the appendix.

2 Related Literature

2.1 Theory

Tiebout's (1956) hypothesis[1] and the capitalisation of local fiscal variables in housing values lie at the heart of the economics of the local public sector. Although the connection between the two dates back to the famous "Henry George Theorem",[2] the implications that the Tiebout equilibrium exerts on the equilibrium of the housing market remained unknown until Oates's (1969) seminal paper, which, for the first time, studied the link between the Tiebout

[1] According to the Tiebout hypothesis, citizen-consumers shop among different communities offering varying packages of local public services and select as a residence the community that offers the tax–expenditure programme best suited to their tastes, i.e. citizens "vote with their feet", generating an efficient allocation of local public goods through a mechanism similar to the market system without the necessity of real polling. The Tiebout hypothesis was formalised by Alonso (1964), Muth (1969) and Ellickson (1971) in the "bid and sorting model". According to the bid and sorting model, the amount of money every agent is willing to pay for land and/or housing services depends on the location (i.e. the distance from the central business district), on the local tax public benefit package, and on the quality of the local amenities.

[2] According to the Henry George theorem, the aggregate land values equal the discounted present value of expenditure on local public goods. For a general analysis of the theorem see Arnott and Stiglitz (1979), who showed that the Henry George theorem is quite general and holds whether or not the level of the pure public good is optimal. The Figure and thoughts of Henry George are well described by Heilbroner (1995).

mechanism and the capitalisation of local fiscal variables in housing values.

Oates (1969) employed a cross-section of north-eastern New Jersey communities for the year 1960, and regressed the median value of housing on the effective property tax rate, per pupil expenditure, and a set of control variables. The final results provided robust empirical evidence in support of his claim that the negative capitalisation of the property tax and the positive capitalisation of the local public expenditure in the housing values were the direct result of the Tiebout mechanism. After a few years, however, Edel and Sclar (1974) and Hamilton (1975, 1976) challenged Oates's approach, suggesting that in the long run the Tiebout hypothesis should result in zero capitalisation. However, the early ambiguous relation between the Tiebout hypothesis and capitalisation was finally disentangled in Oates's favour. In fact, most of the theoretical contributions that followed reached the conclusion that the capitalisation of local fiscal variables in housing values was necessary to reach the equilibrium envisaged by Tiebout, according to which local public services are provided efficiently when the locational choices are such that nobody can be better off from changing jurisdiction.

Let us briefly review the main theoretical contributions that followed Oates's seminal paper. Among others, Pauly (1976) showed that local fiscal variables are capitalised in house values if local public goods are provided inefficiently, because to reach the Tiebout equilibrium housing prices must fall in places where the level of public goods is not in line with consumers' tastes. This is a direct consequence of the contraction in the demand for houses relative to jurisdictions in which local services are provided in line with consumers' preferences. Arnott and Stiglitz (1979) employed a residential location model to show that in equilibrium, in which the locational choices are such that nobody can be better off moving to another jurisdiction, the difference in the aggregate land rents between two open communities with identical individuals, who have the same public expenditure but differ in fiscal efficiency, equals the difference in the aggregate valuation of public services. This result indicates that in an open urban economy with identical individuals, after adjustments for other differences between the communities, one can make valid inferences concerning the differences in the valuation of councils' fiscal packages (or fiscal efficiency) from the differences in their aggregate land rents.[3]

Epple and Zelenitz (1981) constructed a model of urban political economy that explains why the relationship between capitalisation and the Tiebout hypothesis can be ambiguous. Their paper shows that the structure of the housing supply plays a key role in the characterisation of the Tiebout equilibrium. In the case of perfectly elastic supply, which corresponds to the possibility of creating a new jurisdiction without limits and without costs, empirical evidence of the Tiebout hypothesis is the absence of capitalisation,

[3] Arnott and Stiglitz (1979) also showed that in the case of heterogeneous individuals, capitalisation still occurs, but the differences in aggregate land rents across communities systematically understate the value of differences in positive characteristics and overstate the value of differences in negative characteristics.

as advocated by Edel and Sclar (1974). Instead, under the more realistic assumption of jurisdictions with fixed boundaries (which entails in the extreme case a rigid housing supply, as usually assumed in the literature), differences in tax rates or in the level of public services would be capitalised in housing prices in equilibrium, hence Oates's (1969) test of the Tiebout hypothesis is correct.

This important point is illustrated in Figure 2.1, in which we represent the housing market equilibria that can arise after a shift in the demand from D to $D\prime$ due, for example, to a reduction in the local property tax rate or an increase in the quality of local services. In the case of a fixed boundary, the supply function is S^b and the equilibrium moves from A to B, generating an increase in price from p^* to p^b, which gives us a measure of the capitalisation of fiscal variables in the price of housing. In the case of a perfectly elastic supply function S^a, instead, the equilibrium moves from A to C and we observe no capitalisation since $p^a = p^*$. Epple and Zelenitz (1981) concluded their analysis by advocating that in the case of fixed boundaries local fiscal variables must also be capitalised in the price of housing because competition among local jurisdictions cannot prevent bureaucrats' rent-seeking behaviour. In other words, the presence of fixed boundaries does not prevent local governments from setting the level of property tax above its efficient level, which produces capital losses for the homeowners whose assets cannot be moved to another jurisdiction that instead sets local taxes more efficiently.

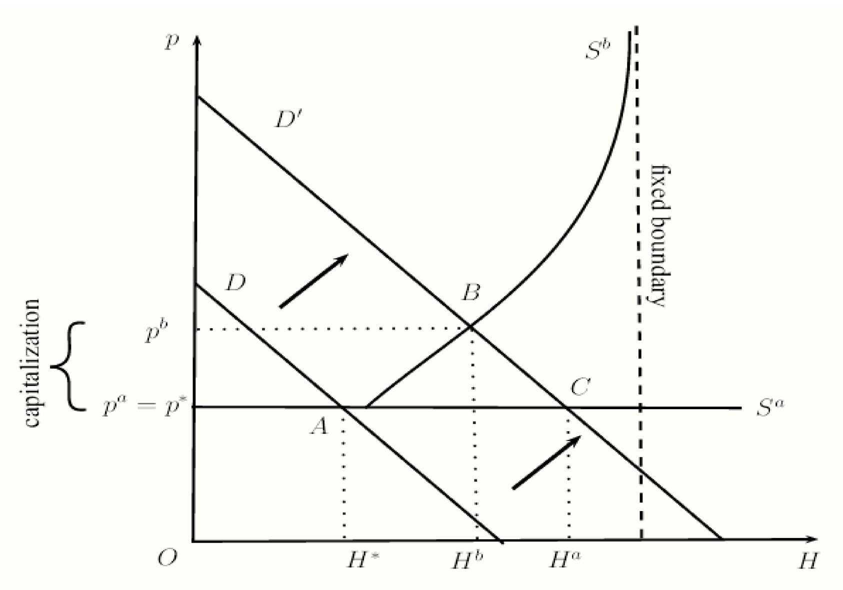


Figure 1: Structure of the housing market and level of capitalisation of local fiscal variables in the price of housing.

Yinger (1982) proposed a model of urban political economy in which, differently from previous studies, households can be of two types: first, movers, whose willingness to pay for housing services increases with the level of local public benefits and determines the equilibrium price in the housing market of the urban area; and second, resident homeowners, who vote for the levels of local fiscal variables and the level of the local public services that maximise the quality of local public goods. In equilibrium, although changes in the services tax package do not alter residents' annual payment for housing, because resident households consider their housing services and prices as fixed, they do alter what movers bid for housing generating capital gains or losses on the residents' houses. The paper shows that in this framework residents behave as if they are selecting the level of local services that maximises the value of their property. Moreover, capitalisation is shown to be a constant characteristic of the Tiebout model. Capitalisation can never disappear, according to Yinger, even in the long run. Amenities (like the distance from the central business district), in fact, cannot be eliminated and the housing supply can never be perfectly elastic, because even if developers can costlessly create new jurisdictions, once the price of housing services equals the agricultural rent, there will be no incentive to add new communities. Only the very restrictive and unrealistic assumptions of effective fiscal zoning and no service variation can eliminate capitalisation. Finally, Pogodzinski (1988), using a generalised and refined version of Yinger's (1982) model, showed again that local fiscal amenities are unambiguously positively capitalised in housing values.

2.2 Empirics

The empirical literature on capitalisation assumes, either implicitly or explicitly, a Tiebout framework in which citizen-consumers move in response to variations in the tax–local benefit packages among jurisdictions. The main scope of this literature has always been that of evaluating the degree of capitalisation of local taxation (mainly property taxation) and the degree of capitalisation of local public benefits in housing values. In this respect, empirical capitalisation studies complement the theoretical models discussed earlier.[4]

Oates (1969), already mentioned at the beginning of the section, produced the first important paper on the subject and started a new stream of literature using the results on capitalisation as a test for the Tiebout mechanism.[5] Rosen and Fullerton (1977) focused their attention upon the measurement of local public benefits; they criticised Oates's approach to measuring local public benefits using expenditure data, because inputs are not likely to be a good measure of outputs. Therefore, they replicated Oates's analysis, replacing per pupil expenditure with student test scores. The final results show that when such information is included in the analysis, the estimates are more consistent with theoretical predictions than when expenditure levels are used.

[4]Consider Ross and Yinger (1999, par. 3) for a complete survey.

[5]Other recent empirical tests for the Tiebut mechanism, not considered here, are based on the measurement of the migration movements; see for example Banzaf and Walsh (2008).

Brueckner (1979, 1982) proposed a different empirical approach: he developed a bid-rent model of property value determination showing that Tiebout efficiency is achieved when aggregate property values are maximised. Therefore, in order to test whether local public goods are produced efficiently, Brueckner regressed property values over local public expenditure and some control variables, and then tested the null hypothesis of Tiebout efficiency according to which small changes in public spending should have no effect on property values. The final results provide evidence in favour of over-provision of public goods in a sample from north-eastern New Jersey communities and no systematic tendency either to under-provide or over-provide public goods in a sample of Massachusetts communities.

Yinger et al. (1988) reviewed many studies that provide empirical evidence that variation in property taxes, both across and within jurisdictions, is negatively capitalised in the price of housing, supporting the theoretical prediction of the Tiebout models. However, as Oates (1969) immediately realised, when the value of houses is regressed on the property tax, it is necessary to cope with the endogeneity of the tax rate. This problem, along with other empirical issues related to the estimation of the property tax capitalisation rate, have been addressed by Palmon and Smith (1998, 1999), who provided further evidence in favour of the negative capitalisation of the property tax.

Finally, another stream of the empirical literature has employed the "hedonic approach" developed by Rosen (1974) in order to infer individuals' valuation of local amenities and local public goods through the degree of capitalisation of their benefits in the price of housing. This approach has been used to a large extent, especially in applications to the role of accessibility in the determination of housing values (Martellato et al. 1998; Bichsel 1999; Debrezion et al. 2006) and to measure the capitalisation of schools' performance on the price of housing (Black 1999, Bogart and Cromwell 2000, Gibbons and Machin 2003, Reback 2005, Kane et al. 2006, Fack and Grenet 2010).

Gyourko and Tracy's (1989) study is, as far as we could check, the closest to ours. This paper investigated for the first time the degree of capitalisation of local government inefficiency in the value of houses. The negative relationship between wasteful local expenditure and the price of housing was derived by introducing a rent-seeking local public sector in a simple Tiebout model based on the main assumptions of costless mobility and a fixed housing supply.

In the empirical section, local governments' rent-seeking behaviour is measured in terms of local public employees' compensation in excess of the predicted wage estimated using US data from the 1977 Current Population Survey. The difference between a specific public employee's wage and its estimated level can be seen as a measure of local government inefficiency. The sample is composed by a cross-section of 36 central cities throughout the United States. The final results provide empirical evidence in favour of the hypothesis that local inefficiency is negatively capitalised in the value of houses, showing that potential residents are compensated through lower property prices in cities where local public employees earn substantially higher wages than similar local public employees earn on average in other cities.

2.3 To sum up

We have seen that the bulk of the theoretical literature on capitalisation leads to the conclusion that the price of housing in a jurisdiction reflects the "value" of the tax–public good package offered in that jurisdiction. This is a very neat result that, in the end, requires only two necessary assumptions: first, the basic assumption of the Tiebout model, i.e. free mobility of citizen-consumers among jurisdictions; second, a housing supply with zero or positive, but not infinite, elasticity. The empirical literature provides evidence that supports the existence of capitalisation of local public benefits and property taxation in the price of housing; the data clearly show that the Tiebout mechanism is not a mere theoretical supposition.

However, at least three problems remain unsolved, and their solutions are required to provide a more accurate empirical analysis: first, all the studies we could review on capitalisation consider local taxes and local public benefits (expenditure) in a separate way; second, it is still not clear how to combine together inputs and outputs of councils' activity in order to evaluate the tax-public benefit package offered by local governments in a comprehensive way; finally, local taxes and local public benefits are usually treated as exogenous variables when, in reality, they should be treated as endogenous.

Moving on from these unsolved problems, this paper provides three contributions to the previous literature. We propose to measure the value of the tax–public package in terms of local government technical efficiency, thereby considering together both the inputs and the outputs of the councils' activity. Then, we show that, in the classical Tiebout framework, the degree of technical efficiency through which the local government provides local services is positively capitalised in the price of housing.[6] The last contribution stems from our empirical analysis, in which we estimate a hedonic model regressing the value of houses on technical efficiency, intergovernmental grants, and other features of the local context. Differently from the paper by Gyourko and Tracy (1989), this paper does not list local tax rates and local public benefits among the regressors because in our model both are endogenous (as usually advocated in the literature). In fact, our approach is to consider the fiscal choices completely determined by technical efficiency, the level of intergovernmental grants, and the features of the local economy. As a result, our capitalisation model is not affected by the problem of tax rates' and local public benefits' endogeneity.

[6] Once controlling for the differences in the local context, the reason why some jurisdictions are less efficient than others can range from the managerial ability to the rent-seeking behaviour of local bureaucrats. Gyourko and Tracy (1989) have already shown that the rent-seeking behaviour of local bureaucrats negatively affects the price of housing, however they did not consider the impact that the rent-seeking behaviour could have had on the level of the property tax.

3 The Theoretical Model

3.1 The model

The theoretical model has the typical ingredients of the Tiebout model. Let us consider a region inhabited by N individuals divided in J jurisdictions with fixed boundaries, all individuals have the same preferences and can move freely from one jurisdiction to the other. Local governments are elected by the residents and are responsible for the production of a pure local public good, their sources of funding are either intergovernmental grants or local taxes.[7]

Every year a sub-set of the N individuals, or households, decides where to live and how much housing services H to buy. Keeping fixed the type and the quality of housing services (residential, commercial, offices or productive activities), households will prefer houses located in jurisdiction j offering the best combination of local public services G and local tax rate t. However, during the sorting process, households can only observe the fiscal packages offered by the local governments. They cannot, in fact, influence local government until they take up residency in the jurisdiction. The problem of the representative individual who prefers a particular type of housing can be framed as follows:

$$v(p, G, t, A, n) \equiv \max_{C,H} u(C, H, G, A, n) \quad s.t. \quad Y = C + pH + tB \qquad (1)$$

where $v(.)$ is the indirect utility function, C and Y are the average level of private consumption and income and A is a measure of local amenities which summarises the environmental features of the local area, that the individual can enjoy in the jurisdiction j. In order to allow for the possibility of congestion n, which is a fraction of N, is introduced. It is endogenously determined. Finally, p is the average price of one unit of housing and B is the average level of the individual tax base in jurisdiction j.[8] The level of income Y, local public services G and local taxation t are exogenous variables from the point of view of the individual since, as stated previously, individuals will influence local government activity only after they become resident in a particular jurisdiction.

The solution to the problem in equation (1) generates the aggregate demand function for housing in each jurisdiction $H^d(Y, p, t, n)$, and the aggregate demand for private consumption $c(Y, t)$. In equilibrium the housing market must clear, as a result:

$$H^d(Y, p, t, n) = H^s(p, T) \qquad (2)$$

[7] It is important to stress that the choice of the tax instrument does not influence the final result, and the same conclusions can be reached assuming a property tax, an income tax, or a head tax.

[8] The tax base B will correspond to the income Y in case of income tax or to the house value in case of property tax, in this last case it is important to note that B should be expressed as a function of the housing demand, for simplicity we ignore this possibility since this does not affect the result and makes only computations more difficult.

where T is the total residential land area in the jurisdiction and the housing supply is assumed to have price elasticity $\eta_p^s \in (0, \infty)$. Finally, using the equilibrium condition of the housing market, it is possible to express p as an increasing function of Y, and as a decreasing function of t:

$$p = f\left[Y_{(+)}, t_{(-)} n_{(+)}, T_{(-)}\right] \tag{3}$$

Moreover, using the equilibrium condition in equation (2) it is possible to show that:

$$\eta_t^p = -2\frac{\eta_t^d}{\eta_p^s} \tag{4}$$

where the elasticity of the price of housing with respect to local taxes η_t^p corresponds to the magnitude of the capitalisation of local taxes into the price of housing. The latter, in turn, depends on the demand elasticity with respect to local taxes η_t^d, and on the price elasticity of the housing supply η_p^s. It is important to note that, η_t^p depends, substantially, from η_p^s since the invariance of individuals' preferences across municipalities implies invariance of η_t^d. Therefore, as pointed out in the literature reviewed in Section 2.1, the magnitude of the capitalisation of local taxes into the price of housing can change across jurisdiction with the supply side of the housing market.

From the above, using the demand function for housing and private consumption, it is possible to characterise the indirect utility function:

$$V = v(p, G, t, A, n) \tag{5}$$

In order to increase the probability of re-election, under the general assumption that individuals who live in jurisdiction j have the same preferences of the potential new residents, local government will choose G and t such that V is maximised. Each local government, however, will set the level of local taxes and the quality of local public services taking into account its budget and technological constraint. Therefore, the problem of each local authority can be framed in the following way:

$$\max_{G,t} v(p, G, t, A, n) \; s.t. \; G = g(x, E); \; x = n(tB + S) \tag{6}$$

where $v(p, G, t, A, n)$ is defined in equation (1), $g(.)$ is the production function, x represents the inputs in terms of local expenditure, E is a measure of technical efficiency - which is a distinctive trait of the council's ability of producing local services -, and S are per capita intergovernmental grants. The production function is assumed to be such that $g'(x) > 0$ and $g''(x) \leq 0$ and the same across jurisdictions since all councils can have access to the same technology. It is important to stress that E is pivotal in our analysis since it captures not only local government technical (in)efficiency but also all kinds of managerial inefficiency including local government rent-seeking behaviour.

In equilibrium each jurisdiction must balance its budget, taking into account the size of local population, the intergovernmental grants S set by the central government and the level of the local tax rates t.

Moreover, considering that in equilibrium free migration implies that utilities are equal across jurisdictions we have the following condition:

$$v(p, G, t, A, n) = V^* \quad (7)$$

Equation (7) shows that, in equilibrium, the maximum utility must be the same everywhere taking into account the local tax rate, the local public good, the price of housing and the level of amenities. Essentially, in equilibrium, the higher benefit deriving from a better fiscal package is compensated by the higher price for housing services.

Therefore, the equilibrium in the housing market (2) and the no-mobility condition (7) define a system of two equations and two unknowns (p, n).

Solving the model (eq. 2 and eq. 7) under the assumptions that each local government adopts a Cournot-Nash strategy choosing the optimal G and t treating other jurisdictions' choices as parameters; C and G are weak complements and B is usually greater that the individual yearly housing consumption H; it is possible to show that (see the proof in the Appendix A) the relationship between the price of housing and the efficiency of local government is:

$$p = f\left[Y_{(+)}, E_{(+)}, A_{(+)}, S_{(+)}\right] \quad (8)$$

3.2 The graphical analysis

In order to summarise the principal relationship between local government efficiency and housing market we propose as an example the following graphical analysis. Figure 3.1 reports the case of a jurisdiction whose level of efficiency declines from E_a to E_b while the other features of the local context remain the same. Panel 1 illustrates the local government problem. The vertical axis measures the quality of local public services G, while the horizontal axis measures the level of per capita local taxes t. The optimal choice of G and t implies the tangency between the highest indifference curve and the budget constraint. In the first period, given the higher level of efficiency, the council is able to achieve a higher indifference curve. This is obtained by setting the level of local taxation (t_a) and the quality of local public services (G_a) below and above, respectively, the optimal values chosen in the second period, when the level of efficiency falls from E_a to E_b. Panel 2 shows the relationship between the price of housing and the level of local taxes when the housing market is in equilibrium (see equation 3). When local public services are provided less efficiently, the difference in the level of efficiency is capitalised in the price of housing; in fact $p_b < p_a$. However, as reported in Figure 3.1, the magnitude of the capitalisation crucially depends on the price elasticity of the housing supply. When the housing supply becomes more elastic, as shown by the dotted line in panel 2, the capitalisation of efficiency in the value of houses

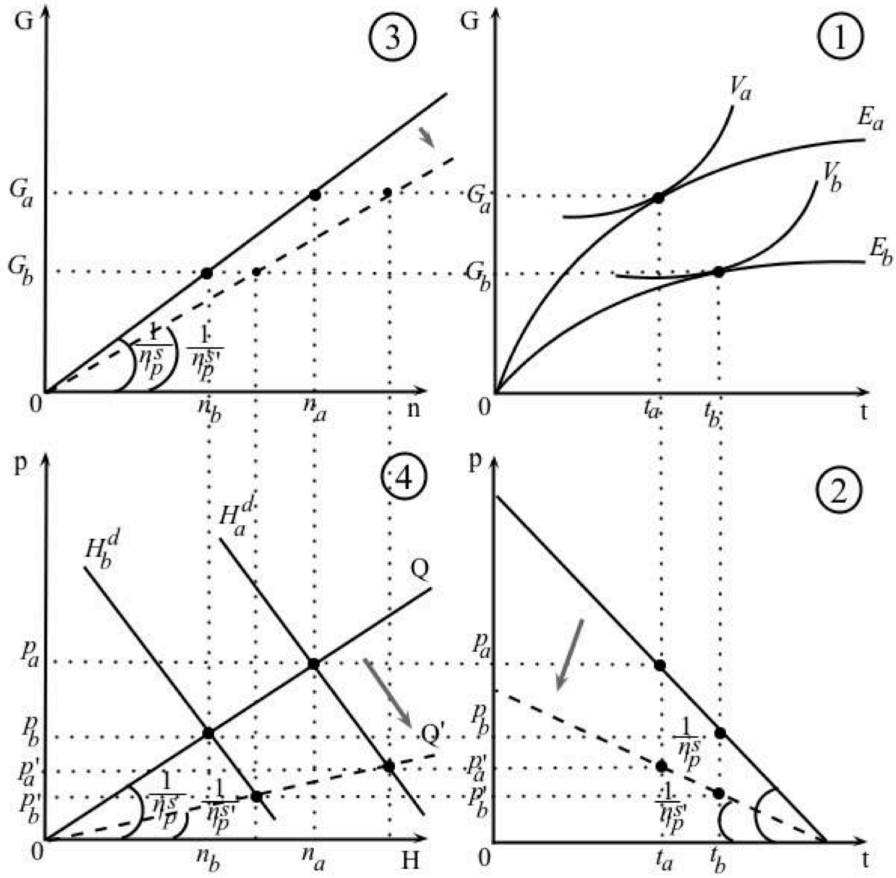


Figure 2: Relationship between the local government technical efficiency and the equilibrium price in the housing market.

decreases (see equation 4). Panel 3 shows the relationship between G and n. When the fiscal package becomes less attractive, free migration produces a decrease in the population from n_a to n_b, which, in turn, as shown in panel 4, yields a downward shift in the demand for housing, from H_a^d to H_b^d. It highlights, once more, the capitalisation of efficiency in the price of housing. Additionally, in panel 4, we also show that a flatter housing supply function leads to a weaker capitalisation as shown, already, in panel 2.

4 Empirical Strategy

4.1 The Cobb–Douglas case

In order to derive an equation that can be tested empirically, we assume, with little loss of generality, a Cobb–Douglas functional form for the households' utility function. The choice of Cobb-Douglas utility function besides the advantage of generating neat results, it allows also to capture the approximate constancy of expenditure shares between public goods, private consumption and housing across jurisdictions and over space.

As a result, the households' problem becomes:

$$\max_{C,H} C^{\alpha} H^{\beta} G^{\gamma} \left(\frac{A}{n}\right)^{\delta} \quad s.t.\ Y = C + pH + tB \tag{9}$$

where the term $\frac{A}{n}$ captures the possibility of congestion and where $\delta > \gamma$ since amenities come free of taxes and, thus, increase households' utility more that a higher level of public good[9].

We can now incorporate the housing market. The individual demand for housing is given by:

$$H^{d} = \left(\frac{\beta}{\alpha+\beta}\right) \frac{Y - tB}{p} \tag{10}$$

Recalling that n is the population of a jurisdiction, the total demand for housing is:

$$nH^{d} = \left(\frac{\beta}{\alpha+\beta}\right) \frac{n(Y - tB)}{p} \tag{11}$$

Since the total residential land area in the jurisdiction is T and defining the structural density of housing as Q, the problem of the housing producer is that of choosing the structural density so as to maximise the profit. Therefore, the housing producer profit-maximisation problem is:

$$\max_{Q} pQ - C(Q) \tag{12}$$

The first-order condition is $p = C'(Q)$. Inverting this function gives $Q = Q(p)$. The supply of housing in the jurisdiction is therefore $TQ(p)$. Thus, the market-clearing condition for housing is:

$$\left(\frac{\beta}{\alpha+\beta}\right) \frac{n(Y - tB)}{p} = TQ(p) \tag{13}$$

Using the demand for housing, the demand for private consumption and the equilibrium in the housing market, we obtain the relationship between the price of housing and the local taxation, as reported in the following equation (14):

$$p = \left(\frac{\beta}{\alpha+\beta}\right) \frac{(Y - tB)}{Q(p)} \frac{n}{T} \tag{14}$$

Under the simplifying assumption of linear supply function we have $Q(p) = mp$, where m can be considered an approximation of the supply elasticity

[9] The literature on agglomeration refers mostly to positive externalities. However, agglomeration, and urban concentrations in particular, may also bring negative externalities such as increased cost, pollution, congestion of local amenities and infrastructures, increased crime and other social problems (Glaeser, 1998; Hanson, 2001; Henderson, 1994 and Quigley, 1998).

$(m \simeq \eta_p^s)$. As a result the relationship between the price of housing and the level of local taxation reported in equation (14) becomes:

$$p = k\left[\frac{(Y - tB)}{m}\frac{n}{T}\right]^{\frac{1}{2}} \tag{15}$$

where $k = \left(\frac{\beta}{\alpha+\beta}\right)^{\frac{1}{2}}$ is a constant term.

The expression for the indirect utility function V (5) becomes:

$$V = k'\left(\frac{A}{n}\right)^{\delta} G^{\gamma}(Y - tB)^{\alpha+\beta}p^{-\beta} \tag{16}$$

where $k' = \left(\frac{\alpha}{\alpha+\beta}\right)^{\alpha}\left(\frac{\beta}{\alpha+\beta}\right)^{\beta}$ is another constant term that is invariant across jurisdictions.

Hence, the local governments' problem is as follows:

$$\max_{G,t} V \ s.t.\ G = n(tB + S + E) \tag{17}$$

For simplicity we assume a linear production function with constant returns to scale, where government's technical efficiency E enters additively.[10] It is important to note that the units in which we measure government expenditure affect only the constant term of the indirect utility function, and in the same way across jurisdictions.[11]

The solution of the constraint maximisation in (17) gives us the optimal level of the local tax revenue:

$$tB = \frac{\gamma Y - (\alpha+\beta)(S+E)}{(\alpha+\beta+\gamma)} \tag{18}$$

Substituting equation (18) into (15), we obtain the price of housing as a function of all the exogenous variables and of total population:

$$p = k^{''}(Y + S + E)^{1/2}\left(\frac{n}{mT}\right)^{1/2} \tag{19}$$

where $k^{''}$ is another constant term.

Recalling that free migration implies that utilities are equal across jurisdictions we can take $V = V^*$ as fixed. Substituting equation (18) and (17) into (16) we obtain the jurisdiction's resident population as a function of all the exogenous variables and of the price of housing:

$$n = \left(\frac{k^{'''}}{V^*}\right)^{\frac{1}{\delta-\gamma}} A^{\frac{\delta}{\delta-\gamma}}(Y + S + E)^{\frac{\alpha+\beta+\gamma}{\delta-\gamma}} p^{-\frac{\beta}{\delta-\gamma}} \tag{20}$$

[10] The results are qualitatively the same if we assume that efficiency enters multiplicatively.

[11] One issue is whether the government treats the price of housing as exogenous or endogenous. Since this goes beyond the scope o this paper we proceed on the assumption that the local government treats the price of housing as exogenous.

where $k^{'''}$ is just another parameter that is invariant across jurisdictions.

Equation (19) and (20) provide us with a system of two equations in two unknowns, p and n. The solution with respect to the price of housing, reported in the following equation (21), gives us the relationship between p and the local government's efficiency E, equivalent to equation (8).[12]

$$p = k^{''''} A^{\frac{\delta}{2(\delta-\gamma)+\beta}} E^{\frac{\gamma}{2(\delta-\gamma)+\beta}} (Y+S)^{\frac{\alpha+\beta+\delta}{2(\delta-\gamma)+\beta}} (mT)^{-\frac{\delta-\gamma}{2(\delta-\gamma)+\beta}} \tag{21}$$

Under the assumptions that citizens have similar preferences across jurisdictions[13], the capitalisation of local government efficiency in the price of housing will be evaluated by estimating an empirical model based on equation (21).

4.2 The empirical model

Given the structure of our dataset, we estimate the linear fixed-effect panel data model reported in the following equation (22) using *least square dummy variables* or the equivalent *within the group* estimator.

$$p_{jt} = \beta E_{jt} + \gamma' \mathbf{Z}_{jt} + \eta_t + u_j + \varepsilon_{jt} \tag{22}$$

where β and γ are now coefficient vectors that will be estimated.

The dependent variable p_{jt} is the natural logarithm of the unit price of housing related to a specific type of property measured in terms of the monthly rent per square metre; E_{jt} is the DEA index of efficiency and β is the main parameter of interest since it captures the degree of capitalisation. $\mathbf{Z}_{jt}$ is a vector of control variables that may influence both the price of housing and the provision of local public services. It contains variables such as the household income (Y), the per capita intergovernmental grants (S), the extension of parks and gardens (A), etc. Finally, η_t is a set of year dummies, u_j is the municipal fixed effect, and ε_{jt} is the *i.i.d.* error term.

It is important to stress that the impact exerted by the structure of the supply side of the housing market, related to the slope of the supply function m and to the total residential land area in the jurisdiction T, is captured by the municipal fixed effect given the short-run horizon of our analysis.

According to elementary valuation theory, housing value (W) equals the present value of future rents, therefore, the relationship between p and W is as follows:

$$W = \frac{p}{r-g} \tag{23}$$

where r is the interest rate and g the future growth rate of rents.[14]

[12] In equation (21) $k^{''''}$ is just another parameter that is invariant across jurisdictions.

[13] The assumption of similar preferences is supported by the fact that the sample is made up of similar municipalities located in the same country.

[14] In more sophisticated valuation theory, differences across jurisdictions in the degree of uncertainty about the future growth rate affect the rent-to-value ratio too.

Therefore, if we consider as a dependent variable the value of houses instead of the value of rents, the empirical model based on equation (21) becomes:

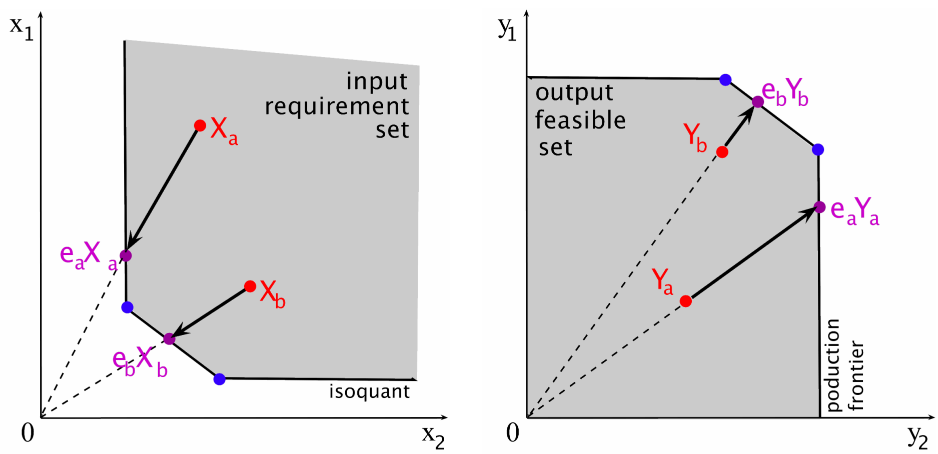
$$W_{jt} = \beta E_{jt} + \gamma' \mathbf{Z}_{jt} + \theta(g_{jt} - r_{jt}) + \eta_t + u_j + \phi_{jt} \tag{24}$$

where the dependent variable W_{jt} is the natural logarithm of the unit price of housing related to a specific type of property measured in terms of the housing market values per square metre.

Since it is likely that different jurisdictions face the same interest rate r and the same expectations about the rate of growth of rents g, the impact of these two new variables is mostly captured by the years dummies. Therefore, thanks to the panel structure of our dataset, and to the fact that the municipalities of our analysis share the same interest rate and the same general structure of the housing market, the parameter β in (24) captures the relationship between local governments efficiency and housing values with a good level of approximation.

4.3 Measurement of efficiency

The main issue for the estimation of model (22) is the estimation of the level of technical efficiency E achieved in the provision of local services by each council j in each year t. To this end, *Data Envelopment Analysis* (DEA hereafter) is used as a non-parametric estimator of the *Debreu–Farrell* index of technical efficiency (D-F hereafter).



(Input approach) (output approach)

Figure 3: Graphical representation of the Debreu-Farrell index of technical efficiency.

In order to obtain a general idea about the D-F measure of technical efficiency, let us consider the two graphs in Figure 4.3 related to the input and the output approach, respectively. In the input approach case, on the left-hand side, let us consider the input requirement set necessary to produce one unit of output assuming a two-input/one-output production function. For simplicity let us focus our attention only on two input combinations: X_a, X_b. Both X_a and X_b are inefficient because they lie inside the input requirement set and their indices of efficiency are the scalars $\frac{\overline{0e_aX_a}}{\overline{0X_a}}$ and $\frac{\overline{0e_bX_{jb}}}{\overline{0X_b}}$, which correspond to the minimum proportional reduction in both inputs necessary to hit the isoquant along the ray that connects the input combination to the origin. A similar argument works in the case of a two-output/one-input production function (output approach) displayed on the right-hand side of Figure 4.3. The indices of efficiency are, in this case, the scalars $\frac{\overline{0Y_a}}{\overline{0e_aY_a}}$ and $\frac{\overline{0Y_b}}{\overline{0e_bY_b}}$, which correspond to the proportional increase in output required to hit the production frontier, keeping the quantity of input fixed.

DEA allows the estimation of the isoquant (or the production frontier) along with the distance of each input (output) combination from the frontier through linear programming. In the case of the input approach, the DEA *input index* $e_{jt}^{IN} \in (0,1]$ has, therefore, the following intuitive interpretation: if council j was using the technology efficiently at time t, its inputs could all be scaled down by a fraction $1 - e_{jt}^{IN}$ and it would still be able to produce the same quantity of outputs. In the case of the output approach, the *DEA output index* $e_{jt}^{OUT} \in (0,1]$ has a similar interpretation: if council j was using the technology efficiently at time t, its outputs could all be scaled up by an amount $\frac{1}{e_{jt}^{OUT}} - 1$, whilst using the same quantity of inputs. Therefore, with both approaches, a fully efficient municipality will have an index equal to one.

DEA allows us to handle production functions with many outputs and many inputs (as in this case) and does not require any restriction on the shape of the production function. The only assumptions required are the convexity of the input requirement set and free disposability. However, it has been proved that DEA is an upward-biased estimator of the true D-F index of technical efficiency[15] and, on top of that, its rate of convergence slows down as we increase the number of inputs and outputs, as can be seen in the following equation (25), where l is the number of inputs and q is the number of outputs (see Kneip et al. 1998 for more details).

$$\widehat{e} = e + O_p(n^{-\frac{2}{l+q+1}}) \tag{25}$$

Therefore, DEA estimates may not be reliable in small samples. Even if we have a sample of more than 500 observations, to take into account these problems and to analyse the statistical property of the indices of efficiency, we use an i.i.d. non-parametric bootstrap (as suggested by Simar and Wilson 1998, 2000, 2007) to estimate a bias-corrected measure of efficiency together with the 95% interval of confidence.

In order to verify the influence of the bias, we adopt the following procedure: first, we implement the bootstrap procedure proposed by Simar and

[15]Essentially, the bias is due to the piecewise shape of the DEA production frontier that by construction lies inside the true unobserved production frontier. As a result, DEA underestimates the distance of all input/output combinations from the true frontier, providing an upward-biased measure of efficiency.

Wilson (1998, 2000, 2007) to estimate a bias-corrected measure of efficiency (see Appendix D for more details); subsequently, to test the precision of this new measure of efficiency, a sample of bias-corrected indices is constructed using only efficiency scores considered statistically significant according to the criteria listed below, which must hold simultaneously. First, we retain those observations for which the mean-square error of the bias-corrected efficiency score is smaller than the mean square error of the biased measure of efficiency (as recommended by Simar and Wilson 2007). Second, we calculate the quartiles of the distribution of the bias-corrected index of efficiency, then we retain an observation only if the 95% interval of confidence lies entirely in one quartile, otherwise we drop it. Since the Simar-Wilson correction procedure shows that the bias is irrelevant for the main analysis we use the original data, while values obtained with the procedure are reported as robustness check (see Section 6.3 and Table 11 in the Appendix C).

4.4 The data

The empirical analysis is based on Italian municipalities, the lowest level of government in Italy. In Italy there are more 8,100 municipalities, but most of them are very small, counting no more than 15,000 inhabitants. Because of that, most of the data we need are available only for a small group of municipalities, namely the provincial capitals corresponding to the largest Italian cities; therefore, the cross-section dimension of the data set shrinks to 111.[16] Information about the housing market refers to the period 2002–2007; this time span defines the time series dimension of our data set. Council efficiency is computed in relation to the urban transport sector, which, as stated earlier, we believe can be considered a good proxy for the overall council efficiency. Not only this sector absorbs 25% of the total municipal capital expenditure and 10% of the total municipal current expenditure (see Figure 4.4) but also, the current expenditure on transport services is correlated at 70% with the total current expenditure (the highest among the 5 top areas of expenditure except general affairs). Moreover, the outcome of the urban transport services is measurable and highly visible to all kinds of citizens (residents and non-residents) and its perceived quality and performance is easily determined. Finally, during electoral campaigns, issues related to the transport service are usually among the most debated.

[16]It is important to stress that the two following groups of municipalities have been excluded from the dataset since have been recognised as outliers. The first group of outliers includes Roma, Milano, Torino, Genova, Napoli, Venezia and Catania that are characterised by a more complex production function because, differently from the other municipalities, provide also a metro service or, like in Venice, shipping services. The second group of outliers includes Aosta, Bari, Bergamo, Cagliari, Cosenza, Firenze, La Spezia, Messina, Pescara, Rimini, Siena, Trapani, Trento and Trieste, where at least one of the output measures or the level of per-capita expenditure are either above or below the 99th percentile. As a result the final cross-sectional dimension of our dataset shrinks from 111 to 90. All the summary statistics reported in the paper are based on this final restricted sample.

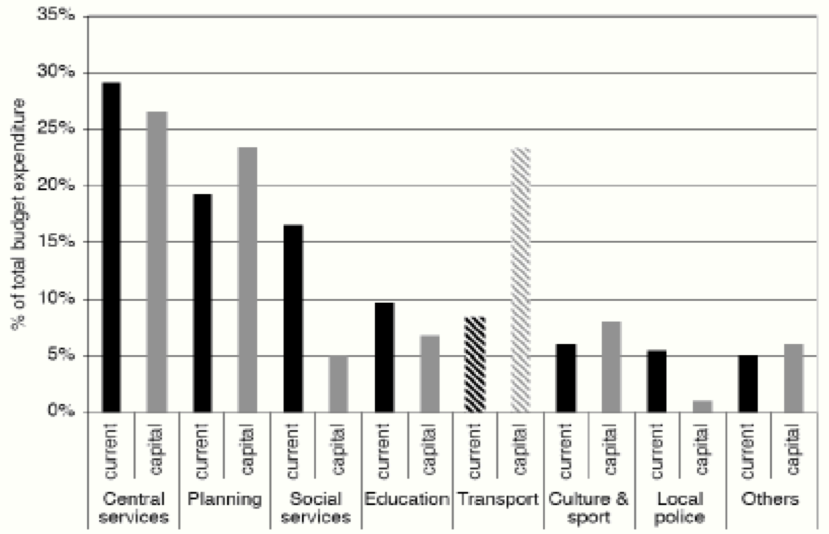


Figure 4: Structure of the municipal expenditure by sector, year 2007.

In the computation of DEA indices of efficiency, as a measure of output we are using the transport indicators published by the Italian Institute of Statistics (ISTAT) for the same period. As reported in Table 3 of the appendix, five measures of output are used: the number of seats available per 1,000 inhabitants for each km of network, the number of accidents per 1,000 inhabitants,[17] the density of the network, the number of carriages per 1,000 inhabitants, and finally the density of stops. As a measure of input (also reported in Table 3 of the appendix) we are using the per capita real current and capital budget expenditure related to the urban transport sector collected from the municipal budget accounts published by the Ministry of the Interior for the period 1998–2007. To account for the long-term nature of the capital expenditure we compute a four-year moving average including the capital expenditure registered in the current and in the three previous years.

The data relating to the rents and the value of houses were provided by the Ministry of Finance following a specific request. As far as we could verify, at the moment, this is the best source of data disaggregated at the municipal level relating to the Italian housing market. Prices are collected on a six-month basis through direct data gathering starting from the second half of 2002.[18] The data come from several sources, such as real estate agencies, auctions, acts of sales, etc. Moreover, prices are available for different types of properties classified according to their use (e.g. residential, commercial, etc.), their location (city centre, suburban zones, etc.), and their quality (e.g. normal, historical, luxury,

[17]As output we used the inverse of this variables.

[18]For each year we used prices collected in the second semester.

ruined, etc.). This segmentation allows us to account for the characteristics of the houses, which may exert a huge impact on the price, without embarking on the impossible job of collecting detailed information about the specific features of the properties.

In particular, in our analysis we are considering only the real estate in normal conditions, classified into four categories: residential, commercial, offices, and productive activities located in the city centre or in the suburban zone. Table 4 of the appendix reports the summary statistics related to the monthly rents per square metre. The lowest rents are registered, on average, for properties used for productive activities and located in suburban areas. The highest rents are registered, instead, for commercial properties located in the city centre. Table 5 of the appendix reports the summary statistics related to the value of houses per square metre. The lowest prices are registered, on average, for properties used in productive activities and located in suburban areas, and the highest prices are registered for commercial properties located in the city centre.

Table 6 of the appendix reports the summary statistics of the control variables, namely the variables related to the local context that can exert an impact either on the provision of the urban transport service or on the price of houses. Among them we can list the number of residents, the local GDP, and a set of variables related to the urban transport sector, such as the number of cars per 1,000 inhabitants. Finally, we also included a set of dummy variables to capture the impact of the local ruling party.

The summary statistics of the control variables that can affect only the price of housing are reported at the bottom of the Table. In particular, we use the intensity of the housing market, equal to the ratio between the percentage of transactions and the total stock of properties, as a proxy for the housing supply in equilibrium. We use also the per capita square metres of parks and gardens as a proxy for the general amenities that may influence the housing demand.

5 Empirical Results

5.1 Properties of the efficiency index

Using a sample of 540 observations (90 provincial capitals observed over a period of 6 years) we have computed DEA indices of efficiency (both in case of input and output approach) along with their bias-corrected values and their 95% interval of confidence following the procedure described above in Section 4.2.

Figure 5.1 and Figure 5.1 report the patterns followed by the bias-corrected indices of efficiency and their 95% interval of confidence respectively across time and across Italian regions ordered from north to south. Efficiency scores follow, on average, a decreasing time trend and it is possible to note that the municipalities of the north exhibit the highest level of efficiency while those in the south the lowest.

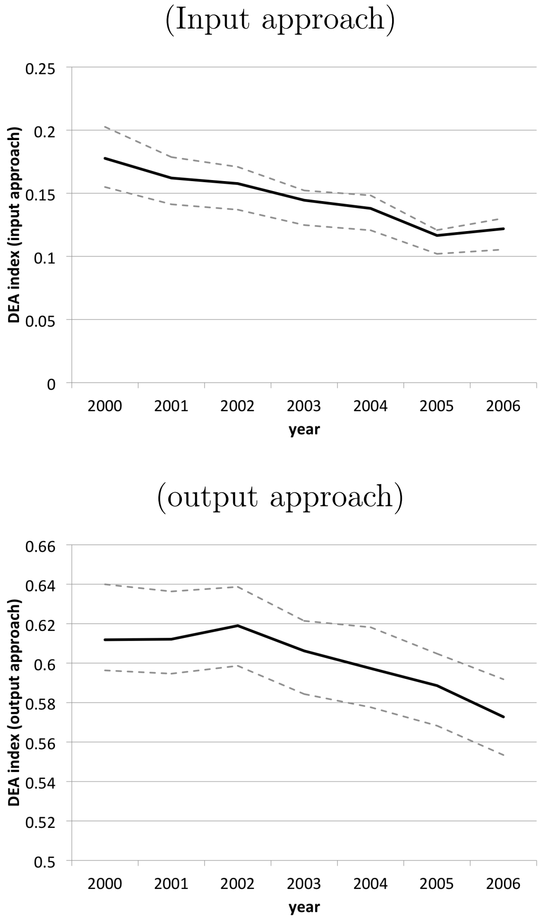
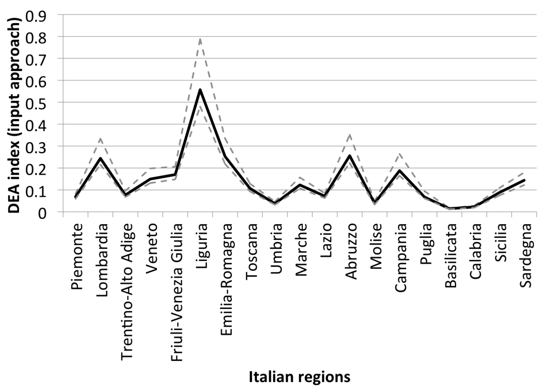


Figure 5: Average DEA scores across years.

5.2 Relationship between the price of housing and local government efficiency

Table 1 reports the first set of point estimates obtained for the coefficient β of the empirical model in equation (22). The price of housing has been measured in terms of the monthly average rent per square metre registered in the city centre, considering only properties in normal conditions. Each cell corresponds to a different model. In the first two rows we report the point estimates obtained without including the control variables in the case of the input and of the output approach. The last two rows report the estimates obtained including all the control variables. Each column corresponds to a particular type of property; this segmentation allows us to control for the influence exerted on the price by the intrinsic characteristics of the property. Given that we are using a log-log specification, the coefficients' estimates can

(Input approach)



(output approach)

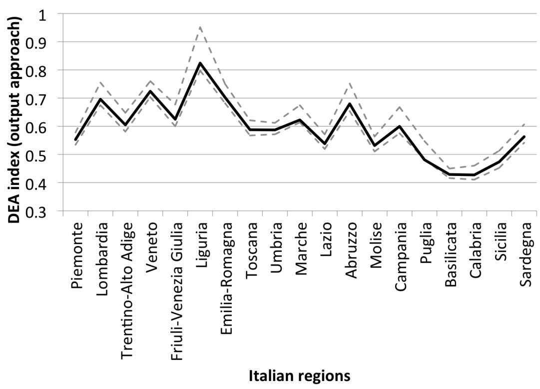


Figure 6: Average DEA scores across Italian regions.

be interpreted in terms of elasticity; therefore, they tell us the percentage increase in the monthly rent per square metre related to a 1% increase in efficiency. In particular, a very significant result can be observed in the case of residential properties, for which the degree of capitalisation of local government efficiency varies from 5% to 28%, and in the case of offices, for which it is stable at 4%. All standard errors are clustered at the municipal level.

In Table 2 the price of housing is measured in terms of the monthly average rent per square metre registered in the suburban area, considering again only the properties in normal conditions. In this case we observe a very significant result in relation to properties used for production activities, for which the degree of capitalisation varies from 7% to 33%, and in the case of commercial properties, for which the degree of capitalisation is stable at around 5%.

Table 1: Point estimates of the relationship between local government efficiency and the price of housing. Monthly rents in the city centre.

Approach	Controls	Residential	Commercial	Offices	Prod. Activities
Input	No	0.05***	0.02	0.04**	0.00
		(0.02)	(0.02)	(0.02)	(0.01)
Output	No	0.23**	0.13	0.13	0.09
		(0.11)	(0.11)	(0.11)	(0.08)
Input	Yes	0.05**	0.04	0.04**	-0.02
		(0.03)	(0.03)	(0.02)	(0.02)
Output	Yes	0.28*	0.18	0.15	0.13
		(0.16)	(0.20)	(0.13)	(0.12)
Observations		540	540	540	540
Municipalities		90	90	90	90
R sq.		0.42	0.18	0.29	0.49

Clustered standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%

6 Robustness Checks

6.1 The price of housing in terms of house values

As a first robustness check, the price of housing is measured in terms of the average house value per square metre, considering only properties in normal conditions.

Table 7 in the appendix shows the point estimates obtained for the coefficient β of the empirical model in (22) registered in the city centre. Similarly to Table 1, it is possible to observe significant evidence in support of the hypothesis of positive capitalisation of efficiency in the price of housing in the case of residential properties and offices, although the magnitude is lower and tends to zero when the control variables are included.

Table 8 of the appendix reports the same point estimates registered in the suburban area. Still we obtain evidence of positive capitalisation, although, as in the case of rents (see Table 2), the magnitude tends to zero when we include the control variables.

6.2 The inclusion of capital expenditures

Tables 9 and 10 of the appendix are related to the second robustness check. Now in the estimation of efficiency we consider, among the inputs, not only the current budget expenditure but also the capital budget expenditure.

In Table 9 the price of housing is measured in terms of the monthly average rent per square metre; as in Tables 1 and 2 it is possible to observe robust evidence in support of the hypothesis of positive capitalisation of efficiency in

Table 2: Point estimates of the relationship between local government efficiency and the price of housing. Monthly rents in the suburban area.

DEA approach	Controls	Residential	Commercial	Offices	Prod. Activities
Input	No	0.04	0.05**	0.02	0.07***
		(0.03)	(0.02)	(0.02)	(0.02)
Output	No	0.02	0.13	0.10	0.33**
		(0.02)	(0.13)	(0.12)	(0.13)
Input	Yes	0.04	0.06*	0.03	0.09**
		(0.03)	(0.03)	(0.02)	(0.04)
Output	Yes	0.12	0.12	0.26	0.42
		(0.21)	(0.19)	(0.17)	(0.27)
Observations		540	540	540	540
Municipalities		90	90	90	90
R sq. (avg)		0.39	0.24	0.32	0.27

Clustered standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%

the price of housing, either in the case of residential properties located in the city centre, or in the case of properties used for production activities located in the suburban area. Instead, in the case of commercial properties and offices, although the point estimates obtained for the coefficient β are still positive, they are not statistically significant.

In Table 10 the price of housing is measured in terms of the average house value per square metre. In this case we can observe robust evidence in support of the hypothesis of positive capitalisation only in relation to residential properties independently of their location.

6.3 The finite sample bias in DEA efficiency index

The Simar-Wilson procedure to estimate a bias-corrected measure of efficiency described in Section 4.3 show that 91% and 81% of the total efficiency scores are statistically significant in the case of the input approach and of the output approach, respectively. Moreover, we found that the Spearman correlation between biased and bias-corrected measures of efficiency is 0.99 and 0.96, in the cases of the input and output approaches, respectively. These results suggests that our indices of efficiency are estimated very precisely and that the bias is, after all, only a minor issue.

Nevertheless, in Table 11 we report the point estimates obtained for the coefficient β of the empirical model in (22) using the smaller sample of robust indices of efficiency. The price of housing is measured in terms of the monthly average rent per square metre. As is apparent, the point estimates are in line with our previous results, providing further evidence in favour of the hypothesis of positive capitalisation of local government efficiency in the price of housing. The point estimates of the degree of capitalisation reported in Table 11 range from 5% to 37% in the case of residential properties located in the city centre. In the case of commercial properties, instead, we register a degree of capitalisation between 7% and 26%. Larger ranges are observed in relation to offices and productive activities.

7 Conclusions

In this paper a simple model of urban political economy is used to show the mechanism through which local government efficiency is capitalised in the price of housing. The theoretical analysis provides the main conditions under which efficiency is capitalised in the price of housing within a general Tiebout framework. It provides a way to measure the local fiscal package using a single indicator, trying to overcome the problem of endogeneity of expenditure and taxation, observed in previous empirical studies. The empirical analysis, based on data related to the urban transport service provided by Italian municipalities over the period 2002-2007, yields robust evidence in support of the hypothesis of positive capitalisation. In particular, our results show that the relationship between the price of housing and local government efficiency is always positive when statistically significant. Its magnitude ranges from 4% to 33%. The final results support the idea that citizens are not completely unaware of the ability of local governments to combine inputs and outputs, even in the Italian context, in which official measures of performance are not available. Moreover, it is possible to conclude that citizens who are able to move and who do not own real estate are able to compensate for the cost (benefit) derived from local government inefficiencies (efficiencies), with a lower (higher) price for housing services. Instead, the cost (benefit) of local government inefficiencies (efficiencies) is entirely borne (gained) by homeowners. It appears, therefore, that citizens would not necessarily dislike places with a heavy local tax burden if the money is used efficiently to produce local services of a high quality compared with those of other jurisdictions. Finally, the results of the empirical study, not only corroborate the theoretical intuition, but provide, also, for the first time, an analysis of the efficiency of the overall urban transport sector, using municipal data.

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A Proof

The capitalisation of local government efficiency into the price of housing is the result of the impact that efficiency exerts on the level of local taxes, therefore it is important to show that, under general conditions, local tax rates and council's efficiency are negatively related. To this end let us reconsider the local government problem in equation (6). Substituting G into (6) we have:

$$v(p(Y,t), g(n(tB+S), E, A), t) = \Phi(t, E) \tag{26}$$

Then, the optimal t is determined by:

$$\Phi_t(t, E) = 0 \tag{27}$$

where subscripts indicate partial differentiation. Using implicit differentiation in equation (27) we have that:

$$\frac{\partial t}{\partial E} = -\frac{\Phi_{tE}}{\Phi_{tt}} \tag{28}$$

Since, by assumption, local authority's objective function V in equation (26) is concave in t, $\Phi_{tt} < 0$. Therefore, in order to show that higher efficiency generates a reduction of local taxes it is necessary that $\Phi_{tE} < 0$ under very general conditions. Using equation (26) it is possible to show that:

$$\Phi_t = (V_t + V_p p_t + V_G g_x nB) g_E \tag{29}$$

So, from equation (29)

$$\Phi_{tE} = (V_{tG} + V_{pG} p_t + V_{GG} g_x nB) g_E \tag{30}$$

The concavity of V with respect to G ensures that $V_{GG} g_x B \leq 0$, g_E is always positive, instead the sign of $V_{tG} + V_{pG} p_t$ is ambiguous. However, from equation (1) we have that:

$$\max u(Y - pH - tB, H, G) = V(G, t) \tag{31}$$

Hence, through implicit differentiation of equation (31): $V_{tG} = -u_{GC} B$ and $V_{pG} = -u_{GC} H$. Therefore, equation (30) becomes:

$$\Phi_{tE} = -\left[u_{GC}(B - Hp_t) + u_{GG} g_x nB\right] g_E \tag{32}$$

As a result $\Phi_{tE} < 0$ if and only if $\frac{B}{H} > p$, a very general result considering that $p_t \in (0, 1)$ measures the degree of tax capitalisation into the price of housing, and the individual tax base B is usually grater than the individual yearly housing consumption H. Moreover, we need also that $u_{GC} > 0$ which implies that the private consumption and the public good are weak complements.

B Descriptive Statistics

Table 3: Output and input variables.Years 2002-2007.

Variables	Mean	Standard deviation		
		overall	between	within
OUTPUT				
Seats km per 1000 inhabitants	1.98	1.00	1.02	0.14
No. of accidents per 1000 inhabitants	6.50	2.20	2.13	0.94
Km of network per 100 km sq. of municipal area	150.13	86.21	88.17	10.42
Carriages per 10000 inhabitants	6.49	2.81	2.93	0.67
No. of stops per km sq. of municipal area	4.22	3.71	3.75	0.18
INPUT				
Current real budget expenditure per capita	79.06	35.00	32.30	15.07
Capital real budget expenditure per capita moving average (years n-3, n-2, n-1, n)	105.94	68.55	55.41	44.46

Source: ISTAT (2008) and Ministero dell'Interno (2010)

Table 4: Housing market rents, property in normal conditions monthly euros per square metre. Years 2002-2007.

Type	Zone	Mean	Standard deviation			Min	Max
			mean	between	within		
Residential	centre	5.81	2.44	2.64	0.63	1.99	17.86
	suburban	4.01	1.53	1.56	0.32	1.40	11.18
Commercial	centre	11.44	6.16	6.59	1.41	3.81	51.48
	suburban	5.55	2.16	2.25	0.48	1.74	17.86
Offices	centre	8.79	2.35	2.34	0.72	4.43	17.84
	suburban	6.02	1.62	1.65	0.64	3.41	15.26
Prod. activities	centre	5.19	2.00	1.99	0.35	2.18	11.68
	suburban	2.98	0.96	0.92	0.29	1.30	7.47

Source: OMI (2010)

Table 5: Housing market values, property in normal conditions euros per square metre. Years 2002-2007.

Type	Zone	Mean	Standard deviation			Min	Max
			mean	between	within		
Residential	centre	1497	645	707	153	502	5397
	suburban	1057	406	384	122	376	3058
Commercial	centre	2126	983	1025	263	678	6908
	suburban	1081	402	412	98	349	3127
Offices	centre	1843	532	566	144	952	4443
	suburban	1271	368	378	112	522	3342
Prod. activities	centre	1100	383	393	81	442	2320
	suburban	610	240	226	59	220	2114

Table 6: Control variables.Years 2002-2007.

Variable	Definition	Mean	Std.Dev.	Min	Max
Resident inhabitants	no.	96502	26799	5728	689511
Local GDP	real euros per capita	5113	4154	1006	25681
Passengers	no. per capita	56	43	1	249
Motorcycles	no. per 1000 inhabitants	84	30	30	218
Limited traffic zones	km sq per 100 km sq. of municipal area	0.95	2.1	0.05	12.73
Cycle paths	km per km sq. of municipal area	21	22	0	126
Cars	no. per 1000 inhabitants	624	46	484	753
Integrated car parks	no. per 1000 vehicles	19	19	1	205
Paying car parks	no. per 1000 vehicles	38	31	2	192
Urban traffic plan approved	dummy	0.73	0.44	0	1
Centre-left council	dummy	0.54	0.5	0	1
Center-right council	dummy	0.38	0.49	0	1
Intergovernmental grants	real euros per capita	519	243	79	1598
Intensity of housing market	% transactions / stock	2.86	0.63	1.06	5.32
Parks and gardens	metre sq. per capita	161	428	2	3091

Source: ISTAT (2009, 2010)

C Robustness Checks

Table 7: Point estimates of the relationship between local government efficiency and the price of housing. House values in the city centre.

DEA approach	Controls	Residential	Commercial	Offices	Prod. activities
Input	No	0.03**	-0.01	0.02*	-0.02
		(0.01)	(0.02)	(0.01)	(0.02)
Output	No	0.16*	-0.01	0.06	-0.01
		(0.10)	(0.02)	(0.08)	(0.11)
Input	Yes	0.01	-0.01	0.03**	-0.04
		(0.02)	(0.01)	(0.01)	(0.03)
Output	Yes	0.03	-0.00	0.09	-0.13
		(0.15)	(0.01)	(0.14)	(0.23)
Observations		540	540	540	540
Municipalities		90	90	90	90
R sq. (avg)		0.44	0.15	0.31	0.30

Clustered standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%

Table 8: Point estimates of the relationship between local government efficiency and the price of housing. House values in the suburban area.

DEA approach	Controls	Residential	Commercial	Offices	Prod. activities
Input	No	0.05*	0.03**	0.02*	0.02*
		(0.02)	(0.01)	(0.01)	(0.01)
Output	No	0.45***	0.07	0.07	0.11
		(0.16)	(0.10)	(0.09)	(0.09)
Input	Yes	0.04	0.03*	0.02	0.01
		(0.03)	(0.02)	(0.02)	(0.01)
Output	Yes	0.16	0.10	0.17	-0.00
		(0.17)	(0.16)	(0.14)	(0.15)
Observations		540	540	540	540
Municipalities		90	90	90	90
R sq. (avg)		0.64	0.23	0.43	0.19

Clustered standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%

Table 9: Point estimates of the relationship between local government efficiency and the price of housing. House rents and current plus capital expenditure.

DEA approach	Controls	Residential	Commercial	Offices	Prod. Activities
City centre					
Input	Yes	0.27	0.06	0.03	-0.00
		(0.17)	(0.07)	(0.03)	(0.03)
Output	Yes	0.81**	0.12	0.04	0.11
		(0.38)	(0.14)	(0.08)	(0.07)
Suburban zone					
Input	Yes	0.12	0.07	0.07	0.17*
		(0.07)	(0.07)	(0.04)	(0.10)
Output	Yes	-0.01	0.10	0.06	0.12
		(0.11)	(0.11)	(0.08)	(0.14)

Clustered standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%

Table 10: Point estimates of the relationship between local government efficiency and the price of housing. House values and current plus capital expenditure.

DEA approach	Controls	Residential	Commercial	Offices	Prod. activities
City centre					
Input	Yes	0.13**	-0.02	0.02	-0.03
		(0.05)	(0.03)	(0.04)	(0.05)
Output	Yes	0.46**	-0.03	0.04	0.06
		(0.17)	(0.10)	(0.09)	(0.12)
Suburban zone					
Input	Yes	0.09*	0.01	0.06	0.01
		(0.05)	(0.04)	(0.04)	(0.04)
Output	Yes	0.15	0.05	0.04	-0.02
		(0.18)	(0.10)	(0.09)	(0.09)

Clustered standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%

Table 11: Point estimates of the relationship between local government efficiency and the price of housing. Bootstrap robust sample. House rents.

DEA approach	Controls	Residential	Commercial	Offices	Prod. activities
City centre					
Input	Yes	0.05*** (0.02)	0.04 (0.04)	0.05** (0.02)	-0.01 (0.02)
Output	Yes	0.37* (0.20)	0.26** (0.12)	0.38 (0.29)	0.23 (0.22)
Suburban area					
Input	Yes	0.05 (0.03)	0.07** (0.03)	0.03 (0.02)	0.10** (0.05)
Output	Yes	0.30 (0.27)	0.36 (0.27)	0.55*** (0.16)	0.78* (0.39)

Clustered standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%

D Bootstrap Procedure

The bootstrap procedure suggested by Simar and Wilson (1998, 2000, 2007) is used to analyse the statistical properties of the estimated efficiency measures and to produce a bias-corrected measure of efficiency.

Let us assume that D-F efficiency indices e related to each local authority j in period t are identically and independently distributed according to the unknown distribution F:

$$(e_{11}, ..., e_{jt}, ..., e_{JT}) \sim i.i.d.F \tag{33}$$

then a smoothed estimator $\widehat{F}$ for F, based on our original DEA indices of efficiency $(\widehat{e}_{11}, ..., \widehat{e}_{jt}, ..., \widehat{e}_{JT})$, is considered. Smoothed estimators are required because there is a boundary problem due to the fact that the efficiency indices are constrained between zero and one. The simplest smoothed estimator is provided by the *Gaussian kernel density* as suggested by Simar and Wilson (1998).

At this stage the bootstrap procedure is made up of the following steps.

1) $J \times T$ draws with replacement are made from the density $\widehat{F}$ to form an *i.i.d.* bootstrap sample $(e^{boot}_{11,b}, ..., e^{boot}_{jt,b}, ..., e^{boot}_{JT,b})$

2) Subsequently the *bootstrap production set* $\widehat{\psi}$ is computed. Considering the input approach, for example, we have the following bootstrap production set:

$$\widehat{\psi} = \ (\widehat{input}_{jt,b}, output_{jt}) \tag{34}$$

where $\widehat{input}_{jt,b} = input_{jt} \frac{\widehat{e}_{jt}}{e^{boot}_{jt,b}}$ for each local authority j in each period t.

3) As a third step, a set of *bootstrap estimates of efficiency* $(\widehat{e}^{boot}_{11,b}, ..., \widehat{e}^{boot}_{jt,b}, ..., \widehat{e}^{boot}_{JT,b})$ is computed using DEA and the bootstrap production set.

4) Finally steps 1 to 3 are repeated B times. In the paper B has been set equal to 3000.

As a result we have the following expression for the bias-corrected indices of efficiency $\widetilde{e}_{jt}$:

$$\widetilde{e}_{jt} = 2\widehat{e}_{jt} - \frac{1}{B}\sum_{b=1}^{B} \widehat{e}^{boot}_{jt,b} \tag{35}$$

The bootstrap variance $\widehat{\sigma}^2$, reported in the following equation (36), will provide an estimate for the variance of the DEA efficiency index $\widehat{e}_{jt}$:

$$\widehat{\sigma}^2 = \frac{1}{B-1}\sum_{b=1}^{B}\left[\widehat{e}^{boot}_{jt,b} - \frac{1}{B}\sum_{b=1}^{B}\widehat{e}^{boot}_{jt,b}\right]^2 \tag{36}$$

In conclusion, using the bias empirical distribution it is possible to compute the 95% interval of confidence inside which should lie our true efficiency D-F efficiency index e_{jt}:

$$\widehat{e}_{jt} - z_{97,5\%} \leq e_{jt} \leq \widehat{e}_{jt} - z_{2,5\%} \tag{37}$$

In (37) z corresponds to the ending points of the bias empirical distribution after deleting $(\frac{1-\alpha}{2} \times 100)\%$ elements from both ends of the distribution (in our case $\alpha = 5\%$).