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Capitalization of local fiscal variables into house prices: Theory and new empirical evidences

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Contents

General Introduction

Since Tiebout (1956), it is generally accepted that property taxes and local public expenditures, as well as a large number of structural and neighborhood characteristics capitalize into house prices.

Tax capitalization is said to occur if, for constant quality of houses in terms of housing structural and neighborhood characteristics, an increase in the tax liability reduces house values. Let us consider two houses which have the same structural characteristics and are located in the same neighborhood. Suppose that there is a EUR 300 tax bill differential between these two houses. If the relevant discount rate for households is 3%, perfect tax capitalization implies that the house with the lower tax bill will be compensated by a $300/0.03 = \text{EUR}$ $10,000$ higher house value. Imperfect capitalization induces that the house values differences will not be equal to the present value of the stream of future property taxes; for example, if the difference of house values between two comparable houses is only EUR 5,000, the tax capitalization rate is 50%.

Empirical capitalization studies are based on two approaches. The most popular, the hedonic approach, establishes a relationship between house prices and the different amenities that characterize houses. Hedonic prices are based on the pioneering theoretical works of Lancaster (1966) and Rosen (1974), and have been used to develop index housing prices and to estimate individuals' willingness-to-pay for various attributes which are not traded on explicit markets (for example, air quality and parks). The second technique is based on the asset pricing approach and has been largely used in the literature on financial markets. House value is defined as the present value of net-of-tax rental values generated to the owner.

As noted by Fischel (2001) and Oates (2006) there is an abundant literature on the capitalization of local fiscal variables into house values. The major part of the literature is based on US

data. Early contributions, like Oates (1969), King (1977) and Reinhard (1981) are based on aggregate data and focus on the extent to which property taxes capitalize into property values. Subsequent empirical literature can be viewed as an attempt to improve the econometric techniques employed to estimate the impact of local fiscal variables on housing prices. Pollakowski (1973) points to a lack of control variables and the presence of omitted variables bias in the original Oates's estimation. These problems have been partially solved by capitalization studies that use micro data and include a greater number of control variables, as in Wales and Wiens (1974), Chinloy (1978), Ihlanfeldt and Jackson (1982) and Yinger et al. (1988).

While the literature provides a profusion of evidence on capitalization, there is still a controversy on the extent to which local fiscal variables capitalize into house values (Palmon and Smith, 1998a) and on the appropriate interpretation one must have with respect to the Tiebout hypothesis. Oates (1973), Church (1974) and Reinhard (1981) report full or overcapitalization. Rosen and Fullerton (1977), Richardson and Thalheimer (1981) and Palmon and Smith (1998b) find intermediate rate of capitalization. Wales and Wiens (1974), Chinloy (1978) and Gronberg (1979) do not find any significant tax capitalization effects.

In contrast to Oates (1969), another strand of literature considers capitalization as a short term phenomenon that follows from a shortage of housing supply and that should disappear over time. Capitalization does not describe a full Tiebout equilibrium. Henderson (1985) and Henderson and Thisse (2001) stress the assumption of the role of active land developers in a context of flexible jurisdictions' boundaries. In such configuration, interjurisdictional housing prices differentials are impossible because land developers reallocate strategically land use in order to catch the profits that stem from capitalization. The communities with desirable fiscal bundles expand over the communities with relatively high taxes and low quality of public services. Moreover, Hamilton (1976a) argues that, in the long run, there is no reason preventing land developers from creating new communities with the desired fiscal bundle, which will eliminate the capitalization of tax and public expenditures into property values. In contrast to the no-capitalization faction, Yinger (1981, 1982) argues that capitalization is a feature of long-term equilibrium. He argues that as land developers create new communities that are under-supplied or housing suppliers build new houses in scarce communities, land becomes scarcer and prices rise. When the cost of converting land from

non-residential to residential use is too high it becomes not profitable for land developers to supply new houses or create new communities. All remaining variation in local fiscal variables is thus capitalized into house values and capitalization occurs even in the long-run.

This debate on the existence of capitalization and its meaning has important practical implications for the efficiency conditions of local public goods provision. Starting with the contribution of Oates (1969), the outcome of a significant degree of tax and public expenditures capitalization was interpreted as a test of the Tiebout hypothesis. Consequently, capitalization of local fiscal variables was often interpreted as a Pareto efficient provision of local public goods. The theoretical argument of Hamilton (1976a) and Henderson (1985) implies in contrast that the Tiebout hypothesis is supported empirically by the *absence* of any correlation between property taxes and house values.

Surprisingly, while it has been raised in the 70's, the question of the persistence of capitalization has not received a definitive answer. Moreover, this debate has recently received new attention by the literature. Brasington (2002) and Hilber and Mayer (2001, 2009) give some support to the no-capitalization faction and show with US data that capitalization decreases in response to housing supply. This thesis aims to contribute to the debate on the existence of capitalization and investigates whether housing supply reaction effectively takes place in practice and whether it affects the degree to which local fiscal variables capitalize into property prices. Since housing supply may or may not react depending on various factors such as the flexibility of jurisdictions' boundaries, the presence of active land developers, the question of the persistence of the tax capitalization is essentially an empirical one. The objective is precisely to empirically determine whether capitalization *actually* persists across space and over time. The extent to which tax and public expenditures capitalize into house values is not only an academic issue but also has several important practical implications. The degree of capitalization is important for fiscal equity. In the absence of capitalization, an increase in property tax payment will not affect the market price of houses. This implies that current homeowners can escape the burden of taxation and transfer tax increases on the future buyers. In contrast, perfect capitalization ensures that current homeowners will pay, in the form of lower house values, any increase of tax payment.

This thesis is organized as follows. The first chapter goes back to the theoretical base of the capitalization hypothesis, namely the Tiebout (1956) model. We argue that while this model is invoked by virtually every capitalization study, capitalization of local fiscal variables is not a feature of the Tiebout model as it does not explicitly include property taxation and housing. We present a survey of the Tiebout literature that fills this gap and examine whether efficiency of public services provision holds with property taxes (Hamilton, 1975, 1976b; Hoyt, 1991; Henderson, 1994). The Tiebout model is also relatively silent on what Oates (2006) calls "the supply side of the Tiebout model". Chapter 1 shows that the response of the literature is to introduce different forms of government in models that preserve the essential Tiebout original assumptions. These models may include for example profit maximizing governments (Sonstelie and Portney, 1978; Henderson, 1985; Scotchmer, 1985a; Pines, 1991) or property value maximizing governments (Wildasin, 1979; Yinger, 1981; Brueckner, 1983; Scotchmer, 1986; Wildasin and Wilson, 1996).

Chapter 2 provides a review of the empirical literature on capitalization. Instead of presenting exhaustively capitalization studies, we focus on the improvements of the techniques and data sets used in the literature. This includes the choice of an appropriate tax price (King, 1977; Reinhard, 1981), a better control for local public services like public school (Rosen and Fullerton, 1977; Sonstelie and Portney, 1980a; Hayes and Taylor, 1996; Downes and Zabel, 2002; Brasington and Haurin, 2005) or for neighborhood variables (Cushing, 1984; Black, 1999). Some studies take advantage of natural experiments (for example school reforms, tax reforms, special jurisdictions) to obtain better measures of tax and public services capitalization (Richardson and Thalheimer, 1981; Yinger et al., 1988; Palmon and Smith, 1998b; Dee, 2000; Reback, 2005).

Chapter 3 contributes to the empirical literature on capitalization by providing estimation results of a unique data set from the Canton of Zurich. We show that Switzerland is a convenient "fiscal laboratory" to study capitalization of local fiscal variables into house prices. We provide a description of our data set that includes, in addition to the local fiscal variables, a large number of environmental, neighborhood and demographic variables. The originality of our estimations relies on the nature of the house price variable, which is the price of a standardized and comparable single family house in each community. Such a standardized house price variable allows us to ignore the structural variables and all the biases they may

entail. Our baseline results exhibit standard results with respect to the literature presented in chapter 2.

Given the result of significant capitalization of income tax and public expenditures in the municipalities of the Canton of Zurich, chapter 4 presents the debate on the existence and the persistence of capitalization and rises two questions. Does capitalization rate significantly decrease over space when housing supply reacts? In order to answer this question, we compare capitalization in different places of the Canton of Zurich that differ in terms of housing supply elasticity. The second question is whether capitalization tends to disappear over time, as we move to long term equilibrium in which housing supply can react without restrictions. General conclusion sums up the main results of this thesis and provides a discussion.

Chapter 1

Capitalization of Local Fiscal Variables and the Tiebout Model: A Theoretical Review of the Literature

THe Tiebout (1956) model is the theoretical basis of almost every theoretical studies on capitalization of local fiscal variables into house values. The first section presents the basic Tiebout mechanism, in which mobility plays an important role.

In this theoretical review, we focus only on the part of the Tiebout literature that simultaneously incorporates land, housing and taxation issues. It is worth noting that in the original Tiebout model, these issues are rather neglected. Capitalization of fiscal variables is even no treated at all. Another strand of the Tiebout literature has been developed on various topics which are not directly related with capitalization, like sorting or stratification and redistribution (Westhoff, 1977; Epple and Platt, 1998; Kessler and Lulfesmann, 2005). This literature goes beyond the scope of this thesis and is thus not addressed in this chapter.

While the Tiebout model is the theoretical basis of virtually every capitalization study, capitalization is not mentioned in the Tiebout's original paper. It is not surprising when one considers that Tiebout hardly mentions property taxes and even housing. In his model, Tiebout ignores a lot of practical issues of the local public sector like the form of the taxation, the type of governance and the existence of housing that affects the consumers' location choice. These shortcomings have thrown ambiguity on the proper interpretation that one must have when considering the Tiebout model. While some authors consider the model as a descriptive theory of local public finance, others only find in this model a simple algorithm for the resolution of the preference-revelation problem of public goods.[1]

A number of authors (see for instance Mieszkowski and Zodrow (1989), Hamilton (1983) and Oates (2006)) agree to say that Tiebout remains very evasive on the revenue side of the local public budget constraint and especially on the type of taxation used by local governments. Tiebout simply assumes that local governments tax mobile consumers accordingly. Oates (2006) even notes that the word "tax" appears only a few times in the Tiebout's original paper. It is not surprising to obtain an efficient pattern of public services when one restricts the tax instruments to non-distortive tax like lump-sum tax, as it seems to be the case in the Tiebout's original paper. Part of the literature has thus attempted to introduce different types of taxes in models that preserve the essential Tiebout features (free mobility, perfect competition among jurisdictions) and to investigate the impact on efficiency.

Since the main source of local tax revenue is the property tax, these models also have to include housing, which is the tax base of the property tax. The joint presence of property tax and housing leads naturally to raise the issue of the capitalization of fiscal differentials into property values (Oates, 1969; Hamilton, 1975, 1976b; Hoyt, 1991). As noted by Oates (1981), the use of property taxation links the issues of efficiency in local public services and in housing market. The main issue addressed is thus the one of efficiency with a distortive tax. Does the Tiebout mechanism still preserve efficiency, despite the introduction of a distortive tax such as property tax?

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[1]For more considerations on the interpretation of the Tiebout model as a normative or a positive theory, see Oates (2006).

An other source of controversy of the Tiebout model is what Oates (2006) calls "the supply side of the Tiebout model". In the same way that Tiebout neglects the system of prices that face the mobile consumers, he does not characterize precisely the process by which taxes and public expenditures are determined nor that he described the type of government he considers. To stay close to his analogy between the private market and the local public sector, Tiebout seems to consider "city managers" (Tiebout, 1956, p. 419) that act like private firms and provide fiscal bundles if there is some profit to get. Section 1.2presents the theoretical literature that fills this gap by introducing an explicit form of government or characterizing explicitly the determination of local fiscal variables.

A first strand of literature, which is in spirit of the original Tiebout original paper, simply ignores the "voice" option and the political process under which taxes and public expenditures are chosen (Sonstelie and Portney, 1978; Henderson, 1985; Scotchmer, 1985a; Pines, 1991). Rose-Ackerman argues that "doing two things at once is difficult. Models in which people both vote and buy housing can easily become intractable and opaque" (Rose-Ackerman, 1983, p. 961). Thus, in the no-politics version of the Tiebout model, prospective (mobile agents) and actual residents have no influence on the determination of the public budget. The determination of the local fiscal variables are left to land developers or entrepreneurs that create communities and set the levels of taxes and public spendings in order to maximize their profits.

In contrast to the "no politics" version of the Tiebout model, a second strand of literature introduces an explicit modeling of the determination of taxes and public spendings. Since this thesis is dedicated to capitalization, we do present the literature that simply combine the median voter and Tiebout model (Rose-Ackerman, 1979; Epple et al., 1983, 1984). The main objective of this literature is to expose the conditions of the existence of an equilibrium and capitalization plays a relatively minor role. Instead, we focus on the property value maximization approach, which state that local governments will set taxes and public expenditures in order to maximize the value of land or property of their residents (Brueckner, 1983; Scotchmer, 1986; Wildasin and Wilson, 1996). This objective is sometimes associated with majority voting (Edelson, 1976; Wildasin, 1979; Yinger, 1981, 1982). Of course, this approach is closely related to the capitalization hypothesis of local fiscal variables into land or property value. Whereas a large part of the literature includes majority voting in the

Tiebout model, some papers consider bureaucratic behavior of local governments (Epple and Zelenitz, 1981; Henderson, 1985; Hoyt, 1990; Caplan, 2001) and ask whether voting with one's feet and competition among are operative mechanisms to eliminate bad politics.

Finally, the club theoretical approach, which shares common features with the Tiebout model (Cornes and Sandler, 1986; Oates, 2006), is presented in the third subsection. The link between Tiebout and clubs theory is especially relevant for the spatial clubs literature, which includes explicitly spatial issues such as land and housing.

1.1   The Tiebout Model

This section presents the original Tiebout model, its underlying assumptions and the main implications for the provision of local public services. Whereas Tiebout is invoked as the main theoretical basis of most of the capitalization studies, capitalization of local fiscal variables is not a feature of the original Tiebout paper. The second part of this section presents the literature that introduce housing and property taxes in model that preserves the main assumptions of the Tiebout model and investigate the implications for the efficiency of public goods provision.

1.1.1   The Basic Model

As noted by Oates (2006), the primary objective of Tiebout is to solve the problem of the revelation of preferences for public goods raised by Samuelson (1954). The Tiebout model can be seen as a response to the Samuelson's statement that no market type solution can solve the free rider problem involved by the provision of public goods. Indeed, Samuelson shows that a pure public good is efficiently provided if the sum of the willingness-to-pay for that public good is equal to the marginal cost of the public good. Unfortunately, it is unlikely that all agents will reveal their true preferences for the public good. Instead, they will underestimate their preferences in order to freely benefit from its consumption, provided

that one cannot exclude anyone from the consumption of a pure public good. Hence, public good will not be produced, as all agents will follow the same free rider strategy.

Thus, the nature of the problem raised by Samuelson is essentially an informational one. If one could extract the true willingness-to-pay from every agent in the economy, the public goods could be optimally produced and consumed. Such information is not available and a state government is necessary to "force" the economy to produce public goods. The Tiebout model precisely deals with this question as its main objective is to determine an institutional design which would allocate public expenditures optimally, without having recourse exclusively to the intervention of a central government.

Tiebout first notes that the Musgrave-Samuelson failure of the market concerns national public expenditures. He underlines that in practice, a substantial part of public expenditures is raised at the local level, so that the argument of Samuelson is not necessarily valid for all public expenditures. Taking into account this particularity, is it possible to find a process under which a sort of market solution would be also optimal? The answer of Tiebout is that in a federal setting, there is a large number of local jurisdictions that offer various fiscal packages. This characteristic of the local public sector gives the opportunity to yield solutions that differ from the "Musgarve-Samuelson" one.

The Tiebout model is based on six main assumptions:

(1) There is free and perfect mobility. Agents' moving decisions are based on fiscal conditions (level of public expenditures, tax rates, definition of the tax base). In this simple framework, no extra economic criteria can bend location choices. Agents are assumed to choose the jurisdiction that best satisfies their preferences.

(2) There is a large number of agents and jurisdictions with various tastes and fiscal packages, such that each individual matches the appropriate community and each community has a sufficient number of individual in order to form at the minimum average cost. As a consequence, each community is inhabited by a homogeneous population with respect to preferences and income. Moreover, new jurisdictions can form without cost.

(3) Agents have perfect information on the fiscal packages offered by the local jurisdictions.

(4) Income is exogenously determined (for instance in the Central Business District).

(5) Local public goods are financed by lump-sum taxation. When a new entrant enters a jurisdiction, he pays a congestion fee equal to the cost his presence implies. The average cost of public good is assumed to be U-shaped. Public goods are provided at the minimum average cost within each community.

(6) There are no spillovers between jurisdictions.

Starting from these assumptions, Tiebout describes a model where mobile agents differ with respect to income and tastes and seek the jurisdiction that best satisfies their preferences. On the supply side, there is a large number of local jurisdictions providing various types of fiscal packages so that any agent can find the appropriate community. Tiebout is not looking for a political process that would allow the local government to adapt to consumers' preferences. Instead, local governments set a fiscal bundle to which the consumers must adapt by moving in the suitable community (i.e. the one that offers the fiscal bundle that maximizes utility). Thus, mobility is the process by which the revelation of true preferences occurs. As agents have to move toward their preferred jurisdiction in order to enjoy the consumption of the local public good, they implicitly reveal their true preferences for it. Consumer mobility is the counterpart to the private market shopping trip and leads to Pareto-efficiency. The foot-voting mechanism effectively converts taxes into a system of efficient price and consumers receive the quantities of public services they would have demanded if they were in a competitive market.

1.1.2   The Introduction of Housing and Property Taxes in the Tiebout Model: The Capitalization Hypothesis

This section focuses on the Tiebout literature that incorporates explicitly housing and property taxation. The main objective of this literature is to introduce housing and property taxation in models that preserve the main characteristics of the Tiebout assumptions about the mobility of individuals and the diversity offered by the local public sector in terms of

fiscal bundles. The task is then to investigate whether the efficiency properties of the original Tiebout model holds (Oates, 1969; Hamilton, 1975, 1976b).

Moreover, while the property tax is not the only source of taxation (Henderson, 1994), theoretical models shows in wide range of situations, property taxes will be prefer to any other tax instruments (Hoyt, 1991; Krelove, 1993).

Property Tax Capitalization: Is The Property Tax a Benefit Tax?

A first step to take into account the effect of the property tax on a Tiebout model is included in Oates (1969) who estimates the capitalization of the benefits and costs of local public services in house values.[2] Oates argues that if mobile households migrate to the suitable community, they should reflect the level of property tax and local public expenditures in their house value. He concludes that the property tax reduces to a fiscal price of the local public good since he shows empirically that a decrease in the house value implied by an increase in the tax rate is compensated by the increase in the house value due to the additional expenditures on public school, resulting in a zero net change in the property value. As a consequence, the Tiebout model with property tax still achieves an efficient pattern of local public good.[3]

In a more formal framework, Hamilton (1975, 1976b) derives the conditions under which the property tax reduces to a head tax, expanding the Tiebout model by an explicit consideration of the housing market and the local use of a property tax. In the first version of the model, each community is homogeneous with respect to house value. The critical assumption is that local governments set zoning ordinances which can be specified as follow: no household can live in a particular community unless it consumes a minimum quantity of housing. When households migrate to the community with the appropriate fiscal bundle, they choose a community whose the minimum housing requirement is just equal to their actual housing

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[2]The results derived by Oates (1969) are essentially empirical and they are described more extensively in the second chapter.

[3]This view on the link between capitalization of local fiscal differentials and efficiency has been heavily criticized by Edel and Sclar (1974) and Hamilton (1976a), among others. They argue that in a *full* Tiebout equilibrium, housing supply adjusts and capitalization disappears. For more details on this issue, see chapter 4.

consumption. Households would not build a house larger than the minimum requirement because it would imply redistribution toward households who buy the minimum requirement; instead they build a larger house in a community with a more restrictive zoning ordinance in order to benefit from lower taxes (because the tax base is higher) and to increase utility. Of course, this result requires a large number of jurisdictions to ensure that an agent always find the suitable community. Moreover, effective zoning ordinances prevent the construction of houses with relatively low house value by poor households who would like to consume local public services at subsidized prices. Zoning ordinances make implicitly enter the housing consumption into the fiscal bundle. Thus zoning control allows preventing any intrajurisdictional redistribution, converting the property tax into a lump-sum tax.[4]

Hamilton (1976a) introduces a second version of the model in which the communities are assumed to be heterogeneous with respect to house values. The coexistence of high and low income households gives rise to fiscal surplus, which are the difference between tax liability of a household and the public service cost it implies. In a heterogeneous community, the housing value of high income households will be less than the same kind of housing in a homogeneous community, because of the presence of poor people with inexpensive houses which alter the total tax base. At this point, Hamilton introduces a strong assumption of perfect capitalization: total value (of housing structures and land) of a homogeneous community is equal to the total value of a homogeneous community if the land areas of the two communities are the same. Since rich households experience a negative fiscal surplus, they have to be compensated by a smaller price of land than in a homogeneous community to reflect the real public service cost they induce. A Symmetrical mechanism arises for poor households in mixed communities, so they undergo a greater price of land than in a homogeneous poor community. Without public intervention, such land value differential would cause market responsiveness: land developers would increase the supply of land toward poor households until the price differential disappears. Again, land regulation like fiscal zoning, allowing preventing from too high levels of low income housing, is needed to achieve efficiency. Hamilton (1976b) concludes that households choose the community with the optimal

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[4]The Hamiltonian view, in which the property tax operates as benefit tax, is also called the *benefit view*. In the alternative *new view*, the property tax is modeled as a tax on capital (see for example Mieszkowski and Zodrow (1989) and Zodrow and Mieszkowski (1983)). We do not explore this view, as it does not imply capitalization issues.

level of local public services, where the quantity restriction of housing satisfies their desired level and where, at the margin, the property tax incremented equals their valuation of those services.[5]

Property Tax vs Other Sources of Revenue

The property tax is not the only tax instrument available at the local level. For example, Henderson (1994) notes that property taxes account for only 38% of locally raised revenues in United States in 1988-1989. He also stresses the great variation of property tax use across localities and the rise of non-tax sources.

To understand what drives local choice of taxation, Henderson (1994) investigates communities' choice of tax instruments, giving them the possibility to use not only property taxes but also land taxes, housing revenues and head taxes to finance a publicly provided private good, in an imperfect competition environment. Henderson introduces in the model the traditional Arrow-Debreu separation of people's decision as shareholders (land or homeowners) and as consumers (voters and residents) in order to justify the difference between property taxes, land taxes and user fees.[6] Since the choice of revenue is likely to be influenced by local political institutions, Henderson derives his results under two types of government objective: the profit-maximization government and the voter control of communities. The results show that the structure of local taxation will completely differ according to government objective function. Profit-maximizing communities prefer user fees over property taxes (or land taxes) and provide public expenditures efficiently. This result arises because user fees efficiently price fiscal-migration externalities. The monopoly power of government only involves collecting a fiscal surplus from residents through the use of fees. If user fees are prohibited, profit-maximizing communities prefers property taxes over land taxes. In this case, the government corporation is forced to use property tax to price fiscal-migration externalities (this

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[5]Fischel (1975) and White (1975) have extended the Tiebout-Hamilton perfect zoning to the case of non-residential property tax on commercial and industrial capital.

[6]Assuming away the Arrow-Debreu separation means that residents incorporate the impact of their voting choices on their income as shareholders and that, as property owner, they take into account wealth effect as property values change. In this alternative scenario, Henderson (1995) shows that homeowners do not choose to finance public expenditures with property taxes.

cannot be done with land taxation, which do not affect the marginal inmigrants; recall the separation assumption between renters and landowners) and to induce a distortion with underconsumption of housing and public goods. In a voter model, land taxes are preferred to property taxes because residents are no shareholders of lands (following from the Arrow-Debreu separation). If land taxation is prohibited, the government is forced to use property tax to expropriate land rents indirectly. It can also possibly use positive or negative fees to balance the budget constraint, depending on the revenue raised by property taxes.

Persistence of Property Taxes

In contrast to Henderson (1994), Hoyt (1991) points out the importance of the property tax as a source of local tax revenue. In particular, he asks why local governments do not move from property to land taxation, despite the increase in welfare this change would imply. As noted by Thisse and Duranton (1996), the use of land taxation is not a new idea: Henry George proposed in *Progress and Poverty*, published in 1879, to fully tax land rents in order to finance public services. This statement, which is known as the Henry Georges Theorem (HGT thereafter) has then been formally proved by several authors like Flatters et al. (1974) in a regional context and Arnott (1979), Arnott and Stiglitz (1979), Stiglitz (1977) and Wildasin (1986) in a urban context with pure public goods.[7] The essence of the HGT is that at the optimal population size, the total differential rent is just equal to the amount of public services.

Hoyt (1991) considers a metropolitan area in which local jurisdictions can finance public services through both property tax, a uniform tax on land and capital expenditures, and a separate per unit tax on land. Public services are assumed to be publicly-provided private goods. Perfect mobility of households across the metropolis implies that, at the equilibrium, the level of utility in each jurisdiction must be equal to the level of utility prevailing in the rest of the economy. When the jurisdictions are utility-taking (i.e. they are small enough to assume that their policies do not affect housing prices and policies in other jurisdictions), perfect mobility implies perfect (property) tax capitalization; an increase in the property tax

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[7]For a spatial version of the HGT, see Thisse and Duranton (1996) and Hochman et al. (1995).

rate is exactly offset by a decrease in the net price of housing, leaving unchanged the gross price of housing. Utility-taking jurisdictions also induce that maximizing rent in a community is equivalent to maximize the utility of its residents (Sonstelie and Portney, 1978). Thus the local jurisdiction maximizes net land rent subject to a balanced budget constraint. Hoyt (1991) shows that the optimal jurisdiction's response is to fully finance local public expenditures by the property tax. The rational behind this result is that there is no gain to obtain from a switching from property to land taxation, because the decrease in the property tax is fully capitalized into property values. However, the property tax cut implies that new residents will be attracted and subsidized by the initial landowners, through land taxation.[8] Intuitively the property tax, unlike land taxation, acts as a congestion price since immigrants pay for the extra cost they induce through property tax payments (Henderson, 1994).

A generalization of the model shows that when jurisdictions have market power (i.e. jurisdictions recognize that their policies have an impact on housing prices and policies in other jurisdictions), the property tax and public service capitalization into housing prices is incomplete and is negatively related to the relative size of the jurisdiction with respect to the metropolis. Imperfect capitalization implies that a jurisdiction's policy affects both net land rents and housing prices; this breaks the link between land rent and utility maximization.[9] Thus, Hoyt (1991) solves the Nash equilibrium by maximizing utility in the jurisdiction subject to a balanced budget constraint and to imperfect capitalization of property tax and government services. The results are a generalization of the utility-taking jurisdiction case and show that whenever there is more than one jurisdiction in the metropolitan area, it is optimal for jurisdictions to finance part of their public expenditures with property tax. The fraction of expenditures financed by the property tax decreases with the market power of the jurisdiction. If the jurisdiction's market power tends to zero, one comes back to the utility-taking jurisdiction case and the property tax is the unique optimal source of tax revenues. However, the benefit of the property tax is decreasing in the market power of a jurisdiction within the metropolitan area. The intuition behind this is that a property tax increase is incompletely capitalized into housing prices (while with utility-taking jurisdictions the tax

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[8]This reasoning implies that in the initial equilibrium all residents are land owners in the jurisdiction.

[9]See Starrett (1981), Pines (1985) and Hoyt (1992).

change was perfectly offset by housing price). This makes the property tax more distorting and less attractive than the separate land tax.[10]

Krelove (1993) shows that the persistence of property taxes can be explained by the fact that local governments cannot impose direct taxes on residence, i.e. they cannot raise revenue in a non-distortionary manner from residents. Krelove develops a model in which the tax structure is not complete. The jurisdictions are assumed to maximize after-tax land rent and finance congestable local public services with property tax on housing and a separate tax on immobile land and mobile capital used in housing production, so that no costless transfers between residents and government are possible. Krelove shows that the property tax emerges endogenously (in contrast to Epple and Zelenitz, 1981 and Henderson, 1985 who assume that property tax is the only revenue source) at equilibrium as the sole source of revenue for local jurisdictions. As in Hoyt (1991) and Henderson (1994), the property tax appears to be a second-best way to price the marginal resident that enters the community, instead of land taxation.

1.2 Which Local Governance for the Tiebout Model?

Tiebout (1956) failed to describe how taxes and public expenditures are chosen in his model. This section presents the three approaches that address this issue. The profit maximizing developers approach, in line with the original Tiebout model, describes a minimalist intervention of government which may simply be considered as developers or entrepreneurs that maximize profit. In contrast, the property value maximizing approach may stem from political pressure, i.e. local governments has strong incentives to adopt a policy that improve the property value of their residents (Fischel, 2001). Finally, the club theoretical approach allows to address formally some issues of the Tiebout model, like the formation of the optimal number of communities.

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[10]The same market share and capitalization argument is used by Hoyt (1992) to explain why large central cities have higher tax rate than the surrounding suburbs.

1.2.1   Profit Maximizing Developers

A first approach to introduce a supply side that models explicitly the objective of the local governments in the Tiebout model is to consider the minimum level of intervention of the local officials. Oates calls this approach the "entrepreneurial version of Tiebout" (Oates, 2006, p. 29). Actually, this view implies no politics in the model as the communities are simply considered as developers or entrepreneurs that create and manage communities so as to maximize their profits.

Sonstelie and Portney (1978) initiate this approach by considering a metropolitan area composed of a large number of communities that provide local public services to their residents. Households are perfectly mobile and consume housing, public services (provided equally and free of charge in each jurisdiction) and a private good. For the sake of simplicity, each house is described by a single physical characteristic, its size. The model does not imply any form of taxes or user charges because the communities are assumed to derive revenues from ownership of land which provides land rents. The rent earned by a house is determined by demand and supply and depends on the house's size and on the level of public services. Perfect competition implies that communities and households are price takers and cannot influence independently the bid-rent function. The cost of providing public services that face communities depends both on the quality of the public services and the number of residents and is U-shaped with respect to the size of the community. As the communities own land, they also bear the cost of constructing houses and maintaining the housing stock. Sonstelie and Portney (1978) define the objective of the local governments as the maximization of profits, which are the sum of rents earned in the community minus the cost of providing the public services minus the total cost relative to the establishment and the maintenance of the housing stock. In order to reach this objective, local governments may use the quality of the public services and the size and the attributes of the housing stock. For instance, if the community rises the level of the public service, the property value, rents, the community's revenue and the cost of providing public services increase. Changing the size of the housing stock also affects the community's revenue through capitalization into property value and rents and the housing cost on the costs side. Of course, the timing of the two control variables is different; while changes in the quality of public services rapidly affect community's cost

and revenues, changes in the housing stock condition have long run effects owing to the long
time horizon of houses. As a consequence, Sonstelie and Portney (1978) define two types
of equilibrium: a short-run equilibrium, in which the only instrument of local governments
is the public services quality and a long-run equilibrium in which local governments can
alter both the public services quality and the housing stock. In the short-run, the migration
of households and community profit maximization results in an efficient allocation of local
public services and the distribution of residents across the fixed housing stock is optimal. In
the long-run, the allocation of public services is still efficient but contrary to the previous
situation, the housing stock may vary. However, Sonstelie and Portney (1978) argue that the
housing stock and the community size are adjusted to maximize profit so that the size and the
composition of the housing stock are also optimal. Their model has normative implications
as it does not explain how communities effectively choose the level of public services but
rather exposes the efficiency properties of community profit maximization.

Henderson (1985) also uses the profit maximizing approach in order to stress the important
role the local land developers have on land use, local public policies and the determination
of an efficient allocation of resources in a Tiebout type model.[11] In his model, individuals
within a community have the same preferences to reflect the Tiebout sorting effect that en-
courages stratification. The number of communities is very large such that they are price or
utility-taking.

In the no politics version of the model,[12] the community is modeled as a club which is
assumed to be owned by a group of land developers.[13] The community chooses per capita
public service level and the property tax rate in order to maximize total profits that consist of
land rents and property taxes on housing minus public services expenditures.

The maximization of profits produces a second-best equilibrium (because of the presence
of distorsive property taxation) with two characteristics: (1) the land management company

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[11]This approach can also be found in Hoyt (1990).

[12]In a subsequent section, Henderson (1985) incorporates "good" and "bad" politics in the Tiebout model.

[13]While Henderson (1985) denotes the local government as a club, his formal approach differs from club
theory in several ways. For instance, the local public good is not submitted to congestion cost and the revenue
side of the club is not based on a simple price membership as in the club theory but rather on property tax and
land rents. See sub-section 1.2.3 for issues on the link between the club theoretical approach and the Tiebout
model.

does not exploit residents fiscally as all property taxes are spent on public services and (2) a second best version of the condition for the provision of public goods is satisfied. In conclusion, in the intracommunity equilibrium, the Tiebout model yields efficient solutions.[14]

Contrary to Henderson (1985) and Wildasin (1986), Pines (1991) investigates the existence of a Tiebout equilibrium in a profit maximizing developer setting, with the idea that it is useless to study the efficiency properties of the Tiebout equilibrium if one does not know whether it exists. The model is based on Stiglitz (1977). A large number of mobile households choose a community where they work, consume a private good and a public good. On the local public sector side, governments act as price-taking (or, equivalently, utility-taking) profit maximizing developers. Their objective is to set the level of public good and households that maximizes the net profit from the production of the private and public goods, with a given wage schedule.

Considering the optimal community size and the issues of existence, uniqueness, and efficiency of equilibrium in his model, Pines (1991) takes into account two hypothesis regarding land scarcity: (1) first, the land is free. It means that the communities ("Islands") are perfectly replicable. In this case, Pines (1991) shows that there exists a unique and efficient equilibrium. (2) In a second step, communities are assumed to be non-replicable or imperfectly replicable so that land is scarce. In such configuration, no equilibrium exists. Pines (1991) argues that in the case of club theory, perfect replicability of clubs is a natural assumption. However, when applied to an urban setting, the spatial dimension and the spatial discontinuities it implies make this assumption more disturbing. As a consequence, a more appropriate assumption, according to Pines, is the one of non-replicability when considering the Tiebout model. It follows from the model that no equilibrium exists in the case of profit maximizing developers and that the existence of an efficient equilibrium requires the presence of politics.

Scotchmer (1985a) deals with similar issues, but in a different framework, namely the club theoretical approach. In particular, the author investigates a Nash equilibrium among profit-

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[14]The model also includes solutions with politics and intercommunity equilibrium but these points go beyond the scope of the current section. The latter issue, which gives an active role to land developers, is considered in the fourth chapter.

maximizing clubs.[15] Clubs are groups of individuals that share club goods. Club goods are defined by two dimensions, the facility size and the price of membership, and subject to congestion cost. Contrary to the previous literature, Scotchmer (1985a) assumes that the profit-maximizing clubs are not utility-takers so that they exploit a market power and make positive profit. She studies a two-stage symmetric Nash equilibrium. In a first stage, firms (clubs) decide whether they enter or not. The entry occurs only if it does not lead the new entrant as well as all other firms to negative profit. In a second stage, firms play a standard symmetric Nash equilibrium, where the strategic variables are the facility size and the entry fee. The game is solved by backward induction. In the second stage, the symmetric Nash equilibrium is characterized by the familiar Samuelson condition. However, the equilibrium price condition differs from the utility-taking firms as the price of membership is greater than the marginal congestion cost. This entails positive profit for firms, reflecting the firms' market power. In the first stage, the equilibrium number of firms is met when the marginal firm is deterred since it would imply negative profit for itself and all the other firms. The entry issue plays an important role in the model. The entry mechanism ensures that there will be a response (i.e. the entry of new firms) to positive profits in order to ensure that the number of clubs will be close to the efficient one. However, Scotchmer (1985a) suggests that one expects generally more than the efficient number of clubs in the equilibrium, especially in the case where there are few clubs that have large market power.

1.2.2　Tiebout and Politics

An alternative view of the intervention of local governments in the Tiebout model introduces explicitly collective choice institutions and the political process that stems from the democratic process. Oates calls this approach the "collective choice version of Tiebout" (Oates, 2006, p. 31).

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[15]Previous literature on club theory and the link with the Tiebout model is discussed more extensively in section 1.2.3.

Maximization of Property Values: A Simple Model

The essence of the property value maximization approach can be described in the following basic model, based on Wildasin (1979), Brueckner (1979) and Helsley (2004). Let's consider a metropolitan area composed of a large numbers of communities in which each community has an exogenous stock of N houses indexed by $i = 1, \ldots, N$.[16] Residents have identical preferences but differ with respect to income; their utility function is $U(x, h, g)$, where x is the consumption of a composite numéraire commodity, h represents the consumption of housing and g the provision of public services.

In this approach, perfect mobility plays a crucial as it implies the capitalization of housing and public services into house rents. The bid rent function for house i denoted $R_i(h_i, g, y)$, which is the maximum amount a resident is willing to pay for the services offered by the house, is implicitly defined by the following utility constraint:

$$U(y - R_i, h_i, g) = U^*(y), \tag{1.1}$$

where $U^*(y)$ is the utility level that a community must offer in equilibrium, depending on the level of income y. Equation (1.1) states that a change in public services or in the housing services entails a migration flow from or toward the community and must be compensated by a change of the rent to satisfy the utility constraint. Applying the implicit theorem to equation (1.1) yields:

$$\frac{\partial R_i}{\partial g} = \frac{\partial U / \partial g}{\partial U / \partial x} > 0, \tag{1.2}$$

$$\frac{\partial R_i}{\partial h_i} = \frac{\partial U / \partial h_i}{\partial U / \partial x} > 0. \tag{1.3}$$

The slope of the bide rent function with respect to the level of public services (housing services) is equal to resident's marginal rate of substitution between the public services (housing services) and the numéraire good. Equations (1.2) and (1.3) reflects that an increase in g or h_i must be compensated by an increase in R_i, causing a reduction in x_i, to hold the utility constant. This means that the benefit of public services are reflected (or capitalized) into house rents. It explains why aggregate property value maximization leads to efficiency.

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[16]Brueckner (1983) extends this approach by introducing housing production in the model.

The provision of public services g is assumed to be financed by a uniform tax t on house values. Denoting $C(g)$ the provision cost function and V_i the value of the ith house, the public budget constraint can be written $t \sum_{i=1}^{N} V_i = C(g)$. The value of a house is the present value of the stream of net-of-tax rents provided by housing services. Assuming a infinite lifetime horizon and constant house rent over time, the house value is:

$$V_i = \frac{(R_i(h_i, g, y) - tV_i)}{\theta}, \tag{1.4}$$

where tV_i is the property tax payment and *theta* the discount rate. Summing (1.4) over the N houses of the jurisdiction and substituting the public budget constraint, we obtain the aggregate property value:

$$\sum_{i=1}^{N} V_i = \frac{(R_i(h_i, g, y) - C(g))}{\theta}. \tag{1.5}$$

The point of the property value maximization literature is precisely to assume that local governments will choose the level of public services by maximizing the aggregate property value in the community described in (1.5). The cost of one another unit of public service will be balanced against the benefit it will implies on residents through increased aggregate property value. Using (1.2), the first-order condition for maximization of (1.5) is

$$\sum_{i=1}^{N} \frac{\partial U / \partial g}{\partial U / \partial x} = \frac{\partial C}{\partial g}. \tag{1.6}$$

The level of public services that maximizes aggregate property value satisfy the Samuelson condition. This means that the aggregate property value maximization behavior leads jurisdictions to efficiency.

Property Value Maximizing Communities

Some models use property value maximization as an alternative objective to profit maximization for local governments. At first glance, this objective seems less natural than decision-making through political process like majority voting. However, the American experience

suggests that land developers play an important role in the creation and management of several cities

Some authors suggest that this objective could emerge as an unspecified political process (Wildasin and Wilson, 1996; Helsley, 2004). Alternatively, property value maximization could be considered as an institutional objective in its own right, to the extent that a significant number of households own their own property.[17]

For Brueckner (1983), the property value maximization objective is associated with a type of entrepreneurial government behavior. In his setting, local governments are part of a large community system, so that they act in a competitive environment; they take consumer utilities as parametric. Communities' area and households' lot size are fixed. Residents have identical endowments and consume a numéraire commodity, housing and a congestable public good. Housing is produced with land and the numéraire; public good is produced only with the numéraire. The house price function, which relates housing and public good consumption to the house value, is obtained by consumer bid-rent function under assumption of parametric utilities.[18] Housing producers supply housing in order to maximize their profit, and subject to the housing price function constraint (or equivalently to the parametric utility constraint).[19] The local government chooses the level of public good in order to maximize aggregate property value in the community, which is defined as the total rent value minus the total cost for the public good.

In a first case, Brueckner (1983) considers that public good is financed by a house tax (a head tax on each house owner) borne by producers (and not residents). The results show that aggregate property value maximization implies that the resulting internal equilibrium is Pareto-efficient, as the optimization government problem yields the familiar Samuelson condition. In a second case, a property tax is introduced instead of a house tax to finance the local public good. The Samuelson rule for the provision of the public good is preserved but

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[17]Wildasin and Wilson (1996) argue that even if landowners are in political minority, their interests may still be reflected in the local political process if they could use mechanisms other than voting.

[18]This assumption reflects perfect mobility across jurisdictions. Note that this housing price function is used in Sonstelie and Portney (1978) and Wildasin (1979) but without any discussion on its determination.

[19]An alternative version of this model without housing production can be found in Brueckner (1979).

internal efficiency is conditional on the inefficient equilibrium housing stock induced by the distortionary property tax.

Internal efficiency does not mean that the system-wide equilibrium is efficient as well. An appropriate distribution of consumers across communities is required for the community system to be globally efficient. Brueckner (1983) shows that property value maximization does not naturally lead to such situations and that, starting from internal efficient equilibrium with two types of consumers, some reallocation of consumers across jurisdictions could lead to Pareto-superior outcome.

In contrast to Brueckner (1983), Scotchmer (1986) considers an imperfect competition framework by assuming a finite number of jurisdictions. She argues that the utility-taking assumption implies that a jurisdiction's policy will not affect land prices in the rest of the economy. Local jurisdictions provide a pure public good which is financed by land taxes. Households receive an initial endowment of private good plus an equal share of rental income raised in the economy. The capitalization of the local public good into land values emerges from the bid-rent approach, i.e. land is allocated through a perfectly competitive decentralized market. A local jurisdiction chooses the level of public goods so as to maximize property value, which is defined by land value minus the total cost of public goods. Scotchmer (1986) shows that under separability assumption on the utility function, the local public goods will be underprovided. The intuition behind this result is that a marginal unit of public good in one jurisdiction decreases land prices in other jurisdictions, in contrast to the perfect competition case. The jurisdiction's policy has a externality on land prices elsewhere and makes the public good less lucrative to the landowners as the positive effect of the public good on the demand for land and land price in that jurisdiction is reduced. Thus local public goods are underprovided.

In an alternative Nash equilibrium, Scotchmer (1986) adds head taxes in addition to land taxes in order to balance the public budget constraint. The choice variables of the jurisdiction are the public good and the head tax. In this case, the use of a new instrument allows the jurisdictions to provide public goods efficiently. The head tax can be viewed as an instrument to manipulate the population size through incentive effects and eliminate the price externality outside the jurisdiction (which was not possible with only one instrument like the level of

public goods). Note that imperfectly competitive jurisdictions use the head tax for a different reason than jurisdictions in a competitive framework. The latter use the head tax only if the public good is congestable.

Wildasin and Wilson (1996) contribute to the tradition of property value maximizing objective in an overlapping-generation model with imperfect mobility. The economy consists of a large and fixed number of identical towns, each with the same amount of land. There are two types of workers, young and old, who live over two periods and supply labor to competitive firms. Costly mobility is represented by a moving cost which is randomly assigned to workers and that occurs if they change residence in the second period. Local governments are assumed to maximize the present value of after-tax land rents, which accrue to absentee landowners. Public goods are assumed to be fixed and identically provided in all towns. A key assumption is that governments have the possibility to differentiate the fiscal treatment of their residents. The first-order condition for the land value maximization program shows that governments exploit their monopsony power over the stayer wage, as high moving costs lead some old workers to stay in their towns. The attachment to place developed by less mobile workers allows governments to capture rents by overtaxing this type of workers.

Property value maximization objective can be viewed as a response to voting and democratic pressures. For example, Edelson (1976) and Wildasin (1979) consider models where residents of a community vote for the public good level which maximizes the value of their own property. Pauly (1976) describes a model which is in line with the Tiebout assumption: households with heterogeneous tastes and income consume a composite private good and a public good, they have location-independent income and are perfectly mobile within the metropolitan area. However, one assumption departs from the traditional Tiebout literature; while the Tiebout literature often assumes that households face a perfectly elastic number of communities (Edel and Sclar, 1974; Hamilton, 1976b), Pauly (1976) considers that there is a fixed supply of the taxed good in each jurisdiction. Given the fixed metropolitan population, it means that capitalization will occur, because of an imperfect matching of individual preferences and public good consumption opportunities. The determination of the level of public goods is investigated under two types of process. Under the majority voting rule, Pauly (1976) shows that net benefit capitalization is likely to occur in equilibrium. Under property value maximizing behavior, voters take into account the feedback effect of their

political choice on rents in their community or in the other. For the sake of simplicity, it is assumed that only property owners vote and that their property is homogeneous so that property value maximization and majority voting rule are equivalent. Pauly (1976) finds that in this case equilibrium generally fails to exist, as the jurisdictions have the incentive to change the level of public goods in order to create excess demand and increase rents.

Yinger (1981, 1982) brings voting issue in a model with capitalization of local fiscal variables into house values. For him, the Tiebout literature is incomplete because it does not fully integrate both actual voting and voting with one's feet. On the one hand, the capitalization of local fiscal variables into house values stems from the mobility of households across jurisdictions in a metropolitan area and influences political choices made within jurisdictions. On the other hand, the pattern of local public services that emerges from voting process also influences the allocation of mobile households to communities. In order to overcome these shortcomings, Yinger (1981, 1982) constructs a model which integrates explicitly housing decisions, household's mobility, location decisions and residential voting. Each jurisdiction provides a local public service financed by property taxes levied on house value. Individuals have an exogenous income that they spend on a composite good, on housing services and on property taxes. Two types of individuals are examined separately, namely movers and residents.[20]

Movers are households that decide to choose a new residential location. They bid for housing in various locations and thereby determine how local public services and taxes are capitalized into house values. More precisely, movers choose a location by maximizing utility subject to their budget constraint. Since movers are not yet residents of a community, their optimization problem does not include a community budget constraint (they have no voting power). Moreover, they take tax rates and public services in different communities as given but local fiscal variables effectively vary through their choice of a community. This optimization problem generates the pattern of housing prices, i.e. the way local fiscal variables are capitalized into house values. However, households' mobility is not sufficient to cause capitalization,

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[20]The duality between movers and residents is also found in Sonstelie and Portney (1980b) who argue that with perfect mobility and no restriction on the number of communities, resident property owners have the incentive to separate consumption activities and investment decisions by voting for the fiscal package that maximizes property value and then moving (if necessary) to the community that offers the highest level of utility.

which also requires variation of service-tax packages across communities. And this variation is allowed by the choice of residents in the political process within each jurisdiction.

Residents are assumed to be property owners. In contrast to movers, they have the power to determine the level of public services and taxes through voting and they treat their consumption of housing services as given (this means that the building of additions is ruled out of the model). Assuming that the decisions made by elected officials reflect the preferences of residents, the democratic process that determines the local fiscal variables can be reduced to the maximization of residents' utility. In contrast to movers, the residents' optimization programs include the public budget constraint, in addition to the private budget constraint. Yinger (1981, 1982) shows that this optimization program is equivalent for residents to maximize their property value subject to the public budget constraint. Intuitively, it reflects the incentive residents have to vote for the fiscal package they would bid the most, although they do not directly bid for it.

In an homogeneous community where the median voter is simply a representative voter, Yinger (1981, 1982) shows that the property value maximization yields the level of public services for which the marginal benefit from services (the increase in the rental value from another unit of public services) equals the marginal cost. In the heterogeneous community case, the median voter picks the level of public services for which his marginal benefit before taxes, adjusted by his position in the distribution of preferences equals his cost. In the special case where the marginal benefit from public services is the same for all residents, the median voter sets the community's mean marginal benefit equal to the mean marginal cost.[21]

Yinger (1981, 1982) argues that capitalization yields inefficient provision of public services, as it breaks the link between property tax and public services. The property tax implies that communities set the marginal cost of public services below the marginal rate of transformation, which leads to underconsumption of housing relative to public services.

In Brueckner and Joo (1991), the interaction between voting with one's feet and actual voting is explicitly considered, in contrast to Yinger (1981, 1982). They develop a dynamic two-

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[21]This result is similar to Edelson (1976), who shows that the efficiency condition (relative to a non-taxed composite good) is met in a heterogeneous community with constant tax shares.

period model in which residents vote for the level of a durable public good which is financed by a property tax levied on house values. Since houses are assumed to be identical, each resident bears an equal share of the cost per period of the public good. The voter lives in the community over two periods after the vote has occurred and eventually leaves in the end of period one, selling his house and moving away. The rental value and the resale value of the house are determined by the arbitrage condition of the buyer who can buy the voter's house or occupy rental housing in other communities with an associated reservation utility. Brueckner and Joo (1991) show that the rule of provision of the level of public good that maximizes voter's utility is given by a weighted average of the net marginal benefit to the resident and the net marginal benefit of the future buyer. In other words, the preference of the future resident is already reflected in the voter's ideal level of public good. It also implies that the difference of outcomes between property value maximization and utility maximization will depend on the closeness of the marginal valuation of the current owner and the prospective buyer. If the voter has a stronger (weaker) preference for the public good than the future buyer, the voter's choice of public good will lie above (below) the property value maximizing level. Property value maximization and utility maximization will be equivalent if the voter and the future buyer have the same preferences for the public good.

Bureaucratic and Rent-Seeking Behavior

Gyourko and Tracy (1989b,a) suggest that not only local public sector rent-seeking, through public sector unions, produces a wage premium for local government employees but is also capitalized in local land markets in the form of lower house values.[22]

The Tiebout model suggests that competition among jurisdiction results in efficient provision of public services. Epple and Zelenitz (1981) investigate whether the mobility of individuals, and the capitalization of local fiscal variables into housing prices it implies, can serve as a

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[22]Gyourko and Tracy (1989b) show, for instance, that a dummy indicating the presence of highly organized union (that is, at least two-thirds of the workforce is organized by unions) significantly decreases the log of median house prices in a sample of 90 U.S cities.

constraint on governments that act in their own interests.[23] They suggest that when considering land explicitly, governments have the possibility to set inefficient high tax by extracting land rent from residents. They consider a metropolis with a fixed land area, equally divided among jurisdictions which have fixed boundary. Households are perfectly mobile among jurisdictions; they consume numéraire goods, housing and public services. Mobility among jurisdictions implies that the property tax capitalizes positively and public expenditures capitalize negatively into housing prices, following a flow of population and the change implied in the housing market. In addition, the tax capitalization impact increases with the number of jurisdictions and the property tax is perfectly capitalized in the perfect competition case (i. e, with an infinite number of jurisdictions). Each government is assumed to maximize profit, which is the excess of tax revenue over government expenditure, without any electoral constraint. Epple and Zelenitz (1981) shows that in perfect competition equilibrium, tax revenue exceeds government spending, and this rent is positively related to housing value and housing supply elasticity. They conclude that competition by itself does not completely eliminate inefficiency. Indeed, while an increase in the number of jurisdiction decreases the equilibrium tax rate, the rent extracted by the government is still positive because they can exploit the housing supply elasticity. This result is easily explained by the assumptions of jurisdiction's fixed land area and inflexible boundaries: while residents can move to escape excessive taxation, land is immobile and landowners cannot move land for instance for a redefinition jurisdictions' boundaries.

Like Epple and Zelenitz (1981), Caplan (2001) considers rent-seeking local governments which are constrained by economic competition in a Tiebout world, but adds a political constraint. There are several types of households that differ in terms of preference for public goods. In each jurisdiction, there are two competing political parties and the winner is chosen trough simple majority voting. However, note that the political competition is imperfect as one party is assumed to be advantaged. The local government objective is a mix of the size of the government, the public expenditures funded by (property tax) revenues, and the taxation in excess of that necessary to finance public expenditures, the bureaucratic rent. The environment is favorable to the capitalization of property taxes: each community has a fixed supply of land and boundaries are fixed. Housing is produced by combining land and capital

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[23]This approach is also found in Hoyt (1990) in order to test whether residents and capital mobility effectively constraints governments inefficiency.

under a Leontief production function, implying the capitalization of property taxes into real estate values.

Caplan (2001) shows that in equilibrium, local governments use the property tax as a tool to extract positive rents from households. Mobility does not prevent households from excessive taxation. The rationale behind this result is that capitalization of property tax implies that landowners bear the full burden of local taxation and cannot escape from excessive taxation by moving to another jurisdiction. This result contrasts with Epple and Zelenitz (1981), who find that competition eliminates at least partially the monopoly power of local governments and that rent extraction essentially depends on housing demand and supply elasticity. In contrast, Caplan (2001) suggests that the only source of efficiency in this case is not the mobility (the exit option) but the strength of the electoral competition (the voice option). Thus Caplan (2001) reverses the Tiebout's result: it is the political constraint rather than the economic pressure that leads the local public sector to an efficient provision of public services.

In contrast to Epple and Zelenitz (1981) and Caplan (2001), Henderson (1985) argues that in the proper defined long run equilibrium of a Tiebout model, "bad politics" are simply impossible. Contrary to Epple and Zelenitz (1981) or Yinger (1982), Henderson (1985) suggests that in a full Tiebout equilibrium one must assume a flexible number of jurisdictions as well as flexibility of jurisdictions' boundaries, in which land developers have an active role over the land use through annexation an d detachment. As a consequence, the price of land of uniform quality is equalized in the long run. There is no place in such model for capitalization of taxes and public goods and no possibility for bureaucrats to exploit housing supply elasticity and extract land rent from landowners.

Hoyt (1999) shows that the size of jurisdictions is related to governments' inefficiency. He argues that Leviathans in large cities are less constrained than in small cities, because property taxes capitalize to a lower extent there. Large cities have a large share of the population of the metropolis. A change of their policy implies a large flow of population and change of utility in the rest of the metropolis. Thus the degree of property tax and public expenditure capitalization in large cities is lower because they can pass the cost of the policy change on the rest of the metropolis. In contrast, policy changes in small cities have almost no impact

on the rest of the metropolis and are fully capitalized in housing prices. Hoyt (1999) argues that voters have less incentive to limit government inefficiency in large cities because they do not bear the entire burden of such inefficient policy.

1.2.3 The Club Theoretical Approach

As described for instance in Scotchmer (1985a), the theory of clubs is primarily concerned with the sharing of the cost of a club good which is subject to congestion (the typical example being the swimming pool). Agents have the incentive to form groups in order to create externalities for each other (Scotchmer, 2002). The seminal paper on the theory of clubs is due to Buchanan (1965), in which agents band together to share the cost of an impure public good. A number of authors (Rubinfeld, 1987; Cornes and Sandler, 1986; Scotchmer, 2002) note that the club theoretical approach is particularly suitable for the formalization of the Tiebout model. Oates (2006, p. 38) argues that the club theory and the Tiebout model are "close cousins" and that "the Tiebout model and the theory of clubs are often addressed in the same breath as if they are virtually interchangeable". Sandler and Tschirhart (1997) argue that Tiebout (1956) contributes to the club literature by developing a theory of jurisdiction size.

A Simple Model

The main results of the theory of clubs can be described in the following simple model, based on Cornes and Sandler (1986). To keep the analysis simple, we focus on a case in which segregation is impossible, i.e. the case of a homogeneous population with identical tastes and incomes (McGuire, 1974). Let the preferences of a representative agent be defined by the utility function $U(x, g)$ with usual properties, where x is a numéraire private good and g is the level of (impure) public good supplied to each member of the club.[24] Each member of the club is endowed with an equal amount of income y. The private good is used to

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[24]Alternative utility functions may directly include the number of sharers in the club in order to describe a pure distaste for association but it does not qualitatively change the results.

produce the club good at cost $C = C(g,n)$ with $\partial C/\partial g > 0$ and $\partial C/\partial n > 0$, where C is the total cost of public good measured in units of the numéraire and n is the size of the sharing group. Writting the total cost function in this way shows explicitly the difference between a club good and a pure public good. The club good is subject to crowding costs; in the case of a pure public good we have $\partial C/\partial n = 0$, i.e. the total cost is not affected by the marginal resident.

Assuming that the club good is equally financed by all the members of the club, the private budget constraint is $y = x + C(g,n)/n$. Substituting the private budget constraint into the utility function, an efficient allocation can be characterized by a vector (g^*, n^*) which solves:

$$Max_{g,n} \ U(y - C(g,n)/n, g). \tag{1.7}$$

This program reveals the trade-off at work in the model. A new member will reduce the average contribution paid by all the members of the club and will allow an increase in the consumption of the private good and the utility level. In the same time, its entry also decreases the quality of the club good enjoyed by club members, because of higher congestion costs.[25] Necessary conditions for a maximum are given by:

$$n\frac{\partial U/\partial g}{\partial U/\partial x} = \frac{\partial C}{\partial g}, \tag{1.8}$$

$$\frac{\partial C}{\partial n} = \frac{C}{n}. \tag{1.9}$$

Equation (1.8) is the familiar Samuelson condition for the Pareto-optimal allocation of public good. In contrast to pure public goods in which the relevant size of the jurisdiction is the entire community, club goods require an entry or a membership condition, which is given by

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[25]Formally, externalities that people create simultaneously for each other can be illustrated by differentiating the utility function specified in the optimization program with respect to n:

$$\frac{\partial U}{\partial n} = -\frac{\partial U}{\partial x}\frac{\partial C}{\partial n}\frac{1}{n} + \frac{\partial U}{\partial x}\frac{C}{n^2}.$$

The first term represents the external diseconomy, for which an increase in n lowers U, since $\partial C/\partial n > 0$. The second term refers to the external economy, for which an increase in n rises U, since it reduces the average contribution and increases the consumption of private good.

equation (1.9).[26] This condition shows that when a new household enters the community, it increases the marginal congestion cost; at the same time, it decreases the average contribution. Thus, equation (1.9) states that the club welcomes new entrants up to the point where the marginal congestion cost is equal to the average contribution. The intuition behind this result is that for large groups, crowding costs dominate the benefits of sharing the cost of the club good. It means that reallocations of individuals in larger groups will not lead to Pareto-superior outcome.[27]

Denoting N the size of the total population in the economy, equation (1.9) implies that there should be N/n identical clubs, a condition that is not certain to occur (this problem, on which we come back later, is known as the integer problem). The entry condition also requires that each of the N/n groups be sized such that the average cost per person C/n be at a minimum. This sheds light on the Tiebout assumption under which voting with one's feet leads each jurisdiction to provide local public services at the minimum average cost. If $\partial C/\partial n < C/n$, the jurisdiction has to attract new residents to benefit from lower sharing costs. If $\partial C/\partial n > C/n$, the jurisdiction has to reduce its population size in order to lower the crowding costs.

Alternatively, the solution to (1.7) can be seen as a two-step optimization program (Scotchmer, 1985a). In a first step, the program (1.7) has to be solved with respect to g; it yields $g(n)$ the efficient allocation of public good for any group of size n. In a second step, $g(n)$ is substituted in (1.7) to give the utility envelope:

$$u(n) \equiv U(y - C(g(n),n)/n, g(n)), \tag{1.10}$$

which is maximized with respect to n to yield the efficient size of the club.

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[26]With a pure distaste for association, the utility function is $U(x,n,g)$ and equation (1.9) rewrites:

$$-n\frac{\partial U/\partial n}{\partial U/\partial x} = \frac{C}{n}.$$

[27]According to Scotchmer (2002) this point explains why club models have been interpreted as models of local public goods.

Non-Spatial Clubs

The main focus of the early literature on clubs was on the characterization of the efficient sharing groups, as in the previous simple model, and on the existence of solutions. The main issue related to the existence of equilibrium in the theory of clubs is the integer problem. Using the equilibrium notion of the core, Pauly (1967, 1970a,b) shows that allocations in the core are efficient but that the core is generally empty. Indeed, a stable group formation requires that the total population N is an integer multiple of n^* (in addition, the efficient club size n^* must be lower than total population). If its not the case, a group of agents can act cooperatively and form a jurisdiction to raise the utility of at least one member. Thus the club formation is unstable - the core is empty.

As argued by Scotchmer (2002), the equilibrium concept used in the club literature and in the Tiebout model are different. Besides the notion of the core, Scotchmer and Wooders (1987a,b) introduce the competitive equilibrium in club economies. In this approach, the competitive conjecture is applied to clubs to see whether a complete price system defined by the memberships in groups leads to an efficient allocation of agents. Scotchmer and Wooders (1987a) show that when there is only one private good every allocation in the core is a competitive equilibrium. The equivalence between the core and the competitive equilibrium implies that the integer problem also applies to the competitive equilibrium.

A third equilibrium concept used in the theory of clubs is the Nash equilibrium. For instance, Scotchmer (1985a,b) studies a Nash equilibrium in which the clubs' strategies are the facility size or both the facility size and the membership price. The nature of the Nash equilibrium will depend on the type of clubs' strategies.

In contrast to the three previous equilibria discussed above, the Tiebout model uses the notion of the free mobility equilibrium. In this setting, the group formation is stable if no agent wants to move to increase utility. Scotchmer (2002) argues that this type of equilibrium is more limited than the core or the competitive equilibrium since it gives the opportunity for a group of agents to make coordinated decisions to reassemble in an efficient size group.

The simple model that we have presented has been extended in many ways. For example, some models allow for a variable visitation or utilization rate (Berglas, 1976b; Berglas and Pines, 1981; Scotchmer and Wooders, 1987a). Moreover, we implicitly assume anonymous crowding in the provision of the public good, i.e. the congestion depends on the number of club members but not on the members' characteristics. In contrast, with non-anonymous crowding, such as peer group effect in schooling, club members generate different types of externalities depending on their individual characteristics. Club literature with non-anonymous crowding includes Berglas (1976a,b), Scotchmer and Wooders (1987b), Brueckner (1989, 1994), Wooders (1989), McGuire (1991), Scotchmer (1997), Gilles and Scotchmer (1997) and Epple and Romano (1998). Scotchmer (2002) shows that non-anonymous crowding confers another dimension to the existence problem discussed above: even if there is no integer problem, it may be impossible for agents to form groups with appropriate combinations of characteristics.

Another issue raised by the Tiebout model is the club's formation with heterogeneous population. Should optimal group formation with heterogeneous population lead to segregated or mixed clubs? This question has important implications on social stratification, the desirability of segregated neighborhoods and exclusionary zoning ordinances. Answer is mixed but the different points of view are inherent to the model used (Sandler and Tschirhart, 1980).[28] For example, Berglas and Pines (1981) show that, in a club model with two types of agents and variable utilization of the facility, it is suboptimal to have two or more identical mixed groups. However, Sandler and Tschirhart (1984) demonstrate that this result depends crucially on a full financing constraint implied by the way the congestion enters the utility function: the toll reduces to an average pricing rule. Consequently, mixed clubs, where heterogeneous agents use different amounts of the club good but pay the same total fees, is always less desirable than homogeneous clubs.

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[28]McGuire (1974), Berglas (1976b) and Berglas and Pines (1981) argue against segregated clubs. In contrast, De Serpa (1977), Sandler and Tschirhart (1980) and Sandler and Tschirhart (1984) argue in favor of mixed clubs.

Spatial Clubs

Spatial considerations have been relatively little explored in the theory of local public goods whereas it allows understanding the difference between club goods and local public goods. Scotchmer (2002) notes that the main difference of clubs is that the population can be partitioned in different ways for different club goods - for instance one club for a museum and another club for a swimming pool - while it can be only once for a jurisdiction. Oates (2006) argues that the problems addressed in the basic theory of clubs is much simpler than those addressed in the Tiebout model. The latter deals with space; households are restricted in a geographically defined jurisdiction, where they consume a given bundle of public services. In contrast, the theory of clubs allows individuals to consume different public goods in different clubs, whose geographical boundaries could well overlap.

Recent literature on clubs includes explicitly spatial issue such as housing and land markets in order to approach the Tiebout features. Hochman (2005) suggests that besides the primary agglomeration of club goods into facilities caused by scale economies in the provision of these goods, space brings two other types of agglomeration. A secondary agglomeration leads households to concentrate around facilities in order to save commuting costs. This secondary agglomeration of population in turns generates a tertiary agglomeration of facilities in the midst of population concentrations. Hochman (2005) argues that the previous literature on urban agglomeration (e.g., Fujita and Thisse (1986), Thisse and Wildasin (1992)) ignores the tertiary agglomeration by assuming a uniform population density (and thus ruling out the secondary agglomeration of population).[29]

Space is not only a new source of agglomeration but it also affects the rule for optimal allocation of public goods and population. Hochman (1982a) studies congestable concentrated local public goods in an urban setting, with endogenous clubs' boundaries. These types of public goods are provided in specific locations to which residents must travel to enjoy their consumption. Hochman (1982a) shows that efficient provision of public goods implies that congestions tolls, equal to the marginal damages to club members by the marginal unit of utilization, are imposed on each unit of utilization. Total congestion tolls paid by club mem-

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[29]Hochman (2009) derives the optimal allocation with the three types of agglomeration pattern and shows that contrary to non-spatial clubs, these optimal solutions may be difficult to decentralize.

bers should be set in proportion to the degree of congestability. In contrast to non-spatial clubs where user charges cover the entire cost of the club goods, efficiency requires that the rest of public expenditures are covered by land rents taxation.[30]

With pure concentrated local public goods, i.e. when the degree of congestability is equal to zero, local expenditures are fully financed by land rents (we come back to the HGT). In contrast, when the degree of congestability is equal to zero local expenditures are fully financed by congestion tolls, that effectively become prices.

Hochman (1982a) notes that compared to the non-spatial theory of clubs, the existence of clubs formation is not only due to the congestion of local public goods but also to the limited accessible land. Limited geographic space constitutes a natural source of congestion. Thus, even in the case of a pure concentrated local public good, i.e. with no direct crowding from the public facility, the formation of club occurs because limited accessible land around facilities still generates a second type of congestion.

Besides the conditions for an efficient allocation of public goods, the introduction of space implies a set of spatial conditions for an efficient location of public goods and fixation of club boundaries. Hochman (1982a) shows that local public goods should be located in such a manner that total travel costs to it by club members are minimized. This occurs when the total travel costs resulting from a shifting of the public facility from the CBD or toward the CBD are equal. Optimal border fixation implies that the marginal rate of substitution between housing and a composite private good of two households on the border of two clubs must be equal.

Contrary to Hochman (1982a) who restricts clubs from providing only one public good with independent boundaries, Hochman et al. (1995) study an institutional structure of local governments that allows for overlapping of clubs' market areas, due to the consumption of multiple local public goods. They show, like Hochman (1982a,b) that the formation of an optimal complex (which is a system of clubs providing the whole range of local public goods to the population) satisfies an extended version of the HGT. However, the decentralization of this

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[30]This result is also derived by Hochman (1982b) in the case of dispersed congestable local public goods and by Hochman et al. (1995) in an overlapping clubs framework.

optimum is problematic because of the overlapping structure of the clubs. With only one local public good, the taxation of land rents accrues only to the club where land is located. With overlapping clubs, the aggregate land rent has to be distributed among different suppliers of the local public goods with common market area. The aggregate land rent must be distributed in such a way that each supplier of the local public goods behaves efficiently.

Hochman et al. (1995) argue that the only way to achieve efficiency is thus to decentralize fiscal responsibilities to land value maximizing local governments that control the clubs' attributes within the boundaries of an optimal complex. Since these local governments should encompass the whole range of local public goods, each serving an optimal area, their boundaries might be relatively large. That's why Hochman et al. (1995) denote these local government as "metropolitan governments". Thus, this model suggests that fiscal responsibilities should be decentralized to only one layer of local governments with larger territorial bases, rather than to multiple layers of governments to provide several types of local public goods.

In contrast to Fujita (1986) and Sakashita (1987) who consider endogenous locations of public facilities but exogenous numbers of public facilities, Berliant et al. (2006) provide a model in which both the locations and the numbers of congestable public facilities are determined endogenously. They derive the Pareto-optimal allocation and show that dispersed public facility configuration occurs for high degree of congestability and unit transportation cost and low household valuation of the public good.

Conclusion

This chapter goes back to the theoretical source of the capitalization of local fiscal variables into house values. Tiebout (1956) argues, in response to Samuelson (1954), that in a local context agents have to move to their preferred jurisdiction and are forced to reveal their preferences for local public goods. This mechanism, which is analogous to the functioning of the private market leads to the efficient provision of local public services.

Wile the Tiebout model is constantly invoked in both theoretical and empirical capitalization studies, there is no mention of capitalization in his original paper. This can be explained by the absence of a complete description of complete system of prices for local public goods and practically no consideration of housing. Once we introduce these two ingredients in a model that preserve the Tiebout features, Hamilton (1975, 1976b) shows that capitalization plays an important role for the efficiency of the provision of local public goods.

The efficiency of local public services in the Tiebout model may seem somewhat trivial when one considers that Tiebout does not fully describe the process under which taxes and public expenditures are chosen. There is three approaches to fill this gap. The profit maximizing communities view is in line with the original Tiebout model. Alternatively, local governments may set fiscal packages in order to maximize the property values of their residents. The Tiebout model also shares common features with the club theoretical approach.

Chapter 2

The Empirical Review of the Capitalization Literature

E very capitalization study is based either on the hedonic approach or the asset pricing approach, which are presented in first section. The former establishes a relationship between the price of a marketable good and the amenities this good contains. It has been used in order to estimate the impact of a large number of non-market goods (like environmental amenities, air pollution, flood hazard) on house prices and to infer their implicit prices. The latter approach is not only used to determine the price of a house but is also used to set the price of other asset like stocks or bonds (Yinger et al., 1988).

As noted by Oates (2006) and Fischel (2001), there is a large literature on capitalization. Of course the objective of this chapter is not to present this literature exhaustively.[1] This chapter surveys the capitalization literature by focusing on the econometric innovations and improvements that occurred over time. The first significant empirical contribution to the capitalization of local fiscal differentials into house values, Oates (1969), is subject to var-

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[1]See the surveys of Bloom et al. (1983), Yinger et al. (1988), Chaudry-Shah (1988) for a review of a part of this literature.

ious biases of different natures. Subsequent literature can be viewed as a continuous effort to reduce these biases and obtain better measures of the degree of tax and public services capitalization.

Some authors (King, 1977; Reinhard, 1981) point to a misspecification of the tax variable in Oates (1969). Pollakowski (1973) argues that Oates (1969), by considering only the annual current expenditure per pupil in dollars as a proxy for the public service quality, does not correctly control for public expenditures in his capitalization regression. A large part of the literature is dedicated to the search of an appropriate control of the public service quality. Section 2.4 shows that most of the articles (McDougall, 1976; Rosen and Fullerton, 1977) introduce for example test scores as a proxy for public school quality. An alternative is to compute the school's value added as a proxy for public school quality (Sonstelie and Portney, 1980a; Reinhard, 1981; Downes and Zabel, 2002).

A difficulty induced by the estimation of capitalization is to isolate the tax rate effect from the public service effect on house prices (Linneman, 1978). Richardson and Thalheimer (1981) and Palmon and Smith (1998b) overcome this difficulty by estimating capitalization in jurisdictions which provide the same level of services but where, for some reasons, there are substantial variations in the property tax rates. This allows to avoid the potential downward bias in the tax capitalization coefficient, induced by error measurement of public services and the positive correlation between public services and tax rates.

A standard capitalization regression requires a lot of information on neighborhood characteristics to avoid omitted variable bias on public services coefficient estimates. To reduce the omitted neighborhood variables bias on public service capitalization, Cushing (1984) and Black (1999) estimate capitalization at the border of two jurisdictions in order to benefit from public services differentials but with relatively little variation in neighborhood attributes.

Due to a lack of informations on individual transactions, the first capitalization studies focus on interjuridictional tax capitalization, that is municipalities with relatively high tax rate have a relatively low median house value. Section 2.6 shows that intrajurisdictional capitalization may occur because of assessment differences that stems from the absence reevaluation of property values at market prices (Yinger et al., 1988), because of systematic and random

assessment (Ihlanfeldt and Jackson, 1982), or because of tax reduction (Chinloy, 1978). Moreover, in contrast to aggregate studies, studies based on micro data allows to estimate either intrajurisdictional capitalization (Church, 1974; Edelstein, 1974; Wales and Wiens, 1974; Chinloy, 1978) or both within and across capitalization (Case, 1978; Hamilton, 1979; Goodman, 1983).

2.1 The Two Approaches for Testing Tax Capitalization

Most of the studies on capitalization are founded on two approaches, namely the house price hedonic approach and the capitalization approach. Each of these approaches is subject to several econometric problems such as measurement errors in the variables, potential left-out variables, simultaneity bias, and potential misspecification of the empirical equation.

2.1.1 The Hedonic Prices Approach

The hedonic prices approach is used both for aggregate studies (Oates, 1969, 1973; Gustely, 1976) and micro-data studies (Palmon and Smith, 1998b; Black, 1999; Brasington, 2001) on tax capitalization and is based on the pioneering theoretical works of Lancaster (1966) and Rosen (1974). Following this procedure, the hedonic prices of differentiated products (which are implicit prices) can be defined as a function of their attributes.

Formally, a house bundle is represented by a vector of n characteristics $Z = (Z_1, \ldots, Z_n)$. Each element of the vector Z is a quantity of an objectively measured attribute, like the number of rooms, the size of the lot or the location. Since land is non-reproducible, each house is unique. However, the price structure is assumed to be identical for the embodied characteristics. The perception of these quantities is homogeneous among consumers, even if their preferences relative to alternative packages may vary. It is assumed that there is a sufficient number of houses with different characteristics so that the choice of various combinations of attributes is continuous. The market price of a house is given by $P(Z)$, the

hedonic price function, which depends on the vector of characteristics. We assume that this price is parametric for households, i.e. they compete with each other for housing and land and they have no market power. Households' preferences are given by the following utility function $U = U(X,Z)$, where X represents a composite non-housing good. If the price of X is equal to one and Y is the income, the budget constraint is $Y = X + P(Z)$. The households choose a house with $(Z_1,\ldots,Z_n)$ characteristics and the quantity of the composite good so as to maximize its utility function subject to the budget constraint. This leads to the following first-order conditions:

$$\frac{U_{Z_i}}{U_X} = \frac{\partial P}{\partial Z_i} = P_i, \quad i = 1,\ldots,n. \tag{2.1}$$

As in the classical urban economic theory (Alonso, 1964; Muth, 1969), we can derive from the utility function a bid rent function $\theta(Z,u,Y)$ using a condition of minimum utility level attainment:

$$U(Y - \theta(Z,u,Y),Z) = u. \tag{2.2}$$

The bid rent function gives the maximum amount of expenditures a household is willing to pay for an alternative bundle of characteristics of a house and for a given level of utility. Differentiating (2.2) yields:

$$\theta_{Z_i} = \frac{U_{Z_i}}{U_X} > 0, \quad \theta_u = -\frac{1}{U_X}, \quad \theta_Y = 1. \tag{2.3}$$

Equation (2.3) shows that the derivative of the bid rent function with respect to a particular characteristic is equal to the willingness to pay (in terms of X forgone) for an additional unit of this characteristic, holding the utility level constant. Moreover, the bid rent is decreasing in the level of utility index and increasing in the income.[2]

Optimality is reached when the minimum price $P(Z)$ the buyer has to pay is equal to his maximum willingness to pay, that is when $\theta(Z^*;u^*,Y) = P(Z^*)$ and then when at the margin:

$$\theta_{Z_i}(Z^*,u^*,Y) = P_i(Z^*), \quad i = 1,\ldots,n. \tag{2.4}$$

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[2]For more details on the form and properties of P and θ, see Rosen (1974).

Combining (2.3) and (2.4), we obtain:

$$\theta_{Z_i} = \frac{U_{Z_i}}{U_X} = P_i, \quad i = 1, \ldots, n. \tag{2.5}$$

This equation offers the theoretical foundation to the interpretation of the parameters of an econometric equation regressing housing price on housing characteristics. It insures that, under optimizing behavior and equilibrium in the housing market, the choice made by the consumers provides information on the marginal willingness to pay for housing characteristics.

To close the model, we have to explain the hedonic price function determination and thus the producers' behavior. Each firm is restricted to produce competitively only one combination of characteristics and has a cost function $C(M,Z)$, with M the number of houses supplied. Again, the assumption of perfect competition insures that the producers take the hedonic price as a parameter. Let the marginal cost of producing more characteristics and houses be positive and increasing. Each firm chooses a combination of attributes and a level of production to maximize its profit $\pi = MP(Z) - C(M,Z)$, which yields the following first-order conditions:

$$P_i(Z) = \frac{C_{Z_i}(M,Z)}{M}, \quad i = 1, \ldots, n \tag{2.6}$$

$$P(Z) = C_M(M,Z). \tag{2.7}$$

Optimum combination of attributes is reached when the marginal cost of an additional unit of characteristics equals its marginal cost of production for all attributes. Moreover, houses are produced until the per unit revenue equals the marginal cost of production.

We can define an offer function for the producers as we made for the consumers and the bid rent function by using the following condition:

$$\pi = M\phi - C(M,Z). \tag{2.8}$$

The offer function indicates the minimum supply price the producer is willing to accept for a given bundle of attributes and profit level. Basic properties can be derived by differentiating

equation (2.8) with respect to Z_i and π:

$$\phi_{Z_i} = \frac{C_{Z_i}}{M} > 0, \quad \phi_\pi = \frac{1}{M} > 0. \tag{2.9}$$

The offer function is increasing in characteristics and in the profit level.[3] Optimum bundle of characteristics and maximum profit requires that the offer price the producer is willing to accept equals the maximum price given by the market condition, so that $\phi(Z^*; \pi^*) = P(Z^*)$ and that

$$\phi_{Z_i}(Z^*; \pi^*) = P_i(Z^*), \quad i = 1, \ldots, n. \tag{2.10}$$

Combining (2.6) and (2.10) yields

$$\phi_{Z_i} = \frac{C_{Z_i}(M, Z)}{M} = P_i, \quad i = 1, \ldots, n. \tag{2.11}$$

Market equilibrium requires that the amount of supplied houses is equal to the amount demanded by consumers for every set of characteristics.

This model provides a theoretical foundation for the link between the price of a house and its characteristics. If we consider that the bundle of attributes enters linearly in the econometric equation,[4] we obtain

$$P_j = \alpha_0 + \sum_{i=1}^{n} \alpha_i Z_{ij} + \beta_{t_j} t_j, \tag{2.12}$$

with P_j the sale price of the jth property, Z_{ij} is a vector of structural and locational characteristics and t_j is the annual rate of property taxation. All elements that may influence the house value enter in the vector Z_{ij}. In this regard, this type of equation has not only been used to study the impact of taxes and public services on house prices but also to estimate the economic value of other phenomenona that are not always traded in an explicit market, like flood hazards (Donnelly, 1989; Harrison et al., 2001) and air pollution (Smith and Huang, 1995; Chay and Greenstone, 2005).

The main disadvantage of this approach is that it has nothing to say about the way the property tax rate enters in the econometric equation (2.12).

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[3]For more details on the second order properties of the offer function, see Rosen (1974).
[4]Conditions for linearity of $P(Z)$ are given in Rosen (1974) and Freeman (1979).

2.1.2 The Capitalization Approach

Another way to derive an econometric equation that estimates the capitalization of fiscal variables is to use a simple asset-pricing principle introduced by the literature on financial markets and that relies house value to property taxes and measures of public services.[5] The house value is defined as being equal to the present value of net-of-tax rental values generated to the owner. Algebraically,

$$P = \sum_{i=1}^{N} \frac{S-T}{(1+r)^i},$$ (2.13)

where P is the house's market value, S is the value of housing services, T the annual property tax payment on the house and r is the real discount rate. Assuming an infinite lifetime horizon, equation (2.13) can be simplified to :[6]

$$P = \frac{S-T}{r},$$ (2.14)

where r can be interpreted as an infinite-horizon discount rate. Yinger et al. (1988) show that the greater the house lifetime horizon and the discount rate, the better the closeness of this approximation. Introducing β as an indicator of the degree of capitalization in equation (2.14) gives:

$$P = \frac{S-\beta T}{r}.$$ (2.15)

If S is assumed to be a linear function of the structural and locational characteristics, we can directly estimate equation (2.15) and calculate the degree of capitalization by multiplying the estimated coefficient of the property tax payment by an assumed real discount rate.

By definition, the annual property tax payment is equal to the effective property tax rate, t, times the house's market value P:

$$T = tP.$$ (2.16)

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[5]A comprehensive overview of this approach is given in Yinger et al. (1988).
[6]For details on the derivation of this simplification, see Yinger et al. (1988).

Substituting (2.16) into (2.15) allows us to obtain a version of the capitalization equation with the effective property tax rate rather than the property tax payment:

$$P = \frac{S - \beta t P}{r}. \tag{2.17}$$

Substituting the hedonic function for housing services $S(Z_i)$ in (2.17) and solving for P yields:

$$P = \frac{S(Z_i)}{r + \beta t}. \tag{2.18}$$

Note that since (2.18) and (2.15) are equivalent, the meaning of β is the same in both equations: it indicates the effect of a one dollar increase in the present value of property tax payment on the house price. Assume this time that S is a multiplicative function of housing and neighborhood characteristics of the form $S(Z_i) = \prod_{i=1}^{n} Z_i$ and take the natural logarithm of (2.18) to obtain:

$$\ln P = \sum_{i=1}^{n} \alpha_i Z_i - \ln(r) - \ln(1 + \frac{\beta}{r} t). \tag{2.19}$$

Contrary to the hedonic prices approach, the capitalization model gives a theoretical guidance not only for explaining the relationship between taxes and public services but also for the functional form that takes the tax price term in the econometric equation. However, it also involves econometric difficulties since equation (2.19) is nonlinear in the property tax rate and the coefficient β and the real discount rate are non separable. As a consequence, equation (2.19) cannot be estimated using a simple OLS regression. In the literature, three solutions are used to solve the problem of the nonlinearity. The first possibility generally used in the literature is simply to ignore or simplify the nonlinearity associated to the property tax rate and to enter t or $ln(t)$ as the tax variable. According to Yinger et al. (1988), this is clearly the less convincing solution because it introduces a bias with unknown magnitude and direction. Moreover, using this kind of approximations is disturbing especially when it is possible to derive an econometric specification from the theory. Another possibility is to use the approximation $ln(1 + a) = a$ when a is small. Contrary to the previous case, we can estimate the impact of this approximation which quality depends on the value of $a = \beta t / r$. For large β and t the approximation may be imprecise. The best solution is to use nonlinear methods to estimate equation (2.19), as in Yinger et al. (1988) who use a nonlinear two-stage least square estimating procedure.

2.2   Interjurisdictional Capitalization and the Tiebout Model: The Oates' Equation

2.2.1   The Oates's Equation

The first major contribution to the capitalization literature is Oates (1969). Even if there are some previous papers dealing with tax capitalization (Wicks et al., 1968), Oates is the first to test both tax and public service capitalization in a unified framework. His main objective is to offer a testable implication for the Tiebout hypothesis which states that the mobility of individuals leads to an efficient allocation of public goods at the local level. As we have seen in the first chapter, the Tiebout model describes a world in which a metropolitan area is composed of a central business district and many suburban communities that provide various types of tax and public services packages. Consumers are mobile and choose the community that offers the fiscal package that maximizes their utility.

Bearing in mind this result, Oates (1969) argues that the relevant variable that determines the location choice is the present value of future streams of benefits resulting from the provision of public services relative to the present value of future tax payments. As a consequence, an increase in the property tax may still rise the net rental income and the property value if tax revenues are used to finance public services that positively affect housing prices.

Oates (1969) extracts an empirical implication from these considerations. As the consumers take into account the effect of local public budgets for their choice of residence's locality, they bid up for houses located in communities with attractive fiscal packages, i.e. with relatively high quality of public services and low level of taxes. On the contrary, local public spending that does not affect location decisions should not affect the demand for housing and the property values.

The aim of Oates (1969) is thus to support empirically this practical implication of the Tiebout model, by testing the effects of local fiscal variables on property values in different communities. According to Oates, finding a positive effect of public services and a negative

effect of property taxes on property values would be consistent with the Tiebout hypothesis. These results would imply that households "vote with their feet" and would be an evidence for efficient allocation of public goods.

Oates (1969) uses a sample of fifty-three municipalities in the northeastern New-Jersey located within the New-York metropolitan region in 1960. Due to the use aggregate data, the author estimates interjurisdictional tax capitalization, which is consistent with the Tiebout model that focuses on interjurisdictional mobility. Moreover, the sample is restricted to residential communities where a large number of residents go outside the community (to the CBD, for example) to their place of employment, i.e. to communities with an employment-residence ratio less than one. The empirical equation takes the following form:

$$V = f(t,E,R,N,Y,M,P), \tag{2.20}$$

where V is the median home value by community, t is the effective tax rate in percent (the median property tax bill per household divided by the median home value), E the annual current expenditure per pupil in dollars. Since the value of a house does not only depend on local fiscal variables, other variables like the house style and location-specific variables that characterize the neighborhood of the house are also introduced in the equation. R, the median number of rooms per owner-occupied house is an indication of the size and N, the percentage of houses built since 1950, is a proxy for the age of the housing stock in the community. Y is the median family income in thousands of dollars in 1959. M, the linear distance in miles of the community from midtown Manhattan, stems from the classical urban theory. P, the percentage of families in the community with an annual income of less than \$3000, captures the effects of the neighborhood characteristics or "the intangible characteristics of a house" (Oates, 1969, p. 961). Indeed, wealthier families are more likely to live in high quality residences. P is used to adjust the median family income variable, because a large number of low-income families will understate the actual median income of homeowners relative to the median family income. Therefore the median income of homeowners and the median value of owner-occupied houses will tend to be higher in the communities with a relatively large number of low-income families.

Regarding the choice of fiscal variables, Oates (1969) uses the effective property tax rate as the tax price term rather than the nominal property tax rate to take into account the difference in assessment ratios between the different communities of the sample (for example, assessment practices may differ from one community to another). The effective property tax rate is included in a log form to approximate for non linearity described in equation (2.19). As a measure of the public services output, the (log of) per pupil school public spending is introduced with the assumption that expenditures vary positively with the level of output of educational services. Oates (1969) is aware that using an input as a proxy for an output is unsatisfactory because the variation of expenditures in two communities could be explained for example by the difference in the size of the school population, without any effect on the quality of education. In order to take into account the differences in the structure of the school population between communities, Oates (1969) determines a "weight pupil enrollment" to adjust the per capita school expenditures.[7]

In a first step, Oates (1969) estimates equation (2.20) with OLS. The results confirm, as expected from the Tiebout model, a positive effect of public services and a negative effect of taxes on the property value. However, the coefficients may be biased by simultaneity between the property tax rate and the property value. It might happen that the tax rate is influenced by the level of the property value because a higher property value in a community allows a given level of public services to be provided at a lower property tax rate, leading to a downward bias of the coefficient estimate of effective property taxes and thus to an upward bias of tax capitalization. The same logic applies for public expenditures with the exception that it may lead to an upward bias of the public service coefficient.

Oates (1969) uses a Two-Stage Least Squares (TSLQ) approach to solve the simultaneity problem in equation (2.20). In the first step, predetermined variables such as education attainment, population density or school's population structure are used to estimate predicted values of tax and spending that are purged of their correlation with the error term. The results are similar to the OLS regression except for the coefficient of the public expenditure variable which is larger. The control variables are all significant and with expected signs. Younger housing stock with higher size increases the property value. Houses are also more expensive

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[7]The following weight is applied for each school district: kindergarten pupils = .5, elementary school pupils = 1, secondary school pupils = 1.25, special pupils = 2.

in wealthier communities with nice neighborhood amenities. The closeness to the CBD positively affects the median house value.

Regarding the fiscal variables which are of primary interest, Oates (1969) finds that an increase in the local property tax from 2% to 3% reduces the market value of a house by about $1,500. The magnitude of tax capitalization is thus about two-third of the theoretical capitalization that would be induced by an equivalent tax rate variation for a typical house with a market value of $20,000 and a time horizon of 40 years, and using a discount rate of 5%.[8] For the expenditure side, Oates shows that for a hypothetical community composed of identical houses with a market value of $20,000 and one public school pupil per family, the increase in the public budget for education implied by 1% rise in the tax rate raises house values by roughly $1,200, assuming that one half of the additional tax revenues is used to finance education. Therefore, not only public education has a positive influence on property value but it also almost offsets the negative effect of an increase in the tax rate on house values. Oates (1969) suggests that this mihgt indicate that the sample's communities have approximately reached a Tiebout equilibrium in the sense that education is provided up to the point where the benefit from an additional unit of output equals the marginal cost. Moreover, the results support the Tiebout hypothesis that consumers shop for public services because communities with high property tax rate have lower house values than communities with low tax rate, holding constant the quality of public services. Thus consumers effectively choose the tax-service package that best satisfies their preference and bid up houses in the communities with relatively low tax rates and high education quality. Another important conclusion in terms of tax incidence is that the property tax is equivalent to a benefit tax. As the negative effect on property value of a tax increase is roughly offset by the public spending allowed by the additional tax revenues, property tax can be seen as a kind of user charges for services provided (Mieszkowski and Zodrow, 1989). This means that efficiency holds in the Tiebout model even with property taxes, if the urban area reaches a Tiebout equilibrium.

While the Oates's equation stimulated a number of papers in the field of tax capitalization, it raised several critics regarding both economic and econometric issues. First, as Oates recognizes himself, the negative relationship between house values and taxes could be a

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[8]For details on the calculus, see Oates (1969), p. 965, footnote 13.

short-run phenomenon and disappear in the long run, because of housing supply adjustment. Moreover, Hamilton (1976b) and Edel and Sclar (1974) argue that estimating significant tax and expenditures capitalization does not necessarily imply efficiency. On the contrary, in a fully adjusted Tiebout equilibrium, supply response to tax differentials should cancel tax capitalization. Thus, efficiency would require no capitalization at equilibrium.[9]

Second, the Oates' study is also subject to several econometric problems. For example, a too little number of control variables for structural and location characteristics of houses is included in the estimation. This could lead to potential left-out variables bias, especially if these variables enter in the characteristics of houses that determine the assessment value. In this case, the property tax payment is correlated with the structural and neighborhoods characteristics. Since houses' structural characteristics generally have a positive effect on the assessed value, left-out variables are likely to under-estimate the extent of tax capitalization (Yinger et al., 1988). Pollakowski (1973) suggests that the estimation of the public service capitalization could also be biased by left-out variables. Oates uses educational expenditure per pupil as a measure of local public services. He argues that primary and secondary education is an important item in local public budget. However, as Oates does not provide a consistent interpretation on his public service variable, it may introduce biases in the estimation of the public good capitalization. Assume that E is a proxy for educational services and that another public service variable which significantly affects the property value is omitted. If the left-out variable is *positively* related to E, the capitalization of the public service variable will be biased *upward*. If the left-out variable is *negatively* related to E, the capitalization of the public service variable will be biased *downward*. In this case, an accurate estimation of public service capitalization will require that only public school expenditures significantly affect the property value or that other types of public service are uncorrelated with E. Therefore the direction of the bias depends on the sense of the relationship between public education expenditures and other types of local public spending that affect the property value. By contrast, if we consider E as being an index for the general level of public services in the community, the estimation of the public services capitalization will be more accurate if E is highly correlated with the left-out variable. To the extent that the left-out public spending variable is related to the property tax variable and that more public expendi-

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[9]The debate on the persistence of capitalization is detailed in chapter 4.

tures may imply more taxes, the tax capitalization is likely to be underestimated. However, if the community finances public services by debts, the property tax and the left-out public spending variable may be negatively correlated and yield a downward bias on the tax coefficient.

Regarding the potential endogeneity problem, Pollakowski (1973) casts some doubts on the two-stage estimation procedure used by Oates (1969). More precisely, he argues that several of the Oates's instruments are also correlated with the error term, whereas the interest of a TSLQ is to find additional variables that are correlated with the tax and the public expenditure variables but not with the error term. Pollakowski gives evidences about the consequences of an inappropriate use of the TSLQ by estimating an empirical equation similar to the one of Oates and using the same data but without illegitimate predetermined variables, such as education attainment, population density and percentage of dwellings owner occupied. The results are no longer satisfactory: tax rate and public education coefficients become imprecise and insignificant at the 5% level.

These critics are only part of those made to the original Oates's equation. Other econometric problems regarding the use of public spending as a measure of public services quality, the proper choice of a tax variable, the use of macro data and the functional form of the capitalization equation have been the object of several critics to the Oates's original estimation. As we said in the introduction of this chapter, the empirical capitalization literature can be seen as a constant improvement of econometric models and procedures, using the particular properties of unique data set. Thus, in the next sections we review with more details these econometric issues and the different approaches that have been adopted to deal with all problems encountered in the original Oates' capitalization equation.

2.2.2 Capitalization and Tax Incidence

Before turning to the various improvements over time of the literature on fiscal capitalization, let us consider the somewhat neglected issue of capitalization of property taxes into rents.

The fiscal capitalization is closely related to the incidence of local property taxes and the fiscal equity. As argued by Orr (1968) and Mieszkowski and Zodrow (1989), the classical view of tax incidence emphasizes that as land is supplied in a fixed quantity, land taxes are borne by the landowners in the form of lower land values. Moreover, taxes on improvements, such as housing taxes, fall upon tenants in the form of higher rents. For instance, an increase in the property tax drops the level of the net return to capital and investment is discouraged. The decrease in the capital stock boosts the price of the housing stock and occurs until the market price of capital compensates the higher tax, resulting in a complete forward shifting. This has an important implication for fiscal equity because it implies that in the case of rental property, taxes are borne by the renters who tend to belong to lower income groups, strengthening the tax regressivity of the taxation structure.

However, following Oates (1969), almost all contributions on tax capitalization focus on the effects of property taxes on house values and evidences that rents capitalize taxes, confirming that forward shifting have been relatively neglected, except Orr (1968), Hyman and Pasour (1973a) and Black (1974) who study the impact of property tax on rental housing. Orr (1968) argues that the conventional theory of the incidence of property taxes is based on a particular assumption regarding the supply elasticity of improvements. More precisely, in the long run, the supply of capital adjusts so that there is no capitalization of taxes in the value of the structure but rather an increase in the rents.

Following alternative assumptions, there are some reasons to think that incomplete forward shifting may occur. Based on Boston metropolitan area data, Orr highlights that only a small portion of housing structures was recently built and thus suggests that the change in the housing stock relative to rent differentials is a very slow process. With an imperfect elastic housing supply curve, a lower part of the tax burden will be borne by tenants. In the extreme case of a perfectly inelastic housing supply,[10] the tax burden will be entirely borne by property owners.

Another implicit assumption of the traditional tax incidence theory is that the property tax is uniformly set in the urban area as a whole. However, in a system of independent local

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[10]This is the basic assumption made in studies on tax capitalization with property owners, on the ground that the quantity of land is given. For a discussion on the validity of this assumption, see chapter 3.

jurisdictions with tax autonomy, there are wide cross-section discrepancies in the level of tax rates. In the Tiebout tradition of residential mobility, these tax differentials should lead households to move toward low taxing jurisdictions.[11] A higher degree of interjurisdictional mobility should lead to a more elastic demand for housing and tend to reduce the forward shifting. In the limit, perfect residential mobility would completely vanish forward shifting and make owners bear all tax differentials. Of course, these arguments on supply and demand elasticity are no longer valid for that portion of the property tax that is common to all jurisdictions.

In conclusion, Orr expects that property taxes in a local context should be at least only partially shifted forward, if not shifted at all. To test this hypothesis, the median monthly gross rent per room (R) is regressed on housing demand and supply characteristics, since the equilibrium rent is found by equalizing the demand and supply for housing in each jurisdiction:

$$R = f(t, X_1, \ldots, X_n, Y_1, \ldots, Y_m), \tag{2.21}$$

where t is the equalized property tax rate, X variables stand for the housing supply characteristics and Y for the demand characteristics. Concerning the housing supply characteristics, Orr includes the average price of land per acre in the jurisdiction to control the effect of tax differentials on land values and a dummy variable that indicate the presence of publicly provided sewage disposal facilities and water. Demand characteristics comprise an index of accessibility to employment opportunities in surrounding communities, an index of the housing stock quality and the annual amount of educational expenditure per pupil in public school expressed as a deviation from the state average. The variable of primary interest is t, the equalized property tax rate on single-family homes. A significant positive coefficient of the tax variable would indicate the extent of the tax shifting to tenants. Equation (2.21) is estimated by linear least squares regression.

t does not enter significantly in (2.21), hence estimation results clearly support the nonshifting hypothesis: for the sample of Boston SMSA, tax differentials are borne by property owners rather than occupants. Orr (1968) finds that even if t was statistically significant,

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[11]In this case, we assume a constant level of public services among jurisdictions.

a 1% increase in tax rate would be shifted forward by only about 20%.[12] This result has important implications for fiscal equity. In contrast to the traditional theory on property tax incidence, Orr (1968) shows that local conditions on housing demand and supply elasticity effectively make property owners bear the tax burden. Since renters tend to belong to lower income groups than property owners, this outcome would leave the local property tax less progressive than expected.

Black (1974) realizes a similar estimation but uses a different sample. Restricting the analysis to the city of Boston, he finds that taxes are more shifted than in the metropolitan area, as an unit increase in the effective property tax rate rises the monthly rent by about 60%. In a city, housing supply is expected to be less elastic because of the lack of land available. This should lead to lower tax shifting estimates. As a consequence, higher tax shifting is likely to be driven by a relative inelastic housing demand. Depending on the appropriate assumption on housing demand elasticity, this result may well be coherent with Orr's findings.[13]

Hyman and Pasour (1973a) also find on a southern state sample of North Carolina a greater degree of tax shifting than Orr (1968). Their empirical results suggest that 60% of a $0.10 differential is shifted to the tenant through an increase in rents. While this seems to be in contrast with Orr's finding, Hyman and Pasour argue that North Carolina SMSAs have a more elastic housing supply relative to the Boston SMSA. This may be explained by several factors such as more land available surrounding municipalities in the state, less restraints on housing construction. Moreover, this result is consistent with another paper of Hyman and Pasour (1973b) that finds no capitalization of owner occupied housing property taxes into property values.

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[12]Heinberg and Oates (1970) cast doubts on Orr's results. They state that the equalized tax rate on single-family homes is an incorrect independent variable because rental housing is likely to be related to multi-family structures. Estimation of tax shifting will thus be biased if there are differences in assessment ratios in single-family and multi-family housing. Orr (1972) argues in response that there are reasons to think that equalized tax rates on singe-family and on rental housing are correlated since assessment ratios are highly correlated. Moreover, they are both calculated with a common nominal tax rate.

[13]Theoretical considerations on demand elasticity in cities argue in favor of either more or less elasticity. On the one hand, housing demand elasticity may be larger because housing units are more homogeneous and better substitutes than those in a metropolitan area, encouraging intrajurisdictional mobility. On the other hand, the standard urban land use model shows that low income population, which may be less mobile, tends to locate in cities. Moreover, low income families may not have the possibility to find appropriate type of housing (such as multiple-family structures) in the rest of the metropolitan area.

Thus these studies give evidence that the effects of property taxation vary over regions and may fall either on renters or on property owners, according to the conditions on housing demand and supply. An important policy implication is that the incidence of local property taxes will also differ across regions and may be more or less fair. As a consequence, the knowledge of these tax capitalization effects is of primary interest for policymakers when they set taxes or transfers.

2.3   The Choice of the Tax Price Term

A large part of tax capitalization studies focus on the property tax because it is, at least in the United-States, the primary source of tax revenue for local governments. In its original equation, Oates (1969) uses the effective property tax rate (which is the nominal tax rate times the assessment ratio) in order to take into account assessment variations across communities. Tax bills are defined as the product of the nominal tax rate and the assessment value of houses. As a consequence, nominal tax rate may not reflect the true tax burden borne by homeowners if the market value differs from the assessment value of houses. Several factors lead to differences in the assessment ratio. In an intrajurisdictional setting there may be systematic and random assessment errors which are related to assessment behaviors (for instance Ihlanfeldt and Jackson (1982) underscore that in U.S cities more expensive properties tend to be under assessed relative to less expensive properties, leading to a decrease in the effective property tax rate as values increase). Assessment discrepancies could also result from the adoption of various assessment practices across municipalities. Moreover, even if property values are correctly assessed at a given time, reassessment or revaluation do not occur everywhere at the same moment.[14] Property values with a high rate of growth are thus under assessed relative to property values with a low rate of growth.

Almost every tax capitalization study uses the effective property tax as the tax price term, except for King (1977) who suggests that in Oates's equation the tax effect is misspecified and introduces a bias on the tax capitalization estimate. He argues that it is the tax burden

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[14] A detailed description of revaluation histories in two of their seven Massachusetts communities sample is given in Yinger et al. (1988).

rather than the tax rate which is capitalized into property values. Using the effective property tax rate amounts to make the dependent variable P come up in the right-hand side of the econometric equation.[15] This tautological link between effective tax rate and property value implies a spurious correlation that has not been discussed by Oates.[16] The Oates' equation can thus be rewritten as:

$$V = \alpha + btV + \sum_i \beta_i X_i, \qquad (2.22)$$

where V is the median home value, tV the annual property tax payment (the effective tax rate applied to the median home value) and X_i the structural, site and public service attributes in the municipality.

However the introduction of a tax payment variable instead of an effective tax rate is not exempt of critics. Wales and Wiens (1974) argue that structural omitted variables, which are positively correlated with both the median home value and the tax payment variable, entail an upward bias for the tax coefficient and drive the estimated extent of the capitalization toward zero. Yinger et al. (1988) stress that it is more difficult to eliminate left-out variable bias in a tax payment specification than in an effective tax rate specification because tax rates are not directly correlated with housing and neighborhood attributes. This is especially the case for the Oates' sample which only includes the median number of rooms and the age of the housing stock as structural control variables.[17] King (1977) replicates the Oates's estimation (one with only public school expenditures as public service variable and one with public school expenditures and municipal spending) and uses a TSLQ procedure to deal with this simultaneity bias. In each case (with and without municipal expenditures), Kings finds a lower extent of tax capitalization than Oates.[18] To overcome the simultaneity problem and make sure that the low capitalization rate result does not come from the use of incorrect instruments for the tax variable,[19] he suggests an alternative form to the equation (2.22) in

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[15]This results from the definition of the effective tax rate which is the ratio of the annual property tax payment over the market value of the house.

[16]Oates only considers the case where the simultaneity bias stems from the fact that higher property values allow a given level of local public services to be provided at a lower property tax rate.

[17]King (1977) notes however that this argument does not hold if a sufficient large set of control variables is included in the estimation equation.

[18]Like Oates, King (1977) assumes a 5% discount rate and 40 years house time horizon to compute the degree of tax capitalization.

[19]As King (1977) does not give the list of instruments we can only infer that he uses the same instruments as Oates. Thus the critics formulated by Pollakowski (1973) to Oates also apply.

which the tax variable is included as part of the dependent variable:

$$V - btV = \alpha + \sum_i \beta_i X_i, \tag{2.23}$$

where b, measuring the extent of tax capitalization, takes the value selected from the interval (0.1-1.0). This equation is then estimated by a maximum likelihood procedure. Equation (2.23) is estimated for various values of b over the interval until R^2 is maximized. For the model including public school and municipal expenditures, the latter procedure generates robust results relative to the TSLQ regression.

Reinhard (1981) takes back King's claim that it is the tax burden which is capitalized into property values but brings two corrections to the equation (2.23). First, he argues that the right-hand side of equation (2.23) should be interpreted as the actual total user cost of the residence, that is the tax price plus the tax costs. However, with the tax coefficient b restrained to be positive, the actual user cost would be lower than the house price obtained without any taxation, but leaving the level of public services unchanged. The tax variable should therefore be added to rather than subtracted from the house price, as made by King (1977). Second, while the tax coefficient should reflect the present discounted value of the stream of future tax bills, equation (2.23) is designed to indicate the capitalization of only one year's tax payment. These considerations lead to the following equation:

$$V + \frac{btV}{r} = \alpha + \sum_i \beta_i X_i, \tag{2.24}$$

where r is the discount rate and time horizon of houses is assumed to be infinite. Regarding the estimation technique, Reinhard (1981) suggests that King's approach is not appropriate for equation (2.24) because the variance of the dependent variable is increasing as b rises. Thus an iterative procedure that maximizes R^2 will tend to select a low level of b. Reinhard overcomes this problem by passing the tax variable, in the form of tax rate, in the right-hand side of equation (2.24):

$$V = \frac{\alpha + \sum_i \beta_i X_i}{(1 + bt/r)}. \tag{2.25}$$

As in King (1977), the extent of capitalization is obtained by reestimating equation (2.25) with various values of b/r, and observing associated changes in the F-statistic.

With this econometric procedure, Reinhard finds complete capitalization and even over capitalization of the tax burden in property values, depending on the inclusion of the per capita municipal expenditures on all functions other than local public schools and debt service. Moreover, Reinhard (1981) points out that this result is not likely to be biased by omitted variables like Oates (1969) and King (1977) because his sample is based on a large sample of micro data (actual sales of individual houses) that carefully specifies structural and amenity characteristics of houses. In contrast to King (1977) who finds that the use of the effective tax rate instead of the tax bill as a tax variable leads to an upward bias of the capitalization, these findings of complete and over capitalization imply the opposite. In conclusion, the specification is important when one wants to characterize the extent of tax capitalization.

2.4   The Control for Public Goods and Other Variables

The taxation side is not the only weakness of the original Oates' contribution. Several critics concerning the control for public services are treated in subsequent capitalization literature. Critics are essentially related to the inappropriate choice of the public services variable and the control for neighborhood characteristics. Different approaches, which are presented in this subsection, are used to overcome this problem.

2.4.1   The Control for Public Services

Tax capitalization in property values reflects the differences in the present value of the future stream of taxes for constant quality houses. As a consequence, an accurate estimate of the extent of tax capitalization requires an appropriate control for all other characteristics of houses, and especially the benefits accruing from the provision of public services at the local level. Given the large number of studies that measure the school premium in house prices, it is probably impossible to describe these contributions exhaustively.

Following Oates (1969), most of tax capitalization studies focus on public schools because it is an important item of local government spending in the United-States. As we have seen above with Pollakowski (1973),[20] the use of only one public services variable may include biases on the tax and public services coefficients in case of omitted variables. This is all the more true for models that use aggregate data with few structural and neighborhood variables that poorly characterize the housing stock. According to Oates (1973), the easiest way to deal with this problem is to reestimate the equation (2.20) containing other spending variables that are also relevant for municipal governments. Oates is able to add a new variable, Z, the municipal spending per capita in 1960 (in dollars) in all functions other than local public schools and debt service. This variable is significant and has the expected sign. In addition, the absolute value of the tax coefficient is higher than when only public school expenditures are included in the hedonic regression, and implies roughly full capitalization of property tax differential into property values.

Gustely (1976) suggests that various outcomes on the extent of tax capitalization may result from aggregation bias over the public output measure. In particular, he notices that the most often used proxy in previous studies, the per pupil education expenditures, is not only composed of locally-raised funds but also of expenditures from state and federal sources. The positive influence of public expenditures on housing prices may then not be due to differences in school quality. While intergovernmental aid may well be capitalized into property values, it is important to distinguish between the effect of having a better school on house prices which is consistent to a Tiebout process and the effect of a higher level of grants that does not reveal any intrinsic public output advantages. To show the impact of the aggregation bias, two models are estimated for a rural, an urban and a combined sample each time.[21] In the first model, property values and rents are regressed on aggregate expenditures for school and nonschool purposes and a set of structural and accessibility variables. The results are unsatisfactory and counterintuitive: whatever the sample, expenditures coefficients are not significant and for most cases they have an unexpected negative sign. In the second model, public expenditures are disaggregated and only local expenditures are considered in the regression. This time, expenditures coefficients have generally a consistent positive sign and significance is substantially increased. These results confirm that external source of

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[20]See subsection 2.2.1.

[21]The sample consists in cities and towns in the Syracuse, New-York area for 1970.

finance implies confusion on the estimation of the effects of municipal spending differential on house prices.[22]

Appropriate Control for Public Education

There is a more disturbing problem with the use of public expenditures as a proxy for the quality of local public services. Rosen and Fullerton (1977) underscore that it is incorrect to control output public schools by expenditures on input variables. Public spending on education may be not perfectly correlated with public school quality differential because educational factor prices, educational production function and many environmental factors may differ among communities, so that some municipalities need more spending than others to reach the same education attainment. As argued by McDougall (1976), a proper use of expenditures as a measure of public services would require communities to have the same resource endowment, the same cost structure, the same technology. To his defense, Oates (1969, 1973) argues that within a metropolitan area such differences may be quite limited so that the level of expenditures is a reasonable measure of education output. In addition, Oates takes into account school specificities that are at least partially reflected in the public services variable as the per pupil school expenditures are weighted by the enrollment scheme.

Brasington and Haurin (2005) suggest that early capitalization studies used public school expenditures per pupil because outcome measures were not available. However, a proper treatment of school quality requires some alternative measures of public school output. The common approach in the literature is to substitute proficiency test scores for expenditures on local education inputs as a measure of school quality. Crone (2006) notes that the profusion of test scores as a standard measure of school quality was favored as they were required by a number of states in the 1980s and 1990s. Moreover, the No Child Left Behind Act of 2001 in the United-States requires students in grades three through eight take statewide standardized tests every year.

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[22]In the second regression the aggregate property tax is also decomposed into school and nonschool property tax to take into account the impact of separate taxing authorities. Regression results indicate that only school tax rates are capitalized into property values and not into rents.

Rosen and Fullerton (1977) replicate the Oates regression using achievement test scores instead of per pupil municipal school expenditures.[23] More precisely, various forms of test scores derived from data on average grades for fourth-grade pupils on readings and mathematics examinations in each community are included: reading score, math score, average of reading and math score and the logarithm of the average test score. They do not focus on a particular form of test score because theory does not specify which test is valued by home buyers and how it enters in the hedonic regression. The public schools quality variables are all significant, with the expected positive sign and perform better than expenditures variables. Moreover, including test scores variables seems to increase also the tax capitalization estimates. Their results imply that about 88% of a 1% tax differential would be capitalized in the form of reduced property value.[24]

A better control for public school quality does not solve the problem of omitted variables. For instance, if the public safety is positively related to property tax rate, tax capitalization will be underestimated. To obtain unbiased estimates of public services and tax capitalization, other local public services than public schools that are relevant for home buyers should enter the hedonic regression. McDougall (1976) includes the quality measure for four primary local services: police, education, fire protection and parks and recreation. As in Rosen and Fullerton, education services are measured by test scores. Police services are measured by two crime rates: the number of personal crimes per unit of population and the number of property crimes per unit of property values. Property crimes are weighted by the property value to take into account the incentives for criminals to operate in high property values communities. A better effectiveness of police protection is expected to be negatively related to crime rates. Parks and recreation services are measured by an index that indicates the number of subfunctions that is performed within the parks and recreation program for each city. A scale of one to ten is used as a proxy for fire protection services. This rating is provided by the Insurance Service Office in each community and the highest level indicates the lowest level of fire protection. It is based on different criteria like city water supply, the fire system alarm, the fire prevention program, etc. The advantage of this approach is to

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[23]They reestimate the Oates's equation using the same community sample but for 1960 and 1970 and find an inconsistent negative effect of per pupil municipal school expenditures on the median property value in the 2SLQ regression.

[24]This capitalization rate rests on the assumption of a $30,000 house with a 40-year use life and a discount rate of 6%.

distinguish the extent to which each public service is valued by home buyers. The results show that, for thirty-five communities within the Los Angeles metropolitan region, property values are responsive to differences in the availability of local public goods but there is heterogeneity regarding the degree to which each public service is capitalized. In particular, households' location is more influenced by public education and police services than by parks and recreation services, and fire protection services.

Controlling Public School Quality: The Value Added Approach

Theory suggests that households care about public school output but proficiency test scores as a measure for school quality present some limitations. Public school quality may not completely explain the differentials in test scores achievement. A part of test scores achievement may also be explained by the native ability of students, the family characteristics of students or even peer group effects. These characteristics should be controlled for if one wants to discriminate the marginal effect or the value added of the school.[25] Some studies (Sonstelie and Portney, 1980a; Reinhard, 1981; Downes and Zabel, 2002) compute the school's value added as the change in test scores between different grades. However, students mobility does not ensure that the scores in the two period refer to the same cohort of students, so that part of the change in test scores may be explained by a component other than the marginal effect of school. Using data on student characteristics, on contemporaneous and previous test scores in the Dallas Independent School District (DISD), Hayes and Taylor (1996) are able to econometrically decompose the students test scores achievement into a school contribution and a peer group contribution.[26] They find no significant effect of the peer group component. The school's value is statistically significant at least in northern Dallas and positively affects house prices. At the same time, using only test scores achievement gives the same qualitative results.

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[25]A brief review of the literature on the decomposition of test scores between students ability, peer group effect and the marginal effect of school is given in Crone (1998).

[26]They cannot however extract any information on students ability because student-level data are not available.

Brasington and Haurin (2005) not only decompose the test scores in 123 Ohio school districts into a school and a peer group contribution, but also into a parental component. For this purpose, they assume an additive educational production function that relates, at the district level, the average student achievement to the average of parental inputs, the school district inputs and the average of innate abilities of students. The production function is modified to address the problem of unobserved innate abilities of students and peer effects. Brasington and Haurin (2005) cast doubt on the importance of the value added as a measure of school quality for households, even if such measures would be theoretically more appropriate for researchers. In contrast to Hayes and Taylor (1996), they find little effect of the school's value added on house prices. This is confirmed by the estimation of an alternative model that only includes the deviations from the mean of the fourth, ninth and twelfth grade proficiency tests. The aggregate level of achievement seems to perform better than the value added model. Brasington and Haurin (2005) argue that homebuyers are more likely to consider standardized indicators of school quality that are easily obtained.

In conclusion, it is not clear which attributes of local public schools are relevant when individuals make their location choice. For instance, Crone (2006) shows that in the Montgomery County, Pennsylvania, test scores at the district level are better indicators of the quality of public education than test scores at the local school level, as they are more valued by home buyers.

Taking Advantage of School Reforms

Other studies take advantage of the specificities of the school system or school reforms to measure the impact of school quality on property values, without introducing any explicit variables that are supposed to represent the school's output. The main advantage of these approaches is that one does not have to make incorrect assumptions on which attributes are valued by home buyers.

Dee (2000) takes advantage of the Serrano decision taken by the California Supreme Court in 1971 and according to which the local property taxation main basis of financing for public

education was unconstitutional since it did not provide equal opportunity for all California's students. This decision was followed by a large number of states and modified the structure of education finance. In particular, states were encouraged to increase their per-student aid to poorer school district. Dee (2000) tests whether this new external funding toward education increases median housing values and rents through a gain in school quality. However, he does not include school expenditures or school quality variables in the hedonic regression. He constructs an interaction variable which is the product of an indicator for the position in the state distribution of the district in terms of locally generated per-pupil revenues and a dummy variable that indicates if state court-ordered education finance reform has been adopted. It allows heterogeneous effects of education finance reform over poor and rich districts. The results show that school finance reforms had larger effect on housing values and rents in poorer districts.[27]

Using repeated sales of individual residential properties in the state of Florida, Figlio and Lucas (2004) test whether the Florida's grading system influences house prices. In 1999, Florida adopted a school grade assignment system in which each school would receive a letter grade ranging from "A" to "F." The grading system was largely based on test scores achievement, but also on socio-demographic structures of schools, suspension rates and absentee rates. Figlio and Lucas (2004) ask whether the information on school reputation contained in the grading system is valued by the housing market in Florida. To test whether there is an autonomous effect of the grading system and neutralize cross-time and cross-section variation in school output, they also include a set of school attributes variables. Differences in school grade assignment strongly affect house values: for instance, the attribution of grade "A" rather than grade "B" rises house prices by 19.6% once one controls for other measures of school quality, neighborhood and structural attributes of properties.

Reback (2005) gets advantage of the particularity of the inter-district school choice program in Minnesota. Since the 1987-1988 school year, an inter-district open enrollment program enables the students of a particular school district to attend the school of another district. Under open enrollment program, property values rise in relatively unpopular districts with a high fraction of outgoing transfers because parents have the opportunity to send their children

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[27]In the first part of the paper, Dee (2000) regresses the same variables on current expenditures per pupil and finds that, following the court-ordered reform, poorer districts received more state aid relative to richer districts.

in a relatively high-quality school without having to pay a premium for living in that school district. For the same reason, property values decrease in districts with a high-quality school and with a high fraction of incoming transfers.

An original alternative approach to characterize the quality of local public services is to use survey data instead of input measures. Carlsen et al. (2009) include in their hedonic regression local public output measures that are based on a questionnaire covering the main services provided by Norwegian municipalities, like school, culture and health care. Each local public service was ranked by respondents on a scale from 1 (very dissatisfied) to 6 (very satisfied) and the municipality average satisfaction was regressed on personal, socio-demographic characteristics and dummy variables for each municipality to take into account the composition of respondents. They find positive and significant effect for three public services (culture, health care and transport). However, in a separate regression that includes input measures, they find no significant effect on house prices. They conclude that previous studies based on input measure may have wrongly rejected capitalization of local public service into house values due to the use of improper proxy.

Taking Advantage of Special Jurisdictions

Finally, a major issue of local public service capitalization is the specification error that may arise from particular assumptions on the local government budget constraint. Linneman (1978) argues that if local expenditures are entirely financed by property tax revenues, taxes and public goods will be perfectly correlated. The estimation of a property value equation will be econometrically impossible, unless measurement errors and omitted variables are present, which would bias the coefficient estimates. A first approach to solve this problem is to restrict the sample of properties to a single taxing jurisdiction where, by definition, there is no variation in the level of local public services, that is to focus on intrajurisdictional capitalization.

A second approach to isolate the tax rate effects from public service effects takes advantage of the particular structure of some local taxing jurisdictions in the United States. Richard-

son and Thalheimer (1981) use a sample of 861 single family residence in Fayette County, Kentucky sold during 1973-74. The properties are located in two intermixed taxing jurisdictions within the county, one with a low tax level and one with a high tax level.[28] While the nonschool tax rate is almost four times as high in the city as in the rest of the county, Richardson and Thalheimer (1981) argue that there is no variation in the perceived quality of services. The only difference is that the city provides streets lightening and trash pickup for its residents. According to the authors, tax differentials would be explained by spillovers and inefficiencies in the provision of city services. Richardson and Thalheimer (1981) estimate property tax capitalization with a linear specification similar to equation (2.12) and a multiplicative specification similar to equation (2.19). In each specification, the tax term enters as a dummy variable, indicating low or high tax jurisdiction. The multiplicative specification gives the more significant results and implies, for a discount rate of 8% and a 10-year horizon, that tax differences are capitalized at 73% of full capitalization. However, Yinger et al. (1988) show that with a more realistic assumption of a 3% discount rate and an infinite horizon, the capitalization rate drops to 15%. Moreover, they fail to explain properly the source of tax rate differences between the two jurisdictions, leading to a likely inexact control of public services.

Palmon and Smith (1998b) study the case of properties located in jurisdictions with unusual features. In the northwest suburbs of Houston, Texas, municipal utility districts (MUDs) were created to finance public infrastructures.[29] The MUDs were financed through the issuance of municipal bonds, the debt service being reimbursed by property taxes. While MUDs had the same level of services, there were substantial variations in the property tax rates because of differences in the borrowing conditions (distribution of bond maturities, period of bond issuance, etc.), the level of development of building activities, the proportion of nonresidential taxable property and economies of scales. This unique data set is used to estimate by a nonlinear maximum likelihood procedure an equation similar to (2.19). Palmon and Smith find substantial capitalization[30] and conclude that spurious correlation between

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[28]The first jurisdiction is the city of Lexington and the second jurisdiction is the areas in the county that have not been annexed by the city.

[29]The area was administered by the Harris County and three suburban school districts with a similar level of educational services.

[30]The degree of capitalization varies from 62% to more than 100% according to the econometric specification and the assumption on the discount rate.

taxes and public services may have led to downward bias of the degree of capitalization in previous studies.

2.4.2   The Control for Neighborhood Characteristics

An exact estimation of the capitalization of public school quality requires a proper control of the neighborhood attributes. For instance, Black (1999) suggests that to the extent that better public schools are located in better neighborhoods, inexact control for neighborhood characteristics will bias upward the effect of a better education. A straightforward solution to this problem would simply rely on the use of improved data set including a large number of neighborhood variables. A second approach is based on the restriction of the sample of properties in small areas with similar neighborhood amenities and variation in the level of public school quality. This occurs at the border of two school districts.

Early treatment of this approach can be found in Cushing (1984) who argues that capitalization of local differentials should be stronger at the border of two jurisdictions. This approach limits the biases that stem from omitted neighborhood variables because amenities and dis-amenities on houses located on the two sides of the border of two jurisdictions should not vary as much as between houses located in the center of two jurisdictions. Moreover, restricting the estimation of capitalization at the border of two jurisdictions makes the distance to CBD less relevant, which is of particular interest to avoid the problem implied by noncentral and multiple recreation locations. Using 86 observations from Detroit, in the Michigan SMSA, the difference in the mean value of owner-occupied units between adjacent central city and the ring blocks is regressed on housing and neighborhood characteristics and on differences in property tax rate and public services (which include education, libraries and fire protection). While Cushing (1984) finds a full capitalization of tax differentials and substantial effects of public services, the results are weakly significant.[31] This may be related to the lack of accuracy in the sample delimitation.[32]

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[31]The public sector variables are significant at the 0.10 level.

[32]In particular no information is given on the maximum distance of properties from the jurisdictions boundaries.

A more recent and refined treatment of this approach is used by Black (1999), who estimates the effect of a better school quality on house prices on the opposite sides of attendance districts boundaries within school districts in Massachusetts. Houses located in such areas benefit from different school quality but with relatively little variation in neighborhood attributes. As in Cushing (1984), this methodology reduces the biases that results from omitted neighborhood variables. But Black (1999) goes further by substituting a full set of boundary dummies that indicate houses that share (on either side) an attendance district boundary for the vector of neighborhood characteristics. Moreover, her results are more detailed because she uses several samples of houses that vary with respect to the distance from attendance boundary (with smaller and smaller distance in order to obtain increasing neighborhood homogeneity). The boundary fixed effect model gives a coefficient on test scores that is about half of the coefficient in a standard hedonic regression that includes a set of neighborhood characteristics instead of boundary dummies. The school quality coefficient is even lower when one restricts the sample of houses with the distance from boundary to 0.20 miles. The results thus confirm the presence of an upward bias in the effect of test scores on house values in previous capitalization studies, stemming from an incorrect control for neighborhood variables. Boundary fixed effects have been largely used in the subsequent empirical literature on school premium and house prices.

2.5   The Simultaneous-Equations Approach

Most of capitalization studies recognize the simultaneity problem that may arise between house values and both taxes and public services. Two-stage least squares are thus generally used to obtain consistent capitalization estimates. However, a number of studies provide a rough treatment of the instruments used in the first stage regression.[33]

At least three papers explicitly analyze the foundation of the simultaneity and use a simultaneous-equations approach to estimate the capitalization of taxes and public services into house val-

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[33]For instance, Pollakowski (1973) criticizes the set of exogenous variables used by Oates (1969). In some studies, simultaneity is not addressed (Richardson and Thalheimer, 1981; Brasington, 2001) or the list of instruments is not provided King (1977).

ues. Dusansky et al. (1981) provide an explicit modeling of the simultaneous determination of rents, land values, house values and school spending. The data contain 62 school districts in Suffolk County, New-York in 1970. The authors use a three-stage least squares procedure to estimate their equations and find a tax capitalization rate that ranges from 43% to 96% (conditional on discount rate of 5% and a 10-40 years horizon). However, the results are probably plagued by the lack of control variables (only five variables are included).

Meadows (1976) estimates a four-equation model with data from the northeastern New Jersey in 1960 and 1970. In addition to the usual property value equation, three local public sector equations are included. School and municipal expenditures and equalized property tax rate are determined by several variables indicating expenditure needs and local fiscal capacity. Meadows (1976) compares capitalization estimates that stem from the single-equation model with those resulting from the four-equations model. The results show that the magnitude of the tax capitalization that stems from the full system of equations is lower than that in the single-equation model. This confirms the upward bias expected to occur when simultaneity is not corrected.

The simultaneous-equations approach does not only address empirical purposes but also theoretical objectives. Gronberg (1979) provides an empirical counterpart of the Yinger's view (Yinger, 1982) that housing and political markets interact. He argues that any empirical strategy should take into account that voting process alters the local fiscal package which in turns affects households' residential location and house values. In a single-equation approach the local fiscal bundle is assumed to be fixed and no political adjustment through local election is possible. This implies that voters do not respond to migration and property value changes in the community. Gronberg (1979) introduces a six-equation model that characterizes a "politico-housing equilibrium" (Gronberg, 1979, p. 445) through three sectors. The housing sector includes a standard property value equation and another equation that explains the median income. The latter equation is designed to test for income stratification as it is expected in the Tiebout model. It also captures the impact of the local fiscal package on income stratification. In the school and municipal sector, related taxes and expenditures are regressed on variables indicating local fiscal capacity and expenditure needs. Unlike Meadows (1976) who has a budgetary accounting approach, Gronberg (1979) provides a behavioral foundation for the determination of taxes and expenditures (based on the median voter approach).

To this purpose, he includes in each local spending equation the Lindahl share price for educational services. The sample includes 83 communities surrounding the city of Chicago in 1970. TSLQ results reveal that municipal expenditures are insignificant in the property value equation but influence significantly income stratification. On the contrary, school expenditures have a positive and significant effect on property values but do not affect income stratification. Gronberg (1979) suggests that these results are consistent with the Tiebout mechanism and that a Tiebout equilibrium is reached in the school sector.

2.6 Within and Across Capitalization

Early empirical contributions on tax capitalization often use aggregate data and relatively poor data set due to the lack of access to information on individual house sales. This leads to a poor control of both structural and neighborhood characteristics of houses and to a weak robustness of tax capitalization estimate. Micro data studies have the advantage to include a large set of variables that control for structural characteristics of houses and are thus less likely to suffer from omitted variables biases.[34] Empirical studies with micro data can be divided into two groups: studies with data covering only one jurisdiction and focusing on intrajurisdictional capitalization and studies with data covering more than one jurisdiction and capturing both intra and interjurisdictional capitalization.

2.6.1 Intrajurisdictional Capitalization

The tax payment for a house is the product of a nominal property tax rate which is set uniformly for all houses within a jurisdiction, and the assessed value of the house. Intrajurisdictional tax capitalization then occurs as a result of differences in assessment of house values, leading to differences in effective property tax rates within a jurisdiction.

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[34]Part of studies mentioned in the previous sections are based on micro data.

Wales and Wiens (1974) employ a set of 1,800 sales of improved residential property in 1972 to study tax capitalization in the municipality of Surrey. As argued by the authors, one of the main advantages of restricting the sample to only one community is that there is no need to control for public services since these services are provided uniformly within a jurisdiction. They are also aware of the simultaneity bias which tends to overestimation of the extent of tax capitalization when the effective property tax rate is introduced in the capitalization equation and to underestimation of the extent of tax capitalization when using the property tax payment.[35] To correct for the simultaneity bias, they use an ad hoc procedure instead of an instrumental variables approach.[36] First, house prices are regressed on a set of housing characteristics and location variables and without tax variable. Second, the fitted values of house prices are introduced in a version of the equation (2.12) in the left-hand side (as a modified dependent variable) and in the right-hand side (as the denominator of the modified effective property tax rate). In this equation, the tax coefficient does not reflect any capitalization effect since the fitted values of house prices have been generated in the absence of tax variable. For this reason Wales and Wiens (1974) can only test the hypothesis of no capitalization. Tax capitalization is tested using the usual F-test, which determines whether the tax coefficient in the basic equation like (2.12) differs from the tax coefficient in the equation that includes the fitted values of house prices. The results suggest that when simultaneity is treated with their procedure, taxes are not capitalized into property values.

Chinloy (1978) argues that within a jurisdiction, the effective property tax rate may differ from the actual tax rate applied to homeowners because of various tax reduction provisions which tax liabilities. Using a sample of 1,224 single-family, owner-occupied dwellings in London, Ontario, Chinloy (1978) estimates two capitalization equations with a TSLQ procedure: one that only includes the effective property tax rate and one in which both the effective property tax rate and the tax credit are considered. In the first specification, the tax coefficient implies a tax capitalization rate of 51%, but is not significant. The extent of capitalization is reduced to zero when considering the effect of tax credit. Moreover, the effective tax rate and the tax credit coefficient are not significantly different. These results suggest no net capitalization of property taxes. Even if there was significant tax capitaliza-

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[35]See section 2.3 on the choice of the tax price term.
[36]They justify this approach by the absence of any suitable instrument.

tion, homeowners would be influenced by the actual effective tax rate net of tax credit rather than the effective tax rate only.

2.6.2 Intrajurisdictional Capitalization and Assessment Errors

Intrajurisdictional tax capitalization will occur if, for constant quality houses, houses with a relatively high assessed value have a relatively low market value. As a consequence, tax capitalization may stem from assessment errors by assessors within a jurisdiction. There will be random error assessment if assessors randomly under or over assess house values and systematic error assessment if assessors systematically under or over assess a given type of houses. Some studies try to discriminate the impact of random and systematic assessment errors on intrajurisdictional tax capitalization. Ihlanfeldt and Jackson (1982) use an elaborate procedure to discriminate between systematic and random assessment on a sample of 1321 single family properties from the 1976 Annual Housing Survey of St-Louis, Missouri. In a first step, they estimate in a semi log equation the house values as a function of 31 housing characteristics and without using a tax variable:

$$lnV_i = \sum_j \alpha_j X_{ji} + \varepsilon_i, \tag{2.26}$$

where V_i is the value of the *ith* property, X_{ji} is the *jth* structural characteristics of the *ith* property. Of course, the exclusion of the property tax rate may lead to an omitted variable bias, but testing this possibility they find no significant bias in the estimated $\hat{\alpha}_j$. In a second step, they calculate the total assessment error (AE), which is defined as the difference between the actual and "fair" tax payment:

$$AE_i = T_i - \bar{t}V_i, \tag{2.27}$$

where T_i is the tax payment and $\bar{t}$ is the average effective property tax rate. The "fair" tax payment is the one that the homeowner would pay if the effective property tax rate did not differ from the average. In the third step, Ihlanfeldt and Jackson (1982) are able to distinguish between systematic and random assessment errors. For this purpose, they regress the AE

variable in equation (2.27) on the predicted value $\hat{V}_i$ of the house value in equation (2.26):

$$AE_i = \beta_0 + \beta_1 \hat{V}_i + \phi_i. \tag{2.28}$$

The predicted value $\hat{V}_i$[37] is interpreted as the systematic assessment error (SAE), that is the assessment error that varies systematically with the assessed value of the house. The error term ϕ_i represents the random error assessment (RAE). The last step consists in the estimation of the impact of SAE and RAE on the difference between V_i the actual house value and $\hat{V}_i$ the house value with no taxation:

$$V_i - \hat{V}_i = \gamma_0 + \gamma_1 SAE_i + \gamma_2 RAE_i + \theta_i. \tag{2.29}$$

$\hat{\gamma}_1$ gives a consistent estimate of the capitalization of systematic assessment error. The results coupled with the assumption of a 40-year horizon and a real discount rate of 5% imply that tax differences that stem from systematic error of assessors are overcapitalized. With a positive expected rate of house price inflation of 8%, a 30-years time horizon and a real discount rate of 6.4%, the capitalization rate is reduced to 40%. Since RAE is measured with error in equation (2.28), $\hat{\gamma}_2$ is biased and inconsistent.[38]

Taking Advantage of Tax Reforms to Estimate Intrajurisdictional Tax Capitalization

Some authors take advantage of revaluation to study whether a change in the tax payments implies a change in house values, using equation (2.15) in change form. Smith (1970) analyzes revaluation in the Sunset District in San Francisco and divides his sample in three groups to see the dynamics of revaluation over time. The first sub-sample contains house transactions that occurred when homeowners became aware that revaluation would be forthcoming. With this sub-sample, Smith is able to test whether revaluation was anticipated by

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[37]$\hat{V}_i$ is used instead of V in order to avoid the simultaneity between assessment error and property value. $\hat{V}_i$ can be considered as an instrument that is correlated with V but uncorrelated with the error term ϕ_i.

[38]However, Ihlanfeldt and Jackson (1982) suggest that γ_2 can still be interpreted as the lower bound of the true amount of capitalization of random assessment error, because $\hat{\gamma}_2$ would have the same sign and would be closer to zero if RAE was measured without error.

homeowners. The second sub-sample contains house transactions that occurred when the tax change was publicly announced. The third sub-sample contains house transactions that took place when homeowners became aware of the actual size of the tax change. Smith (1970) finds significant tax capitalization. Moreover, he shows that anticipated tax changes are capitalized: house values already start to decline when revaluation is announced but before revaluation is implemented.

Yinger et al. (1988) study the capitalization of tax changes produced by revaluation in seven Massachusetts communities. The originality of their approach is that they carefully treat all economic and econometrics problems involved in the previous empirical literature. Their empirical specification takes into account the non linearity associated with the property tax rate since it is based on a version of equation (2.18) which is modified in change form. Their econometric equation removes interjurisdictional change in house values, takes into account federal income taxes, anticipation of revaluation changes in relative housing prices and in housing characteristics. To correct for simultaneity, Yinger et al. (1988) set a second equation that explains the formation of the effective tax rate. As tax changes are involved by the revaluation in their study, they base the determination of the effective tax rate on the assessor's behavior, whose objective is to reach the same assessment ratio for every house after revaluation. They find an intermediate capitalization rate of 21.1% in Waltham and 15.8% in Brockton, where the set of control variables is the most comprehensive. They give evidence that omitted variables or incorrect treatment of simultaneity bias the capitalization rate.

Intrajurisdictional and Interjurisdictional Capitalization

Chaudry-Shah (1988) argues that the instability of the capitalization rate found in the previous literature may arise because usual empirical specifications do not distinguish within and across variation in taxes and public goods quality. With micro data covering more than one jurisdiction it is possible to test for intra and interjurisdictional tax capitalization. For

instance, equation (2.20) may be amended as:

$$V = \alpha + \sum_i \beta_i X_i + v_1 (t - t_m) + v_2 t_m + \varepsilon, \tag{2.30}$$

where V is the property value of the house, t the house effective tax rate, t_m the municipal effective tax rate and X_i the structural and neighborhood characteristics of the house. In this specification, the t_m variable captures the interjurisdictional influences of property taxes and the $t - t_m$ variable measures the intrajurisdictional differences in property taxes.

Hamilton (1979) uses this approach. His objective is to show that local property taxes are less progressive than it has been previously expected. Local jurisdictions have the incentive to exclude low-income households in order to decrease the local tax price for existing residents. Hamilton (1979) argues that jurisdictions can restrict the amount of low-income housing by using zoning and land-use controls. Such a policy implies an indirect redistribution from poor to rich people, as it raises the price of the restricted low-income lots above and decreases the price of high-income housing below the price that would arise in a free market equilibrium. As a consequence, not only the direct burden of the property tax must be studied, but also the price or the capitalization effect induced by zoning ordinance which may offset the former effect and alter the progressivity of the tax. Empirically, the estimating equation differs from (2.30) as it distinguishes the capitalization of random assessment errors within a community and the capitalization of fiscal surplus (defined as the difference between the public benefits received and the property tax payment) across communities:[39]

$$V = \sum_i \beta_i X_i + \beta_{fs} (B - tV) + \beta_e e + \varepsilon, \tag{2.31}$$

where V is the property value, X_i the structural characteristics of the house, B the public benefits accruing to property owners, t the property tax rate, e the random component of the property tax and ε an error term. The per-pupil current expenditure is used as a measure of public benefits. The procedure used to discriminate between the systematic and the random component of the tax is different from Ihlanfeldt and Jackson (1982). In a first step, Hamilton

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[39]The observation subscripts are suppressed for convenience.

estimates the following equation:

$$T = tV + e^*, \tag{2.32}$$

where T is the property tax payment and t the estimated tax rate. The computed residuals e^* resulting from this regression are not identical to the true random component of the property tax that would stem from the following equation:

$$T = tV^* + e, \tag{2.33}$$

where V^* is the unobservable predicted house value that would arise if there was no assessment error. Even if e cannot be directly calculated, it is correlated with e^*. The relationship between e and e^* is found by considering that the house value is the predicted house value less the present value of the tax liability due to the assessment error:

$$V = V^* + \beta_e e. \tag{2.34}$$

Combining (2.32), (2.33) and (2.34), we find the relationship between e and e^*:

$$e = e^*/(1 - \beta_e t). \tag{2.35}$$

Substituting (2.35) into (2.31) and rearranging we obtain the final form of the estimating equation:

$$V = \frac{\sum_i \beta_i X_i + \beta_{fs} B + \beta_e \left[e^*/(1 - \beta_e t) \right] + \varepsilon}{(1 + \beta_{fs} t)}. \tag{2.36}$$

Equation (2.36) is estimated with a nonlinear least squares procedure on a sample of 410 residential properties in ten jurisdictions of the metropolitan Toronto in 1961. The findings show that within a community \$1 of random taxation decreases the property value by \$16.80 and across communities a \$1 difference in the fiscal surplus implies a difference of \$9.37 in the property value. These results confirm that attractive tax liability for low-income households is partially offset by zoning regulation as more than half (9.37/16.80) of the apparent progressivity is compensated by the capitalization of the fiscal surplus into property values. Thus, the local property tax is much more regressive than it could be supposed. However, this conclusion may be biased by neighborhood omitted variables. Moreover, Yinger et al. (1988) point out that the definition of the fiscal surplus is based on the inappropriate assump-

tion that the willingness to pay for public services is invariant across people and communities (everyone is willing to pay \$1 for \$1 of public spending). Finally Hamilton (1979) does not deal with the simultaneity problem, which is particularly problematic as the simultaneity may arise from both the assessor behavior and through the public expenditure determination.

Goodman (1983) also attempts to capture within and across capitalization as well as capitalization of tax base effects, using a sample of 1835 single-family houses in 10 communities in the New Heaven metropolitan area in 1967-1969. In contrast to Hamilton, Goodman (1983) includes a series of neighborhood variables, which are likely to reduce the omitted variables biases. Moreover, his approach differs from that of Hamilton (1979) as he uses a Box-Cox procedure to estimate house values. While this specification has the advantage to be flexible with respect to the functional form of the hedonic regression and with the relation between house value and the tax price term, Yinger et al. (1988) argue that this technique is inappropriate when the empirical specification is based (as Goodman seems to do in the first part of the paper) on the theoretical equation like (2.18) or (2.15).[40] On the basis of a 5% discount rate and 40-year horizon, the results imply almost perfect or overcapitalization of within-jurisdiction tax rate differentials. Across jurisdictions, fiscal deficits and surpluses are capitalized in property values at a rate of approximately 60%.[41]

Conclusion

This chapter has provided a non-exhaustive review of the empirical literature on capitalization. Since the original estimation of Oates (1969), the capitalization literature has benefited from improvements of the techniques and from the use of better data set. These improvements concerns the use of appropriate tax price variables (King, 1977; Reinhard, 1981), control for public services (Rosen and Fullerton, 1977; Sonstelie and Portney, 1980a; Reinhard, 1981; Downes and Zabel, 2002) and neighborhood variables (Cushing, 1984; Black,

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[40]Goodman (1983) is also subject to the same critics as Hamilton (1979) regarding the willingness to pay for public services and the lack of treatment of the simultaneity.

[41]Goodman (1983) does not give direct evidence of interjurisdictional tax capitalization because he combines, as in Hamilton (1979), tax and expenditure capitlization.

1999). A large number of studies take advantage of natural experiments (school reforms, tax reforms, special jurisdictions) to estimate tax capitalization (Richardson and Thalheimer, 1981; Yinger et al., 1988; Palmon and Smith, 1998b; Dee, 2000; Reback, 2005). Finally, the use of micro data allows to include a large set of variables that control for structural characteristics of houses and are thus less likely to suffer from omitted variables bias (Yinger et al., 1988). Moreover, micro data that covers more than one jurisdiction allows to capture both within and across capitalization.

Chapter 3

Estimation of Capitalization in the Canton of Zurich

T His chapter contributes to the empirical literature on capitalization and present estimation of capitalization of local fiscal variables into house prices from the municipalities of the Canton of Zurich in Switzerland. The first section presents some stylized facts about Switzerland, the Canton of Zurich, the functioning and the particularities of the Swiss local pubic sector. As noted by Brulhart and Jametti (2006), Switzerland is a convenient "fiscal laboratory". Local jurisdictions have large autonomy on taxation and spending decisions. The Swiss political system is characterized by direct democracy at the federal, cantonal and municipal level.

Our capitalization estimation is based on a sample of 169 municipalities of the Canton of Zurich. For our purpose, we use a unique data set which exhibit special characteristics. Empirical capitalization are based either on aggregate data (Oates, 1969, 1973; Rosen, 1982) or on micro data (Palmon and Smith, 1998b; Black, 1999; Brasington, 2001). In these two approaches, the estimation of tax and expenditures capitalization requires to consider constant quality houses, that is to control for many structural and neighborhood characteristics. In

contrast, our endogenous variables is the price of a standardized and comparable single family house in each community. This allows to ignore the control of the structural characteristics in the estimation. However, we still have to control for neighborhood and environmental variables.

In contrast to most of the previous literature presented in chapter 2, we focus on the capitalization of the income tax rate. To our knowledge, only one study (Stull and Stull, 1991) of this type has been conducted with US data. The advantage of using the income tax rather than the property tax is that it reduces the risks of omitted variables and simultaneity bias.

In section 3.2, we present a wide array of controls (such as neighborhood, environmental and demographic variables) which are included in a standard capitalization equation. The results are presented in section 3.3. Our standard OLS regressions give standard and consistent results with respect to the previous literature. Finally, we check the sensibility of our basic results to the inclusion of additional variables and the use of alternative functional form.

3.1   Institutional Background in Switzerland and in the Canton of Zurich

Switzerland is characterized by federalism, decentralization and direct democracy. Switzerland has a federal structure with three layers of government: the Confederation, the cantons and municipalities. There are 26 cantons and around 2500 municipalities (see Figure 3.1. Since municipalities have high autonomy, Switzerland is often called a "federation of federations". A special feature of the Swiss political system that reinforces local autonomy is the exercise of direct democracy through referendums and popular initiative.

Table 3.1 shows that in Switzerland, municipalities have autonomy over a wide range of expenditures, from education to health and culture. Total expenditures of municipalities represents about one third of expenditures of all public administrations.

Table 3.1: Municipal expenditures in Switzerland by functions, in millions of CHF

Fonction	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
General Administration	3372.984	3281.525	3335.328	3395.28	3361	3417	3691.204	3863.611	3783.493	3825.689	3920.339	4069.358	4069.358
Justice, Police,	1798.682	1789.41	1792.335	1808.952	1783	1834	3663.611	2065.302	2097.495	2128.258	2171.728	2201.476
Fire Protection							1966.344				
National Defense	379.845	352.808	302.043	280.773	260	249	238.619	231.35	210.756	212.327	213.496	211.623
Education	8768.6	8886.221	8923.6	9043.483	9028	9283	9662.847	9755.194	9589.799	9777.613	9916.553	9776.43
Culture	2038.008	2045.197	1994.366	2093.792	2062	2158	2205.995	2291.3	2447.277	2495.85	2533.489	2764.248
Health	6903.056	6923.23	6922.349	7035.063	7260	7393	7741.352	8208.623	8747.355	9155.637	9226.531	9139.875	9422.062
Social Security	4988.627	5206.023	5346.286	5592.103	5878	6013	5885.297	6118.144	6467.397	7001.931	9777.613	7567.654	7707.764
Traffic	2944.86	2939.774	2873.314	2787.268	2921	2913	3018.192	3027.357	3171.481	7303.813	3294.529	3419.62	3542.666
Environment	3288.009	3405.798	3378.031	3529.124	3485	3530	3603.008	3552.064	3579.743	3165.044	3501.299	3622.183	3629.363
Public Economics	837.436	800.402	621.43	699.723	707	850	820.16	676.287	699.437	3532.314	648.822	643.111	675.361
Finance and Taxes	3107.115	3065.661	2982.247	3061.795	2969	2958	2945.025	3007.928	2805.666	677.838	2627.046	2608.816	2541.856
Total	38427.222	38696.049	38471.329	39327.357	39714	40599	41708.609	42498.202	44131.293	44330.357	45079.415	45853.923	46542.206

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* Source: Administration fédérale des finances, Switzerland.

The metropolitan area of Zurich (see Figure 3.2) has approximately 1.3 million inhabitants and is the most populous of all 26 Swiss cantons. Moreover, it is also one of the most densely populated areas in Europe. The city of Zurich itself is the economic core of the agglomeration and also the biggest city in Switzerland. Including commuters, around a million people either work or live there. The canton's 171 municipalities are very autonomous: they have a wide range of sovereignty concerning taxation and expenditures. The amounts and the evolution of the municipal expenditures in the canton of Zurich are described in Table 3.2. Regarding the taxation side, the main source of tax revenues is tax on individual income and net wealth. The municipalities levy income taxes via a municipal collection rate, which is added to the cantonal and the federal tax. The fact that income taxes are levied simultaneously by the Swiss Confederation, the cantons and the municipalities implies tax base overlapping (Brulhart and Jametti, 2006).

Table 3.2: Municipal expenditures in the canton of Zurich by functions, in thousands of CHF

Fonction	1991	2003	2004	2005	2006	2007	2008
General Administration	1 084 710	876 601	905 009	898 958	896 472	947 539	1 210 919
National Defense	553 246	756 408	778 963	794 681	810 973	823 038	914 038
Education	1 357 814	2 176 523	2 211 250	2 191 347	2 223 896	2 259 428	2 504 404
Culture	609 722	796 213	803 985	752 781	839 043	868 197	894 894
Health	649 191	1 012 454	1 017 769	1 091 904	1 127 297	1 186 729	1 276 638
Social Security	1 101 367	2 240 547	2 414 285	2 540 014	2 584 423	2 645 280	2 587 678
Traffic	794 069	961 736	963 065	997 240	1 084 254	1 014 385	1 212 826
Environement	834 622	1 093 795	1 089 622	1 099 497	1 100 183	1 117 396	1 146 513
Public Economics	1 187 915	1 082 041	1 118 167	1 166 346	1 185 753	1 171 699	1 367 434
Finance and Taxes	1 920 545	2 403 036	2 380 777	2 473 880	2 940 233	2 939 380	2 257 060
Total	10 093 201	13 399 355	13 682 891	14 006 648	14 792 527	14 973 071	15 372 403

[*] Source: GEFIS, Statistisches Amt des Kantons Zürich.

3.2   Empirical Specification and Data

3.2.1   Empirical Specification

The basic estimating equation is based on the hedonic approach described in subsection 1.1 and relates the property value to a set of fiscal and non fiscal characteristics of the property:

$$V_{jt} = \beta_0 + \sum_{i=1}^{n} \beta_{ijt} Z_{ijt} + \beta_{\tau_j} \tau_{jt} + \varepsilon_{jt}, \tag{3.1}$$

where V_{jt} is the property value in jurisdiction j at time t, the Z_i's are the locational and neighborhood characteristics, including measures of public services. τ_{jt} is the tax rate variable and ε_{jt} an error term. Equation (3.1) can be estimated by OLS.

Regarding the tax variable, previous capitalization studies generally focus on property tax because it is the main tax instrument of the US local governments. However, as mentioned in Stull and Stull (1991), in a Tiebout setting with tax and expenditure autonomy of jurisdictions and free mobility of agents, differentials of income taxes may also result in residential property value differences. Using aggregate data on the Philadelphia Metropolitan Statistical Area (PMSA) in 1980, they show that not only the income tax rate set by municipalities and school districts has significant and negative effect on the median value of owner-occupied single-family houses but also that it is capitalized at an equivalent rate compared to the property tax.

In contrast to most of the capitalization studies based on US data, we include the income tax rate rather than the property tax rate as a measure of the tax variable. Unlike in the United States, property taxes play a minor role in local tax revenues in Switzerland. The advantage of including the income tax compared to property tax is twofold. First, it avoids the empirical specification problem raised by Yinger et al. (1988); that is from the capitalization equation

Figure 3.1: The Map of Switzerland

Source: Encyclopédie Universalis 2008

Figure 3.2: The Map of the Canton of Zurich and its 171 municipalities

Source: Sozialbericht Kanton Zürich 2008, Bundesamt für Statistik

we expect a nonlinear relationship between the property tax and the property value, as it can be seen in equation (2.19). Generally, the nonlinear relationship is approximated by including the log of the property tax rate in a hedonic regression (Oates, 1969; Pollakowski, 1973; Rosen and Fullerton, 1977). However, this approximation may be source of a bias that depends on the values of the tax rate, the tax capitalization estimate and the discount rate. In Switzerland, where income taxes are one of the main sources of local tax revenues, there is no *a priori* or theoretical reason to expect a nonlinear relation between income tax rate and property values. This reduces considerably the risk of specification bias. A direct consequence is that the hedonic approach fits well with our data.

A second advantage of focusing on the income tax is that it may reduce the simultaneity bias that follows from the reciprocal relationship existing between the property value and the property tax rate. In particular, the definitional link (the fact that the property tax payment is the nominal property tax rate multiplied by the assessed price of the house) and the behavioral link (a random shock to a house's market value, if observed by the assessor, changes the assessed value and thus both the tax payments and the effective property tax rate) are completely ruled out. However, the simultaneity bias may remain if housing prices and income are positively correlated, because higher property value will provide a given level of public goods at a lower level of income tax rate.

3.2.2   Data

The dataset contains observations for all variables and all 171 municipalities located in the Canton of Zurich for the 1998-2004 period. The variables were obtained from the Statistical Office of the Canton of Zurich, the Secretary for Education of the Canton of Zurich, the Financial Statistics of the Canton of Zurich and the Cantonal Bank of Zurich. The variables include an array of different expenditure categories, the income tax rate, and a number of population specific controls as well as location specific variables. The control variables, their sources, medians, means and standard deviations are given in Table 3.3.

Table 3.3: Description and Sources of Communal Dataset

Variable	Description and Source	Median	Mean (SD)	Range [min, max]	Correlation
HousePrice	Price in 1000 Swiss Francs of a comparable single family house. Cantonal Bank of Zurich.	787.600	804.500 (134.628)	[554.000, 1330.000]	
TaxRate	Mean income tax rate multiplier (without churches). Statistical Office of the Canton of Zurich.	119.000	113.900 (14.880)	[69.000, 132.000]	-0.747
DebtRepay	Number of (theoretical) years for full debt repayment using tax revenues only (total debts divided by total tax revenues). GEFIS Financial Statistics and Statistical Office of the Canton of Zurich.	1.370	1.724 (1.278)	[0.023, 9.875]	-0.432
ExpCulture	Expenditure for culture in Swiss Francs per capita. GEFIS Financial Statistics and Statistical Office of the Canton of Zurich.	77.000	93.170 (63.554)	[27.000, 438.000]	0.570
ExpSocial	Expenditure for social well-being in Swiss Francs per capita. GEFIS Financial Statistics and Statistical Office of the Canton of Zurich.	264.000	295.500 (158.652)	[57.000, 997.000]	0.471
ExpHealth	Expenditure for health in Swiss Francs per capita. GEFIS Financial Statistics and Statistical Office of the Canton of Zurich.	138.000	152.500 (83.244)	[56.000, 621.000]	0.545
ExpAdmin	Expenditure for administration in Swiss Francs per capita. GEFIS Financial Statistics and Statistical Office of the Canton of Zurich.	355.000	375.300 (142.681)	[78.000, 1928.000]	-0.029 (p=0.324)
ExpEnvironment	Expenditure for environmental facilities and environmental improvements in Swiss Francs per capita. GEFIS Financial Statistics and Statistical Office of the Canton of Zurich.	54.000	60.390 (34.404)	[30.000, 555.000]	-0.033 (p=0.256)
DistSchool	Average distance to next school in meter. Cantonal Bank of Zurich and Statistical Office of the Canton of Zurich (GIS system).	852.500	864.700 (226.489)	[438.500, 2018.000]	-0.240

Table 3.3: Description and Sources of Communal Dataset (continued)

Variable	Description and Source	Median	Mean (SD)	Range [min, max]	Correlation
ClassSize	Average class size in primary school. Secretary for Education of the Canton of Zurich.	20.300	19.900 (1.831)	[13.000, 25.000]	0.063 (p=0.030)
GrammarSchool	Identifier whether community has a grammar school. Secretary for Education of the Canton of Zurich.	0	0.030 (0.170)	{0, 1}	0.150
MedianIncome	Median income to tax of natural persons in 1000 Swiss francs. Statistical Office of the Canton of Zurich.	46.550	47.280 (5.762)	[33.450, 72.900]	0.728
Commuters	Commuters outgoing over labor force in community. Statistical Office of the Canton of Zurich.	0.698	0.689 (0.069)	[0.443, 0.834]	0.150
Elderly	Percentage of population over 65 years. Statistical Office of the Canton of Zurich.	0.123	0.126 (0.030)	[0.054, 0.238]	0.489
Foreigners	Percentage of foreigners. Statistical Office of the Canton of Zurich.	0.120	0.132 (0.076)	[0.022, 0.425]	0.329
Unemployment	Unemployment rate. Statistical Office of the Canton of Zurich.	2.000	2.231 (1.238)	[0.100, 7.600]	0.212
Lakeview	View on lake in number of hectare. Cantonal Bank of Zurich and Statistical Office of the Canton of Zurich (GIS system).	11.850	362.100 (869.598)	[0.000, 5157.000]	0.523
SWExposition	Percentage of hectare with south and west exposure. Cantonal Bank of Zurich and Statistical Office of the Canton of Zurich (GIS system).	0.400	0.428 (0.275)	[0.000, 1.000]	0.173
DistCenter	Average time in minutes to Zurich main station. Cantonal Bank of Zurich and Statistical Office of the Canton of Zurich (GIS system).	26.730	26.810 (8.569)	[10.100, 46.360]	-0.684

Table 3.3: Description and Sources of Communal Dataset (continued)

Variable	Description and Source	Median	Mean (SD)	Range [min, max]	Correlation
DistShop	Average distance to next shopping facility in meter. Cantonal Bank of Zurich and Statistical Office of the Canton of Zurich (GIS system).	964.500	1 220.000 (722.299)	[363.000, 4618.000]	-0.348
NO2Pollution	Environmental damage as NO2 in microgram per cubic meter. Cantonal Bank of Zurich and Statistical Office of the Canton of Zurich (GIS system).	17.000	17.770 (4.171)	[8.803, 33.780]	0.363
Density	Population per square kilometer. Statistical Office of the Canton of Zurich.	400.800	597.700 (598.265)	[37.600, 2931.000]	0.613
AccessFasttrain	Indicator for access to fast train (S-Bahn) (0 = no direct access). Statistical Office of the Canton of Zurich (GIS system).	27.000	32.130 (32.751)	[0.000, 100.000]	0.300
AvailableLand	Unused construction area in square meter per capita. Statistical Office of the Canton of Zurich.	46.490	50.010 (23.664)	[9.352, 131.500]	-0.405

[1]Notes: The medians, means, standard deviations, ranges, and correlations are based on 1183 observations for 169 municipalities from 1998 to 2004. The column "Correlation" presents correlation coefficients for the respective variable with the variable HousePrice.

The sample includes a large number of municipalities offering varying fiscal packages and located in the same metropolitan area with a common CBD, the city of Zurich. This is in line with the Tiebout setting where individuals live in a central city and reside in the community which offers the most suitable tax-expenditure program.[1]

The originality of the current estimation relies on the nature of the house price variable. The empirical review of the literature shows that capitalization studies use different units of observation: municipalities for studies with aggregate data (the median property value) and house sale for studies with micro data (sales price). All these studies look at price differences between heterogeneous houses and thus have to control for structural characteristics in order to separate the effects of taxes and public services. In contrast, the dependent variable for this study is the price of a standardized and comparable single family house in each community. The standardized house is end-terraced, has five rooms, two bathrooms, 450 m^2 area including garden, 750 m^3 volume, and a single garage. The data has been obtained from the Cantonal Bank of Zurich, the largest real estate bank in the canton, which evaluates houses by the sales comparison approach based on actual transactions. The sales comparison approach is a commonly used valuation method in real estate appraisals. The Cantonal Bank of Zurich uses a set of over 15000 house sales in the canton to determine the magnitude of the effects of construction specific attributes only, such as the number of rooms, the age of the house, the number of bathrooms etc. on property values in the cantonŠs communities. The comparable single family house for each community with the same construction attributes is derived from the estimates and used for economic decisions including mortgage provisions.

This approach is convenient because we do not really know which characteristics really matter for the valuation of houses. Moreover, it is difficult to gather exhaustive data on houses structural characteristics. For instance, Hamilton (1979) finds an inconsistent negative impact of the square feet of floor space on sale value; this result is probably biased by the absence of some other important house characteristics. Johnson and Lea (1982) find that the number of bedrooms negatively affects house prices but argue that this counter-intuitive finding is explained by the presence of the square footage in the regression: for a given square footage, an increase in the number of bedrooms implies smaller rooms. The specification

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[1]Pollakowski (1973) shows that the choice of the sample has strong implications for the extent of tax capitalization.

of our dataset avoids this kind of problem. Looking at comparable houses, the effect of the houses' physical characteristics on prices is neutralized and we do not have to control for these characteristics specifically.

The advantage of such a price is to reduce the risk of omitted variable bias. Studies based on aggregate data generally include only one or two structural characteristics (Oates, 1969; Rosen, 1982) like the age and the square footage of the house and their results are likely to be plagued by omitted variables. The potential structural left-out variables are generally positively correlated with house value. These variables are considered by assessors to determine assessed value and should boost both assessed value and property tax payments, leading to an upward bias of tax capitalization estimate. This bias holds with income taxation if house prices are positively correlated with income but it is less likely to happen because the income tax payments or income tax rate are not directly linked to the house value.

On the public sector side, we have a number of different fiscal variables including taxes and expenditures that allow us to analyze fiscal bundles. As argued in chapter 1, public expenditure is not an ideal variable to measure the public services quality. As the public production function or the production costs may differ from one municipality to another, one euro may produces services of heterogeneous quality. However, this problem may be moderate because the sample incorporates relatively homogeneous municipalities located in the same metropolitan area. The harmonized public accounting standard of communities in Zurich requires a clear functional accounting which allows us to derive results for specific expenditure categories. Consequently, as opposed to Oates (1969), we have a complete set of disaggregate data on public expenditures (expenditures for social well-being, administration, health and culture). We take into account the municipal debt by constructing a theoretical number of years that it takes for a community to fully pay back its debts. No bail-out is possible in Switzerland as it has been ruled illegal by the Federal Court.

The current literature often focuses on education expenditures and school characteristics when analyzing housing prices (Black, 1999; Figlio and Lucas, 2004; Brasington and Haurin, 2005). The school organization in the canton of Zurich is different from other European municipal school structures. In Europe, primary schools are usually managed by the communities and standards are set by the national government. In Zurich, schools can either be

managed by the municipality or a special school municipality. These special school commu-
nities can overlap and often include a number of other geographical neighbors. The school
communities have autonomous budgets and their accounts are often not consolidated in the
municipality because of the overlapping structure. Consequently we do not have a consis-
tent and reliable measure for education expenditures. Instead, we have constructed a dummy
variable which is 0 if municipality and school are apart and takes the value of 1 if the munic-
ipality itself manages its schools. Furthermore we control the presence of a grammar school
in the community and for the average class size in primary schools in all our regressions.

Consistent estimates of tax and public service capitalization require to reason on constant
quality houses. As argued above, our sample introduces comparable houses which neu-
tralize, by definition, structural differentials. However, there may remain neighborhood or
environmental characteristics differentials affecting house values. In the empirical analysis
we always control for the fraction of elderly people in the community. Furthermore, we
include the population density and the median income. The unemployment rate and the frac-
tion of foreigners are used in robustness tests. They represent controls for population and
demographic specific effects.

Besides we take account of mobility issues in a variety of specifications by including the
fraction of commuters that leave the municipality every day. In our sample, 69.7% of labor
force commutes outside of their municipality of origin to work. This is consistent with the
Tiebout world that requires an exogenous source of income. We also include the fraction of
foreigners, with no *a priori* on the sign of the coefficient, which depends essentially on the
socio-demographic background of the foreign population.

Our dataset allows us to control for real estate specific variables. These include the view
of the lake, the exposition of the house, the distance to Zurich main station and therefore
to the economic core, pollution. The view of the lake follows from the urban-amenities
theory. The distance to Zurich, denoted in travel time, is equivalent to the "distance to the
CBD" variable commonly used in the literature and is derived from the standard urban theory
(Alonso, 1964; Muth, 1969; Fujita, 1989). Local pollution levels are measured as the NO2
level in micrograms per cubic meter. Finally the exposition to the south and west for our

comparable houses in each community is used as an additional location specific control. The real estate characteristics remain constant over time.[2]

Finally, we do not include the city of Zurich and Winterthur in our estimations because as opposed to the other municipalities they are clearly considered as cities and have a different structure. For example, Zurich and Winterthur have each a number of separate districts that form these cities. These districts differ in important aspects such as median incomes, unemployment rates, the fraction of foreigners, etc.[3]

3.3   Estimation Results

3.3.1   Baseline Results

The results of the basic hedonic regressions are presented in Table 3.4. All regressions include time fixed effects. The coefficients reported come from OLS regressions based on versions of the model described in equation (3.1). We also derive from estimated coefficient the impact in Swiss francs of one percent increase in the mean of the respective independent variable on property prices for all significant variables. It gives an interpretable information on the magnitude of capitalization and a clearer picture of the extent of the impact of each variable on housing prices. From a general viewpoint, estimations are of a good quality (the adjusted R^2 ranges from 0.857 to 0.889) and most of the variables have the expected sign and are highly significant.

Column (1) shows that the basic OLS estimates are significant and consistent with the theory and the literature (Oates, 1969; Stull and Stull, 1991): the tax rate has a negative influence and public expenditures have a positive influence on housing prices. More precisely, a one percent increase in the mean income tax rate reduces house values by 1066.3 Swiss

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[2]The initial sample includes a greater number of control variables than those used in the current estimation. In a previous study, a Bayesian Model Averaging has been used to find the most important independent variables for capitalization. See Stadelmann (2010)

[3]Robustness tests show that results remain valid without excluding these observations.

francs. As opposed to Oates (1969), we are able to distinguish between different expenditure categories. The harmonized public accounting standard of communities in Zurich requires a clear functional accounting which allows us to derive results for specific expenditure categories. Specification (1) shows that expenditures for culture, social well being and health positively capitalize into house prices. The magnitude of expenditures capitalization is largest for social-well being expenditures (this result holds for the other specifications). A one percent change in the mean of this expenditure category increases house values by 328.7 Swiss francs. Health expenditures have an impact of 272.9 Swiss francs and a one percent change in mean cultural expenditures increases house prices by 183.6 Swiss francs. In contrast, administrative expenditures have a negative impact on property prices, even though this negative effect is smaller than for other expenditure categories and non-significant. This result is consistent with the intuition as households may consider that they do not directly benefit directly from this expenditure category. Expenditures for environmental facilities and environmental improvements are also capitalized in the form of lower housing prices. While this result seems to be more paradoxical than for administrative expenditures, the coefficient estimate is weakly significant (at 10% level), not robust to changes of the specification and the impact of a one percent increase in the mean of environmental expenditures decrease house values by only 65.9 Swiss francs. This result may reflect an inefficient environmental policy at the local government or that housholds consider that municipalities are not the appropriate layer of government for the environmental policy.

The capitalization literature points that expenditures are inappropriate proxies for public sector output. Thus, we include proximity to next school, the class size and the presence of a grammar school in order to pick up public school quality more precisely. A house located at a greater distance from a public school has a lower value. A one percent decrease in the mean distance from a public school rises housing prices by 173.1 Swiss francs. Class size and the presence of a grammar school have respectively a consistent negative and positive impact on housing prices but are insignificant. The insignificance of these variables may be explained by the fact that, as argued by Brasington and Haurin (2005) and Crone (2006), they are not relevant for households' choice of a community. Residents seems to be more influenced by simple and readable information like public expenditures and proximity to public facilities.

Table 3.4: Estimation of Capitalization in the Canton of Zurich

Variable	Specification (1) Coefficient	Impact* in CHF	Specification (2) Coefficient	Impact* in CHF	Specification (3) Coefficient	Impact* in CHF	Specification (4) Coefficient	Impact* in CHF
Intercept	820.353^a		827.093^a		801.252^a		860.232^a	
	(56.638)		(57.169)		(58.097)		(58.600)	
TaxRate	-0.937^a	-1066.3	-0.841^a	-957.6	-0.846^a	-962.9	-0.944^a	-1075.0
	(0.197)		(0.196)		(0.194)		(0.187)	
DebtRepay			-4.713^a	-81.2	-4.537^a	-78.2	-4.030^a	-69.5
			(1.258)		(1.265)		(1.292))	
ExpCulture	0.197^a	183.6	0.198^a	184.6	0.184^a	171.6	0.177^a	164.5
	(0.036)		(0.036)		(0.036)		(0.036)	
ExpSocial	0.111^a	328.7	0.114^a	336.5	0.107^a	315.5	0.086^a	253.5
	(0.014)		(0.014)		(0.016)		(0.016)	
ExpHealth	0.179^a	272.9	0.178^a	271.6	0.173^a	264.0	0.164^a	250.6
	(0.028)		(0.028)		(0.027)		(0.028)	
ExpAdmin	-0.017	-64.4	-0.009	-35.2	-0.005	-20.2	0.005	19.4
	(0.011)		(0.011)		(0.011)		(0.011)	
ExpEnvironment	-0.109^c	-65.9	-0.098	-59.4	-0.086	-51.8	-0.057	-34.6
	(0.064)		(0.062)		(0.061)		(0.058)	
DistSchool	-0.020^a	-173.1	-0.019^a	-167.4	-0.020^a	-168.7	-0.017^a	-149.3
	(0.006)		(0.006)		(0.006)		(0.006)	
ClassSize	-0.265	-52.7	-0.618	-122.9	-0.517	-102.8	-0.695	-138.4
	(0.943)		(0.945)		(0.953)		(0.916)	
GrammarSchool	2.467	0.7	2.442	0.7	3.399	1.0	0.909	0.3
	(6.971)		(6.802)		(6.694)		(6.874)	
MedianIncome	6.396^a	3023.7	6.370^a	3011.3	6.558^a	3100.5	6.305^a	2980.9
	(0.588)		(0.581)		(0.595)		(0.587)	
Commuters	-48.041^c	-331.0	-64.482^b	-444.3	-48.562^c	-334.6	-69.189^b	-476.7
	(26.717)		(26.261)		(26.166)		(27.358)	
Elderly	536.244^a	674.5	542.885^a	682.9	551.155^a	693.3	469.553^a	590.6
	(71.640)		(71.356)		(71.910)		(70.874)	
Lakeview	0.037^a	134.0	0.037^a	133.7	0.037^a	134.4	0.035^a	127.3
	(0.002)		(0.002)		(0.002)		(0.002)	
SWExposition	68.995^a	295.5	66.759^a	285.9	67.997^a	291.2	70.108^a	300.3
	(5.532)		(5.488)		(5.489)		(5.337)	
DistCenter	-6.346^a	-1701.1	-6.157^a	-1650.3	-5.962^a	-1598.1	-5.924^a	-1587.9
	(0.315)		(0.325)		(0.344)		(0.343)	
DistShop	-0.013^a	-163.4	-0.013^a	-159.6	-0.012^a	-146.5	-0.012^a	-150.4
	(0.003)		(0.003)		(0.003)		(0.003)	
NO2Pollution	-6.314^a	-1121.7	-6.242^a	-1109.0	-6.408^a	-1138.4	-6.247^a	-1109.9
	(0.544)		(0.544		(0.545)		(0.602)	
Foreigners					106.422^a	140.9	82.008^b	108.6
					(35.254)		(36.022)	
Unemployment					-4.689^b	-104.6	-4.931^b	-110.0

Table 3.4: Estimation of Capitalization in the Canton of Zurich (continued)

Variable	Specification (1) Coefficient	Impact* in CHF	Specification (2) Coefficient	Impact* in CHF	Specification (3) Coefficient	Impact* in CHF	Specification (4) Coefficient	Impact* in CHF
					(2.115)		(2.077)	
Density							0.005	27.1
							(0.005)	
AccesFasttrain							0.142^a	45.7
							(0.050)	
AvailablaLand							-0.298^a	-148.9
							(0.071)	
Year fixed effects	YES		YES		YES		YES	
Adj R2	0.892		0.893		0.893		0.896	
N	1183		1183		1183		1183	

*Impact in CHF denotes the impact of a one percent increase of the mean of the respective independent variable on property prices. The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
[a] indicates a significance level of below 1 %; [b] indicates a significance level between 1 and 5 %; [c] indicates significance level between 5 and 10 %.

Turning to non-fiscal variables, we find that most of them have the expected sign and are significant at a 5% level. House prices react positively to a higher fraction of elderly. A one percent increase in the mean of the share of elderly rises house values by 674.5 Swiss francs. This result is easily explained by the fact that the population of elderly is characterized by higher income and lives in high quality neighborhood. Moreover, a higher median income in the municipality, which indicates a better neighborhood, has a signifiacant positive impact on house values: A one percent increase in the mean of median income rises house values by 3023.7 Swiss francs. All location specific controls have the expected signs: while the average view on the lake and a good exposition are positively capitalized, distance to the center and the level of air pollution decrease house prices. In addition, we observe that locations specific controls have heterogenous impact on house prices; While the view on lake and the average distance to next shopping facility have relatively modest impact, the proximity to CBD and the level of pollution have substantial effect on house prices. A one percent increase of the mean of the distance to Zurich main station drops house values by 1701.1 Swiss francs and a one percent increase of the mean of NO2 decreases house values by 1121.7 Swiss francs.

3.3.2   Alternative Specifications and Robustness

We now present alternative specifications for the empirical equation (3.1) in order to check the robustness of our basic coefficients. The results are presented in Table 3.4 (specification (2) to (4)) and Table 3.5.

In the column (2) of Table 3.4, we add a variable indicating the capacity of municipalities to repay debt with tax revenues as an additional fiscal variable. Indeed, for a given tax rate a community has the possibility to finance additional expenditures by debt. We examine whether residents consider local debt policy when they choose a jurisdiction. We find that the Debtrepay variable negatively influences house prices. A one percent increase in the mean of the number of years for full debt repayment using tax revenues decreases house values by 81.2 Swiss francs. This result means that local officials cannot use debt to decrease the tax burden and increase house values and their chance of reelection, because actual homeowners have to pay this indebtedness immediately through a lower house values. This implies a form of Ricardian equivalence.

In specification (3), we consider the impact of two additional variables controlling for the characteristics of the population on house prices, namely the percentage of foreigners and the unemployment rate. These variables have moderate influence on house prices and do not change significantly the previous results. The fraction of foreigners has a marginal positive influence on house prices, as a one percent increase in the mean share of foreigners rises house prices by 140.9 Swiss francs. This result is in contrast to the capitalization literature based on North American data and can be explained by the large number of well educated expatriates in the Canton of Zurich. The situation on the job market is also a relevant variable for prospective homebuyers, as the unemployment rate negatively affect house prices.

Specification (4) investigates the impact of the proximity to a major rail transport network and of the location of the municipalities in the metropolitan area on house prices and on the previous capitalization effect. In contrast to the distance to the CBD, the dummy indicator for access to fast train has only a marginal positive effect on house prices. Moreover, we introduce two proxies for municipalities' location in the metropolitan area, the density and the available land for construction. We expect municipalities that are close to the CBD to

have a denser population and less available space for construction. Results indicate that while density has no effect on house prices, a one percent increase in unused construction area entails a fall of 148.9 CHF of house values.

Table 3.5: Estimation of Capitalization in the Canton of Zurich: Robustness

Variable	WLS log (pop) (1)	WLS Commuters (2)	Semi log (3)	log - log (4)
Intercept	817.799[a]	837.346[a]	6.806[a]	6.402[a]
	(60.891)	(57.984)	(0.064)	(0.297)
TaxRate	-0.867[a]	-0.877[a]	-9.7E-04[a]	-1.3E-01[a]
	(0.186)	(0.183)	(2.1E-04)	(2.5E-02)
DebtRepay	-4.226[a]	-3.218[b]	-6.6E-03[b]	-1.3E-02[b]
	(1.489)	(1.501)	(1.6E-03)	(2.9E-03)
ExpCulture	0.171[a]	0.184[a]	1.5E-04[a]	1.3E-02[a]
	(0.037)	(0.038)	(3.8E-05)	(3.5E-03)
ExpSocial	0.089[a]	0.088[a]	9.7E-05[a]	1.2E-02[b]
	(0.016)	(0.017)	(1.8E-05)	(4.5E-03)
ExpHealth	0.155[a]	0.168[a]	1.7E-04[a]	6.0E-03[a]
	(0.026)	(0.028)	(3.0E-05)	(2.9E-03)
ExpAdmin	0.011	0.011	-1.6E-05	1.4E-02
	(0.012)	(0.011)	(1.3E-05)	(5.2E-02)
ExpEnvironment	-0.046	-0.063	-8.3E-05	-1.5E-02
	(0.055)	(0.059)	(6.5E-05)	(4.5E-02)
DistSchool	-0.015[b]	-0.014[b]	-2.8E-05[a]	-2.6E-02[a]
	(0.007)	(0.006)	(7.1E-06)	(8.1E-03)
ClassSize	-0.727	-0.603	4.8E-04	1.0E-02
	(0.956)	(0.918)	(1.0E-03)	(2.2E-02)
GrammarSchool	0.902	-0.838	3.8E-03	1.3E-02[c]
	(5.529)	(7.600)	(6.1E-03)	(7.2E-03)
MedianIncome	6.810[a]	6.597[a]	6.5E-03[a]	4.1E-01[a]
	(0.621)	(0.616)	(6.4E-04)	(3.9E-02)
Commuters	-69.705[b]	-86.671[a]	-7.1E-02[b]	-3.1E-03
	(29.176)	(29.752)	(3.2E-02)	(4.4E-02)
Elderly	523.066[a]	462.304[a]	3.6E-01[a]	5.9E-01[a]
	(68.012)	(70.752)	(7.5E-02)	(8.4E-02)
Lakeview	0.035[a]	0.036[a]	4.2E-05[a]	1.1E-02[a]
	(0.002)	(0.002)	(2.0E-06)	(7.5E-04)
SWExposition	71.362[a]	67.231[a]	8.8E-02[a]	5.9E-02[a]
	(5.461)	(5.304)	(6.0E-03)	(7.1E-03)
DistCenter	-5.727[a]	-5.826[a]	-7.8E-03[a]	-1.3E-01[a]
	(0.365)	(0.354)	(3.8E-04)	(1.2E-02)
DistShop	-0.013[a]	-0.012[a]	-1.8E-05[a]	-1.6E-02[a]
	(0.003)	(0.003)	(2.9E-06)	(5.1E-03)
NO2Pollution	-6.415[a]	-5.911[a]	-7.1E-03[a]	-8.1E-02[a]
	(0.581)	(0.583)	(6.7E-04)	(1.7E-02)
Foreigners	101.402[a]	87.737[b]	9.2E-02[b]	1.9E-01[a]
	(35.684)	(37.056)	(4.2E-02)	(5.0E-02)
Unemployment	-5.564[b]	-4.733[b]	-5.2E-03[b]	-7.7E-03[b]
	(2.166)	(2.100)	(2.4E-03)	(3.0E-03)
Density	0.005	0.002	2.0E-06	1.3E-05
	(0.005)	(0.005)	(5.7E-06)	(6.5E-05)

(continued on next page)

Table 3.5: Estimation of Capitalization in the Canton of Zurich: Robustness (continued)

Variable	WLS log (pop) (1)	WLS Commuters (2)	Semi log (3)	log - log (4)
AccesFasttrain	0.125^b	0.129^b	1.7E-04^a	4.0E-03^a
	(0.052)	(0.051)	(5.8E-05)	(1.2E-03)
AvailablaLand	-0.301^a	-0.328^a	-4.0E-04^a	-1.8E-02^a
	(0.076)	(0.070)	(8.3E-05)	(4.6E-03)
Year fixed effects	YES	YES	YES	YES
Adj R2	0.899	0.893	0.898	0.857
N	1183	1183	1183	1183

The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
^{a} indicates a significance level of below 1 %; ^{b} indicates a significance level between 1 and 5 %;
^{c} indicates significance level between 5 and 10 %.

In specification (1) and (2) of Table (3.5), we weight the OLS estimates by the logarithmic population of the communities and the share of commuters outgoing over labor force in community, in order to ensure that our results are not driven by a number of small communities or by mobility issues. The results do not exhibit outstanding changes with respect to the previous coefficient estimates.

In specification (3) and (4) of Table (3.5), we check whether the functional form of the estimated equation has an impact on the previous results. A number of capitalization studies use semi log specification by considering the logarithm of the house prices variables (Oates, 1969; Black, 1999). Brasington (2001) note that the semilog is the most popular form used in the literature. To test for the possible influence of a logarithmic form, we estimate in specification (3) a partial logarithmic model using the house prices in logarithmic form and in column (4) a log-log specification. Clearly, the coefficient estimates change with respect to the previous specifications but the interpretation is also different. The qualitative results on the tax, expenditures and other control variables are preserved.

Conclusion

This chapter provides estimation of capitalization of local fiscal variables into house prices for the municipalities of the Canton of Zurich in Switzerland. Switzerland is a convenient "fiscal laboratory" because local jurisdictions have large autonomy over taxation and spending decisions. The originality of the current estimation relies on the nature of the house price variable. Usual literature uses either the median property value for studies with aggregate data and sales price for studies with micro data. All these studies look at price differences between heterogeneous houses and thus have to control for structural characteristics in order to separate the effects of taxes and public services. In contrast, the dependent variable for our study is the price of a standardized and comparable single family house in each community. Our approach allows to ignore the control of the structural characteristics.

Our main findings exhibits standard and consistent results with respect to the literature. Most of the control variables have an expected sign and are significant at a 5% level. The tax rate has a negative and public expenditures have a positive influence on housing prices. Moreover, fiscal variables have a significant magnitude, especially the income tax rate: a one percent increase in the mean income tax rate reduces house values by around 1000 Swiss francs. The robustness tests show that baseline results are not altered qualitatively by the introduction of additional control variables or by changes of the functional forms of the estimated equation.

Chapter 4

Persistence of Capitalization

THe findings of significant tax and public expenditures capitalization, as we find in chapter 3, has been largely documented in the empirical literature. Testing the presence of fiscal capitalization is often referred to a test of the Tiebout hypothesis. For instance, Oates (1969) argues that similar magnitude of tax and expenditures capitalization implies that the provision of local public services is efficient and that communities are in Tiebout equilibrium. However, some authors criticize this interpretation of the Tiebout model. Hamilton (1976a) and Levin (1982) argue in contrast that capitalization of local fiscal variables is a temporary phenomenon that stems from a short term disequilibrium between housing demand and supply. Henderson (1985) considers that jurisdictions' boundaries are flexible and that active land developer can reallocate land appropriately in order to eliminate capitalization. While this view has several implications for the test of the Tiebout hypothesis and for the efficiency provision of local public services, it has been rather neglected in the literature.

The first section exposes the controversy on the Tiebout hypothesis and its relation with the capitalization. Then we use our data set from the Canton of Zurich to the test the hypothesis of varying capitalization rate over the metropolitan area and to contribute to the debate on the persistence of capitalization. If the no-capitalization faction is right, we expect to find

greater capitalization of taxes and public expenditures in communities with lower housing supply elasticity.

Section 4.2 put the controversy on the existence of capitalization in a dynamic framework. Most of capitalization studies are based on cross-sectional differences of house prices. In this static framework, it is not surprising to find significant capitalization. The reaction of housing supply cannot take place instantaneously. This supply side reaction requires some times, for land developers to reallocate land so as to eliminate completely capitalization. For example, Edel and Sclar (1974) estimate capitalization in 5 separate regressions over several decades for the Boston area and find that the degree of capitalization decreases over time, as housing supply approaches long-run equilibrium. To our knowledge, this is the only attempt to estimate the change of capitalization over time. Thus, in section 4.2, we take advantage of our panel data set from the Canton of Zurich to give additional evidence on the timing of capitalization.

4.1   Capitalization and the Supply Side Reaction

The empirical literature shows that a number of authors find significant substantial capitalization of fiscal variables into property values. Our basic estimation confirms that capitalization also occurs in the Canton of Zurich. However, part of the theoretical and empirical literature on capitalization points out that capitalization is a disequilibrium phenomenon that should disappear if the supply side of the market is taken into account.

In this section, we examine the theoretical and empirical debate between the yes and no-capitalization faction. We then present a theoretical model that reconciles the two sides of the debate and argues, following Brasington (2002) and Hilber and Mayer (2001, 2009), that fiscal capitalization should vary across an urban area depending on the value of the elasticity of housing supply. We use our panel data set from the Canton of Zurich to test whether the capitalization effectively differs depending on the location of the community in the metropolitan area.

4.1.1 The Theoretical and Empirical Debate

In chapter 1, we have seen with Oates (1969) that both property tax and public goods which are approximated by expenditures were capitalized into house prices. Oates (1969) argues that if consumers migrate to the jurisdiction offering the tax-public good package which is the best suitable to their preferences, they have to be aware of local fiscal variables among the different jurisdictions. These differences should be reflected in the price of housing services that individuals are willing to pay to live at a certain location providing their preferred tax-public service combination. It seems reasonable to think that, given a certain level of taxes, households bid up property values in the community providing the best quality of public goods.

In the subsequent empirical capitalization literature, a number of papers confirm Oates' results but report various degrees of tax capitalization. Oates (1973), Church (1974) and Reinhard (1981) report full or overcapitalization. Rosen and Fullerton (1977), Richardson and Thalheimer (1981) and Palmon and Smith (1998b) report intermediate rate of capitalization. In a comprehensive study, Yinger et al. (1988) present more modest but significant tax capitalization.

Edel and Sclar (1974), Hamilton (1976a), Henderson (1985) or Henderson and Thisse (2001) defend a completely opposite vision about fiscal capitalization. They state that capitalization does not or at least should not occur in a fully Tiebout equilibrium because it is a demand side phenomenon. The common critic is that in Oates (1969), capitalization occurs because the supply reaction of housing has not taken place yet. Fiscal capitalization results from scarcity of land that prevents households from moving toward communities with favorable tax-expenditure packages. Hamilton (1976a) argues that rational behavior of consumers could even imply negative capitalization of public services in property values if there was a shortage of low-expenditure communities since these communities would be bid up. However, according to these authors land and community developers can react strategically (Henderson, 1985; Henderson and Thisse, 2001) and housing supply can adjust in the long run. As soon as a community offers more favorable taxes and demand increases, house developers seize the opportunity and supply new dwellings until the market clears. In addition,

Hamilton (1976a) argues that there is no reason preventing land developers from creating new communities with the desired fiscal bundle and then eliminate the capitalization of tax and public expenditures into property values. Little tax capitalization can also be explained if jurisdiction boundaries are flexible and fiscal zoning is used. Communities with desirable tax-public spending packages will devour others and price differentials, due to differences in taxes and public services, will vanish: communities can freely expand in response to demand and the supply of new houses is perfectly elastic. House prices are then constant across communities. Therefore, the supply of any arbitrary tax-public service combination is perfectly elastic; capitalization can only be considered as a temporary disequilibrium and vanishes once housing supply occurs.

There are some empirical evidences supporting the no capitalization hypothesis. Wales and Wiens (1974), Chinloy (1978), and Gronberg (1979) find no capitalization of property taxes into property values. Edel and Sclar (1974) estimate the evolution of the extent of tax and school expenditures capitalization in 5 separate regressions over several decades for the Boston area and find that the degree of capitalization decreases as communities approach the complete Tiebout equilibrium. Gronberg (1979) and Man and Rosentraub (1998) also confirm the lack of non-schooling municipal expenditures and changes in schooling expenditures capitalization respectively. In two related papers on the effect of property tax differential on residential rents and property values in North Carolina, Hyman and Pasour (1973a,b) postulate that the supply of housing capital is considerably more elastic than in the North-eastern cities treated by Oates (1969). They find the consistent result that property taxes do not affect property values and are rather shifted forward to tenants.

The debate over the existence of fiscal capitalization is important because it has implication for the efficiency and the interpretation of the Tiebout hypothesis. Again, there are two competing views about the implication of fiscal capitalization for the efficiency. Oates (1969) argues that if the magnitudes of the capitalization of public services and taxes are similar, then the community is at the Tiebout equilibrium in the sense that taxes represent an efficient price for entry in the community, a price of the public services enjoyed by residents. In Oates' study, the effects of the tax and public school expenditures are of a roughly equivalent magnitude, allowing him to claim that his results are consistent with the Tiebout hypothesis. Instead, Edel and Sclar (1974) and Hamilton (1976a) argue that the Tiebout hypothesis is

confirmed and efficiency is achieved only if there is no significant relationships between fiscal variables and property values.

Recently, Brasington (2002) and Hilber and Mayer (2001, 2009) find a common ground between the two opposing views of fiscal capitalization. Brasington (2002) argues that the two views are consistent if one considers that the elasticity of housing supply -the source of the controversy- varies across the urban area. It is quite intuitive that land developers have few opportunities to develop housing near the center of a metropolitan area, because of the high population density and land scarcity. Therefore, land supply should be fairly inelastic and capitalization of amenities and fiscal variables should occur to a much greater extent toward the interior of the urban area. Conversely, land developers have greater opportunities to develop housing toward the edge of an urban area, where there is lower population density, land is more readily available and the community boundaries are more flexible. Thus land supply should be more elastic in the exterior of the metropolitan area, yielding a lower extent of capitalization. Using a set of housing purchases that occurred during 1991 in Ohio, Brasington (2002) tests the prediction that the rate of capitalization varies depending on the location over the urban area. He splits the total sample into two sub-samples: communities on the inside and communities on the edge of the urban area. Brasington (2002) uses the population density to discriminate between the two types of communities. Communities located in the edge and inside the urban area have at least 100 persons per square miles.[1] However, edge communities are those jurisdictions that share common boundaries with school districts that have less than 100 persons per square miles. In a first stage, Brasington (2002) separately estimates the two sub-samples applying OLS procedure. The results show that capitalization of public service quality inside communities is twice greater than in the urban fringe. In a second stage, Brasington (2002) includes in the first model new variables that interact taxes and public service quality and a dummy variable indicating whether the community belongs to the inside of the urban area. All the interaction variables except the one involving the effective property tax rate are highly statistically significant and suggest that the extent of

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[1]Note that the split leads to two balanced sub-samples as the number of observations in the inside and edge sample is respectively 12,864 and 14,115.

capitalization is greater near the center of the urban area, where the elasticity of housing supply is lower.[2]

Like Brasington (2002), Hilber and Mayer (2001, 2009) argue that the degree of capitalization depends on the elasticity of land supply for housing and thus on the amount of developable land. They use repeated sales data from the Commonwealth of Massachusetts over the 1990-94 period and take advantage of the Proposition $2^{1/2}$[3] to show that supply side reaction effectively decreases the extent of capitalization. In contrast to Brasington (2002), Hilber and Mayer (2001, 2009) do not base the distinction between high and low elasticity supply communities on a measure of population density. They argue that population density might be related to other factors than land availability such as the mix of residential and commercial activities and local zoning restrictions. They also exclude the distance from the CBD variable because it is especially inappropriate for urban areas with multiple suburban centers. Instead, they use a direct measure of land availability as a proxy for housing supply elasticity, namely the percent of developed land in each community. Then they divide the total sample into two equal-sized sub-samples indicating communities with less developable land and communities with more developable land. They find that school spending has a greater effect in communities with more developed land than in communities with less developed land. As opposed to Brasington (2002), Hilber and Mayer (2001, 2009) do not interact fiscal variables with their proxy for housing supply elasticity. They rather provide further empirical evidence on the fact that the land supply is effectively more elastic in communities with more developable land.

The reasoning of Brasington (2002) and Hilber and Mayer (2001, 2009) is interesting because it explains why previous empirical studies find various degrees of capitalization. It might be the case that complete capitalization occurs because the sample includes a well developed urban area or an area where zoning regulations prevent land developers from adjusting housing supply. Intermediate capitalization may reflect that the supply side is reacting to house price differentials and that communities are effectively approaching the Tiebout

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[2]Brasington (2002) addresses the issue of heteroskedasticity by performing Generalized Least Square (GLS) and finds the same qualitative results about capitalization.

[3]The objective of the Proposition $2^{1/2}$ was to restrict the effective property tax rate and the nominal annual growth in property tax revenues to 2.5 percent. Communities had the possibility to exceed the latter limit through a referendum.
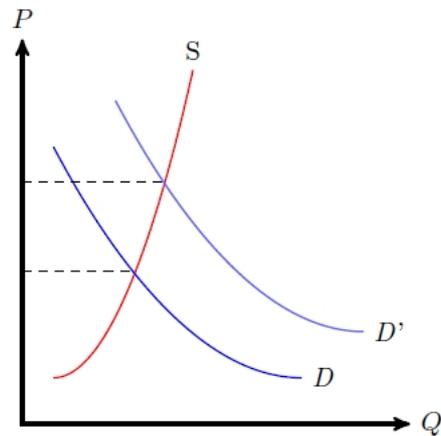
Figure 4.1: Capitalization with inelastic housing supply

equilibrium. Finally, no capitalization results would concern communities that are located in the urban fringe, where there is considerably more land to develop.

The difference of capitalization rate with respect to housing supply elasticity is illustrated in figures 4.1 and 4.2 that represent housing market in a community. In figure 4.1 we consider, as in Oates (1969) or Sonstelie and Portney (1980a), an inelastic supply of housing. Suppose that the community improve the quality of local public services without any increase of taxes; New households migrate in that community and housing demand increases. The price effect is relatively large because of the inelastic housing supply. In figure 4.2 we consider in contrast an elastic housing supply as in Hamilton (1976a) and Henderson (1985). In this case, the positive demand shock has a relatively little impact on housing prices because land developers have the possibility to convert agricultural and available land into residential land in response.
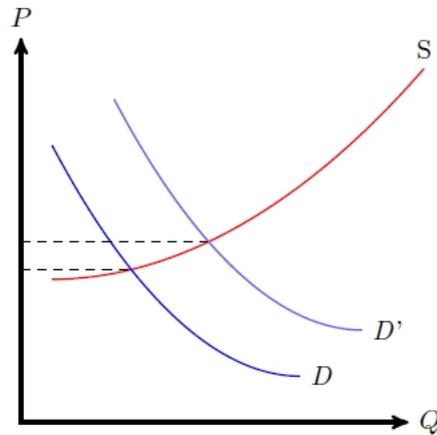
Figure 4.2: Capitalization with elastic housing supply

4.1.2   A Simple Theoretical Model

In order to illustrate the theoretical controversy outlined in the previous sub-section, we develop a basic model that includes the two sides of the debate. The model is a very simple version of a "Tiebout model"[4] described by Epple and Zelenitz (1981) in which the property tax is replaced by income tax to fit with the Swiss case.

We consider a metropolitan area composed of N residents and I jurisdictions, each inhabited by identical households who are perfectly mobile and have identical tastes and incomes. A household's income $\bar{y}$ can be spent on a composite consumption good x_i with unit price and on housing services h_i with price p_i. From its location independent income $\bar{y}$ the household has to pay income taxes $T_i = t_i \bar{y}$ for which it receives public services g_i. When choosing a residential location, it takes account of the level of public services. In other words, a representative household tries to maximize the utility function

$$U(x_i, h_i) + \gamma(g_i), \tag{4.1}$$

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[4]As argued in the first chapter, the Tiebout world is sufficiently ambiguous to have various modeling interpretation.

which exhibits the standard properties[5] and taking account of its budget constraint

$$y_i = x_i + p_i h_i, \tag{4.2}$$

where $y_i = \bar{y} - T$ is disposable income. As mentioned by Yinger (1982), the community's budget constraint is not included in the household's maximization problem. When looking for a jurisdiction to live in, households consider tax/service combinations as given. The household's maximization problem yields the indirect utility function $V(y_i, p_i, g_i)$ and a demand function for housing services[6] $h_i = h_i(p_i)$. Location decisions and housing demand therefore depend on the price of housing and after-tax household income.

Housing Supply and Capitalization with Perfectly Competitive Jurisdictions

In a first case, we consider a sufficiently large number of jurisdictions I so that jurisdiction are small enough with respect to the metropolitan area to assume that a unilateral change of their policies will not affect housing prices and policies in other jurisdictions. This is the utility-taking or the price-taking assumptions described in Brueckner (1983), Hoyt (1990, 1991). Perfect mobility across jurisdictions implies that in equilibrium, the utility level in each jurisdiction must be equal to the utility level prevailing in the rest of the metropolitan area:

$$V(\bar{y}(1-t_i), p_i, g_i) = \overline{V}, \ i = 1, \dots, I. \tag{4.3}$$

Suppose that equation (4.3) is not satisfied; for example a community enjoys a greater utility level than in the rest of the metropolitan area. Then, a migration flow of individuals occurs from the rest of the metropolitan area to that community. Housing prices increases in the community with high utility and decreases in the rest of the metropolis until equation (4.3) is satisfied. The price gradients are thus determined entirely by the equal utility constraint (4.3). Differentiating equation (4.3) with respect to the level of public good g_i and applying

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[5]The separability assumption simplifies the analysis as it ensures that a change in public service level does not affect the demand for housing.

[6]We omit the demand function for the numéraire since it is not of interest.

Roy's identity gives:[7]

$$\frac{\partial p_i}{\partial g_i} = \frac{MRS_i}{h_i} > 0,$$ (4.4)

where $MRS_i = (\partial V/\partial g_i)/(\partial V/\partial y)$ is the marginal rate of substitution between public goods and income. Differentiating equation (4.3) with respect to the income tax rate t_i yields:

$$\frac{\partial p_i}{\partial t_i} = -\frac{\bar{y}}{h_i} < 0.$$ (4.5)

Equations (4.5) and (4.4) shows that, as expected, the income tax rate is negatively capitalized into housing values while the public good is positively capitalized into housing values. More precisely, Equation (4.5) describes the decrease in housing prices in the jurisdiction i required by a increase in the income tax to satisfy the utility constraint (4.3), following the flow of individuals from the jurisdiction i to the rest of the metropolitan area.

From (4.5) and (4.4) we also observe that the capitalization rates are given for a particular jurisdiction, as they do no depend on housing demand or supply elasticity. This means that in perfectly competitive environment, the jurisdictions have no market power and are too small to influence the capitalization rates by converting land for alternative use.

Jurisdictions with Market Power

We now consider a situation in which the number of jurisdiction is not too large, so that each jurisdiction have a sizable population share of the metropolis (Scotchmer, 1986; Hoyt, 1991; Henderson, 1994). In this case, a unilateral change of a jurisdiction's policy will entail a significant migration and will thus affect housing prices and utility level in the rest of the metropolis. As a consequence, the utility level received by residents of a jurisdiction must be treated endogenously and equation (4.3) must be amended as:

$$V(\bar{y}(1-t_i), p_i, g_i) = V(\bar{y}(1-t_j), p_j, g_j), \ j \neq i.$$ (4.6)

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[7]Detailed steps for equations (4.4) and (4.5) are given in appendix.

Two additional equilibrium conditions must be considered. First, all N residents of the metropolis must be housed such that:

$$\sum_{i=1}^{I} n_i = N, \tag{4.7}$$

where n_i is the number of households residing in jurisdiction i. Second, equilibrium requires that housing market clears in each jurisdiction:

$$n_i h_i(p_i) = H_i(p_i), \; i = 1, \ldots, I, \tag{4.8}$$

where $H_i(p_i)$ denotes aggregate housing supply in community i. As noted by Hilber and Mayer (2009), the use of aggregate housing supply simplifies the analysis but is analogous to the case of an elastic supply of land. Substituting (4.8) in (4.7), we obtain:

$$\sum_{i=1}^{I} \frac{H_i(p_i)}{h_i(p_i)} = N, \tag{4.9}$$

To analyze the impact of public goods on housing prices in a jurisdiction i, we differentiate (4.6) and (4.9) with respect to g_i:

$$-h_i \frac{\partial p_i}{\partial g_i} + h_j \frac{\partial p_j}{\partial g_i} = -MRS_i, \tag{4.10}$$

$$\frac{n_i}{p_i}(\eta_i - \varepsilon_i) \frac{\partial p_i}{\partial g_i} + \sum_{j \neq i} \frac{n_j}{p_j}(\eta_j - \varepsilon_j) \frac{\partial p_j}{\partial g_i} = 0, \tag{4.11}$$

where $\eta_j = \frac{\partial H}{\partial p} \frac{p}{H} > 0$ is the price elasticity of housing supply, and $\varepsilon_j = \frac{\partial h}{\partial p} \frac{p}{h} < 0$ is the price elasticity of housing demand. Substituting (4.10) in (4.11) and solving for $\partial p_i / \partial g_i$ yields:[8]

$$\frac{\partial p_i}{\partial g_i} = \frac{\sum_{j \neq i} \frac{n_j}{p_j}(\eta_j - \varepsilon_j) MRS_i}{\Omega} > 0, \tag{4.12}$$

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[8]Detailed steps for equations (4.12) and (4.13) are given in appendix.

where $\Omega = \frac{n_i}{p_i}(\eta_i - \varepsilon_i)h_j + \sum_{j \neq i} \frac{n_j}{p_j}(\eta_j - \varepsilon_j)h_i > 0$. Under standard assumptions regarding housing demand and supply elasticities and utility function ($MRS > 0$) and assuming positive population sizes and housing prices, public goods capitalize positively into housing prices. Derivation of the tax capitalization effect is similar to the public goods case. We find that:

$$\frac{\partial p_i}{\partial t_i} = -\frac{\sum_{j \neq i} \frac{n_j}{p_j}(\eta_j - \varepsilon_j)\bar{y}}{\Omega} < 0, \tag{4.13}$$

The income tax rate negatively capitalizes into housing prices. However, we observe that, in contrast to the perfectly competitive environment, housing supply elasticity influences capitalization rates. More precisely, the supply elasticity in a community may increase when more land is available. Computing the effect on capitalization of public goods and taxes due to an increase in the supply elasticity yields:

$$\frac{\partial^2 p_i}{\partial g_i \partial \eta_i} = -\frac{\left(\sum_{j \neq i} \frac{n_j}{p_j}(\eta_j - \varepsilon_j)MRS_i\right)\left(\frac{n_i}{p_i}h_j\right)}{\Omega^2} < 0, \tag{4.14}$$

$$\frac{\partial^2 p_i}{\partial t_i \partial \eta_i} = \frac{\left(\sum_{j \neq i} \frac{n_j}{p_j}(\eta_j - \varepsilon_j)\bar{y}\right)\left(\frac{n_i}{p_i}h_j\right)}{\Omega^2} > 0. \tag{4.15}$$

Equations (4.10) and (4.10) means that increases in housing supply elasticity negatively affect the capitalization rate of public goods and positively affect capitalization of taxes.

If enough land is available for construction, supply may be perfectly elastic, i.e. $\eta_i \to \infty$ and capitalization rates become:

$$\lim_{\eta_i \to \infty} \frac{\partial p_i}{\partial g_i} = 0, \tag{4.16}$$

$$\lim_{\eta_i \to \infty} \frac{\partial p_i}{\partial t_i} = 0. \tag{4.17}$$

Thus, for perfectly elastic supply, the model predicts that capitalization of fiscal variables does not persist, as argued by Edel and Sclar (1974), Hamilton (1976a) and Henderson (1985).

4.1.3 Data and Empirical Strategy

In this sub-section, we use our panel data set from the Canton of Zurich to test the prediction described in the previous theoretical model and under which capitalization rates decline when the elasticity of land and housing supply increases. Of course, we do not have a direct measure of land supply elasticity. Two different methods allow us to approximate land supply conditions and to identify differences in capitalization of fiscal variables over space. Each of these approaches uses the standard amenity model presented in the previous section.

The first approach is to divide the dataset into two distinct samples. This method is used by Brasington (2002) and Hilber and Mayer (2001, 2009). As opposed to Brasington however, the split is not based on population density but on a direct measure of the land availability for construction. Hilber and Mayer (2001) argue that population density could obscure the link between land supply elasticity and capitalization in the presence of zoning regulation. For example, consider a sparsely populated community. Land supply will still be low if zoning ordinance prevents new residential constructions or reserves the available land for commercial use. The average available construction area over all 169 communities in the dataset was 55.425 square meters per capita in 1998. Communities with less than 55.425 square meters of available construction area per capita form the "No space available" set, while communities with more than (or equal to) 55.425 square meters per capita form the "Space available" set. A dummy variable denoted $DummyLandAvailable_i$ identifies the communities as belonging to the "No space available" set if $DummyLandAvailable_i = 0$ or the later "Space available" set if $DummyLandAvailable_i = 1$.[9] If housing supply reacts to differences in tax-public good packages, capitalization should be significantly higher in the "No space available" set than in the "Space available" set. To formally test for such significant differences in capitalization across communities, we interact the dummy variable for land availability with tax rates, aggregate public expenditures as well as different public expenditure categories. Housing supply can be sufficiently elastic only if developable construction space is available . Moreover, if housing development reacts to capitalization we expect tax interaction coefficients to be positive and expenditure interaction coefficients to be negative, i.e. capitalization in communities with supply reactions should be lower.

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[9]In robustness tests we consider changes in the definition of this dummy variable.

Our second method to evaluate differences in capitalization of fiscal variables is to analyze a linear interaction model. The empirical model interacts a standardized measure for available construction area with taxes and expenditure variables.[10] If housing supply reacts significantly to fiscal packages then the interaction of taxes with available construction areas should be positive while the interaction of public expenditures with available construction areas should be negative, i.e. capitalization tends to decrease with more construction space within the communities.

As in the chapter 2, the set of explanatory variables includes fiscal variables like income taxes and public expenditures, as well as location specific and environmental variables. Several additional variables are used for robustness tests and are presented in Table 4.1.

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[10]The standardized construction area is equal to available construction area in jurisdictions *i* minus the average construction area available, i.e. *LandAvailable$_i$* − $\overline{LandAvailable}$. Standardization is performed to facilitate the interpretation of interaction effects.

Table 4.1: Description of Sources of Instruments for Land Availability

Variable	Description and Source	Median	Mean (SD)	Range [min, max]	Correlation
NoSchoolComm	Indicator of whether the school is managed by the community itself or a separate school community. Secretary for Education of the Canton of Zurich.	0.000	0.197 (0.398)	{0, 1}	
CommunityCenter	Community has common border with cities of Zurich or Winterthur. Statistical Office of the Canton of Zurich (GIS system).	0.000	0.172 (0.377)	{0, 1}	0.170
CommunityBorder	Community is at the cantonal border. Statistical Office of the Canton of Zurich (GIS system).	0.000	0.367 (0.482)	{0, 1}	-0.102
AreaTrafficFrac	Fraction of traffic over the communal area. Statistical Office of the Canton of Zurich (GIS system).	0.049	0.058 (0.034)	[0.015, 0.206]	0.239

[1] Notes: The medians, means, standard deviations, ranges, and correlations are based on 1183 observations for 169 municipalities from 1998 to 2004. The column "Correlation" presents correlation coefficients for the respective variable with the variable HousePrice.

4.1.4   Estimation Results

The main results are presented in Table 4.2. Taking a look at coefficient estimates of specifications (1) and (2) we find that the tax rate has a negative and significant influence on house prices. Similarly, aggregate public expenditures (column 1) as well as expenditures for culture, social well being, and health (column 2) significantly increase house prices. Expenditures for administrative purposes do not capitalize significantly. Moreover, the distance to the nearest school has a negative impact on house prices in both specifications as does class size which is significant for both samples. The form of school organization does not have any significant impact. House prices react positively and significantly to higher median incomes as commonly documented in the literature. More densely populated areas with a higher fraction of elderly people have higher prices too but the significance depends on the sample chosen. Clearly, commuting imposes costs on individuals and capitalizes negatively and significantly in the "Space available" sample as does the unemployment rate in the "No space available" sample. The fraction of foreigners has a positive and significant influence on house prices in both specifications because of a large number of well educated expatriates in the Canton of Zurich. All location specific controls have the expected signs. The average view on the lake and good exposition increase prices, whereas the distance to the center and the next shopping facility as well as the level of air pollution decrease them.

Table 4.2: Capitalization and Land availability

Variable	No space available ExpAgg (1)	Impact* in CHF	Space available ExpAgg (2)	Impact* in CHF	No space available Categories (3)	Impact* in CHF	Space available Categories (4)	Impact* in CHF	Interaction ExpAgg (5)	Impact* in CHF	Interaction Categories (6)	Impact* in CHF
Intercept	726306[a] (69760)		926000[a] (85185)		753932[a] (71690)		946800[a] (88030)		799903[a] (133300)		815713[a] (140500)	
TaxRate	-1140.61[a] (424.70)	-1298.8	-654.60[b] (308.92)	-745.4	-1100.86[a] (421.90)	-1253.5	-568.50[c] (312.00)	-647.3	-1111.83[b] (490.20)	-1266.0	-1007.80[b] (492.70)	-1147.5
Int Tax * DummyLandAvailable									446.44 (490.20)		361.31 (633.60)	
ExpAgg	123.78[a] (16.51)	669.8	103.50[a] (22.68)	560.0					119.376[a] (25.400)	646.0		
Int ExpAgg * DummyLandAvailable									-5.344 (37.350)			
ExpCulture					239.010[a] (41.610)	222.7	174.340[a] (42.71)	162.4			241.349[a] (87.450)	224.9
Int ExpCulture * DummyLandAvailable											-197.535 (124.100)	
ExpSocial					75.043[a] (20.430)	221.8	86.730[a] (30.510)	256.3			69.971[c] (37.170)	206.8
Int ExpSocial * DummyLandAvailable											27.613 (50.400)	
ExpHealth					156.163[a] (31.800)	238.1	152.200[a] (45.860)	232.1			149.108[a] (50.300)	227.3
Int ExpHealth * DummyLandAvailable											-52.117 (75.260)	
ExpAdmin					-10.445 (17.980)	-39.2	-13.070 (11.500)	-49.0			-5.006 (40.420)	18.8
Int ExpAdmin * DummyLandAvailable											-37.983 (40.190)	
DummyLandAvailable									-64692 (83340)		-40989 (85870)	
DisSchool	-10.534 (8.640)		-24.760[a] (8.676)	-214.1	-5.609 (8.594)		-26.690[a] (9.095)	-230.8	-20.066 (15.940)		-18.900 (15.520)	
ClassSize	-2140.63[b] (1082.93)	-426.03	-3354[a] (1127.49)	-667.5	-2110.14[c] (1120.26)	-420.0	-2889.00[b] (1132.42)	-575.0	-183.74 (1822.42)		-87.98 (1791.78)	
NoSchoolComm	8781.69 (9623.91)		-15070 (14303)		9480.51 (9513.23)		-1461.12 (4556.12)		2517.86 (9786.34)		3111.98 (9678.56)	
MedianIncome	7.034[a] (0.694)	3325.21	6.051[a] (0.813)	2860.6	6.408[a] (0.694)	3029.4	5.866[a] (0.841)	2773.3	6.942[a] (1.373)	3281.9	6.408[a] (1.362)	3029.6
Density	4.506 (5.041)		66.500[a] (12.839)	397.4	2.748 (5.335)		63.730[a] (12.920)	380.9	5.899 (12.010)		7.703 (12.650)	
Elderly	7142.40[a] (862.600)	898.39	1069 (1099.588)		6799.57[a] (882.900)	855.3	999.70 (1137)		5158.53[a] (1462)	648.9	4836.06[a] (1512)	608.3
Commuters	-44849.11 (36270)		-209300[a] (38034)	-1442.3	-37727 (36690)		-216800[a] (38080)	-1493.7	-41268.66 (66770)		-45713.13 (68260)	

Table 4.2: Capitalization and Land availability (continued)

Variable	No space available ExpAgg		Space available ExpAgg		No space available Categories		Space available Categories		Interaction ExpAgg		Interaction Categories	
	(1)	Impact* in CHF	(2)	Impact* in CHF	(3)	Impact* in CHF	(4)	Impact* in CHF	(5)	Impact* in CHF	(6)	Impact* in CHF
Unemployment	-5858.10[b] (2925)	-130.71	-2868.00 (3375.842)		-5025.42[c] (2804)	-112.1	-3267 (3304)		-6567.72[b] (3197)	-146.5	-5776.05[c] (3062)	-128.9
Foreigners	1720.39[a] (462.700)	227.73	1397.01[b] (625.466)	-184.9	1729.14[a] (437.010)	228.9	-1320.01[b] (585.956)	-174.7	1166.40 (708.30)	160.0	1208.61[c] (766.100)	160.0
Lakeview	34.488[a] (1.784)	124.87	39.250[a] (8.281)	142.1	34.380[a] (1.811)	124.5	41.140[a] (8.594)	149.0	34.631[a] (4.574)	125.4	34.670[a] (4.545)	125.5
SWExposition	7098[a] (7025.01)	304.02	41800[a] (9778.96)	179.0	71252[a] (6777.03)	305.2	41780[a] (9486.02)	178.9	70235[a] (14110)	300.8	71564[a] (13380)	306.5
DistCenter	-4987.05[a] (434.30)	-1336.82	-7429.02[a] (520.09)	-1991.4	-4989.37[a] (433.30)	-1337.4	-7583.02[a] (541.80)	-2032.7	-5915.44[a] (791.90)	-1585.7	-5993.76[a] (792.30)	-1606.7
DistShop	-19.731[a] (3.615)	-240.68	-0.360 (3.366)		-21.277[a] (3.591)	-259.5	-1.291 (3.434)		-11.595[c] (6.853)	-141.4	-12.545[c] (6.774)	-153.0
NO2Pollution	-6097.82[a] (613.30)	-1083.37	-6754.02[a] (1407.73)	-1200.0	-5983.09[a] (641.40)	-1063.0	-6593.03[a] (1610.47)	-1171.4	-6691.39[a] (1418.94)	-1171.1	-6528.81[a] (1487.03)	-1159.9
YearFixedEffects	YES		YES		YES		YES		YES		YES	
Community Clusters	NO		NO		NO		NO		YES		YES	
Adj. R2	0.903		0.824		0.904		0.826		0.894		0.896	
N	783		400		783		400		1183		1183	

*Impact in CHF denotes the impact of a one percent increase of the mean of the respective independent variable on property prices. The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
[a] indicates a significance level of below 1%; [b] indicates a significance level between 1% and 5%; [c] indicates significance level between 5% and 10%.

Oates (1969) was criticized by Edel and Sclar (1974), Hamilton (1976a) and a number of other authors who argued that capitalization rates should tend to zero because of housing supply reactions. As more land for construction is available housing supply can react more easily to differences in fiscal packages. Consequently capitalization of fiscal variables can be expected to be lower in communities with ample construction possibilities. Looking at the results for specifications (3) and (4) we find that a one percent increase in the mean income tax rate reduces house values by 1298.80 Swiss francs in the "No space available" set and by 745.40 Swiss francs in the "Space available" set. Thus, tax capitalization seems to be lower when housing supply is able to react due to more developable land. Similarly, capitalization of a one percent increase in aggregate expenditures is 669.80 Swiss francs when fewer construction areas are available and 560.00 Swiss francs when more construction areas are available.

Specifications (5) and (6) use diverse public expenditure categories instead of aggregate public expenditures. Again, we find that taxes capitalize less in jurisdictions with more construction space. Similarly, a one percent increase in public expenditures for culture rises house values by 222.70 Swiss francs when construction land is scarce as opposed to an increase of 162.40 Swiss francs when construction possibilities are available. For social expenditures the effects are less robust as capitalization of this category is lower in the "No space available" set. Capitalization for administrative expenditure is negative and not significant in both samples. Finally, health expenditures have again a marginally larger impact when construction space is scarce.

Even though estimates for separate samples point to a lower capitalization in communities with more available construction areas per capita, it is unclear whether these differences are statistically significant. Point estimates of tax coefficients in columns (1) to (4) are significantly different from zero but not necessarily significantly different from each other. For public expenditures point estimates are relatively close. In columns (5) and (6) we estimate a dummy interaction model to test whether the differences in capitalization in the sets are statistically significant. The identifier whether construction areas are scarce or easily available, *DummyLandAvailable$_i$*, is interacted with the tax and aggregate public expenditure variables in specification (5) and with tax and different expenditure categories in specification (6). Taxes themselves capitalize negatively and significantly in both cases. The interaction be-

tween taxes and the identifier for available land is positive but not significant. Consequently, supply reactions when more construction areas are available do not tend to diminish capitalization of taxes in a statistically significant manner. Results for aggregate expenditures as well as different expenditure categories show a similar picture. The interaction between aggregate expenditures and available land is negative but not significant as shown in column (5). Cultural expenditures and health expenditures also capitalize insignificantly less while social expenditures seem to capitalize at an insignificantly higher rate when more space for new constructions is available. Expenditures for administration do not have any significant effect. Thus, capitalization is not significantly different when comparing jurisdictions with more land for construction with jurisdictions having less developable land.

To make sure that these results are not only valid for the chosen threshold of the identifier $DummyLandAvailable_i$, we investigate the relationships when the threshold changes by +/- 15% in Table 4.3 and 4.4. We analyze the data in the same way as presented in Table 4.2 and find essentially the identical results. Generally, capitalization is lower when more construction area is available but the effects are never significant. Thus, capitalization seems to be robust even if supply reactions are possible.

Table 4.3: Capitalization over Space with -15 % Change of the Land Availability Dummy

Variable	No space available -15% (ExpAgg)	Space available -15% (ExpAgg)	No space available -15% (Categories)	Space available -15% (Categories)	Interaction -15% (ExpAgg)	Interaction -15% (Categories)
Intercept	750416a	986300a	774919a	1020000a	794245a	792296a
	-59700	-103100	-62340	-104800	-129100	-133400
TaxRate	-1059.517^a	-711.500c	-1051.863^a	-561.600^b	-1081.153^b	-899.111^c
	(199.800)	(401.700)	(199.453)	(277.300)	(466.300)	(465.700)
*Int(Tax * DummyLandAvailable)*					579.759	-122.245^b
					(841.300)	(61.180)
ExpAgg	131.419^a	81.180^a			125.156^a	
	(14.564)	(27.830)			(24.040)	
*Int(ExpAgg * DummyLandAvailable)*					-22.102	
					(43.750)	
ExpCulture			206.798^a	136.250^a		226.303^a
			(40.290)	(23.160)		(84.700)
*Int(ExpCulture * DummyLandAvailable)*						-105.580
						(117.100)
ExpSocial			97.072^a	51.490^c		88.478^b
			(18.330)	(26.510)		(36.310)
*Int(ExpSocial * DummyLandAvailable)*						-7.890
						(56.770)
ExpAdmin			-4.487	-17.980		-4.967
			(16.650)	(13.060)		(37.400)
*Int(ExpAdmin * DummyLandAvailable)*						-43.163
						(40)
ExpHealth			158.148^a	117.400^a		156.025^a
			(30.910)	(34.450)		(47.340)
*Int(ExpHealth * DummyLandAvailable)*						-48.661
						(74.620)
LandAvailable (Dummy)					-70991	-27705
					(108600)	(23730)
DistSchool	-21.248^a	-15.720	-18.154^b	-21.540	-20.654	-18.329
	(6.878)	(12.390)	(7.046)	(13.240)	(15.710)	(15.240)
ClassSize	-962.555	-2643^b	-932.328	-2046^c	-153.500	-210.271
	(1034)	(1238)	(1076)	(1216)	(1840)	(1831)
NoSchoolComm	8467.9	2300.0	8778.45	2210.0	3150.910	4178.265
	(8541)	(4353)	(8484)	(4971)	(9982)	(9871)
MedianIncome	6.822^a	4.635^a	6.262^a	4.266^a	6.890^a	6.391^a
	(0.627)	(1.052)	(0.645)	(0.968)	(1.391)	(1.394)
Density	2.680	92.640^a	1.263	87.340^a	5.887	7.186
	(4.978)	(15.420)	(5.267)	(15.020)	(12.110)	(12.860)
Elderly	6438.103^a	-1494	6172.415^a	-1671	5127.163^a	4672.333^a
	(772.800)	(1111)	(797.100)	(1108)	(1493)	(1505)
Commuters	-28290	-224800^a	-29703	-23860^a	-40242	-37193

(continued on next page)

Table 4.3: Capitalization over Space with -15 % Change of the Land Availability Dummy

Variable	No space available -15% (ExpAgg)	Space available -15% (ExpAgg)	No space available -15% (Categories)	Space available -15% (Categories)	Interaction -15% (ExpAgg)	Interaction -15% (Categories)
	(32630)	(49040)	(33500)	(48380)	(67450)	(71220)
Unemployment	-4496.54^c	1326.00	-3775.02	1416	-6019.45^c	-5767.074
	(2638)	(3979)	(2575)	(3831)	(3270)	(3139)
Foreigners	1213.170^a	-1575^b	1199.846^a	-1541^b	1039.377	1067.884
	(421.100)	(783.100)	(409.700)	(746.900)	(781.600)	(724)
Lakeview	35.543^a	32.590^a	35.597^a	38.710^a	35.068^a	35.181^a
	(1.832)	(11.410)	(1.840)	(11.220)	(4.650)	(4.682)
SWExposition	70676.454^a	46290^a	71638.522^a	44570^a	68945.384^a	70427.342^a
	(6108)	(12020)	(5985)	(10610)	(13830)	(13010)
DistCenter	-5600.569^a	-7038^a	-5670.456^a	-7299^a	-5941.547^a	-5937.229^a
	(385.500)	(605.300)	(396)	(662)	(805.500)	(816)
DistShop	-17.029^a	-0.026	-17.946^a	-1.101	-11.249	-12.120^c
	(3.261)	(3.855)	(3.263)	(3.888)	(6.852)	(6.720)
NO2Pollution	-6545.546^a	-5193^a	-6511.754^a	-4833^a	-6586.229^a	-6497.936^a
	(597.300)	(1566)	(624.800)	(1639)	(1421)	(1482)
YearFixedEffects	YES	YES	YES	YES	YES	YES
Community Clusters	NO	NO	NO	NO	YES	YES
Adj. R2	0.901	0.760	0.902	0.768	0.893	0.894
N	901	282	901	282	1183	1183

The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.

^{a} indicates a significance level of below 1%; ^{b} indicates a significance level between 1% and 5%; ^{c} indicates significance level between 5% and 10%.

Table 4.4: Capitalization over Space with +15 % Change of the Land Availability Dummy

Variable	No space available 15% (ExpAgg)	Space available 15% (ExpAgg)	No space available 15% (Categories)	Space available 15% (Categories)	Interaction 15% (ExpAgg)	Interaction 15% (Categories)
Intercept	771800^a	824100^a	788547^a	864300^a	807304^a	798481^a
	(83770)	(75580)	(85940)	(77928)	(142100)	(135200)
TaxRate	-1158.159^a	-769.500^a	-1122.194^a	-758.200^a	-1121.501^b	-915.862^b
	(257.546)	(271.200)	(252.898)	(274.452)	(530.100)	(465.500)
Int(Tax *					402.099	-94.933^c
DummyLandAvailable)					(581.500)	(50.430)
ExpAgg	132.250^a	119.800^a			111.380^a	
	(19.280)	(19.490)			(26.130)	
Int(ExpAgg *					-19.884	
DummyLandAvailable)					(32.590)	
ExpCulture			190.734^a	171.800^a		227.580^b
			(48.820)	(49.943)		(92.670)
Int(ExpCulture *						-97.624
DummyLandAvailable)						(129.400)
ExpSocial			52.646^b	93.340^a		72.881^b
			(23.030)	(24.997)		(36.210)
Int(ExpSocial *						28.066
DummyLandAvailable)						(41.340)
ExpAdmin			-4.661	-9.494		-8.048
			(20.630)	(10.743)		(46.540)
Int(ExpAdmin *						-31.979
DummyLandAvailable)						(44.950)
ExpHealth			135.893^a	133.600^a		162.873^a
			(34.700)	(33.645)		(49.010)
Int(ExpHealth *						-13.720
DummyLandAvailable)						(56.390)
LandAvailable (Dummy)					-67408.96	-6817.81
					(77740)	(22210)
DistSchool	-19.160^c	-17.370^b	-13.736	-14.960^b	-20.618	-16.534
	(10.010)	(7.561)	(9.990)	(7.439)	(15.850)	(15.170)
ClassSize	-3582^a	-3025^a	-3347.236^a	-2505^b	-3.955	-14.410
	(1195)	(1111)	(1240)	(1140.459)	(1833)	(1833)
NoSchoolComm	6762	-8700	7460.150	-8773^c	3085.383	3610.933
	(5232)	(8215)	(5134)	(5187.352)	(9856)	(9714)
MedianIncome	7.273^a	6.528^a	6.779^a	5.895^a	7.056^a	6.531^a
	(0.828)	(0.781)	(0.816)	(0.819)	(1.396)	(1.404)
Density	0.168	42.440^a	1.541	42.790^a	7.037	8.450
	(5.411)	(12.140)	(5.665)	(12.060)	(12.100)	(12.900)
Elderly	7726^a	2868^a	7597.201^a	2312^a	5173.488^a	4902.997^a
	(961)	(880)	(968.400)	(850.871)	(1471)	(1501)
Commuters	-29490	-128500^a	-18928	-12330^a	-45568	-46478
(continued on next page)						

Table 4.4: Capitalization over Space with +15 % Change of the Land Availability Dummy

Variable	No space available 15% (ExpAgg)	Space available 15% (ExpAgg)	No space available 15% (Categories)	Space available 15% (Categories)	Interaction 15% (ExpAgg)	Interaction 15% (Categories)
	(44300)	(33610)	(45160)	(35061)	(66910)	(68780)
Unemployment	-6794.12[b]	-5350.56[c]	-5442.60	-4877.21[c]	-6512.24[b]	-5591.84[c]
	(3444)	(2808)	(3345)	(2695.08)	(3204)	(3131)
Foreigners	2282[a]	-813.400	2283.877[a]	-836.200	1206.670	1104.305
	(542)	(604.700)	(518.100)	(569.309)	(768.600)	(709.300)
Lakeview	33.190[a]	40.610[a]	32.632[a]	43.640[a]	34.586[a]	34.309[a]
	(1.813)	(5.923)	(1.822)	(6.185)	(4.571)	(4.550)
SWExposition	75880[a]	46850[a]	75018.593[a]	47370[a]	71814.700[a]	70253.186[a]
	(8277)	(8160)	(8039)	(8251.254)	(14370)	(13110)
DistCenter	-4985[a]	-6945[a]	-4981.802[a]	-7058[a]	-5956.137[a]	-5935.330[a]
	(534.500)	(477.200)	(534.600)	(492.125)	(817.200)	(791.500)
DistShop	-20.360[a]	-4.305	-22.364[a]	-5.632[c]	-12.025[c]	-12.847[c]
	(4.212)	(3.063)	(4.251)	(3.135)	(6.860)	(6.847)
NO2Pollution	-6563[a]	-6367[a]	-6479.163[a]	-6202[a]	-6615.432[a]	-6571.660[a]
	(669.700)	(1100)	(699.800)	(1167.192)	(1462)	(1497)
YearFixedEffects	YES	YES	YES	YES	YES	YES
Community Clusters	NO	NO	NO	NO	YES	YES
Adj. R2	0.903	0.849	0.904	0.851	0.893	0.895
N	617	566	617	566	1183	1183

The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
[a] indicates a significance level of below 1%; [b] indicates a significance level between 1% and 5%; [c] indicates significance level between 5% and 10%.

We now turn to the results from the linear interaction model, presented in Table 4.5. The base effect of taxes in column (1) is negative and significant while the base effect of aggregate public expenditures is positive and significant. Their impacts in Swiss francs on house prices are comparable to previous estimates. The interaction effect for taxes and the standardized measure for available construction area has a positive sign but is insignificant. The interaction effect for aggregate expenditures is negative and insignificant. Thus, capitalization of fiscal variables is not significantly different when more space for construction is available for housing supply to react.

Table 4.5: Capitalization over Space: Linear Interaction Model

	OLS ExpAgg		OLS Categories		IV ExpAgg		IV Categories	
Variable	(1)	Impact* in CHF	(2)	Impact* in CHF	(3)	Impact* in CHF	(4)	Impact* in CHF
Intercept	781600[a]		826300[a]		764997[a]		864100[a]	
	(48990)		(129800)		(132100)		(141200)	
TaxRate	-976.300[a]	-1111.7	-961.100[b]	-1094.4	-812.618[a]	-925.3	-848.600[a]	-966.3
	(164.000)		(431.300)		(214.600)		(283.800)	
Int(Tax *	6.174		6.612		17.919		10.330	
LandAvailable)	(4.048)		(12.640)		(27.940)		(24.390)	
ExpAgg	123.300[a]	667.0			102.178[a]	553.0		
	(11.280)				(31.050)			
Int(ExpAgg *	-0.343				-1.513			
LandAvailable)	(0.285)				(1.788)			
ExpCulture			168.100[b]	156.6			133.100[a]	124.0
			(77.610)				(30.790)	
Int(ExpCulture *			-2.145				-2.100	
LandAvailable)			(2.186)				(7.338)	
ExpSocial			82.150[a]	242.8			104.300[a]	308.2
			(31.200)				(37.880)	
Int(ExpSocial *			0.342				2.231	
LandAvailable)			(0.984)				(2.517)	
ExpAdmin			-0.636				-2.132	
			(28.850)				(29.260)	
Int(ExpAdmin *			-1.314				-2.701	
LandAvailable)			(0.816)				(3.414)	
ExpHealth			182.500[a]	278.3			153.700[b]	234.3
			(47.070)				(61.860)	
Int(ExpHealth *			-2.055				-0.719	
LandAvailable)			(1.332)				(4.414)	
LandAvailable (standardized)	-1150.02[b]	-575.2	-704.600		-988.206		267.600	
	(515.151)		(1706.12)		(3122.02)		(2861.03)	
DistSchool	-21.040[a]	-181.9	-20.930		-18.948		-27.410[c]	-237.0
	(6.787)		(14.790)		(15.620)		(15.940)	
ClassSize	-85.750		-92.090		-100.561		-67.180	
	(786.600)		(1808.00)		(1898.00)		(1971.00)	
NoSchoolComm	3208		-4104		-1059.391		2209	
	(3708)		(9913)		(10990)		(10390)	
MedianIncome	6.934[a]	3278.1	6.045[a]	2857.8	7.186[a]	3397.0	5.860[a]	2770.2
	(0.449)		(1.390)		(1.417)		(1.439)	
Density	4.744		9.078		9.640		32.630[c]	195.0
	(4.658)		(13.850)		(20.230)		(19.220)	
Elderly	5308[a]	667.7	4779[a]	601.1	4546.750[a]	571.9	4599[a]	578.4
	(675.200)		(1458)		(1510)		(1545)	
Commuters	-42460		-35490		-40659		-51860	

(continued on next page)

Table 4.5: Capitalization over Space: Linear Interaction Model (continued)

Variable	OLS ExpAgg (1)	Impact* in CHF	OLS Categories (2)	Impact* in CHF	IV ExpAgg (3)	Impact* in CHF	IV Categories (4)	Impact* in CHF
	(27250)		(68960)		(71070)		(74610)	
Unemployment	-6017^a	-134.2	-4729		-5155.606		-2998	
	(2189)		(3140)		(3543)		(3255)	
Foreigners	1162.40^a	153.9	1074.14		1373.150		673.400	
	(373.40)		(763.900)		(868.400)		(873.400)	
Lakeview	34.600^a	125.3	34.910^a	126.4	36.035^a	130.5	35.140^a	127.2
	(1.864)		(4.495)		(4.690)		(4.532)	
SWExposition	69930^a	299.5	73020^a	312.7	72630^a	311.1	75800^a	324.6
	(5251)		(12990)		(14510)		(13840)	
DistCenter	-5906^a	-1583.2	-6152^a	-1649.2	-6004.977^a	-1609.7	-7081^a	-1898.1
	(307)		(817)		(1055)		(1058)	
DistShop	-12.090^a	-147.4	-13.030^c	-158.9	-11.370^c	-138.7	-10.450	
	(2.240)		(6.811)		(6.653)		(6.554)	
NO2Pollution	-6575^a	-1168.2	-6688^a	-1188.2	-7110.985^a	-1263.4	-7774^a	-1381.2
	(506.800)		(1496)		(1645)		(1547)	
YearFixedEffects	YES		YES		YES		YES	
Community Clusters	YES		YES		YES		YES	
Adj. R2	0.893		0.896		0.902		0.895	
N	1183		1183		1183		1183	
J-Test					0.458		0.122	
F-Test (LandAvailable)					20.160		18.570	
Instruments					Center + Border + AreaTraffic		Center + Border + AreaTraffic	

*Impact in CHF denotes the impact of a one percent increase of the mean of the respective independent variable on property prices. The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
^{a} indicates a significance level of below 1%; ^{b} indicates a significance level between 1% and 5%; ^{c} indicates significance level between 5% and 10%.

In specification (2) higher taxes capitalize again negatively and significantly. Moreover, aggregate expenditures are divided into different categories. Expenditures for culture, social welfare and health have a positive and significant impact on house prices while administrative expenditures capitalize negatively but insignificantly. All interaction effects are insignificant and consequently no housing supply reactions can be found even though more space for construction is available.

So far, we only reported results from OLS estimations. However, such estimates could suffer from a possible simultaneity bias.[11] Available construction areas do not only depend on geography but also on political decisions by citizens. Even though available construction space in the canton of Zurich only slightly changed over time, it is not necessarily exogenously given but might be the result of fiscal preferences. It could be possible that high house prices induce communities to either restrict the amount of land for construction in order to preserve house values or to increase the amount of land for construction to make additional profits by selling land. In either case additional land for construction could emerge endogenously. This, of course, would leave our coefficient estimates for available land and the interaction effects biased. To address this problem, we estimate 2SLS regressions in columns (3) and (4). As instruments we use geographical variables which are independent of local political decisions. The first instrument is whether the community is next to the cities of Zurich or Winterthur and consequently forms part of the densely populated center. As a second instrument we look if the community lies at the cantonal border where densities are lower and more framing land might be rezoned and used for construction. Finally, we take the fraction of traffic area as a measure for communal development as well as communal importance. This measure is stable over time and is usually influenced only by cantonal decisions instead of local decisions. All instruments do not have a directly discernible influence on house prices and on fiscal variables when controlling for measures of density and distance to the center. Specifications (3) and (4) show that the F-Test for the first stage and the variable "available land" are highly significant concerning the quality of the instrument.[12] The J-statistics which deal with the overidentifying restrictions, do not point to problems with the instruments. The coefficients of the fiscal variables and the interaction effects are similar to the OLS estimates. Taxes capitalize negatively and significantly while aggregate expenditures as well as the different expenditure categories capitalize positively and significantly.[13] The hypothesis that housing supply reacts more when construction space is available can be rejected as none of the interaction effects is statistically significant.

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[11]Most recent articles on capitalization do not focus on endogeneity problems (Palmon and Smith, 1998b; Brasington, 2001).

[12]F-Tests for the first stages of the interaction effects which are instrumented are also highly significant.

[13]An exception is capitalization of administrative expenditure which has a negative coefficient and is insignificant.

Table 4.6: Yearly Estimates for Testing for Decreasing Capitalization over Space (Aggregate Expenditures)

Variable	1998 ExpAgg	1999 ExpAgg	2000 ExpAgg	2001 ExpAgg	2002 ExpAgg	2003 ExpAgg	2004 ExpAgg
Intercept	684000^a	751358^a	759100^a	708103^a	769900^a	719000^a	824900^a
	(130200)	(131800)	(147600)	(134400)	(143700)	(143300)	(144700)
TaxRate	-984.50^b	-1268.95^a	-916.60^c	-831.78^c	-937.30^c	-954.40^c	-1137.10^b
	(460.600)	(440.600)	(492.100)	(440.900)	(521.900)	(504.500)	(527)
Int(Tax *	10.330	5.131	14.080	11.795	7.907	2.970	1.926
LandAvailable)	(12.420)	(13.600)	(13.280)	(13.390)	(16)	(14.340)	(15.600)
ExpAgg	84.810^a	92.487^a	72.220^b	167.721^a	164.300^a	167.400^a	132.800^a
	(31.040)	(31.830)	(35.850)	(33.220)	(29.270)	(34.340)	(35.090)
Int(ExpAgg *	-0.071	-1.016	-0.573	-1.301	-0.264	-0.274	-0.124
LandAvailable)	(0.773)	(0.862)	(0.967)	(0.969)	(0.911)	(0.915)	(0.822)
LandAvailable	-1532	-1387.20	-2170	-2206.45	-1244	-754.100	-85.390
(Continous)	(1535)	(1699)	(1655)	(1804)	(2038)	(1760)	(1834)
DistSchool	-24.080	-28.702c	-22.110	-20.300	-20.250	-16.730	-18.990
	(15.510)	(16.870)	(16.860)	(15.420)	(16.480)	(15.550)	(15.880)
ClassSize	-908.400	-2729	-910.300	-27.654	-3083	-839.500	-523.400
	(2194)	(2102)	(2252)	(2194)	(2269)	(2303)	(2419)
NoSchoolComm	-76.500	1499.468	-259.600	6135.988	5403	6553	2419
	(11230)	(11430)	(11210)	(10550)	(9030)	(9293)	(9739)
MedianIncome	9.053^a	7.455^a	7.430^a	6.586^a	7.318^a	6.633^a	6.230^a
	(1.718)	(1.652)	(1.719)	(1.622)	(1.410)	(1.317)	(1.203)
Density	3.169	5.940	10.780	4.629	1.025	-0.304	9.321
	(13.880)	(14.030)	(15.870)	(14.240)	(13.170)	(13.900)	(12.600)
Elderly	7162.10^a	6927.48^a	6494^a	3511.88^b	3087.23^c	3291.15^c	3909.45^b
	(1599)	(1559)	(1683)	(1576)	(1819)	(1718)	(1884)
Commuters	-61300	-86221	-83490	-18766	-27740	-39900	-62040
	(62220)	(61220)	(73180)	(73640)	(71120)	(74780)	(69680)
Unemployment	2027	-4427.30	6101	-10663.8	-7747	-9335	-16360^b
	(5231)	(7547)	(10620)	(10200)	(6298)	(6940)	(6469)
Foreigners	1098	1270.307	557.300	936.802	1217	1263	2169^c
	(916.100)	(890)	(920)	(969.100)	(1010)	(1140)	(1274)
Lakeview	36.030^a	34.108^a	33.410^a	32.440^a	32.830^a	34.420^a	34.120^a
	(5.122)	(4.940)	(5.165)	(4.749)	(4.814)	(4.518)	(4.357)
SWExposition	75510^a	70471^a	70640^a	57719^a	63290^a	62930^a	75200^a
	(13500)	(14260)	(14040)	(14180)	(14060)	(14670)	(14010)
DistCenter	-6063^a	-6284.35^a	-6224^a	-5387.41^a	-5437^a	-5599^a	-6063^a
	(901.980)	(784.450)	(822.200)	(895.102)	(874.300)	(894.500)	(836.300)
DistShop	-11.290	-10.338	-13.940^c	-12.254^c	-12.230^c	-11.170	-11.120
	(7.003)	(7.476)	(7.215)	(7.131)	(7.209)	(6.966)	(6.744)
NO2Pollution	-7979^a	-7657.70^a	-6515^a	-6468.90^a	-6212^a	-5725^a	-5835^a
	(1447)	(1425)	(1540)	(1401)	(1317)	(1468)	(1570)
Adj. R2	0.879	0.875	0.871	0.890	0.898	0.892	0.887
N	169	169	169	169	169	169	169

The left-hand-side variable in all regressions is the average price of a single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
[a] indicates a significance level of below 1%; [b] indicates a significance level between 1% and 5%; [c] indicates significance level between 5% and 10%.

Table 4.7: Yearly Estimates for Testing for Decreasing Capitalization over Space (Disaggregate Expenditures)

Variable	1998 Categories	1999 Categories	2000 Categories	2001 Categories	2002 Categories	2003 Categories	2004 Categories
Intercept	748900[a]	750087[a]	770892[a]	734400[a]	833600[a]	817400[a]	901400[a]
	(143000)	(137400)	(156300)	(139800)	(151600)	(147900)	(141300)
TaxRate	-989.60[b]	-1167.27[a]	-885.71[c]	-834.12[c]	-949.50[c]	-927.95[c]	-1175.02[b]
	(488.600)	(432.400)	(525.200)	(467.100)	(500.600)	(473.600)	(466.700)
Int(Tax *	22.350	101.492	150.636	160	44.310	72.470	-96.250
LandAvailable)	(88.840)	(78.700)	(92.920)	(99.210)	(121.600)	(124.300)	(125.700)
ExpCulture	150.100[c]	155.088[c]	168.179[c]	186.800[b]	140.600[c]	163.300[c]	110.300
	(81.580)	(83.800)	(87.550)	(86.560)	(83.820)	(86.090)	(76.950)
Int(ExpCulture *	-2.062	-3.218	-3.475	-1.242	-0.726	-2.953	-2.312
LandAvailable)	(2.471)	(2.759)	(2.604)	(2.706)	(2.257)	(2.470)	(2.335)
ExpSocial	63.160[c]	74.833[c]	49.532[c]	111.400[b]	104[b]	88.920[b]	71.600[b]
	(37.290)	(40.350)	(31.780)	(45.750)	(45.790)	(44.670)	(38.320)
Int(ExpSocial *	-0.392	1.585	0.783	1.188	0.113	0.372	0.373
LandAvailable)	(1.449)	(1.396)	(1.779)	(1.710)	(1.436)	(1.200)	(0.949)
ExpAdmin	-62.370	-5.330	-20.866	-8.992	-4.038	-16.120	-9.178
	(39.290)	(34.410)	(35.510)	(36.570)	(32.550)	(28.250)	(28.820)
Int(ExpAdmin *	-1.344	-1.931	-1.137	-0.620	-1.086	-1.194	-2.495
LandAvailable)	(1.037)	(1.374)	(1.136)	(1.124)	(0.853)	(0.801)	(2.921)
ExpHealth	137.500[c]	97.786[c]	88.379[c]	249.400[a]	308.300[a]	343.300[a]	337.500[a]
	(70.300)	(60.100)	(54.840)	(52.950)	(73.580)	(91.090)	(113.600)
Int(ExpHealth *	-1.269	-2.844	-1.204	-1.162	-1.508	-2.191	-3.739
LandAvailable)	(2.712)	(3.392)	(2.962)	(1.375)	(2.427)	(3.250)	(3.271)
LandAvailable	335.600	309.004	830.855	2.374	131.600	162.600	665.500
(Continous)	(581.300)	(696.500)	(738.900)	(799.600)	(793.900)	(868.100)	(911.600)
DistSchool	-22.280	-24.728	-21.737	-17.880	-18.840	-13.650	-23.850
	(15.260)	(16.620)	(16.430)	(16.520)	(15.600)	(14.920)	(15.250)
ClassSize	-650	-2489	-713.158	-1128	-3257	-1361	-678.600
	(2339)	(2114)	(2310)	(2551)	(2408)	(2371)	(2430)
NoSchoolComm	1727	1575.259	376.838	8426	8834	10720	3682
	(11490)	(11190)	(11220)	(9801)	(8701)	(8958)	(9228)
MedianIncome	8.049[a]	6.963[a]	6.861[a]	6.178[a]	6.607[a]	5.137[a]	4.584[a]
	(1.756)	(1.656)	(1.725)	(1.652)	(1.469)	(1.448)	(1.274)
Density	4.275	13.955	21.167	10.878	5.721	6.959	14.630
	(15.740)	(13.910)	(16.370)	(15.820)	(14.570)	(14.020)	(11.400)
Elderly	7098.68[a]	5882.91[a]	5222.32[a]	2916.89[c]	2451.65	2652.45	3264.87[c]
	(1641)	(1464)	(1579)	(1507)	(1811)	(1741)	(1836)
Commuters	-31200	-60110	-65334	-48620	-62790	-77660	-75000
	(63790)	(66630)	(80900)	(88180)	(77740)	(75100)	(69210)
Unemployment	278.600	-3044.35	7778.290	-8354	-5760	-7205	-15250[b]
	(5348)	(7965)	(10220)	(10400)	(5827)	(6298)	(5896)
Foreigners	752.700	1001.098	216.090	617.700	1056	1014	2255[c]
	(882.400)	(858.700)	(840.800)	(893.100)	(949.100)	(1055)	(1155)

(continued on next page)

Table 4.7: Yearly Estimates for Testing for Decreasing Capitalization over Space (Disaggregate Expenditures)

Variable	1998 Categories	1999 Categories	2000 Categories	2001 Categories	2002 Categories	2003 Categories	2004 Categories
Lakeview	36.850^a	34.298^a	34.078^a	31.920^a	31.940^a	32.880^a	33.240^a
	(5.460)	(4.792)	(5.188)	(4.320)	(4.778)	(4.354)	(4.009)
SWExposition	80440^a	75061^a	72749^a	51220^a	60050^a	63680^a	77260^a
	(13230)	(13310)	(13260)	(13810)	(13670)	(13790)	(13080)
DistCenter	-6398^a	-6123.63^a	-6144.66^a	-5268^a	-5584^a	-6009^a	-6334^a
	(936.400)	(793.200)	(847.100)	(841.400)	(872.015)	(948.026)	(840.700)
DistShop	-10.620	-9.691	-12.905^c	-12.900^c	-12.520^c	-13.130^c	-11.130^c
	(6.715)	(7.425)	(7.199)	(7.369)	(7.226)	(6.673)	(6.394)
NO2Pollution	-8158^a	-7477.22^a	-6526.56^a	-6502^a	-5942^a	-5655^a	-5660^a
	(1470)	(1432)	(1557)	(1367)	(1354)	(1568)	(1582)
Adj. R2	0.879	0.877	0.871	0.890	0.898	0.895	0.894
N	169	169	169	169	169	169	169

The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
[a] indicates a significance level of below 1%; [b] indicates a significance level between 1% and 5%; [c] indicates significance level between 5% and 10%.

To ensure that these results do not only depend on a specific time frame chosen, we investigate the relationships for each year individually. The respective specifications (1) and (2) of Table 4.5 are estimated separately for the 1998-2004 period in Tables 4.6 and 4.7. The base effects for taxes remain negative and significant. Public expenditures usually have a positive and significant influence. None of the interaction terms with available land for construction and fiscal variables ever turns significant. Thus, housing supply does not influence capitalization of fiscal variables when more construction area is available.

4.2   The Dynamic of Capitalization

In the previous section, we find no empirical evidence of a decrease in capitalization as land supply elasticity rises. Contrary to the outcome of similar American studies (Brasington, 2002; Hilber and Mayer, 2009), capitalization of fiscal variables seems to persist across

space in the Zurich metropolitan area. This suggests that supply side is not effective or that land and housing developers do not necessarily react to local fiscal differentials. However, this result focuses on cross-sectional differences in land availability between communities.

In this section, we show that the theoretical criticism made to Oates (1969) implies that supply side reaction can take much time to be effective. Thus, we should explore capitalization as a dynamic process. Taking advantage of our panel data set from the Canton of Zurich we test whether capitalization decreases over the 1998-2004 period, indicating some housing supply reaction over time.

4.2.1 Some Theoretical Considerations

Finding no reaction of fiscal capitalization to differences in housing supply conditions across space seems to give empirical support against the argument that supply side reaction in the housing market completely eliminates capitalization. However, in its criticism of the Oates's reasoning about the Tiebout hypothesis and capitalization, the no-capitalization faction stresses the importance of the timing for the achievement of supply reaction.

For example, Edel and Sclar (1974) argue that Oates's single period cross-section hedonic regression is inappropriate to characterize the impact of local fiscal variables on property values. More precisely, capitalization occurs simply because supply is not in long-run equilibrium. As a consequence, capitalization regressions have to be performed over a long period of time in order to allow housing supply to react effectively. Edel and Sclar (1974) estimate the change in tax and school expenditures capitalization rates in five separate regressions over several decades for the Boston area. They find that the degree of capitalization decreases over time, as housing supply approaches long-run equilibrium. This result indicates that housing supply does not adjust instantaneously to fiscal differences and that the decrease of fiscal capitalization needs a minimum period of time to hold effectively. Similarly, the flexibility of the American community numbers and boundaries stressed by Henderson (1985) becomes effective only after several decades.

Therefore observing capitalization persistence across space in our data set is not surprising. First, it means that the sample period is too short to allow supply reaction to completely eliminate capitalization. Second, in the previous section we focus on the cross-sectional differences in land supply elasticity between communities. However, the existence of capitalization at a given point in time does not rule out supply side reaction and a decreasing pattern of capitalization, as cross-section regression gives only a snapshot of the situation.

Fortunately, the panel structure of our data set allows us to study the change of fiscal capitalization over time. In particular, if housing supply *reacts* during the sample period, we should observe a decrease in capitalization rates over time, as argued by Edel and Sclar (1974) and Henderson (1985). In contrast, if housing supply reaction *does not react* during the sample period, we should observe capitalization persistence over time.

The impact of capitalization over time is theoretically ambiguous. As opposed to Edel and Sclar (1974) and Henderson (1985), Yinger (1981, 1982) sets up an elaborated model in which capitalization is a feature of the long-run equilibrium. He argues that as land developers create new communities that are under-supplied or housing suppliers build new houses in scarce communities, land becomes scarcer and prices rise. Inevitably, there is a moment where the opportunity cost of converting land from non-residential to residential use becomes so important that it is no longer profitable for land developers to supply new houses or create new communities. Yinger (1981, 1982) concludes that jurisdictions with desirable tax/public service packages will devour others and capitalization will disappear only if jurisdiction boundaries are flexible. If this is not the case, then all remaining variation in local fiscal variables will be capitalized into house values and capitalization occurs even in the long-run.

There are two visions on the persistence of capitalization over time. Thus this question has to be answered empirically. The next section presents the empirical setting used to test if there is a change of capitalization rates over time.

4.2.2 Data and Empirical Strategy

Our first approach is a linear interaction model. In a fist step, we use the panel structure of our dataset from 1998 to 2004 and all fiscal variables are interacted with year dummies. The base year is 1998. Our empirical model for yearly interactions has the following form:

$$
\begin{aligned}
V_{it} = \ & \beta_1 + \beta_2(\text{TaxRate})_{it} + \beta_3(\text{TaxRate})_{it}(1999)_i + ... + \beta_8(\text{TaxRate})_{it}(2004)_i \\
& + \beta_9(\text{ExpAgg})_{it} + \beta_{10}(\text{ExpAgg})_{it}(1999)_i + ... + \beta_{15}(\text{ExpAgg})_{it}(2004)_i + \quad (4.18) \\
& + \beta \mathbf{X} + \varepsilon_i
\end{aligned}
$$

where V_{it} is the price of the standardized house in community i at period t, and $\mathbf{X}$ represents a matrix of covariates including the trend and β the corresponding vector.

We also perform a second model that interacts a time trend variable with fiscal variables:[14]

$$
\begin{aligned}
V_{it} = \ & \delta_1 + \delta_2(\text{TaxRate})_{it} + \delta_3(\text{TaxRate})_{it}(\text{TimeTrend})_i \\
& + \delta_4(\text{ExpAgg})_{it} + \delta_5(\text{ExpAgg})_{it}(\text{TimeTrend})_i + \qquad (4.19) \\
& + \beta \mathbf{X} + \varepsilon_i
\end{aligned}
$$

The coefficient of any fiscal variable that is not interacted with a year dummy represents the capitalization effect for the base year. All interaction terms have to be interpreted relative to 1998. Thus, they represent changes between the year in question and the base year. The sum of the base year's coefficient (for example β_2 or δ_4) and the coefficient of the interaction term (for example β_3 or δ_5) yields the capitalization of the given variable for the respective year:[15] Changes in capitalization rates over time are therefore represented by significant interaction terms. If capitalization is decreasing over time, we should observe significant interaction terms starting with a certain year and persisting over time. The sign should be the opposite of the base year's coefficient. Note that this procedure estimates the longitudinal changes

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[14]The time trend vector equals 0 for observations of the year 1998, 1 for observations of the year 1999, etc. and 6 for observations of the year 2004.

[15]For the linear time trend specifications, the respective coefficients have to be multiplied by the trend to find the impact for the year.

in the slope of taxes and public expenditures.[16] We perform this estimation strategy for tax rates and aggregate fiscal expenditures as well as for disaggregate expenditure categories.

For our second approach, we run separate regressions for all seven years of our panel data set with the same control variables in each regression. For each year, we take the coefficients and the robust standard errors of the models separately. If there is either an increasing or decreasing linear trend in the coefficient, we can test this for this trend by calculating a Spearman correlation for each coefficient using the seven different observations of the respective coefficient over the years. Clearly the limited number of observations might be a problem in this case. As it is generally known for asymptotic theory, the coefficients follow for a large number of observations a normal distribution with the expectation equaling the regression's coefficient and the standard deviation equaling the regression's standard error (Greene, 2003). A straightforward approach is therefore to bootstrap the coefficients of each year and calculate separate bootstrapped Spearman correlations for all fiscal variables.[17] This allows us to identify linear trends in the coefficients and take account of possible small sample bias.

The data used to estimate equations (4.18) and (4.19) are identical to those used in chapter 2 and can thus be found in Table 3.3. The only new variables included are time dummies interacted with local fiscal variables.

4.2.3   Estimation Results and Robustness Tests

Year Dummies Results

As mentioned above, Oates (1969) estimations were criticized by Edel and Sclar (1974) and Henderson (1985) and a number of other authors who argued that capitalization rates should change over time because of supply side reactions. More precisely, the coefficients

---

[16]The coefficient of the interaction terms represents increases or decreases in capitalization of contemporaneous variables with respect to the base year.

[17]For a detailed overview of bootstrap theory and applications, see Davison and Hinkley (1997).

for capitalization of fiscal variables should decrease in absolute values as housing suppliers react to rent differentials and develop more housing projects in areas with favorable fiscal packages. The results are presented in Table 4.8. In specifications (2) and (3) we have the possibility to test this hypothesis for a panel of seven years by using interaction effects for all fiscal variables.

Table 4.8: House Values and Capitalization: Testing for Decreasing Capitalization

Variable	Specification (1) Coefficient	Impact in CHF	Specification (2) Coefficient	Impact in CHF	Specification (3) Coefficient	Impact in CHF	Specification (4) Coefficient	Impact in CHF
(Intercept)	657255[a]		676746[a]		725699[a]		769739[a]	
	(-45707)		(-46339)		(-67552)		(-64984)	
TaxRate	-762.006[a]	-867.70	-702.443[a]	-799.80	-1228.23[a]	-1398.50	-1343.66[a]	-1530.00
	(197.959)		(188.100)		(429.460)		(401.615)	
Int.TaxRate.1999					204.348		194.409	
					(558.342)		(523.491)	
Int.TaxRate.2000					364.769		367.678	
					(534.633)		(520.742)	
Int.TaxRate.2001					624.584		898.842[c]	1023.50
					(522.998)		(494.361)	
Int.TaxRate.2002					550.164		816.201	
					(531.098)		(509.762)	
Int.TaxRate.2003					688.196		1043.83[b]	1188.60
					(542.033)		(506.755)	
Int.TaxRate.2004					751.605		882.973[c]	1005.40
					(529.595)		(512.927)	
ExpCulture			208.692[a]	194.40			237.696[a]	221.50
			(33.863)				(84.010)	
Int.ExpCulture.1999							15.917	
							(117.186)	
Int.ExpCulture.2000							-17.330	
							(123.646)	
Int.ExpCulture.2001							-52.120	
							(112.395)	
Int.ExpCulture.2002							-68.148	
							(114.724)	
Int.ExpCulture.2003							-63.864	
							(119.127)	
Int.ExpCulture.2004							-57.084	
							(115.319)	
ExpSocial			112.482[a]	332.40			77.558[b]	229.20
			(15.376)				(34.939)	
Int.ExpSocial.1999							36.744	
							(44.950)	
Int.ExpSocial.2000							30.688	
							(46.078)	
Int.ExpSocial.2001							28.133	
							(44.159)	
Int.ExpSocial.2002							40.520	
							(43.160)	
Int.ExpSocial.2003							40.946	

(continued on next page)

Table 4.8: House Values and Capitalization: Testing for Decreasing Capitalization (continued)

Variable	Specification (1) Coefficient	Impact in CHF	Specification (2) Coefficient	Impact in CHF	Specification (3) Coefficient	Impact in CHF	Specification (4) Coefficient	Impact in CHF
Int.ExpSocial.2004							(40.627) 42.539 (39.780)	
ExpAdmin			-24.257^b (10.546)	-91.00			-58.443^c (31.645)	-219.30
Int.ExpAdmin.1999							48.506 (43.224)	
Int.ExpAdmin.2000							44.076 (39.859)	
Int.ExpAdmin.2001							39.277 (37.077)	
Int.ExpAdmin.2002							36.894 (39.466)	
Int.ExpAdmin.2003							13.246 (41.787)	
Int.ExpAdmin.2004							38.137 (44.881)	
ExpHealth			155.499^a (28.507)	237.10			156.220^b (68.447)	238.20
Int.ExpHealth.1999							-155.159 (115.365)	
Int.ExpHealth.2000							-78.895 (96.177)	
Int.ExpHealth.2001							22.078 (84.306)	
Int.ExpHealth.2002							82.486 (88.776)	
Int.ExpHealth.2003							98.200 (98.007)	
Int.ExpHealth.2004							98.167 (102.853)	
ExpAgg	59.739^a (9.723)	547.50			38.347^c (19.780)	351.40		
Int.ExpAgg.1999					11.546 (28.131)			
Int.ExpAgg.2000					7.600 (28.132)			
Int.ExpAgg.2001					13.827 (28.274)			
Int.ExpAgg.2002					36.398 (26.110)			
Int.ExpAgg.2003					30.445			

Table 4.8: House Values and Capitalization: Testing for Decreasing Capitalization (continued)

Variable	Specification (1) Coefficient	Impact in CHF	Specification (2) Coefficient	Impact in CHF	Specification (3) Coefficient	Impact in CHF	Specification (4) Coefficient	Impact in CHF
Int.ExpAgg.2004					(27.716) 37.690 (25.948)			
ClassSize	-442.406 (316.145)		-292.772 (205.876)		-449.018 (318.075)		-347.877c (208.239)	-70.20
Elderly	6513.83^a (718.18)	819.30	5062.13^a (707.94)	636.70	6601.45^a (706.053)	830.30	4996.82^a (683.393)	628.50
Density	32.537^a (4.278)	194.50	14.171^a (4.710)	84.70	32.538^a (4.257)	194.50	13.534^a (4.634)	80.90
MedianIncome	6.921^a (0.466)	3271.90	7.047^a (0.506)	3331.30	6.970^a (0.474)	3295.00	6.984^a (0.516)	3301.60
Lakeview	36.035^a (1.982)	130.50	35.645^a (1.952)	129.10	35.856^a (1.965)	129.80	34.822^a (1.932)	126.10
AccessFasttrain	-6457.01^a (295.645)	-1730.90	-6214.42^a (313.952)	-1665.80	-6426.41^a (292.922)	-1722.70	-6084.29^a (318.073)	-1630.90
NO2Pollution	-5497.46^a (580.718)	-976.70	-6294.34^a (591.583)	-1118.30	-5497.40^a (576.638)	-976.70	-6178.03^a (588.295)	-1097.60
SWExposition	65065^a (5699.53)	278.70	64983^a (5451.85)	278.30	64613^a (5686.99)	276.70	63528^a -5407	272.10
Adj R2	0.873		0.887		0.873		0.8863	
N	1183 (169)		1183 (169)		1183 (169)		1183 (169)	

*Impact in CHF denotes the impact of a one percent increase of the mean of the respective independent variable on property prices. The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
^{a} indicates a significance level of below 1%; ^{b} indicates a significance level between 1% and 5%; ^{c} indicates significance level between 5% and 10%.

Specification (3) does not distinguish between different expenditure categories but simply uses aggregate expenditures. If capitalization rates of fiscal variables change over time, as proposed by Edel and Sclar (1974) and Henderson (1985) then the interaction terms should reflect these changes. For income tax rates we find positive interaction terms. For the base year 1998 the effect of an increase in tax rates is negative. This negative effect is reduced (in absolute values) over the years by the positive interaction terms but none of them is significant. For example, in 2003 the total effect of an increase in tax rates is the absolute coefficient of the base year 1998 minus the coefficient for the year 2003. Still, as no interaction term

is significant the hypothesis of no changes in capitalization rates and therefore no reaction of the supply side cannot be rejected. Looking at the possible changes in the capitalization of public expenditures we find a positive effect of aggregate fiscal expenditures in base year 1998. The coefficients of the interaction terms are positive but insignificant. A positive interaction term indicates that capitalization becomes more important over time and supply side adjustments do not seem to take place.

Looking in more detail at expenditures allows us to distinguish changes in capitalization rates for different categories. In column (4) we interact the income tax rate and all four expenditure variables with year dummies. Again, for the base year we find a negative and significant capitalization effect of the income tax rate. Its impact is -1500 Swiss francs. In this setting we find that there are positive interaction terms for the years 2001, 2003 and 2004. The impact of the income tax rate consequently decreases over time. Analyzing different expenditure categories such an effect cannot be found. However, expenditures for cultural activities seem to decline in their capitalization effect. Still the opposite is true for expenditures on social well-being and health but not at a significant level. Finally, it seems that there are no systematic supply side reactions to rent differentials which can be explained by the inelasticity of the supply curve.

In order to further analyze the possibility of a supply side adjustment, we perform a number of robustness tests in Tables 4.9 and 4.10.

Table 4.9: Robustness-Tests for Interaction Model

Variable	(1) WLS pop	(2) WLS pop	(3) OLS controls	(4) OLS controls	(5) OLS commuter	(6) OLS commuter
(Intercept)	716370[a]	746312[a]	662752[a]	741738[a]	746772[a]	781431[a]
	(66378)	(64398)	(67688)	(65270)	(69313)	(68537)
TaxRate	-1222.78[a]	-1320.91[a]	-1072.39[a]	-1170.27[a]	-1117.32[a]	-1199.53[a]
	(416.215)	(391.118)	(413.531)	(401.846)	(409.889)	(402.412)
Int.TaxRate.1999	208.440	210.484	119.357	83.366	132.558	87.801
	(543.908)	(509.471)	(531.347)	(522.862)	(527.347)	(523.128)
Int.TaxRate.2000	397.858	395.811	341.697	303.420	365.709	310.954
	(519.872)	(506.680)	(508.289)	(521.306)	(502.647)	(520.139)
Int.TaxRate.2001	686.546	914.515[c]	581.213	788.050	622.814	810.871
	(504.021)	(476.997)	(490.619)	(494.225)	(486.375)	(493.624)
Int.TaxRate.2002	619.089	824.764[c]	440.555	622.334	506.811	663.409
	(511.533)	(495.316)	(495.872)	(507.587)	(491.401)	(506.639)
Int.TaxRate.2003	763.006	1061.501[b]	584.484	856.255[c]	654.028	899.881[c]
	(521.575)	(494.110)	(512.181)	(513.329)	(507.755)	(511.447)
Int.TaxRate.2004	828.543	935.[c]	665.808	717.812	731.672	770.874
	(510.648)	(500.600)	(497.107)	(514.390)	(496.854)	(515.059)
ExpCulture		228.781[a]		227.210[a]		215.700[b]
		(83.778)		(83.288)		(83.879)
Int.ExpCulture.1999		20.563		-0.777		-1.724
		(114.931)		(117.446)		(118.289)
Int.ExpCulture.2000		-17.186		-20.172		-20.117
		(121.154)		(124.996)		(125.711)
Int.ExpCulture.2001		-55.643		-55.384		-55.836
		(110.954)		(113.089)		(113.684)
Int.ExpCulture.2002		-61.551		-83.832		-84.648
		(113.640)		(115.553)		(116.078)
Int.ExpCulture.2003		-55.851		-51.072		-53.539
		(119.466)		(120.480)		(121.390)
Int.ExpCulture.2004		-41.921		-56.234		-55.392
		(115.463)		(116.106)		(116.874)
ExpSocial		80.349[b]		75.805[b]		69.442[b]
		(34.821)		(34.255)		(34.281)
Int.ExpSocial.1999		36.118		29.392		29.818
		(43.993)		(44.252)		(44.062)
Int.ExpSocial.2000		31.589		12.211		12.670
		(45.670)		(45.305)		(45.018)
Int.ExpSocial.2001		30.343		13.721		13.675
		(44.063)		(43.727)		(43.369)
Int.ExpSocial.2002		44.640		36.415		37.220
		(42.509)		(42.314)		(42.086)
Int.ExpSocial.2003		44.985		47.092		47.239
		(40.250)		(39.947)		(39.736)
Int.ExpSocial.2004		45.565		48.729		49.109

(continued on next page)

Table 4.9: Robustness-Tests for Interaction Model (continued)

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	WLS pop	WLS pop	OLS controls	OLS controls	OLS commuter	OLS commuter
		(39.581)		(38.754)		(38.529)
ExpAdmin		-53.256^c		-48.031		-44.612
		(32.065)		(30.478)		(31.043)
Int.ExpAdmin.1999		51.107		48.100		46.889
		(44.055)		(41.750)		(42.281)
Int.ExpAdmin.2000		44.682		50.185		50.004
		(41.410)		(38.255)		(38.698)
Int.ExpAdmin.2001		37.017		43.939		42.650
		(37.907)		(35.364)		(35.950)
Int.ExpAdmin.2002		38.807		41.798		41.363
		(40.278)		(37.408)		(38.014)
Int.ExpAdmin.2003		13.095		18.903		17.728
		(42.360)		(39.301)		(39.912)
Int.ExpAdmin.2004		41.038		44.393		42.480
		(45.325)		(41.713)		(42.232)
ExpHealth		152.499^b		160.367^b		161.506^b
		(70.093)		(68.585)		(68.330)
Int.ExpHealth.1999		-164.818		-142.031		-135.649
		(115.281)		(114.395)		(114.215)
Int.ExpHealth.2000		-79.273		-63.906		-64.387
		(96.334)		(94.825)		(94.534)
Int.ExpHealth.2001		23.015		15.063		17.122
		(84.543)		(83.492)		(83.408)
Int.ExpHealth.2002		71.636		63.854		67.465
		(89.623)		(88.613)		(88.191)
Int.ExpHealth.2003		83.718		69.342		75.695
		(97.798)		(96.271)		(95.902)
Int.ExpHealth.2004		81.385		66.735		73.143
		(101.774)		(101.401)		(100.519)
ExpAgg	44.185^b		44.686^b		41.483^b	
	(19.142)		(19.205)		(19.433)	
Int.ExpAgg.1999	10.881		5.348		6.097	
	(27.289)		(27.960)		(27.895)	
Int.ExpAgg.2000	9.454		0.417		1.443	
	(27.392)		(27.222)		(27.105)	
Int.ExpAgg.2001	16.988		9.083		11.262	
	(26.825)		(26.427)		(26.300)	
Int.ExpAgg.2002	38.988		30.247		32.714	
	(25.008)		(24.898)		(24.881)	
Int.ExpAgg.2003	33.354		31.585		33.343	
	(26.363)		(26.615)		(26.529)	
Int.ExpAgg.2004	40.428		36.504		37.552	
	(24.846)		(25.123)		(25.382)	
ClassSize	-417.960	-335.756^c	-352.881	-322.019^c	-390.358	-342.541^c

(continued on next page)

Table 4.9: Robustness-Tests for Interaction Model (continued)

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	WLS pop	WLS pop	OLS controls	OLS controls	OLS commuter	OLS commuter
	(296.236)	(198.648)	(244.508)	(187.980)	(238.291)	(189.604)
NoSchool	1460.84	3007.05	-962.37	2069.12	-754.82	2075.89
Community	(4052.55)	(3902.85)	(4127.61)	(4015.61)	(4089.31)	(4004.67)
Elderly	7050.57^a	5619.62^a	7171.72^a	5337.58^a	6216.55^a	4946.89^a
	(700.851)	(688.095)	(675.971)	(688.475)	(689.383)	(701.025)
Density	30.028^a	13.374^a	20.597^a	10.898^b	24.511^a	13.235^a
	(4.089)	(4.521)	(4.289)	(4.633)	(4.476)	(4.927)
MedianIncome	7.144^a	7.308^a	7.598^a	7.091^a	7.964^a	7.269^a
	(0.481)	(0.528)	(0.521)	(0.537)	(0.550)	(0.555)
Lakeview	35.243^a	34.138^a	36.879^a	35.337^a	35.565^a	34.698^a
	(1.874)	(1.872)	(1.842)	(1.888)	(1.816)	(1.868)
DistCenter	-6403.54^a	-5981.87^a	-5595.97^a	-5723.30^a	-5775.00^a	-5807.34^a
	(300.262)	(325.577)	(325.634)	(342.516)	(319.376)	(342.572)
NO2Pollution	-5857.69^a	-6447.12^a	-6139.32^a	-6328.92^a	-6039.98^a	-6246.79^a
	(557.637)	(580.625)	(557.731)	(572.450)	(569.548)	(574.353)
SWExposition	66151.39^a	65445.86^a	65931.95^a	63949.70^a	66494.79^a	64147.59^a
	(5698.69)	(5430.85)	(5558.49)	(5384.18)	(5464.30)	(5326.62)
DebtRepay			-5747.01^a	-4381.312^a	-6656.18^a	-4830.45^a
			(1804.54)	(1499.82)	(1853.62)	(1507.61)
Unemployment			-7499.97^a	-6981.76^a	-6642.30^a	-6557.45^a
			(2373.55)	(2276.19)	(2396.67)	(2304.94)
Foreigners			2666.90^a	1448.58^a	2114.14^a	1262.26^a
			(364.583)	(360.715)	(375.733)	(356.651)
Commuters					-108038^a	-53539^c
					(29408)	(30303)
Time Fixed Effects	YES	YES	YES	YES	YES	YES
Adj R2	0.879	0.891	0.886	0.889	0.888	0.889
N	1183	1183	1183	1183	1183	1183
	169	169	169	169	169	169

The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.

^{a} indicates a significance level of below 1%; ^{b} indicates a significance level between 1% and 5%; ^{c} indicates significance level between 5% and 10%.

Table 4.10: Robustness-Tests for Interaction Model (continued)

Variable	(7)	(8)	(9)	(10)	(11)	(12)
	WLS commuter	WLS commuter	OLS log	OLS log	2SLS	2SLS
(Intercept)	707440[a]	736320[a]	1.36E+01[a]	1.36E+01[a]	651229[a]	877902[a]
	(65964)	(64102)	(7.68E-02)	(7.37E-02)	(63107)	(132355)
TaxRate	-1194.68[a]	-1296.14[a]	-1.15E-03[b]	-1.29E-03[a]	-905.26[b]	-2001.86[b]
	(411.887)	(387.584)	(4.82E-04)	(4.48E-04)	(446.641)	(920.381)
Int.TaxRate.1999	205.299	210.391	5.14E-05	7.38E-05	-414.144	286.255
	(539.254)	(505.881)	(6.27E-04)	(5.93E-04)	(733.109)	(1293.649)
Int.TaxRate.2000	399.324	403.923	2.12E-04	2.48E-04	-505.084	173.673
	(515.647)	(502.763)	(6.00E-04)	(5.90E-04)	(732.941)	(1277.440)
Int.TaxRate.2001	688.313	915.721[c]	5.44E-04	8.95E-04	-258.309	-21.532
	(498.987)	(472.718)	(5.87E-04)	(5.61E-04)	(732.050)	(1261.442)
Int.TaxRate.2002	625.301	825.598[c]	7.50E-04	1.06E-03[c]	-571.853	-305.507
	(506.595)	(491.703)	(5.89E-04)	(5.61E-04)	(731.076)	(1269.60)
Int.TaxRate.2003	774.821	1063.108[b]	8.41E-04	1.23E-03[b]	-307.606	-223.024
	(516.113)	(491.054)	(6.04E-04)	(5.66E-04)	(740.506)	(1250.50)
Int.TaxRate.2004	841.355[c]	944.867[c]	9.60E-04	1.08E-03[c]	-309.328	-6.821
	(504.889)	(497.019)	(5.88E-04)	(5.72E-04)	(749.211)	(1222.47)
ExpCulture		227.131[a]		2.19E-04[b]		243.713
		(83.748)		(9.12E-05)		(446.114)
Int.ExpCulture.1999		21.802		3.08E-05		1.740
		(114.695)		(1.28E-04)		(630.373)
Int.ExpCulture.2000		-14.795		-1.88E-05		11.785
		(120.431)		(1.37E-04)		(614.234)
Int.ExpCulture.2001		-55.438		-5.87E-05		-27.315
		(110.526)		(1.23E-04)		(611.755)
Int.ExpCulture.2002		-60.367		-9.19E-05		-22.080
		(113.441)		(1.21E-04)		(622.705)
Int.ExpCulture.2003		-53.127		-9.90E-05		-25.041
		(119.555)		(1.23E-04)		(616.642)
Int.ExpCulture.2004		-38.842		-1.02E-04		-82.032
		(115.302)		(1.20E-04)		(618.660)
ExpSocial		81.765[b]		9.07E-05[b]		46.102
		(34.806)		(4.31E-05)		(123.842)
Int.ExpSocial.1999		35.787		4.91E-05		22.020
		(43.987)		(5.41E-05)		(173.193)
Int.ExpSocial.2000		30.988		4.18E-05		36.536
		(45.610)		(5.37E-05)		(171.674)
Int.ExpSocial.2001		30.115		3.25E-05		77.982
		(44.063)		(5.11E-05)		(172.326)
Int.ExpSocial.2002		44.823		4.15E-05		110.670
		(42.476)		(5.07E-05)		(175.708)
Int.ExpSocial.2003		45.561		3.51E-05		134.738
		(40.235)		(4.78E-05)		(175.798)
Int.ExpSocial.2004		45.572		3.97E-05		167.106

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Table 4.10: Robustness-Tests for Interaction Model (continued)

Variable	(7)	(8)	(9)	(10)	(11)	(12)
	WLS commuter	WLS commuter	OLS log	OLS log	2SLS	2SLS
		(39.590)		(4.66E-05)		(176.228)
ExpAdmin		-50.626		-1.01E-04[b]		-209.942[b]
		(31.930)		(3.95E-05)		(93.766)
Int.ExpAdmin.1999		51.426		5.50E-05		22.521
		(43.940)		(5.25E-05)		(132.980)
Int.ExpAdmin.2000		44.226		5.37E-05		36.247
		(41.371)		(4.84E-05)		(133.813)
Int.ExpAdmin.2001		36.143		5.49E-05		74.761
		(37.441)		(4.73E-05)		(133.233)
Int.ExpAdmin.2002		38.810		4.48E-05		89.857
		(39.852)		(4.87E-05)		(136.458)
Int.ExpAdmin.2003		13.623		1.85E-05		108.897
		(41.807)		(5.20E-05)		(136.344)
Int.ExpAdmin.2004		41.803		3.67E-05		132.498
		(44.878)		(5.37E-05)		(136.128)
ExpHealth		153.254[b]		1.56E-04[b]		-416.571
		(70.265)		(7.54E-05)		(378.265)
Int.ExpHealth.1999		-166.432		-1.53E-04		-20.642
		(115.165)		(1.28E-04)		(546.869)
Int.ExpHealth.2000		-77.803		-9.15E-05		-70.571
		(96.500)		(1.13E-04)		(532.345)
Int.ExpHealth.2001		23.517		4.14E-05		-146.496
		(84.441)		(9.45E-05)		(522.169)
Int.ExpHealth.2002		69.598		9.18E-05		-211.697
		(89.726)		(9.60E-05)		(508.249)
Int.ExpHealth.2003		79.674		1.07E-04		-280.234
		(97.682)		(1.07E-04)		(492.302)
Int.ExpHealth.2004		78.083		1.17E-04		-264.519
		(101.497)		(1.12E-04)		(479.570)
ExpAgg	46.213[b]		2.31E-05		67.423[a]	
	(19.017)		(2.25E-05)		(10.285)	
Int.FinExpAgg.1999	10.551		1.94E-05		-47.626	
	(27.187)		(3.07E-05)		(33.468)	
Int.FinExpAgg.2000	9.365		1.08E-05		-51.497	
	(27.327)		(3.07E-05)		(33.853)	
Int.FinExpAgg.2001	16.804		1.92E-05		-51.575	
	(26.669)		(3.02E-05)		(33.644)	
Int.FinExpAgg.2002	38.693		3.57E-05		-41.980	
	(24.880)		(2.78E-05)		(31.254)	
Int.FinExpAgg.2003	33.405		2.55E-05		-36.611	
	(26.200)		(2.96E-05)		(31.280)	
Int.FinExpAgg.2004	40.495		3.36E-05		-31.942	
	(24.677)		(2.72E-05)		(31.801)	
ClassSize	-411.588	-333.018[c]	-6.17E-04	-4.70E-04[c]	-430.620	49.182

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Table 4.10: Robustness-Tests for Interaction Model (continued)

Variable	(7)	(8)	(9)	(10)	(11)	(12)
	WLS commuter	WLS commuter	OLS log	OLS log	2SLS	2SLS
	(290.661)	(195.883)	(4.12E-04)	(2.76E-04)	(322.884)	(82.130)
NoSchool	1452.40	3037.57	-2.09E-03	-2.19E-04	467.60	269.863
Community	(4052.61)	(3903.79)	(4.59E-03)	(4.37E-03)	(4170.98)	(3950.09)
Elderly	7106.28^a	5691.30^a	5.28E-03^a	3.64E-03^a	5812.96^a	9018.23^a
	(697.393)	(684.858)	(7.73E-04)	(7.68E-04)	(828.543)	(771.741)
Density	29.448^a	13.111^a	4.21E-05^a	1.71E-05^a	33.204^a	15.433^a
	(4.075)	(4.498)	(4.81E-06)	(5.05E-06)	(4.590)	(5.047)
MedianIncome	7.221^a	7.395^a	7.45E-06^a	7.79E-06^a	7.391^a	8.332^a
	(0.483)	(0.531)	(5.21E-07)	(5.68E-07)	(0.410)	(0.417)
Lakeview	35.267^a	34.161^a	4.35E-05^a	4.20E-05^a	37.320^a	33.464^a
	(1.877)	(1.874)	(2.23E-06)	(2.13E-06)	(1.992)	(1.846)
DistCenter	-6358.47^a	-5927.26^a	-8.65E-03^a	-8.16E-03^a	-6414.83^a	-6251.08^a
	(301.800)	(327.102)	(3.29E-04)	(3.63E-04)	(313.229)	(265.825)
NO2Pollution	-5873.26^a	-6430.198^a	-5.98E-03^a	-6.81E-03^a	-5552.44^a	-6052.68^a
	(556.425)	(580.688)	(6.59E-04)	(6.59E-04)	(573.101)	(604.155)
SWExposition	65260.02^a	64646.63^a	8.30E-02^a	8.04E-02^a	66852.03^a	67769.09^a
	(5686.68)	(5429.58)	(6.65E-03)	(6.32E-03)	(5814.62)	(5401.24)
Time Fixed Effects	YES	YES	YES	YES	YES	YES
Adj R2	0.879	0.8903	0.8684	0.884	0.872	0.879
N	1183	1183	1183	1183	1183	1183
	169	169	169	169	169	169

The left-hand-side variable in all regressions is the average price of a comparable single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.

^{a} indicates a significance level of below 1%; ^{b} indicates a significance level between 1% and 5%; ^{c} indicates significance level between 5% and 10%.

In specifications (1) and (2), we weight the OLS estimates by the logarithmic population of the communities. This is done in order to ensure that the results are not only driven by a number of small communities. In column (1) no significant interaction term can be identified. Though the base effect for taxes is negative and the interaction terms are positive, a systematic supply adjustment to tax rate differences cannot be found. As in the baseline results the effect of aggregate expenditures is positive and again the interaction terms are positive but insignificant. In column (2) we find similar results as in specification (4) of Table 4.8. The base effect of income taxes is negative and significant whereas the base effect of the different expenditure categories is positive and significant except for administrative expenditures which seem to represent a burden. Concerning the interaction terms, only those of the tax

rate for the years 2001 to 2004 are significant. Minor supply side adjustments might therefore occur in larger communities as far as tax differentials are considered. It is interesting to note that expenditures do not change their capitalization coefficients significantly and that the signs of the interaction terms indicate a larger capitalization.

In columns (3) and (4), we include two additional controls. The first one represents the theoretical number of years it takes to a community to fully pay back its current debts using its tax revenue. Clearly, we expect a negative sign for this variable as longer debt repayment periods make future tax increases more likely. Additionally, we include the communal unemployment rate as a variable which represents further demographic characteristics. The sign of the unemployment rate is negative and significant as expected. Concerning the interaction terms for income taxes and aggregate expenditures, we note that the overall picture does not change. Income taxes capitalize negatively in the base year and the interaction terms are negative but not significant. Aggregate expenditures capitalize positively in the base year. The interaction terms indicate higher capitalization over the seven years of this analysis. However, the effects are not significant. In specification (4), we consider disaggregate expenditures. Again, only minor changes can be identified. Neither the interaction terms for the income tax rate nor the interaction terms for the disaggregate expenditure categories are significant. Moreover, expenditures for administration do not capitalize significantly but the sign of the coefficient in the base year remains negative.

Individuals mobility plays a central role for capitalization. In order to control for mobility issues, we include in specifications (5) and (6) the fraction of commuters who leave the community to work in the city. Clearly, we expect a negative sign for this coefficient as commuting imposes costs on individuals. The influence of this additional control on the capitalization coefficients for taxes and expenditures is minor. In column (5) we find that income taxes capitalize negatively in 1998 and all interaction terms are positive but insignificant. For aggregate expenditures we find a positive capitalization coefficient with positive interaction terms. Disaggregate expenditure estimates lead to almost completely the same coefficients as in column (4). Falling absolute capitalization rates can be rejected on the basis of this data.

In specifications (7) and (8), we perform additional tests concerning mobility issues. We use the logarithmic total number of outgoing commuters as weights for our estimates. The sign for the income tax rate in 1998 is negative in column (7), the other interaction terms being positive. Only the interaction term for the year 2004 is significant. The capitalization effect of income taxes decreases after a period of seven years. The reverse is true for aggregate expenditures. Expenditures positively capitalize in the base year and all interaction terms are positive too. The interaction term for the year 2004 is close to the 10% level. Although taxes seem to capitalize less, this is clearly not the case for expenditures which seem to capitalize more. Taking a closer look at the disaggregate data supports this view. In column (8) interaction terms for the tax rate are positive and significant for the years 2001 to 2004. The interaction terms for cultural expenditures show a negative sign but are far for being significant. Interaction terms for social expenditures are always positive. Administrative expenditures do not capitalize significantly in the base year 1998 nor in the other years of this analysis. Finally, expenditures for health capitalize significantly at the beginning and seem to increase their influence over time. The coefficients of all disaggregate interaction variables are not significant.

Next, we examine whether the functional form of the estimated equation matters. A number of capitalization studies using amenity models look at the logarithm of the endogenous variable house values (see Oates (1969) and Yinger et al. (1988)). Still, there is a large literature that considers non-logarithmic forms such as Stull and Stull (1991). To test for the possible influence of a logarithmic form we estimate a partial logarithmic model using the house prices in logarithmic form. Columns (9) and (10) give the results. The values of the coefficients change but our main results remain almost unchanged. The effect of income taxes in the base year 1998 is significant and negative. The interaction terms for all other years are positive but not significant.

Analyzing aggregate expenditures, we find a positive but insignificant impact. Interaction terms are also positive but insignificant. For disaggregate expenditures, we find a positive impact of cultural, social and health expenditures and a negative one for administrative expenditures. All coefficients are significant. Interaction terms for cultural and administrative expenditures indicate falling absolute capitalization rates. On the other hand, expenditures

for social well-being and health seem to capitalize more over time. However, none of the effects of the interaction terms is significant at the 10% level.

Finally, we take account of a possible endogeneity problem. Usually reverse causation is not a large discussion in the house price hedonic literature. Contributions such as Palmon and Smith (1998b) and Brasington (2001) do not mention this problem nor do they control for it. Oates (1969) discusses the problem of reverse causation for property taxes. As property taxes are levied on the property value, some reverse causation might be a problem in this case. Here, we do not consider property taxes but local income taxes which should not increase if house prices rise. Still, we instrument our tax and expenditure variables with the fraction of Catholics, the fraction of left cantonal parties, the population, population squared, the fraction of area for farming, the fraction of area for forests, the fraction of the population younger than 18 years and whether the community has a grammar school. Columns (11) and (12) show the second stage. Again, taxes and public expenditures have the expected sign. The interaction terms of taxes are negative but insignificant. The interaction terms of aggregate expenditures are negative and insignificant. For disaggregate expenditures we find that none of them is significant at the 10% level. Only income taxes capitalize negatively. Neither the interaction terms for the tax rate nor any interaction term for the different expenditure categories capitalize significantly. Consequently, instrumentation of taxes and expenditures does not show any significant decrease in capitalization rates over the analyzed period of seven years for municipalities in the Swiss canton of Zurich.

Time Trend Results

Contrary to the previous section, we now include in the estimated amenity model a variable that interacts tax and public expenditures with a time trend. Generally, an opposite sign of the interaction variable with respect to the base capitalization effect indicates a reduction of the degree of capitalization over time and a reaction of housing supply. The results are presented in Table 4.11.

Table 4.11: Linear Interaction Model: Time Trends

	Specification (1)		Specification (2)	
Variable	*Coefficient*	*Impact* in CHF*	*Coefficient*	*Impact* in CHF*
Intercept	841493^a		879605^a	
	(59445)		(62038)	
TaxRate	-1360.72^a	-1549.40	-1413.67^a	-1609.68
	(280.828)		(289.950)	
Int.TaxRate.Trend	115.405^c	131.41	158.357^b	180.31
	(66.613)		(69.221)	
FinExpAgg	32.773^b	300.34		
	(13.751)			
Int.FinExpAgg.Trend	6.677^c	61.19		
	(3.474)			
ExpCulture			198.978^a	185.38
			(57.557)	
Int.ExpCulture.Trend			-10.148	
			(16.036)	
ExpSocial			70.638^a	208.76
			(22.876)	
Int.ExpSocial.Trend			5.407	
			(4.943)	
ExpAdmin			-18.866	
			(19.787)	
Int.ExpAdmin.Trend			1.196	
			(5.288)	
ExpHealth			93.479^c	142.52
			(49.582)	
Int.ExpHealth.Trend			28.625^b	43.64
			(13.677)	
DistSchool	-20.963^a	-181.27	-17.991^a	-155.58
	(6.393)		(5.991)	
ClassSize	746.435		-87.248	
	(963.218)		(922.693)	
NoSchoolComm	1150.18		3942.96	
	(3992.05)		(3887.46)	
MedianIncome	7.328^a	3464.30	6.679^a	3157.51
	(0.593)		(0.608)	
Density	21.190^a	126.64	10.486^b	62.67
	(4.660)		(5.052)	
Elderly	6054.94^a	761.61	4785.99^a	602.00
	(677.502)		(695.121)	
Commuters	-107387^a	-739.94	-61539^b	-424.03
	(28298)		(27980)	
Unemployment	-5248.87^b	-117.12	-4042.22^c	-90.19
	(2454.35)		(2225.76)	
Foreigners	1789.40^a	236.86	872.436^b	115.48

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Table 4.11: Linear Interaction Model: Time Trends (continued)

	Specification (1)		Specification (2)	
Variable	*Coefficient*	*Impact* in CHF*	*Coefficient*	*Impact* in CHF*
	(378.029)		(354.429)	
Lakeview	35.585^a	128.84	34.845^a	126.16
	(1.810)		(1.877)	
SWExposition	73142^a	313.27	69105^a	295.98
	(5653.87)		(5411.12)	
DistCenter	-6098.09^a	-1634.64	-6054.95^a	-1623.07
	(318.409)		(335.633)	
DistShop	-12.069^a	-147.22	-12.276^a	-149.74
	(2.796)		(2.649)	
NO2Pollution	-6554.43^a	-1164.49	-6658.62^a	-1183.00
	(578.233)		(584.214)	
Year fixed effects	YES		YES	
Adj R2	0.885		0.893	
N	1183		1183	

*Impact in CHF denotes the impact of a one percent increase of the mean of the respective
independent variable on property prices. The left-hand-side variable in all regressions is the
average price of a comparable single family house for the respective years 1998 to 2004 across
169 municipalities. Robust standard errors in parenthesis. ^{a} indicates a significance level of
below 1%; ^{b} indicates a significance level between 1% and 5%; ^{c} indicates significance level
between 5% and 10%.

The specification (1) displays the results using aggregate expenditures only. In contrast to
the previous results, we observe that the interaction term for the tax variable is positive and
significant, which indicate a decrease of the tax capitalization rate, as expected by the no-
capitalization faction. Note however that the degree of significance is only 10%. Reagarding
aggregate expenditures results, we find a weakly significant positive coefficient that is not
consistent with a reaction of housing supply over time, as it indicates an increase of the
capitalization of municipal spendings into house prices.

Column (2) confirms the results found with aggregate expenditures. The interaction term
for income tax rate exhibits a positive coefficient with a higher significance of 5%. The
interaction terms for the different categories of public expenditures are inconsitently positive
but are not significant (except for the case of health expenditures).

In contrast to the year dummies results, specifications that include time trends in the interaction variables seem to indicate some reaction of housing supply and a decrease of the capitalization, at least on the income tax side. However, this reaction is weakly significant in the aggregate expenditures specification and is inconsistent for the case of public expenditure, as the coefficients indicates a increase of the capitalization over time.

Bootstrap Results

We now turn to the last possibility to identify changes in capitalization rates. Table 4.12 presents seven regressions with the same independent variables for the years 1998 to 2004 including aggregate expenditures. Table 4.13 presents seven regressions using disaggregate expenditures for the same years.

Looking at the coefficients for the income tax rate in Table 4.12, we find that they are always negative. They are significant for the years 1998 and 1999 and marginally for the rest of the years. Aggregate expenditures always capitalize positively and significantly for the years 1999 to 2004. All other variables have the expected signs and were discussed previously.

In Table 4.13, we find the same pattern for income tax rates as in Table 4.12. Furthermore, cultural expenditures capitalize positively and significantly for the 1999-2004 period. Expenditures for social well-being capitalize positively too and significantly for the same period as cultural expenditures. Coefficient values for administrative expenditures are insignificant. Apart from the year 1999 and 2000, health expenditures are always positive and significant.

We use these coefficients and their standard errors of the different years and compute spearman correlations for each variable over the seven years. Finally we bootstrap the computed values 10,000 times. The results are given in Table 4.14 and Table 4.15.

Column (1) of these tables gives simple Spearman correlation coefficients and column (2) provides the respective p-values for the sign of each of these coefficients. At a first glance, it seems that the tax rate shows a positive linear trend indicating lower capitalization over time. The p-value for the coefficient in Table 4.14 is below 0.1. When Spearman correlations

Table 4.12: Regressions for Different Years and Aggregate Expenditures (1998 to 2004)

Variable	Year 1998 (1)	Year 1999 (2)	Year 2000 (3)	Year 2001 (4)	Year 2002 (5)	Year 2003 (6)	Year 2004 (7)
(Intercept)	546697^a	652872^a	595753^a	597446^a	595873^a	544829^a	653146^a
	(132277)	(134432)	(145399)	(131218)	(143947)	(142054)	(143591)
TaxRate	-867.830^c	-958.060^c	-834.358	-718.441	-669.748	-542.401	-794.207
	(503.889)	(521.750)	(525.392)	(473.711)	(494.798)	(478.008)	(497.433)
ExpAgg	34.140	43.908^c	56.564^b	73.867^a	93.729^a	85.024^a	84.229^a
	(22.223)	(23.698)	(23.894)	(21.369)	(21.761)	(23.298)	(21.106)
ClassSize	-6302.32^a	-194.139^b	-4676.53^b	-5100.75^b	-1429.75	-5308.85^b	-3978.53
	(2118.69)	(80.843)	(2025.01)	(1991.19)	(2401.090)	(2490.26)	(2630.30)
NoSchool	-3116.77	-2794.03	-1486.72	-2281.25	147.978	700.39	881.28
Community	(11097)	(11526)	(11320)	(10661)	(9757.43)	(10039)	(9325.49)
Elderly	8139.60^a	6743.96^a	6026.31^a	4282.44^a	4165.29^b	5868.98^a	4717.85^b
	(1683.68)	(1707.12)	(1690.34)	(1628.32)	(1871.46)	(1883.66)	(1829.41)
Density	20.463^c	23.808^c	24.274^c	24.844^b	20.258^c	19.970^c	25.140^b
	(12.104)	(12.078)	(12.451)	(11.938)	(10.961)	(11.358)	(10.991)
MedianIncome	9.183^a	8.570^a	7.967^a	7.114^a	8.120^a	7.426^a	6.482^a
	(1.601)	(1.611)	(1.640)	(1.593)	(1.482)	(1.296)	(1.183)
Lakeview	36.703^a	36.030^a	33.431^a	33.781^a	33.986^a	34.802^a	34.085^a
	(5.033)	(5.154)	(5.158)	(4.517)	(4.557)	(4.498)	(4.274)
DistCenter	-6436.33^a	-6057.81^a	-5893.21^a	-5564.39^a	-5168.13^a	-5546.90^a	-5979.39^a
	(830.305)	(794.759)	(791.427)	(852.482)	(928.537)	(855.426)	(769.703)
NO2Pollution	-7660.55^a	-6772.49^a	-6176.55^a	-5901.90^a	-5465.83^a	-5529.66^a	-5745.51^a
	(1419.72)	(1537.45)	(1581.21)	(1434.02)	(1405.44)	(1449.65)	(1438.26)
SWExposition	68906^a	68627^a	65005^a	60690^a	62207^a	60394^a	72605^a
	(13736)	(14223)	(13782)	(13950)	(14323)	(15008)	(15141)
DebtRepay	-1799.07	-1773.80	-4936.29	-6636.17	-10327^b	-9858.46^c	-6130.54
	(3817.46)	(3436.55)	(4505.42)	(5346.12)	(4959)	(5024.70)	(4566.75)
Unemployment	-220.861	358.347	-2826.70	-22728^c	-12217^b	-7828.49	-18241^a
	(5560.52)	(6553.84)	(11019)	(11561)	(5888)	(7592.69)	(6620)
Foreigners	1585.33^c	1718.29^c	1155.66	2231.29^b	2706.04^a	2216.85^c	3433.59^a
	(919.75)	(917.761)	(943.177)	(1060.94)	(1028.31)	(1216.76)	(1287.15)
Commuters	-95997	-101137	-135059c	-106587	-96626	-121629	-90721
	(64701)	(75899)	(77095)	(80010)	(78778)	(75702)	(76874)
Adj R2	0.875	0.863	0.867	0.879	0.886	0.882	0.882
N	169	169	169	169	169	169	169

[*] The left-hand-side variable in all regressions is the average price of a single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
[a] indicates a significance level of below 1%; [b] indicates a significance level between 1% and 5%; [c] indicates significance level between 5% and 10%.

Table 4.13: Regressions for Different Years and Disaggregate Expenditures (1998 to 2004)

Variable	Year 1998 (1)	Year 1999 (2)	Year 2000 (3)	Year 2001 (4)	Year 2002 (5)	Year 2003 (6)	Year 2004 (7)
(Intercept)	609682^a	628762^a	597916^a	626483^a	654796^a	625559^a	666531^a
	(135136)	(136826)	(152936)	(135091)	(143132)	(140956)	(141332)
TaxRate	-895.978^c	-865.768^c	-732.279	-690.221	-683.692	-600.087	-840.539^c
	(486.117)	(500.878)	(536.928)	(456.360)	(492.628)	(455.684)	(460.353)
ExpCulture	140.394	194.530^b	180.534^c	184.370^b	143.560^c	180.766^c	156.841^c
	(89.814)	(91.719)	(96.788)	(90.838)	(84.600)	(95.690)	(88.713)
ExpSocial	62.639	95.307^b	73.553	112.376^a	130.220^a	113.973^a	100.731^a
	(43.448)	(44.562)	(53.861)	(40.289)	(41.112)	(39.797)	(34.900)
ExpAdmin	-50.867	-14.027	22.605	12.703	5.100	-10.298	14.031
	(38.668)	(32.786)	(29.142)	(18.434)	(25.716)	(24.511)	(31.232)
ExpHealth	142.022^b	-3.144	85.168	228.298^a	282.178^a	304.708^a	311.491^a
	(70.005)	(97.131)	(74.053)	(53.277)	(63.021)	(77.717)	(87.022)
ClassSize	-5612.69^a	-170.626^b	-3912.53^c	-3435.90^c	-259.527	-4376.17^b	-4517.95^c
	(2038.50)	(74.630)	(1994.88)	(1878.02)	(2227.22)	(2023.69)	(2483.20)
NoSchool	-1497.79	-1660.13	-684.722	3866.16	5372.86	6881.70	444.056
Community	(10884)	(11414)	(11700)	(10163)	(9413.98)	(9243.55)	(9359.41)
Elderly	7771.93^a	6647.89^a	5522.16^a	2666.80	2590.89	2700.61	2841.33
	(1742.97)	(1779.43)	(1762.88)	(1640.87)	(1788.09)	(1812.75)	(1825.67)
Density	11.401	16.005	18.735	10.387	5.365	7.768	15.069
	(13.333)	(13.393)	(14.958)	(12.846)	(12.368)	(12.538)	(11.465)
MedianIncome	8.208^a	8.167^a	7.516^a	6.537^a	7.564^a	6.393^a	5.817^a
	(1.652)	(1.652)	(1.684)	(1.608)	(1.406)	(1.309)	(1.231)
Lakeview	36.857^a	35.967^a	34.055^a	33.242^a	31.170^a	32.813^a	31.176^a
	(5.225)	(5.308)	(5.325)	(4.577)	(4.994)	(4.420)	(4.214)
DistCenter	-6799.38^a	-5914.73^a	-5974.23^a	-5123.73^a	-5147.88^a	-5652.70^a	-5826.65^a
	(907.231)	(857.834)	(833.923)	(912.023)	(935.476)	(932.555)	(867.753)
NO2Pollution	-8331.27^a	-7098.80^a	-6437.12^a	-6148.63^a	-5613.27^a	-5297.07^a	-5046.19^a
	(1390.87)	(1518.36)	(1631.50)	(1355.69)	(1311.00)	(1447.60)	(1582.75)
SWExposition	73197^a	66510.992^a	64709.89^a	44423.34^a	56386.00^a	57009.92^a	72673.34^a
	(13636)	(13999)	(13795)	(13781)	(13679)	(13894)	(13933)
DebtRepay	-780.863	-1457.96	-5111.61	-6637.08	-7143.66^c	-5244.69	-3462.02
	(3201.48)	(3214.93)	(4143.41)	(4616.29)	(3868.77)	(4104.02)	(4093.06)
Unemployment	-2729.72	-418.256	-1844.56	-15261.32	-9697.75^c	-5145.05	-14357^b
	(5368.31)	(6796.20)	(10493)	(10190)	(5237.97)	(6670.39)	(6140.465)
Foreigners	1097.61	965.910	741.493	1179.82	1664.97^c	791.162	2050.03c
	(870.398)	(863.065)	(939.160)	(924.843)	(952.993)	(1101.34)	(1227.03)
Commuters	-37325	-29276	-82869	-53077	-63935	-90160	-87273
	(69049)	(79737)	(86214)	(87733)	(79285)	(76149)	(76402)
Adj R2	0.880	0.867	0.867	0.889	0.897	0.895	0.890
N	169	169	169	169	169	169	169

* The left-hand-side variable in all regressions is the average price of a single family house for the respective years 1998 to 2004 across 169 municipalities. Robust standard errors in parenthesis.
^{a} indicates a significance level of below 1%; ^{b} indicates a significance level between 1% and 5%; ^{c} indicates significance level between 5% and 10%.

Table 4.14: Bootstrap Results for Aggregate Expenditures

Variable	Spearman Correlation (1)	p-Value (2)	Bootstrap Correlation (3)	Bootstrap Bias (4)	Bootstrap Standard Error (5)
TaxRate	0.750	0.066	0.643	-0.464	0.395
FinExpAgg	0.857	0.024	0.821	-0.177	0.226

Column (1) gives simple Spearman Correlations for the respective coefficients of the variables as calculated in Table 3. Column (2) is t p-Value of the Spearman Correlation. Columns (3) to (5) bootstrap the seven observations 10,000 times using the coefficient and its standard error from Table 4.12.

Table 4.15: Bootstrap Results for Disaggregate Expenditures

Variable	Spearman Correlation (1)	p-Value (2)	Bootstrap Correlation (3)	Bootstrap Bias (4)	Bootstrap Standard Error (5)
TaxRate	0.643	0.139	0.179	-0.071	0.394
ExpCulture	0.000	1.000	0.571	-0.580	0.394
ExpSocial	0.714	0.088	0.429	-0.119	0.343
ExpAdmin	0.500	0.267	0.571	-0.260	0.326
ExpHealth	0.893	0.012	0.679	0.057	0.176

Column (1) gives simple Spearman Correlations for the respective coefficients of the variables as calculated in Table 3. Column (2) is t p-Value of the Spearman Correlation. Columns (3) to (5) bootstrap the seven observations 10,000 times using the coefficient and its standard error from Table 4.13 .

are derived using disaggregate expenditures in Table 4.15, the correlation is not significant any more. Aggregate expenditures have a positive correlation indicating higher capitalization over time. The value of 0.857 is significant and close to the 1% level. When analyzing expenditures in more detail, we can see where the aggregate positive correlation comes from. For cultural expenditures, no clear trend can be established. Indeed, the regression coefficients of Table 4.15 for this variable show no clear trend as they starts from 140.394, go to 184.370 in the year 2001 and fall back to 156.841. Expenditures for social well-being have a clearer trend. The Spearman correlation for this variable over time is 0.714 which is significant at the 10% level. Administrative expenditures show a positive trend too, indicating lower capitalization over time as the variable itself capitalizes usually negatively. However, the correlation coefficient is not significant. Finally, expenditures for health have a clear and significant positive trend. The Spearman correlation indicates that for the observed time frame health expenditures tend to capitalize more in the canton of Zurich. The cultural expenditures have a negative and significant correlation indicating falling capitalization rates too. Social welfare expenditures as well as administrative expenditures show no clear pattern whereas health expenditures seem to capitalize more.

Analyzing linear trends in the coefficients is not enough as we do not take account of uncertainty in these point estimates for the seven observations of each coefficient over time. Consequently, we bootstrap the coefficient estimates 10,000 times for tax rate, aggregate expenditures and disaggregate expenditures, as explained above. This allows us to calculate a bootstrapped Spearman correlation for all fiscal variables in column (3). Bootstrap methods also allow to compute a possible bias of the point estimates which is particularly interesting when the number of observations is limited and when high uncertainty is associated with the estimates. Column (4) gives the estimation. Finally, column (5) gives the bootstrap standard errors.

Looking at the bootstrapped correlations and their biases in Table 4.14, we can see that the bias is very high with respect to the coefficient in column (3). This indicates that the values in column (1) cannot be directly interpreted as a linear trend. The uncertainty and the bias in the trend estimation are high. Even if the capitalization of taxes seems to decrease over time, the bootstrapping results do not show a clear trend. This remains true for expenditures categories (Table 4.15). They seem to capitalize more but bootstrapping results show again that the bias is high and unbiased estimates, in column (3) and (4), of the correlation coefficients are closer to zero than the simple Spearman correlation of column (1). Dividing the unbiased estimates by the standard error of column (5) shows that only for health expenditures and aggregate expenditures a positive trend can be observed. For taxes and other expenditure categories no significant changes in capitalization rates can be identified. Aggregate expenditures and the category of health expenditures seem to capitalize more over time indicating that at least for the observed time period and the data used, the ideas of Edel and Sclar (1974) concerning a supply side reaction cannot be supported.

Conclusion

Even though we find significant capitalization of taxes and public expenditures in the municipalities of the canton of Zurich, some authors argue that this is only a temporary phenomenon that should disappear as soon as land developers build new housing in response to price differentials (Hamilton, 1976a; Henderson, 1985). This chapter has presented the controversy

on the existence of capitalization and its implications for the test of the Tiebout hypothesis. We also show with a simple theoretical model that the degree of fiscal capitalization depends on housing supply elasticity. Thus, the persistence of capitalization is essentially an empirical question.

Using our panel data set from the canton of Zurich, we estimate the change of capitalization over the metropolitan area by including in a standard amenity model interaction variables between fiscal variables and available land, a proxy for housing supply elasticity. We also try to detect change of capitalization over time by interacting fiscal variables with year dummies and a time trend. Overall, our estimation seems to indicate a persistence of tax and public expenditures capitalization both across space and over time, as most of interaction variables as well as the bootstrapped coefficients are not significant. These results gives support to the pro-capitalization faction that argues that housing supply is restricted at the local level by zoning regulations land scarcity and that capitalization is persistent features of local governments (Yinger, 1981; Fischel, 2001; Oates, 2006).

General Conclusion

Since the Tiebout (1956) model, many empirical capitalization studies have confirmed that taxes have a negative and public services have a positive impact on housing prices. The first chapter of this thesis has presented the theoretical roots of capitalization. While it is generally invoked to rationalize capitalization, the Tiebout model does not directly deal with capitalization. Subsequent literature has solved some of the problems that are not raised in the original Tiebout model, like the question of the form of taxation (Hoyt, 1991; Henderson, 1994) and its impact on the efficiency of public services provision (Hamilton, 1975, 1976b). The original Tiebout model is also silent on the form and the objectives of governments that provide local public goods and choose the level of taxes. Three approaches address this issue. The profit maximizing developers approach (Sonstelie and Portney, 1978; Henderson, 1985) is in line with the original Tiebout view of local governments, as it describes entrepreneurs that provide local public goods in order to maximize profits. The second approach considers that the governments objective is to maximize property value (Brueckner, 1983; Scotchmer, 1986). This objective is sometimes associated with a form of political pressure (Wildasin, 1979; Yinger, 1981; Fischel, 2001). The last approach is the club theory that shares common features with the Tiebout model (Cornes and Sandler, 1986; Oates, 2006). In all these models, the efficiency of local public services provision does not emerge automatically as in the Tiebout model but depends on the particular set of assumptions on the type of taxes and governments objective.

Chapter 2 has provided a non-exhaustive review of the empirical literature on capitalization. As argued by Fischel (2001), there have been so many capitalization studies that it is "now an undergraduate exercise". Thus we have focused our attention on studies that significantly improved the techniques and data sets or estimate capitalization with original methods.

In chapter 3, we have estimated the capitalization of income taxes and public expenditures in 171 municipalities from the Canton of Zurich. Our estimations are based on a unique data set that allows to control for a variety of fiscal, environmental, neighborhood and demographic variables. Our endogenous variables is the price of a standardized and comparable single family house in each community. In contrast to the usual aggregate or micro data studies, this approach allows us to ignore the structural variables that may induce various biases on the tax and public services capitalization estimates. Our capitalization estimates are standard and consistent to the literature; Most of the control variables have significant and expected sign. The baseline results show that a a one percent increase in the mean income tax rate reduces house values by around 1000 Swiss francs. Regarding local public expenditures, the capitalization effect depends on the item considered. Social expenditures have larger impact on house prices than health and cultural expenditures. Environment and administrative expenditures have no significant influence on property values.

In line with Oates (1969), the estimation of fiscal capitalization has often been used in the literature as a test for the Tiebout hypothesis. Oates (1969) shows that his capitalization estimates imply equivalent impact of taxes and public school expenditures on house prices; Thus the property tax is equivalent to a benefit tax, as the negative effect on property value of a tax increase is roughly offset by the public spending allowed by the additional tax revenues. This would indicate that communities have reached a Tiebout equilibrium and an efficient pattern of local public services. In contrast, some authors (Hamilton, 1976a; Henderson, 1985) criticize this view and argue that capitalization of local fiscal variables does not describe a full Tiebout equilibrium. Chapter 4 has presented the debate on the existence and the meaning of capitalization and provided a simple model that sums up the two sides of the debate. We find that for a perfect elastic supply of housing, capitalization of taxes and public expenditures should disappear. However, for inelastic supply of housing, capitalization tends to persist. Thus, the implication of this model is that the question of the persistence of fiscal capitalization is essentially an empirical one. Chapter 4 has estimated the change of the capitalization rate in response to housing supply differences across space and over time. We introduce a land available variable as a proxy for housing supply elasticity and which is interacted with fiscal variables. Then fiscal variables are interacted with time dummies and a time trend in order to detect changes of capitalization over time. In all cases,

a decreasing pattern of capitalization is supported if the interaction variables have opposite sign to the base effects of taxes and public expenditures on housing prices. The signs of interaction variables are consistent with a reaction of housing supply but coefficient estimates are generally not significant. The only specification that exhibits some (weak) reaction of housing supply over time is the one that includes the interaction term between tax rate and a time trend. These results seem to indicate that capitalization of income taxes and public expenditures into housing prices is persistent both across space and over time in the Canton of Zurich.

What are the implications of our results for the evaluation of the municipal public policies of the Canton of Zurich? The no-capitalization faction argues that a full Tiebout equilibrium and an efficient pattern of local public services is actually associated with *no correlation* between local fiscal variables and housing prices. Thus, according to this approach, our main results seem to indicate that municipalities provide local public services inefficiently. In contrast, Fischel (2001) argues that capitalization is an important ingredient of local efficiency and is consistent with the intensive use of zoning regulations at the local level. Houses are the major asset of communities' residents and capitalization helps to keep the link between them and local officials. In particular, Fischel (2001) argues that capitalization of local fiscal variables constraints politicians to adopt efficient policies. For instance, if a jurisdiction decides to settle a waste collection center without the agreement of residents, house prices will decrease as the probability of reelection of the mayor. Thus, it is in the interest of the local government to set the policy that increase property values.

The reader may wonder why we do not find any reaction of housing supply across space and over time in the Canton of Zurich. Regarding the time dimension, the persistence of capitalization may simply be explained by the relatively small number of observations; while housing supply is likely to take long time to react, we only have seven years of observations. Regarding the space dimension, the no-capitalization argument implies that capitalization should be larger near the CBD than in the fringe of the metropolitan area. In contrast, we find that capitalization persists in any place of the metropolitan area, that is, whatever the conditions prevailing on the housing supply. This result may be explained by several factors. The theoretical model presented in chapter 4 shows that the reaction of capitalization to housing supply differentials occurs only if local jurisdictions have a significant market power

over the metropolitan area. Our results may thus reflect that the relative small size of munic-ipalities of the Canton of Zurich. The argument of the no-capitalization faction requires that land developers have the possibility to reallocate land use appropriately in order to eliminate capitalization. Let us Consider, for example, a municipality with a relatively high quality of public services and a low level of taxes. Without any constraint, land developers would convert agricultural land into residential land until housing price differentials vanish. As mentioned above, Fischel (2001) argues in contrast that municipalities have an elastic supply of housing and that zoning is an important municipal function. The change of capitalization rate is related to the assumption of flexible jurisdiction's boundaries. In the long run, flexi-ble boundaries allow communities with desirable fiscal bundles to expand over communities with less desirable fiscal bundles until house prices differentials disappear. In contrast to this theoretical requirement, the municipal level in Switzerland exhibits a huge institutional stability. For example, the number of municipalities in Switzerland has changed from 3205 to 2896. In the Canton of Zurich, the number of communities is stable (171 municipalities) since 1941 (Federal census of the population 2000).

The last factor that may explain our results is related to the nature of the house price variable used in these estimations. In contrast to the literature, we do not use sales transactions or median property value but the price of a standardized and comparable single family house. However, if the housing is segmented in several sub-markets, it is possible that housing supply reactions concern other sub-markets than the particular one we analyze. In such a case, we are not able to detect these reactions and their impact on the tax and public expenditures capitalization without any additional data on other types of houses. This implies that our study should be reproduced with different data sets including sales transactions for example.

In conclusion, this thesis offers a new sight on capitalization of local fiscal variables. Con-trary to the arguments of the no-capitalization faction and the recent empirical findings of Brasington (2002) and Hilber and Mayer (2009), we have shown that not only capitalization is a natural feature of local jurisdictions, but it is also likely to be a persistent phenomenon. Subsequent research has to be conduced to confirm these findings.

Appendix

Detailed Steps for Capitalization Equations (4.4), (4.5), (4.12) and (4.13)

Capitalization Equations for Perfectly Competitive Jurisdictions

Differentiating (4.3) with respect to g_i yields:

$$\frac{\partial V}{\partial p_i}\frac{\partial p_i}{\partial g_i}+\frac{\partial V}{\partial g_i}=0. \tag{A1}$$

Applying Roy's identity and $MRS_i = (\partial V/\partial g_i)/(\partial V/\partial y)$ on (A1) and solving for $\partial p_i/\partial g_i$, we obtain (4.4).

Differentiating (4.3) with respect to t_i gives:

$$-\frac{\partial V}{\partial y_i}\bar{y}+\frac{\partial V}{\partial p_i}\frac{\partial p_i}{\partial t_i}=0. \tag{A2}$$

Applying Roy's identity and solving (A2) for $\partial p_i/\partial t_i$ yields (4.5).

Capitalization Equations for Jurisdictions with Market Power

Differentiating (4.6) with respect to g_i yields:

$$\frac{\partial V}{\partial p_i}\frac{\partial p_i}{\partial g_i}+\frac{\partial V}{\partial g_i}-\frac{\partial V}{\partial p_j}\frac{\partial p_j}{\partial g_i}=0.$$

Applying Roy's identity and $MRS_i = (\partial V/\partial g_i)/(\partial V/\partial y)$, we obtain:

$$-h_i \frac{\partial p_i}{\partial g_i} + h_j \frac{\partial p_j}{\partial g_i} = -MRS_i. \tag{A3}$$

Then differentiating equation (4.9) with respect to g_i gives:

$$\frac{\partial H_i}{\partial p_i} \frac{\partial p_i}{\partial g_i} \frac{1}{h_i} - \frac{\partial h_i}{\partial p_i} \frac{\partial p_i}{\partial g_i} \frac{H_i}{h_i^2} + \sum_{j \neq i} \left(\frac{\partial H_j}{\partial p_j} \frac{\partial p_j}{\partial g_i} \frac{1}{h_j} - \frac{\partial h_j}{\partial p_j} \frac{\partial p_j}{\partial g_i} \frac{H_j}{h_j^2} \right) = 0. \tag{A4}$$

Using equation (A4), making appear the demand and housing supply elasticity, and combining with equation (A3), we get:

$$\frac{n_i}{p_i}(\eta_i - \varepsilon_i) \frac{\partial p_i}{\partial g_i} + \sum_{j \neq i} \left(-\frac{n_j}{p_j}(\eta_j - \varepsilon_j) \left(\frac{MRS_i}{h_j} - \frac{h_i}{h_j} \frac{\partial p_i}{\partial g_i} \right) \right) = 0. \tag{A5}$$

Solving (A5) for $\partial p_i/\partial g_i$ yields equation (4.12).

We proceed analogously for deriving the tax capitalization equation. Differentiating (4.6) with respect to t_i, applying Roy's identity and the definition of the MRS gives:

$$-h_i \frac{\partial p_i}{\partial t_i} + h_j \frac{\partial p_j}{\partial t_i} = \bar{y}. \tag{A6}$$

Differentiating equation (4.9) with respect to t_i and making appear the demand and housing supply elasticity gives:

$$\frac{n_i}{p_i}(\eta_i - \varepsilon_i) \frac{\partial p_i}{\partial t_i} + \sum_{j \neq i} \left(\frac{n_j}{p_j}(\eta_j - \varepsilon_j) \frac{\partial p_j}{\partial t_i} \right) = 0. \tag{A7}$$

Combining equation (A6) and equation (A7), we obtain:

$$\frac{n_i}{p_i}(\eta_i - \varepsilon_i) \frac{\partial p_i}{\partial t_i} + \sum_{j \neq i} \left(\frac{n_j}{p_j}(\eta_j - \varepsilon_j) \left(\frac{\bar{y}}{h_j} + \frac{h_i}{h_j} \frac{\partial p_i}{\partial t_i} \right) \right) = 0. \tag{A8}$$

Solving (A8) for $\partial p_i/\partial t_i$ yields equation (4.13).

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RÉSUMÉ

Cette thèse analyse la dynamique spatiale et temporelle de la capitalisation des variables fiscales locales (impôts et dépenses publiques) dans les valeurs immobilières des communes du Canton de Zurich. Bien que la littérature ait maintes fois mis en évidence le phénomène de capitalisation, la question de l'ampleur de la capitalisation ainsi que son interprétation reste ouverte. Bon nombre d'analyses interprètent la capitalisation comme un test de l'hypothèse de Tiebout et associe sa présence à une fourniture Pareto-optimale des biens publics. Cependant, une partie de la littérature considère que la présence de capitalisation signifie au contraire que les collectivités locales n'ont pas atteint un équilibre de Tiebout. Bien que cette question ait été soulevée pendant les années 70, elle n'a toujours pas trouvé de réponse définitive.

Le premier chapitre de cette thèse offre un panorama de la littérature théorique associée au modèle de Tiebout, en se concentrant sur les articles qui abordent le phénomène de capitalisation. Le second chapitre remet en perspective différentes innovations économétriques réalisées dans le domaine de l'estimation de la capitalisation fiscale. Le troisième chapitre présente des estimations de base de la capitalisation dans le Canton de Zurich. Pour estimer l'impact des variables fiscales des communes Zurichoises sur les valeurs immobilières, nous utilisons une variable endogène originale : le prix d'une maison standardisée et comparable pour l'ensemble des communes. Cette approche permet d'ignorer les variables structurelles (nombre de pièces, taille, âge, style) qui entrent dans les facteurs explicatifs de la valeur d'un logement. En revanche, la variable de prix immobilier est régressée sur un grand nombre de variables explicatives, allant des variables de voisinage aux variables fiscales, démographiques ou environnementales. Le chapitre 4 contribue au débat sur la persistance de la capitalisation en estimant le changement du taux de capitalisation des variables fiscales en réaction à des différences d'offre immobilière selon la situation de la commune dans l'agglomération Zurichoise et à travers le temps. Ainsi, le taux de capitalisation devrait être plus faible dans les collectivités disposant d'une plus grande quantité de terre disponible et devrait décroître à travers le temps, à mesure que l'offre immobilière s'ajuste par le biais de nouvelles constructions dans les communes attractives. Les résultats indiquent cependant à l'inverse de la théorie une persitence de la capitalisation fiscale à la fois sur l'ensemble de l'agglomération Zurichoise et à travers le temps. Ces résultats soulignent l'importance de l'utilisation du zonage par les autorités locales, qui rendent rigides l'offre immobilière et favorise le phénomène de capitalisation.

Mots-clés : capitalisation fiscale, prix hedonique, réaction de l'offre, valeurs immobilières.

Codes JEL : R14, R31, R52.

ABSTRACT

This thesis analyzes the dynamic of fiscal capitalization across space and over time in the Canton of Zurich. While the literature provides a profusion of evidence on capitalization, there is still a controversy on the extent to which local fiscal variables capitalize into house values and on the appropriate interpretation one must have with respect to the Tiebout hypothesis. The outcome of a significant degree of tax and public expenditures capitalization is often interpreted as a test of the Tiebout hypothesis and associated with a Pareto efficient provision of local public goods. Some authors criticize this view and argue that capitalization of local fiscal variables does not describe a full Tiebout equilibrium. Fiscal capitalization results from scarcity of land that prevents households from moving toward communities with favorable tax-expenditure packages. While it has been raised in the 70's, the question of the persistence of capitalization has not received a definitive answer. This thesis aims to contribute to this debate.

Chapter 1 provides a survey of the theoretical literature on the Tiebout model, which is the basis of virtually every empirical capitalization study. Chapter 2 provides a review of the econometric innovations and improvements made by the empirical literature on capitalization. Chapter 3 contributes to the empirical literature on capitalization by providing estimation results of a unique data set from the Canton of Zurich. For our purpose, we use the price of a standardized and comparable single family house in each community. This allows to ignore the control of the structural characteristics in the estimation. We regress this house price variable on a large set of fiscal, neighborhood, environmental and demographic characteristics. Chapter 4 contributes to the debate on the persistence of capitalization and estimates the change of the capitalization rate in response to housing supply differences across space and over time. We use data on land availability as a proxy for housing supply elasticity. We estimate amenity models in which we interact the dummy variable for land availability with local fiscal variables. We also test for a decrease of capitalization over time by interacting local fiscal variables with year and time trend dummies. In addition we compute Spearman correlation to check the presence of a linear trend in the fiscal variables coefficients. Since the time horizon of our sample is relatively small (7 years), we bootstrap the basic capitalization coefficients 10,000 times. Overall, our estimation seems to indicate a persistence of tax and public expenditures capitalization both across space and over time, as most of interaction variables as well as the bootstrapped coefficients are not significant. These results are consistent with the intensive use of zoning regulations at the local level.

Keywords: Fiscal capitalization, hedonic house price, amenity models, housing supply, property values, taxes.

JEL classification: R14, R31, R52.