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THE EFFECT OF THREE-RATE PROPERTY TAXATION ON HOUSING CONSTRUCTION

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Abstract: This paper examines the effect on housing construction of taxing undeveloped residential land at a higher rate than developed land. In 2001, Finnish municipalities were allowed to levy an extra property tax on undeveloped land zoned for housing. The aim of the reform was to encourage housing construction. As of 2007, almost 30 percent of municipalities had implemented the new three-rate tax system with different tax rates on land pre development, land post development and buildings. The remaining municipalities have a two-rate system with a uniform land tax and a building tax. A theoretical model of decisions by landowners under the Finnish-type three-rate system suggests that pre-development land tax ought to lead to faster development, but also the density of development may be affected. Municipality-level panel data for the period 1998 – 2006 are used in this study to estimate the effect of the pre-development tax on housing starts. Fixed-effects Poisson estimations suggest that adopting the three-rate property tax system increased single-family housing starts annually by roughly 10 percent on average. The size of new single-family units is not affected. However, the results for all housing starts provide some evidence that development density might have decreased, attenuating the effect of faster development.

Key words: Property taxation, land taxation, land development, housing construction, count data

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Tiivistelmä: Tässä tutkimuksessa tutkitaan rakentamattoman rakennuspaikan ylimääräisen kiinteistöveron vaikutusta asuntorakentamiseen. Suomalaiset kunnat ovat vuodesta 2001 lähtien voineet verottaa asuntorakentamiseen kaavoitettua rakentamatonta tonttia korkeammalla veroasteella kuin rakennettua tonttia. Uudistuksen tavoitteena oli lisätä asuntorakentamista. Vuoteen 2007 mennessä noin 30 prosenttia kunnista oli ottanut käyttöön kolmiportaisen kiinteistöverojärjestelmän, jossa rakennettuun ja rakentamattomaan asuntotonttiin sekä itse rakennukseen kohdistuu eri veroasteet. Loput kunnat soveltavat kaksiportaista kiinteistövero-järjestelmää, jossa maapohjaa ja rakennusta verotetaan eri veroasteilla. Tutkimuksen teoriaosan mukaan korkeampi rakentamattoman tontin veroaste johtaa nopeampaan rakentamiseen mutta saattaa toisaalta vaikuttaa myös rakennustehokkuuteen. Empiirisessä osassa hyödynnetään kuntatason paneeliaineistoa vuosilta 1998–2006 ja estimoidaan rakentamattoman tontin verotuksen vaikutus rakentamiseen. Tulosten mukaan kolmiportaisen verojärjestelmän käyttöönotto lisäsi omakotirakentamista jopa 10 prosenttia. Uusien omakotitalojen kokoon komiportainen järjestelmä ei ole vaikuttanut. Kaikkea asuntorakentamista tutkittaessa saatiin viitteitä siitä, että rakennustehokkuus on saattanut pienentyä kolmiportaisen järjestelmän myötä.

Asiasanat: kiinteistövero, asuntorakentaminen

Contents

1. Introduction

In 2001, Finnish municipalities were allowed to tax undeveloped land zoned for housing at a higher property tax rate than developed land. The aim of the reform was to give municipalities a way to encourage housing construction by creating tax incentives to develop land zoned for housing. It was hoped that the reform would curb house price inflation by increasing housing supply. By 2007 30 per cent of Finnish municipalities had adopted the reform. These municipalities have a three-rate property tax system with different tax rates on imputed land value pre and post development and a separate tax rate on buildings. The remaining municipalities have a two-rate property tax system with a uniform residential land tax and a building tax. Both two-rate and three-rate property tax systems have been analyzed extensively in the theoretical literature on urban development and there are empirical studies using data from two-rate jurisdictions (see Plassman & Tideman, 2000). However, the three-rate system has neither been applied explicitly in practise elsewhere nor studied empirically.[1] This paper studies the effects of the Finnish type three-rate system on residential development both theoretically and empirically.

It is generally acknowledged in the theoretical literature on land owners' development decisions that, in a property tax system with different tax rates on developed and undeveloped land, a higher tax rate on undeveloped land should hasten development. However, as a side effect of faster development the density of development may also be affected. (Arnott & Lewis, 1979; Turnbull, 1988; McFarlane, 1999 and Capozza & Li, 1994.) The theoretical part of this paper is based on Turnbull's (1988) dynamic model of a land owner considering the timing and density of development on a parcel of land he owns. The model is modified to describe the Finnish type three-rate system. Turnbull derives the comparative static results under the assumption that undeveloped land receives preferential tax treatment. This assumption is reversed in this paper, and as a consequence some results change.

The comparative static results suggest that increasing the tax rate on undeveloped land while keeping other property taxes unchanged distorts land owners' decisions on the timing and density of development in the following way. First, the timing of development is distorted towards faster development regardless of market conditions by making holding undeveloped land costlier. Second, the optimal density decision, given the time of development, is unaffected. The change in the optimal development time may nonetheless affect the density of development if optimal density changes over time. If optimal density increases

[1] In most countries, land and buildings are taxed at the same rate but some jurisdictions, e.g. Denmark, Australia and Pittsburgh U.S.A., tax land at a higher rate than buildings. Some jurisdictions may implicitly tax land before and after development at different effective tax rates by applying different assessment methods for developed and undeveloped land.

over time, a higher tax rate on undeveloped land decreases the density of development by moving development to a time with a lower optimal density. If optimal density decreases with time, undeveloped land tax increases density by moving development to a time with a higher optimal density. As regards the effects of other components of the three-rate property tax system, tax on developed land and tax on buildings have either ambiguous effects or the effect depends on market conditions. Under a two-rate regime, land tax has the effect of hastening development if optimal density is increasing or decreasing over time but there is no effect if optimal density is stable. The effect of a building tax is qualitatively the same under two-rate and three-rate tax systems.

Turnbull's (1988) model is based on the model of Arnott and Lewis (1978), which considers the development timing and density decision of a land owner in a dynamic setting where development is irreversible and additions cannot be made later. Arnott and Lewis build on earlier work on the development timing decision by Shoulp (1970). More recent contributions include McFarlane (1999), who considers the effect of various taxes and fees on construction activity in the type of urban economy depicted by Capozza and Helsley (1989), and Arnott (2005) and Arnott & Petrova (2006), who discuss how neutrality is achieved in different tax systems. Capozza and Li (1994) describe the landowner's problem in a stochastic framework. Turnbull's (1988) framework was chosen from various alternatives as the basis for this study because it poses minimal assumptions on the process of transforming capital used for construction to urban rent from the developed parcel of land, and is thus a useful guide for empirical work and helpful in interpreting the empirical results. The lesson to be learned from the theoretical models of a land owner's development decision is that the effect of property taxes on construction is often ambiguous or the sign and magnitude of the effect depends on market conditions which cannot be measured accurately. The Finnish-type pre-development land tax is an exception in this respect since at least its qualitative effect is unambiguous a priori.

Plassmann et al. (2000) review empirical studies on the effects of property taxes on construction activity. Most empirical studies have failed to find significant effects. In their own analysis Plassmann et al. (2000) find that the difference between tax on land and tax on buildings has a positive effect on the number of building permits but no significant effect on value per permit.

Data for 378 Finnish municipalities observed in 1998/q1–2006/q3 are used in this study. Building permits are typically used as the dependent variable in empirical papers on property taxes and development. We use actual housing starts instead. Following Plassmann et al. (2000), count data analysis is chosen as the econometric framework. The effect of property taxes on housing starts is examined by estimating fixed-effects Poisson count data models of housing starts on tax variables and control variables. The fixed-effects Poisson model was proposed by Hausman et al. (1984) and later shown to be consistent with very mild assumptions by Wooldridge (1999). The tests in the study are based on robust standard errors that allow for overdispersion or underdispersion.

In the empirical part of the paper, single-family housing starts and all housing starts are studied separately. Three measures of housing starts are used: 1) number of buildings, 2) number of dwellings, and 3) volume of housing starts in cubic meters. The first two are measures of the number of new units and reflect development timing considerations by land owners. The volume of buildings started measures the amount of structural housing services produced and is aimed at capturing both the effects of timing and development density considerations. The effect of property taxation on the number and volume of housing starts is estimated first by means of a dummy variable indicating whether the municipality has a three-rate or two-rate tax system, and then by using a complete set of tax rates and their interactions with the tax system dummy. The results suggest that introducing the three-rate tax system resulted in increased construction activity. The effect of three-rate taxation on single-family housing starts seems to be higher than on all housing starts. Models with tax rates as explanatory variables are likely to suffer from measurement errors, since we are unable to measure the effective tax rate and use statutory tax rates instead. However, the estimated effect of the undeveloped land tax is positive in these models also.

Chapter 2 describes the Finnish property tax system. Chapter 3 presents a theoretical model of the effects of property taxes on the timing and density of housing construction. The model is based on Turnbull’s (1988) model which is modified to describe the Finnish property tax system. There is a discussion of the comparative static results of property taxes in the three-rate system and their implications for empirical work. Chapter 4 discusses the empirical model. Chapter 5 presents the data and the empirical results. Chapter 6 concludes.

2. The Finnish property tax system

In Finland, there has been a municipal property tax since 1993. The tax is payable by those who own the taxable property at the beginning of the calendar year. All zoned land and buildings are subject to property taxation. Agricultural land and forests are not taxed. The target taxable value of both developed and undeveloped zoned land is 73.5 percent of the annually evaluated local market price. The valuation method utilizes regional transaction data, which are used to estimate the market value of a square meter of land zoned for different purposes. However, the valuation regulations allow concessions when land prices are rising. Thus in practise taxable values may follow market values sluggishly. The taxable value of buildings is 70 per cent of their replacement cost, adjusted for depreciation. Property tax is deductible in income taxation, provided that the property has been used for rental or business purposes. All the property of the taxpayer was also subject to net wealth tax until 2006, when the wealth tax was abolished.

The current Finnish property tax system allows municipalities to apply different tax rates on different types of real property. Here only the taxation of residential land and buildings is discussed.[2] Municipalities decide annually, within limits set by the government, what rates will be used in their particular municipality for each type of real property. In 2007, the limits set for property tax rates are the following:

- general property tax 0.50 – 1.00 per cent (zoned land, commercial buildings, etc.)
- property tax on permanent dwellings 0.22 – 0.50 per cent
- property tax on undeveloped residential lots 1.00 – 3.00 per cent

Applying the undeveloped residential land tax is optional. If the municipality chooses not to apply it, undeveloped residential lots will be taxed at the general property tax rate. Before the reform of 2001, all land was taxed at the general property tax rate, but the reform gave municipalities the option to tax undeveloped land at a higher rate. Whether the pre- or post-development land tax is applied depends on the state of the site at the beginning of the year. The site is regarded as undeveloped until foundation work starts. The pre-development land tax can be applied only to lots that are zoned for residential purposes and have sufficient infrastructure.

[2] In addition, it is possible to apply separate rates to non-permanent dwellings, non-profit organizations and power stations.

Table 1 shows the proportion of municipalities with a three-rate property tax system in 2000–2007. Roughly 11 per cent of municipalities adopted the three-rate system right from the beginning in 2001, and the share of three-rate municipalities has been rising thereafter. In 2006, the share of municipalities with a three-rate system rose from 20 to 27 per cent, partly because the government forced 14 municipalities in the province of Uusimaa around the capital Helsinki to introduce the three-rate system with a pre-development land tax at least one percentage point higher than the post-development land tax. Two of these municipalities already had a three-rate system, and thus only 12 municipalities were affected. In 2007, almost 30 per cent of municipalities have a three-rate system. Only a few of the municipalities that introduced the three-rate system have switched back to the two-rate system. There were a total of nine transitions from a three-rate to a two-rate system in the period 2001 – 2007.

Table 1. The proportion of municipalities with three-rate property tax (N=398)*

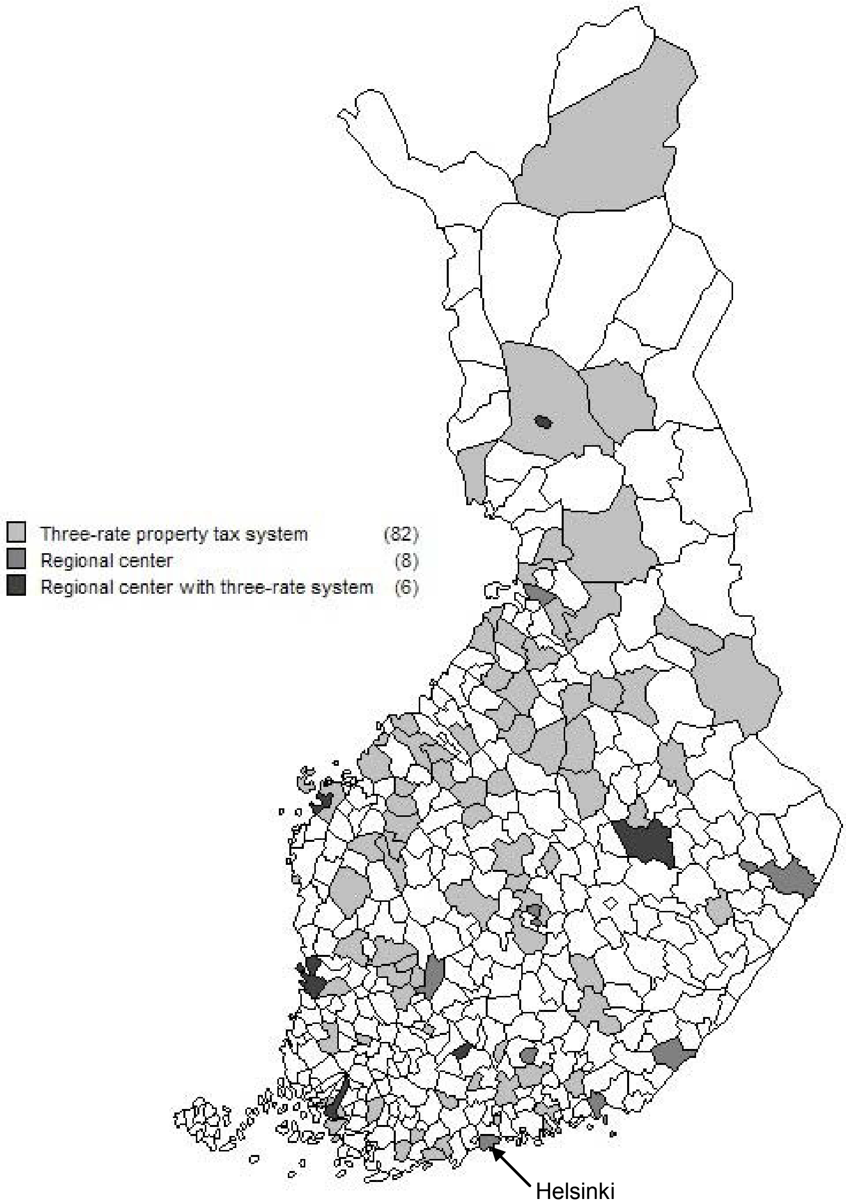
	2000	2001	2002	2003	2004	2005	2006	2007
Three-rate property tax system %	0	10.6	12.8	14.5	18.1	19.8	27.3	29.4
Two-rate property tax system %	100	89.4	87.2	85.5	81.9	80.2	72.7	70.6

* Province of Åland and municipalities that merged with another municipality in 2001–2007 excluded.

Along with the imposition of three-rate taxation, a concession was made which may limit the potential effect of three-rate taxation on construction activity in the 12 Helsinki area municipalities. Pre-development land tax is not applied to lots owned by a household occupying a house built on a neighbouring lot. Thus the three-rate tax does not apply, for instance, to so-called veterans' house (*rintamamiestalo*) lots. These single-family houses were built after WWII on large lots, which are typically not built up to the full efficiency permitted by the town plan. One of the channels through which three-rate taxation could increase single-family unit construction is the incentive to sell parts of these lots, provided that the lot has been split in the town plan. Moreover, three-rate taxation was imposed within a short time span. Typically, there is a one year transition period between the decision to switch to a three-rate system and the actual introduction of the system. As regards the 12 Helsinki region municipalities, the government proposal for the three-rate system in 2006 was only issued in October 2005. Thus one would expect the three-rate taxation to take effect later and to be weaker in the 12 Helsinki region municipalities than in the municipalities that chose three-rate taxation voluntarily. Because of these differences compared to voluntary introduction of the three-rate system, the 12 municipalities with an imposed three-rate tax are dropped from the data in the econometric part.

Chart 1 shows the geographical distribution of three-rate municipalities in 2005. A disproportionally large share of regional centers (large cities and towns) have a three-rate system. The three-rate system also seems to be common in municipalities surrounding regional centers, but there are also three-rate municipalities outside densely populated urban areas.

Chart 1. Geographical distribution of three-rate municipalities in 2005 (N=432)



Local income tax and certain shares of corporate tax revenues are the main sources of revenue for Finnish municipalities. Table 2 shows that property tax revenues are minuscule. In 2005, total municipality tax revenue was € 14.2 billion or € 2700 per person, while building tax revenue per person was only € 41 per person and general property tax revenue € 84 per person. Note that the general property tax is also applied to non-residential land and commercial buildings. Even though pre-development land tax rates are much higher than other property tax rates, the tax-base of the pre-development tax is so narrow that revenues are negligible compared to other property taxes. Pre-development tax revenues in three-rate municipalities amounted to less than € 2 per person in 2005. The empirical part shows that, even though revenues are low, the pre-development land tax has significant effects on housing construction.

Table 2. Property tax revenues

	2003	2004	2005
All municipality taxes (income tax, corporation tax and property taxes)			
Tax revenue (€ million)	13499	13674	14248
Tax revenue/person (€)	2586.2	2611.3	2711.0
Housing related property taxes			
Building tax			
Tax base (€ million)	73568	74141	77706
Average tax rate %	0.27	0.27	0.28
Tax revenue (€ million)	199	230	216
Tax revenue/person (€)	38.1	43.9	41.1
General property tax			
Tax base (€ million)	58056	59163	60525
Average tax rate %	0.70	0.72	0.73
Tax revenue (€ million)	407	429	442
Tax revenue/person (€)	78.0	81.9	84.1
Pre-development land tax			
Tax base (€ million)	64	73	76
Average tax rate %	2.09	2.37	2.29
Tax revenue (€ million)	1.34	1.73	1.74
Tax revenue/person (€)	1.54	1.73	1.56

3. Theoretical model

This section presents a theoretical model of the effects of property taxes on housing construction. Turnbull's (1988) model was chosen as the basis since his definition of the landowner's value function imposes minimal assumptions on the determination of urban rents stemming from capital used in construction. The model is modified to describe the Finnish property tax system by assuming that the pre-development land tax rate is higher than the post-development land tax rate. Turnbull analyzed the opposite case. As a result of this change to Turnbull's (1988) model, the effect of post-development tax on development time, given capital used in development, is no longer ambiguous. However, the qualitative comparative static results are only slightly affected. Discussion on the features of the model from the point of view of empirical work and illustrative graphical analysis of the comparative static results following Arnott & Petrova (2006) is also provided.

Turnbull's (1988) model discussed here is a dynamic model of an atomistic land owner who considers simultaneously the timing and density of development on a previously undeveloped parcel of land he owns. Once the land is developed, the buildings are immutable. The following notation is used:

K = the amount of capital used in construction

r = interest rate

$R(K,t)$ = market rent

$R^*(t)$ = land rent in non-housing use

τ_b = effective pre-development land tax rate

τ_a = effective post-development land tax rate

θ = effective building tax rate

The rent function translates the amount of capital used in construction to rent. The factors affecting the rent function include demand for housing, construction costs, production technology etc. It is assumed that marginal returns are diminishing ($R_K > 0$ and $R_{KK} < 0$). The comparative static results depend crucially on the time derivative of the marginal rent R_{Kt}, which is allowed to take negative or positive values.

Let us start with a model without taxes. The landowner's problem is to choose the time of development T and the amount of capital used K so as to maximize the value of the site. Following the conventional parlance of the literature, capital used in construction will be also referred to as development density. The landowner's objective function $V(K,T)$ is the present value of the plot of land given structural density K and development time T

(1) $$V(K,T) = \int_t^T R^*(s)e^{r(t-s)}ds + \int_T^\infty [R(K,s) - rK]e^{r(t-s)}ds\,.$$

The present value of the plot consists of the present value of agricultural (or other non-housing use) rent until the land is developed and the present value of rent on the building less the annualized opportunity cost of capital from the development time onwards. Differentiating w.r.t. K and T gives the following first-order necessary conditions (FOCs) for structural density and the timing of development.

The structural density condition

(2) $$\int_T^\infty R_K(K,t)e^{r(T-t)}dt = 1$$

states that the present value of an incremental increase in rent from greater structural density equals the additional development cost.

The timing condition

(3) $$rK + R^*(T) = R(K,T)$$

states that the landowner waits until the annualized construction cost plus the opportunity cost of developing the lot equals the annual rent from developing the lot.

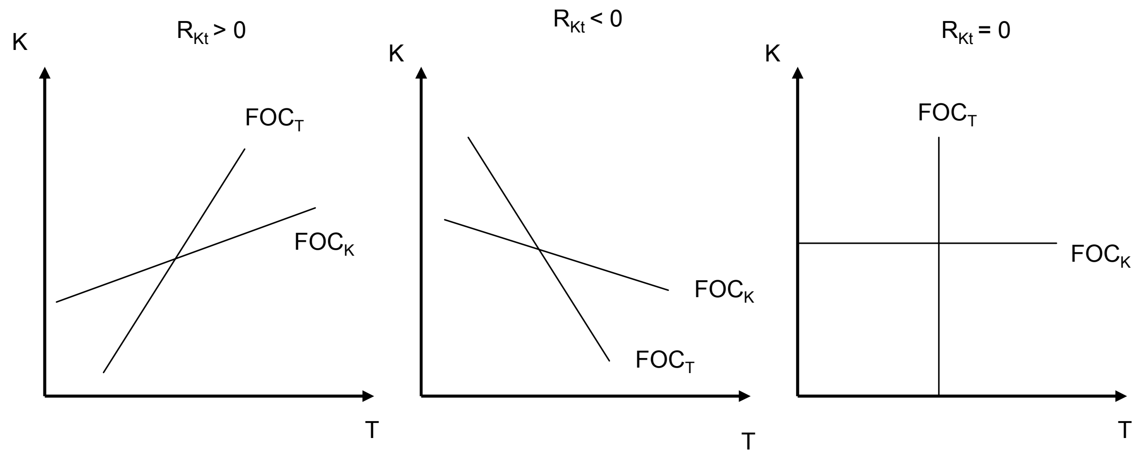
The first-order conditions define the optimal combinations of capital and development time for the lot. Figure 1 depicts the loci of combinations of capital and development time that satisfy the FOCs. The slopes of the lines depicting the FOCs are found by applying the implicit function theorem to the FOCs. The slopes are

$$\left(\frac{\partial K}{\partial T}\right)_{FOC_T} = -\frac{V_{TT}}{V_{TK}} \text{ and } \left(\frac{\partial K}{\partial T}\right)_{FOC_K} = -\frac{V_{KT}}{V_{KK}}.$$

From the second-order conditions for the interior solution, we get that $V_{TT} < 0$ and $V_{KK} < 0$. The sign of V_{TK} depends on the shape of the rent function $R(K,t)$. Both FOC_T and FOC_K are upward-sloping in the T-K space if $R_{Kt} > 0$, that is, if the additional rent for more capital-intensive land use is rising over time. If $R_{Kt} < 0$, the FOC lines are downward-sloping. From the second-order condition $(V_{TT}V_{KK} - V_{KT}^2) < 0$ it follows that the locus of FOC_T has to be steeper than that of FOC_K for there to be an interior solution. Accordingly, if $R_{Kt} = 0$, the FOC_T line is vertical and FOC_K is horizontal.

In the literature, agricultural rent $R^*(t)$ is often assumed to be zero or constant (e.g. Arnott & Petrova 2006, Capozza & Li 1994). In the absence of agricultural rents, the second-order condition $V_{TT} < 0$ implies that development takes place only if returns on housing investment are rising. Adding agricultural rent to the model makes development possible also with decreasing returns on housing investment. The second-order condition $V_{TT} < 0$ then requires that returns on housing investment are growing faster or declining slower than agricultural rent.

Figure 1. Optimal timing and density conditions



The intuition behind Figure 1 depicting the FOCs is as follows. If rents for more capital-intensive land use are rising, postponing development moves development to a time with higher optimal density (left panel in Fig. 1). Capital and development time are said to be complements in the land profit function. On the other hand, if rents are decreasing, postponing development moves construction to a time with lower optimal density (center panel in Fig. 1). In this case, capital and time are substitutes. Finally, if rents are stable, postponing construction does not affect optimal density and capital and time are unrelated (right panel in Fig. 1). Figure 1 will be used to illustrate the effect of property taxation on development timing and density in different market conditions.

Property taxes are now included in the model. The tax base of the property tax on land is land value $V(t)$. The pre-development effective land tax rate is denoted by τ_b and the post-development effective land tax rate is τ_a. In order to make the model representative of the Finnish system, Turnbull's (1988) assumption that $\tau_b < \tau_a$ is replaced with $\tau_b > \tau_a$. The tax base of the property tax on buildings is construction cost K and the effective tax rate is denoted by θ. Depreciation is neglected here. Arguments K and T are dropped for the time being and the argument of V denotes time. The present value of profits from a parcel of land developed under strategy (K,T) at time $t < T$ is written as

$$(4) \qquad V(t) = \int_t^T R^*(s)e^{r(t-s)}ds + \int_T^\infty [R(K,s) - rK]e^{r(t-s)}ds - \int_T^\infty \theta K e^{r(t-s)}ds$$

$$- \int_t^T \tau_b V(s)e^{r(t-s)}ds - \int_T^\infty \tau_a V(s)e^{r(t-s)}ds\,.$$

The first term on the RHS is the present value of land rents before development and the second term is the present value of urban rent less the opportunity cost of capital. The last three terms represent the present values of property tax liabilities. The model is solved recursively for $V(t)$ following Turnbull's (1988) outlines for the two-rate tax system case $(\tau_b = \tau_a = \tau)$.[3] The objective function becomes

$$(5) \quad V(K,T) = \int_t^T R^*(s)e^{(r+\tau_b)(t-s)}ds + e^{(r+\tau_b)(t-T)}\int_T^\infty [R(K,s) - (r+\theta)K]e^{(r+\tau_a)(T-s)}ds\,.$$

The first term is the present value of rents before development and the second term is the present value of rents after development. It is seen that the pre-development tax reduces the present value of the lot by increasing the discount rate prior to development and the post-development tax reduces the value of land by increasing the post-development discount rate. Tax on buildings decreases land value by increasing the user cost of capital. The first-order conditions are as follows.

The structural density condition is given as

$$(6) \qquad \int_T^\infty R_K(K,t)e^{(r+\tau_a)(T-t)}dt = \int_T^\infty (r+\theta)e^{(r+\tau_a)(T-t)}dt\,.$$

The density condition states that the present value of an incremental increase in rent from higher capital intensity equals the discounted additional development cost. The density condition is unaffected by pre-development tax, and the tax on buildings increases the marginal costs of development. Thus, for further use when deriving the comparative static results of taxes we have $V_{K\tau_b} = 0$ and $V_{K\theta} > 0$. The post-development land tax affects both sides negatively through the discount rate. Which effect dominates depends on the form of the rent function R. If the marginal rent for increased density grows over

[3] First, write the value of land from development time T onwards, differentiate in respect of t and solve the resulting differential equation for $V(T)$. Then, plug $V(T)$ into (4), differentiate in respect of t and solve the differential equation for $V(t)$ to get (5).

time $(R_{Kt} > 0)$, the post-development land tax will have a greater effect on marginal revenues than on costs, and vice versa if the rent stream is front-loaded $(R_{Kt} < 0)$. If the rent stream is flat $(R_{Kt} = 0)$, the optimal density, given development time, is unaffected by the post-development land tax. Thus, the partial derivative in respect of post-development tax depends on whether time and density are complements or substitutes in the profit function in the following way

$V_{K\tau_a} > 0$, if $R_{Kt} < 0$;

$V_{K\tau_a} < 0$, if $R_{Kt} > 0$ and

$V_{K\tau_a} = 0$, if $R_{Kt} = 0$.

Applying Leibnitz's rule to (5) we get the following timing condition

$$(7) \qquad (r+\theta)K + R^*(T) = R(K,T) + (\tau_b - \tau_a)\int_T^\infty [R(K,t) - (r+\theta)K]e^{(r+\tau_a)(T-t)}dt .$$

The condition states that the landowner waits until the annualized construction cost plus the opportunity cost of developing the lot equals the rent at development time plus savings due to the lower land tax rate post development. The building tax rate increases the benefits of waiting but also decreases the costs of waiting by increasing the cost of capital. The pre-development land tax imposes an extra cost for waiting, which does not exist under a uniform land tax. The post-development land tax decreases the cost of waiting by narrowing the land tax differential and decreasing the tax base through the discount rate. For further use we have $V_{T\tau_b} < 0$, $V_{T\tau_a} > 0$ and $V_{T\theta} > 0$.

Note that in accordance with the Finnish three-rate system, it is assumed that $\tau_b > \tau_a$. With $\tau_b < \tau_a$, as in Turnbull (1988), the sign of $V_{T\tau_a}$ is ambiguous since τ_a has two counteracting effects on the last term in (7), which now changes from a cost of waiting to a benefit of waiting. On the one hand a higher τ_a increases the benefits of waiting by widening the tax rate difference, but on the other hand the value of the tax rate difference is decreased since the discount rate increases with τ_a. Moreover, the timing distortion of the building tax can be shown to be greater with $\tau_b > \tau_a$ than with $\tau_b < \tau_a$.

Figures 2a, 2b and 2c show the effects of the three taxes on development timing and density under different market conditions. The panel on the left depicts the situation with increasing optimal density, the centre panel with decreasing optimal density and the right panel with stable optimal density. Table 3 summarizes the comparative static results in respect of the three tax rates.

Again applying the implicit function theorem, we see how changes in tax rates move the FOC lines depicted in Figures 2a – 2c. For the pre-development land tax, we obtain

$$\left(\frac{\partial T}{\partial \tau_b}\right)_{FOC_T} = -\frac{V_{T\tau_b}}{V_{TT}} < 0\,, \left(\frac{\partial K}{\partial \tau_b}\right)_{FOC_K} = 0\,.$$

An increase in the pre-development tax shifts the FOC_T line to the left and FOC_K is unaffected. In Figure 2a, it is seen that a higher pre-development tax leads to faster development regardless of market conditions. If optimal density is increasing (decreasing) over time, a higher pre-development tax leads to lower (higher) density by moving construction to a time with lower (higher) optimal density.

Figure 2a. Optimal timing and density conditions when pre-development tax increases

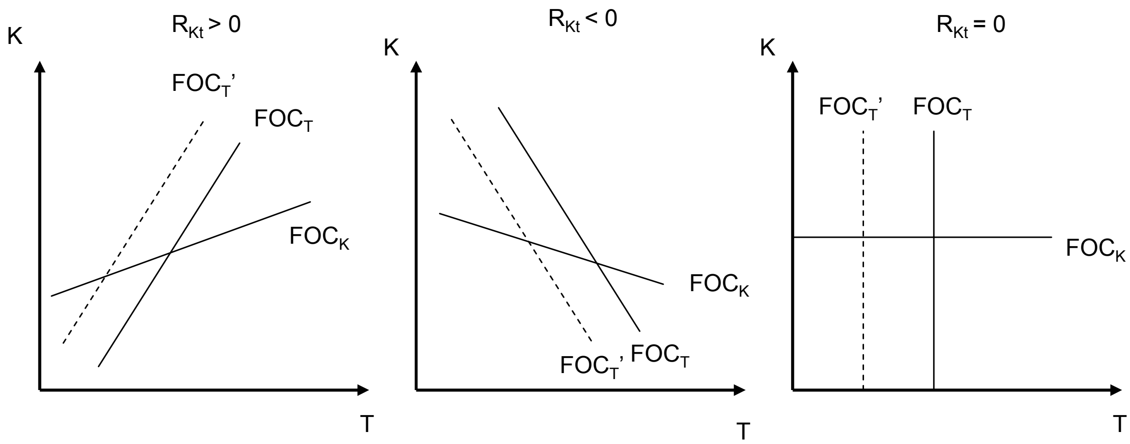


Figure 2b shows the comparative static effects of the post-development land tax. A higher post-development land tax leads to a later optimal development time by reducing the cost of holding vacant land. Thus, the timing condition line moves to the right, $\left(\frac{\partial T}{\partial \tau_a}\right)_{FOC_T} = -\frac{V_{T\tau_a}}{V_{TT}} > 0$. The density condition line moves up or down or remains unchanged depending on R_{Kt} in the following way

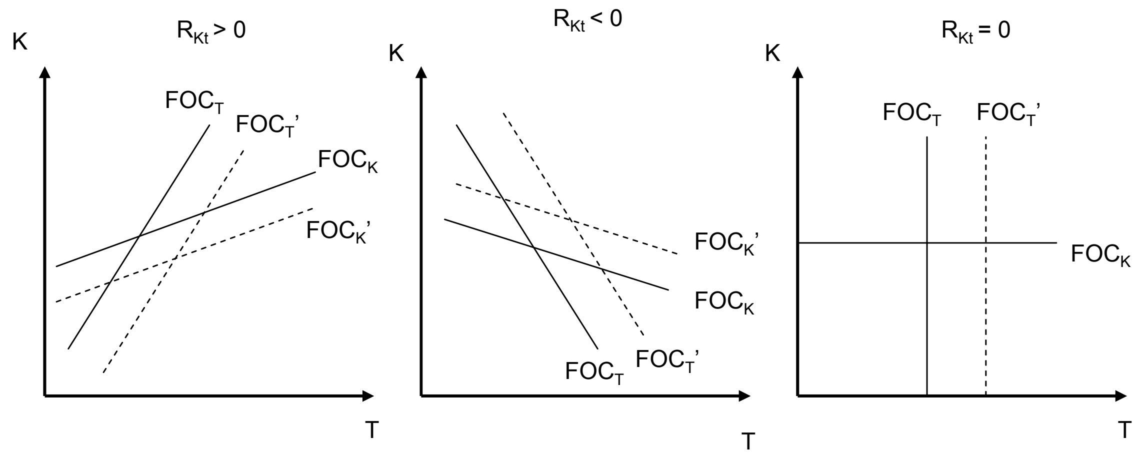
$$\left(\frac{\partial K}{\partial \tau_a}\right)_{FOC_K} < 0 \text{ , if } R_{Kt} > 0;$$

$$\left(\frac{\partial K}{\partial \tau_a}\right)_{FOC_K} > 0 \text{ , if } R_{Kt} < 0 \text{ and}$$

$$\left(\frac{\partial K}{\partial \tau_a}\right)_{FOC_K} = 0 \text{ , if } R_{Kt} = 0 .$$

In Figure 2b, it is seen that if capital and development time are complements or substitutes, the effect of post-development land tax is ambiguous. If density and timing are unrelated, post-development tax is neutral in respect of density but leads to later development.

Figure 2b. *Optimal timing and density conditions when post-development tax increases*



Note that in the econometric part of this paper, housing starts are regressed on the difference between pre-and post-development land taxes $(\tau_b - \tau_a)$ and on the pure post-development land tax rate and the building tax rate. Thus the estimate of the effect of τ_a in the three-rate system pertains to the situation where $(\tau_b - \tau_a)$ is fixed. Theoretically, the effect of post-development land tax on FOC_T holding $(\tau_b - \tau_a)$ constant is weaker than when $(\tau_b - \tau_a)$ is allowed to change since in the former case τ_a works only through the discount rate in (7).

Figure 2c shows the effects of the tax on buildings on the development decision. A higher building tax rate delays development (given density) and discourages density (given development time). We have

$$\left(\frac{\partial T}{\partial \theta}\right)_{FOC_T} = -\frac{V_{T\theta}}{V_{TT}} > 0 \text{ and}$$

$$\left(\frac{\partial K}{\partial \theta}\right)_{FOC_K} = -\frac{V_{K\theta}}{V_{KK}} < 0 .$$

Thus, the timing condition line shifts to the right and the density condition line shifts down. It is seen that the combined effect is delayed development and lower density if the returns on housing investment are stable or decreasing over time (center and right panels in Fig. 2c). The effect of the building tax is ambiguous if returns are increasing over time (left panel in Fig. 2c). In the latter case, however, it is not possible for density to increase and development to be faster. Table 3 summarizes the comparative static results of property taxes under the three-rate tax system.

Figure 2c. Optimal timing and density conditions when building tax increases

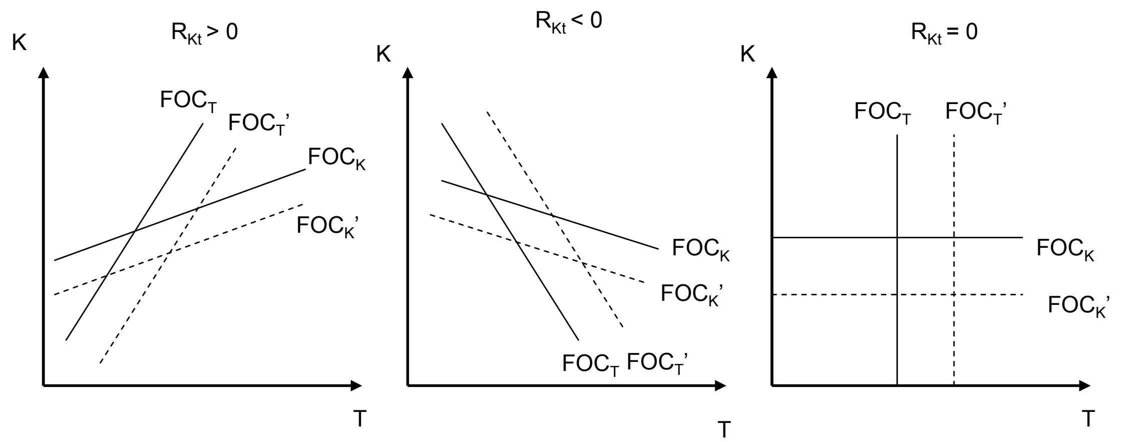


Table 3. Effects of increases in tax rates on development timing and density in three-rate system

	Assumption on R_{Kt}	**Effect on T**	**Effect on K**
Pre-development land tax	$R_{Kt} > 0$	-	-
	$R_{Kt} = 0$	-	0
	$R_{Kt} < 0$	-	+
Post-development land tax (general property tax)	$R_{Kt} > 0$, $R_{Kt} < 0$	?	?
	$R_{Kt} = 0$[a]	+	0
Improvements tax	$R_{Kt} > 0$	?	?
	$R_{Kt} = 0$, $R_{Kt} < 0$	+	-

[a] Turnbull (1988) and Anderson (2005) assume that post-development land tax is higher than pre-development land tax and find that the effect of post-development land tax is ambiguous also with $R_{Kt} = 0$.

The table above gives the expected effects of the different taxes in three-rate municipalities. The data used in this study comprises municipalities with two-rate or three-rate tax systems. Some of the municipalities switch from a two-rate to a three-rate system by introducing a pre-development land tax. In three-rate municipalities land after development is taxed at the general property tax rate and the pre-development tax is higher than the general rate. In two-rate municipalities the pre-development and post-development land tax rates are the same (the general property tax rate). When setting up the empirical model, it is important to note that the effect of the general property tax rate is likely to be different in two-rate municipalities than in three-rate municipalities.

The two-rate system is discussed only briefly here since the results do not differ from Turnbull (1988) and Anderson (1999). From the first-order conditions (6) and (7) it is seen that the effect of building tax on development timing and density under a two-rate regime is qualitatively the same as under a three-rate regime (See Figure 2c.) but the quantitative effects may be different. The timing distortion towards slower development is stronger under the Finnish three-rate system since the building tax negatively affects the value of the tax rate difference in (7), which is zero in a two-rate system.

Figure 3 illustrates the effect of land tax (general property tax) in two-rate municipalities. From the timing condition (7) it is seen that if the pre- and post-development taxes are equal, land taxes vanish from the timing condition. Land tax affects timing only through its effect on the density condition. From the density condition (6) it is seen that a uniform land tax ($\tau_a = \tau_b = \tau$) increases the discount rates of both the marginal benefits and marginal costs of using more capital. Intuitively, if the rent stream from an additional unit of capital is increasing ($R_{Kt} > 0$), an increase in the discount rate has a greater downward effect on the present value of the marginal benefit stream than on the present value of the flat marginal cost stream. Thus, higher land tax leads to lower optimal density, given development time, if $R_{Kt} > 0$. Because time and density are complements in the land value function, lower density leads to faster development. Figure 3 (left panel) illustrates the situation. Respectively, if the marginal benefit stream is front-loaded ($R_{Kt} < 0$), land tax increases density, given timing, and hastens development. If the rent stream is flat ($R_{Kt} = 0$), land tax is neutral because it cannot change the relative present values of different projects.

Figure 3. *Optimal timing and density conditions when land tax increases (two-rate tax system)*

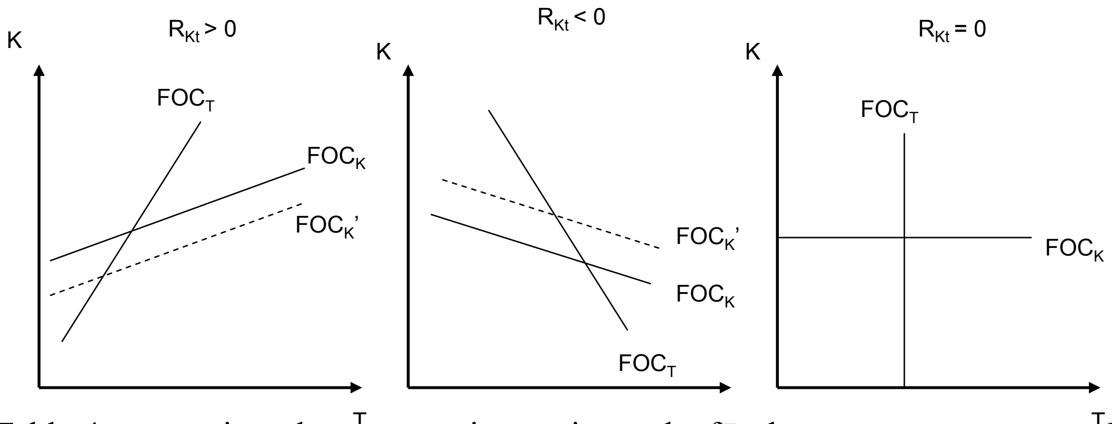


Table 4 summarizes the comparative static results for the two-rate tax system. It is important to note that the general property tax has different effects under two-rate and three-rate property tax systems. The effect of building tax is qualitatively the same under two-rate and three-rate regimes, but the magnitude of the effect may be different. In the empirical model, the general property tax rate and the building tax rate are interacted with a three-rate system dummy in order to allow for the differential effects in the two types of municipalities.

Table 4. *Effects of increases in tax rates on development timing and density in the two-rate system*

	Assumption on R_{Kt}	**Effect on T**	**Effect on K**
Land tax	$R_{Kt} > 0$	-	-
(general property tax)	$R_{Kt} = 0$	0	0
	$R_{Kt} < 0$	-	+
Improvements tax	$R_{Kt} > 0$	?	?
	$R_{Kt} = 0$, $R_{Kt} < 0$	+	-

Land use regulations

The effect of land use regulations, such as zoning, is relatively straightforward to include in the model (see Turnbull, 1991, 2002, 2005.). A binding upper limit to development density makes the density condition irrelevant and property taxes affect only timing. Binding density restrictions speed (slow) development when returns on housing investment are rising (falling) over time (Turnbull 1991 and 2002). The effects of property taxes with binding upper limits to K can be easily seen by drawing a horizontal line below the optimal K in Figures 2a – 3. Development takes place at the time when the timing condition line crosses the development density limit. The effect of property taxes on development time is determined solely by their effects on the timing condition. In the three-rate system with a binding upper limit to density, the pre-development land tax hastens development and the post-development tax and building tax delay development. In the two-rate system with binding density restrictions, land tax is neutral and building tax delays development. In Finland, all residential lots are assigned a maximum allowed number of square meters. It is not clear whether the model with or without binding density restrictions is empirically more relevant.

Implications for empirical work

An important observation from the theoretical model is that the effects of property taxes on starting time and density depend crucially on the form of the rent function *R*. Therefore, from the point of view of empirical work, it is important to take a closer look at the rent function.

Let us consider a case where the rent function is the product of the rental rate (p) for a unit of buildings on the site and the building production function Q, which has the properties $Q_K > 0$ and $Q_{KK} < 0$. The production function gives the amount of building produced by using K euros of capital. First assume that the building production function does not change over time. For instance, Arnott and Petrova (2006) write the urban rent function as $R(K,t) = p(t)Q(K)$. It is seen that R_{Kt} can be negative only if the rental rate is decreasing.

Now also let the building production function change over time. The rent function becomes $R(K,t) = p(t)Q(K,t)$ and $R_{Kt}(K,t) = p'(t)Q_K(K,t) + p(t)Q_{Kt}(K,t)$. Thus, the incremental rent for an additional euro of capital used to build housing may decrease even when the rental rate is increasing. Changes in prices of construction inputs, for example, cause Q to change over time. Thus, rising housing prices or rents do not necessarily indicate rising returns on new housing investment.

The theoretical model presented in this section is deterministic and assumes that the developer knows future rents with certainty. In practice, there is uncertainty about the factors affecting returns on housing investment and developers base their decisions on expectations. In the empirical part of the paper, a set of quarterly time indicators is included in the model to catch the variation in current and expected construction costs, interest rates and other country-wide factors possibly affecting construction. The regional housing price index and the ratio of housing stock to population are included in the explanatory variables in order to capture current and expected rents.

Because of the difficulty in measuring the expected change in the rent function, the empirical model cannot test all the predictions of the theoretical model.

However, the qualitative effect of pre-development land tax does not depend on market conditions. Thus adequately controlling for other factors driving construction should give us a rough estimate of the average effect of pre-development land tax on housing starts in the period of the study. The results may not be universal since the magnitude of the effect of pre-development tax depends (non-monotonously) on R_{Kt} which cannot be measured. The effect of other taxes on housing starts cannot be estimated reliably since the sign of the effect depends on R_{Kt}. In fact, one may argue, based on the theoretical model, that property taxes do not have universal average partial effects, distinct from market conditions, on construction activity that could be estimated empirically. This complexity of the effects of property taxes on construction activity has not been adequately recognized in the existing empirical literature.

The model presented in this chapter is a partial equilibrium model. It gives the effect of property taxes on housing starts in a case where tax is levied only on one parcel of land and on buildings erected on that parcel. The ideal data would be site-level panel data as in Zax and Skidmore (1994). Alas, site-level data is not available, and thus we have to content ourselves with municipality-level data. Nevertheless, we think that the model provides a useful basis for setting up an empirical model utilizing municipality-level data for housing starts, tax variables and covariates, and for interpreting the results.

4. Empirical model

The appropriate modeling framework for municipality-level housing starts data is count data analysis because housing starts are intrinsically discrete and because there is a significant number of zero observations (roughly 20 per cent in this study). A linear model would be problematic since it would give negative predicted values for housing starts (*STARTS*) at some values of regressors. Furthermore, the typical natural log transformation log(*STARTS*) cannot be used since it is not defined for zero observations. Additional transformations, such as log(*STARTS*+1), would be needed. With count data, it is better to model the conditional expectation of *STARTS* directly and to choose functional forms that ensure that *STARTS* is positive for any values of regressors and parameters. Plassmann et al. (2000) also apply count data methods in their study of two-rate property taxes and building permits.

We estimate the fixed-effects Poisson (FEP) model originally proposed by Hausman et al. (1984), who show that if individual observations follow Poisson distribution with a mean (and variance) of $c_i m(X_{it}, \beta)$, then conditioning on the sum of counts across time yields a multinomial distribution for the vector of counts. This distribution does not depend on the individual heterogeneity c_i. Therefore the β parameters can be estimated by standard conditional MLE. The Poisson assumption that variance equals mean is very restrictive and seldom holds with actual data. However, Wooldridge (1999) shows that the fixed-effects Poisson estimator is consistent under much weaker assumptions. In fact, the conditional mean assumption

$$(8) \qquad E(STARTS_{it} \mid X_{i1},\ldots,X_{iT},c_i) = c_i m(X_{it},\beta)$$

is sufficient for consistent estimation of the β parameters. There can be overdispersion or underdispersion and there are no restrictions on the dependence between $STARTS_{it}$ and $STARTS_{ir}$, $t \neq r$. Parameter c_i is a multiplicative fixed effect which captures the average of *STARTS* over the time range and can be correlated with the explanatory variables *X*. Function *m* is the mean function and is given the exponential form $m(X_{it},\beta) = \exp(\beta' X_{it})$. The exponential function is convenient since the parameter estimates then give the semi elasticity of the dependent variable in respect of the independent variables (or elasticity if the explanatory variable is in logs). It is also intuitive to assume that the impact of the explanatory variables is proportional to *STARTS*.

A further advantage of the FEP model for the purposes of this study is that the dependent variable does not have to be a count. Any non-negative variable can be used (Wooldridge, 1999). Thus the FEP model can be used for both the number of starts and the volume in cubic meters of buildings started. The number of starts reflects land owners' choice of development timing and the volume in cubic meters of buildings started is thought to reflect both the timing and development density considerations of land owners. An alternative to direct modeling of volume would be to estimate separate models for the number of starts and volume per start. Modeling volume directly is preferable since volume per start is not defined for zero observations.[4]

The log-likelihood of *STARTS* for municipality *i* at time *t* conditional on the sum of *STARTS* over *t* in the same municipality is

$$\ell_i(\beta) = \sum_{t=1}^{T} STARTS_{it} \log\left[\frac{\exp(\beta X_{it})}{\sum_{t=1}^{T}\exp(\beta X_{it})}\right]. \tag{9}$$

The usual maximum likelihood standard errors are valid if housing starts conditional on explanatory variables and unobserved heterogeneity follow Poisson distribution and there is no dependence between $STARTS_{it}$ and $STARTS_{ir}$, $t \neq r$. Exploring the data suggests that there is overdispersion and housing starts are very likely to be autocorrelated since developing a site today means that it cannot be developed in the future. Thus the usual MLE standard errors are not valid and we use the robust variance covariance matrix estimator proposed by Wooldridge (1999) to obtain robust standard errors (see also Wooldridge, 2002). Earlier applications of the fixed-effects Poisson model that report robust standard errors include Lee et al (2001) and Page (1995). Plassmann et al. (2000) also report fixed-effects Poisson estimates with robust standard errors.

Since municipalities get to choose the property tax system and tax rates, the results may suffer from endogeneity. The choice of property tax system may be related with other policies affecting housing starts such as zoning and land use regulations. The fixed effects c_i control for time-constant unobserved heterogeneity but not for changes in land use policy. Endogeneity issues are discussed and a model testing for endogeneity of land use policy is estimated in the next chapter after presenting the main results.

The FEP model is not the most efficient model if the Poisson assumption does not hold. However, more efficient estimation calls for more restrictive assumptions. The problem of overdispersion is typically addressed by assuming that the Poisson parameter follows gamma distribution. This assumption gives rise to the negative binomial model. Plassmann et al. (2000) find the gamma

[4] Plassmann et al. (2000) estimate a count data model for the number of building permits and a standard linear fixed-effects model for the log of the value per permit, and calculate the effect of two-rate tax on the total value of permits as the sum of the two estimates. They do not specify how zero observations with an undefined value per permit are treated, but the reported sample sizes indicate that undefined observations are included in the estimations using some transformation.

assumption unappealing and assume a lognormally distributed Poisson parameter, which calls for some alternative to the ML estimation method since there is no closed form solution of the joint distribution of observations. In this study, the FEP model was chosen because it does not require any distributional assumptions and because it permits direct modeling of the volume of buildings started. The large size of our data set permits sacrificing some of the asymptotic efficiency for robustness.

A fixed-effects negative binomial model with variance to the mean ratio $1+\alpha\exp(X_{it},\beta)$ was also estimated in order to test the Poisson assumption that variance equals mean. The conditional negative binomial model yields the same estimator as the fixed-effects Poisson model, and does not give estimates of the overdispersion parameter that cancel out in the conditioning (see Allison et al. 2002). Thus the unconditional estimator with dummy variables for each municipality was estimated. The estimated overdispersion parameter α varied around 0.2, indicating overdispersion, and thus the Poisson assumption was dropped and the inference is based on robust standard errors. The negative binomial model was abandoned since it restricts the functional form of overdispersion and does not allow for underdispersion. Diagnostic analysis indicated that starts data for some municipalities exhibit underdispersion. Furthermore, the unconditional negative binomial model may suffer from incidental parameters bias (Allison et al., 2002).[5] Cameron and Trivedi (1999) provide a more detailed discussion on panel data count models.

[5] Allison et al. (2002) provide evidence based on a Monte Carlo experiment that the bias is likely to be small.

5. Data and empirical analysis

Data

We use municipality-level panel data from 1998/q1 – 2006/q3 in our empirical analysis. After dropping a few municipalities with missing data and municipalities that merged with another municipality in the time period studied we end up with a balanced panel of 391 municipalities observed in 35 quarters, which further reduces to 379 municipalities in fixed-effects Poisson estimations as the 12 Helsinki region municipalities with an imposed three-rate system were dropped. The number of municipalities with a three-rate system in at least one year in the period 2001–2007 is 118. Total number of municipalities in 2007 was 416. Data on housing starts (monthly), population (yearly), dwelling stock (yearly) and housing prices (quarterly) were collected from the ALTIKA data base provided by Statistics Finland. These data were augmented with property tax rates provided by the Association of Finnish Local and Regional Authorities (*Kuntaliitto*). Housing price indices are at the municipality level for 33 cities and towns for which such indices are available. For the remaining municipalities, province-level housing price indices are used. Housing starts were originally monthly, but they were aggregated to quarterly level to reduce the number of zero observations.

Compared to the data used in Plassmann et al. (2000), the quality of the Finnish data used in this study is high. Instead of building permits, we have data on actual housing starts which measure construction activity more accurately than permits since obtaining a permit does not necessarily mean that construction is started. The sample size contributing to the estimates of interest is much larger in this study. We have 4130 or 13265 observations (118–379 municipalities and 35 quarters) contributing to the estimates of the effects of taxes on construction, depending on whether two-rate municipalities are included. In Plassmann et al. (2000) the number of observations contributing to their estimate of interest is only 330 or less since there are only 15 two-rate municipalities and the data is annual for 22 years. Unlike this study, they do not have information on tax rates but only on the difference between land tax and building tax, the use of which is not supported by the theoretical model in Chapter 3. Furthermore, a fixed-effects approach is more justified in this study since the time span of the data in this study is only eight years, compared with 22 years in Plassmann et al. They are also forced to restrict their analysis to cities with shrinking populations because, in their sample, all the municipalities that adopted two-rate tax were “under economic distress” and were experiencing a population decrease. This restricts the generality of their results. Under a two-rate tax system the effect of land tax on construction activity depends on market conditions and may be close to zero if returns on new housing investment are relatively stable over time.

Descriptive analysis

Tables A1 and A2 in the appendix report summary statistics of all the variables used in the econometric estimations separately for municipalities that had adopted the three-rate system by 2007 and for all municipalities. Three-rate and two-rate municipalities do not seem to be very different in terms of average property tax rates, housing prices or dwelling stock per capita. The correlation matrices of the variables used in the regressions are reported in Table A3 of the appendix. There do not seem to be severe multicollinearity problems.

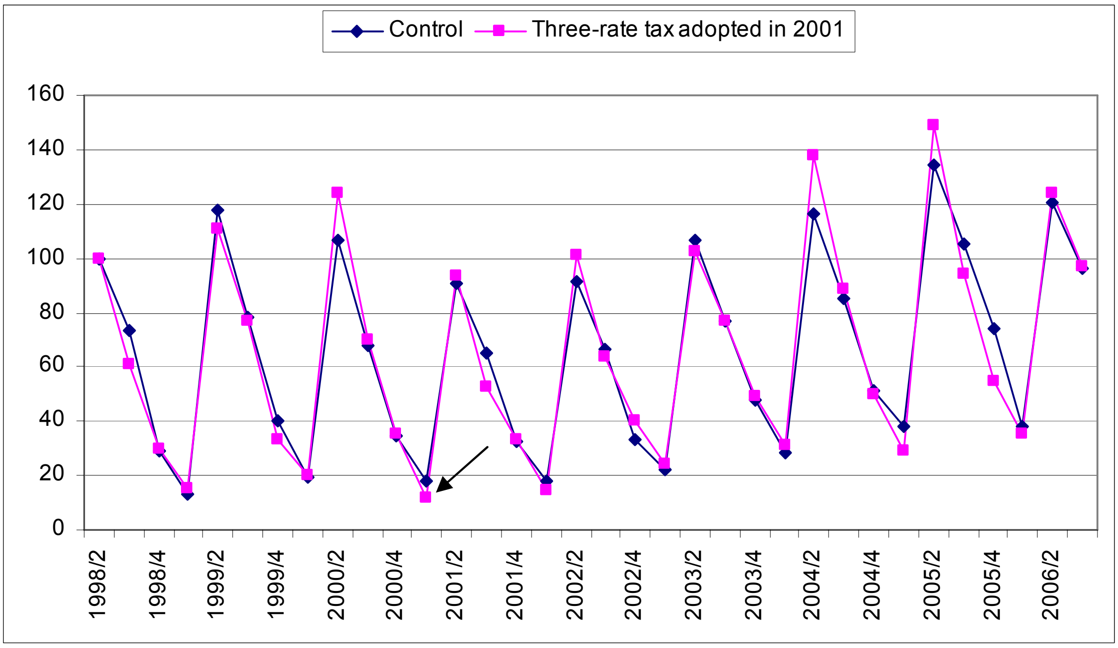
Next, time series of housing starts are examined in order to get a preliminary view of the impact of three-rate taxation on housing starts. The time pattern of the impact is also of interest. The focus is now on single-family housing starts since the impact of three-rate taxation and its time pattern are more pronounced for single-family starts than for all housing starts, which include more projects not affected by the pre-development tax. Graphs 1a – 1g compare quarterly time series for single-family housing starts (number of dwellings) in municipalities that stayed in the two-rate system (labeled *control* in the graphs) with municipalities that adopted the three-rate property tax system in different years during the period 2001 – 2007. Graph 1a represents new three-rate municipalities in 2001, Graph 1b new three-rate municipalities in 2002, and so forth. The small arrows mark the quarter in which the three-rate system came into effect.

In Graph 1a, there seems to be an upward jump in starts in 2000, one year before the three-rate system came into effect in 2001. The years following the switch to a three-rate system also suggest that housing starts increase somewhat. Graph 1b, in contrast, does not show a jump in starts in the year preceding the tax system switch in 2002. In the year of introduction housing starts increase and roughly follow the changes in starts in two-rate municipalities thereafter.

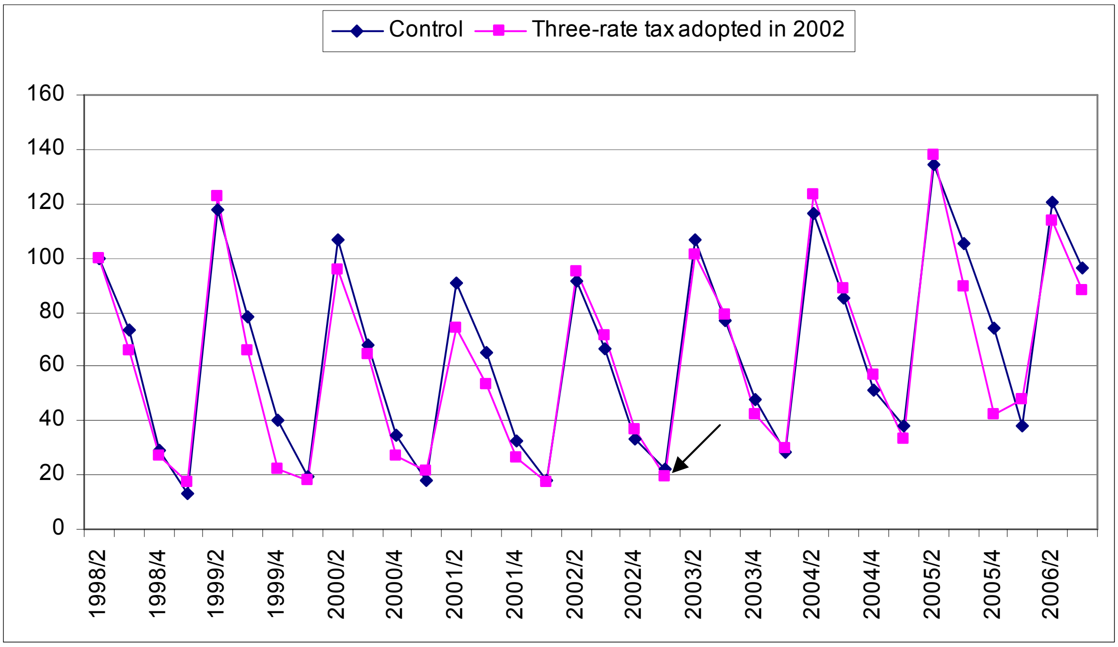
From Graph 1c and 1d it seems that introducing a three-rate system leads to a remarkable increase in construction activity. There is an upward shift in housing starts already in the year preceding the introduction of the system since there is typically a transition period of one year between the decision to adopt the three-rate system and its actual introduction. Also in Graph 1e, there seems to be a strong year-before effect in 2004 and starts also remain at a higher level (compared to 2003 and 2002) thereafter.

Graph 1f shows the time series for housing starts in the new three-rate municipalities of 2006 with and without the 12 imposed three-rate municipalities in the Helsinki region. Three-rate taxation seems to have the desired effect when the 12 municipalities are excluded but not when they are included. One possible explanation is that the imposition of three-rate taxation was only decided on in the fall of 2005, leaving developers very little time to react. The effect of three-rate taxation may also be weaker in the Helsinki area because concessions were made for some lots (see Chapter 2). Furthermore, the graph may reflect the scarcity of vacant land zoned for single-family housing in the booming Helsinki area. The 12 imposed three-rate municipalities are not included in the econometric analysis. Graph 1b also diverges from the general pattern in that there is a mild drop in housing starts in the year prior to the tax system change but there are no grounds to suspect the divergence is non-random. It is not clear from Graph 1g whether the forthcoming switch to a three-rate system in 2007 affected starts in 2006.

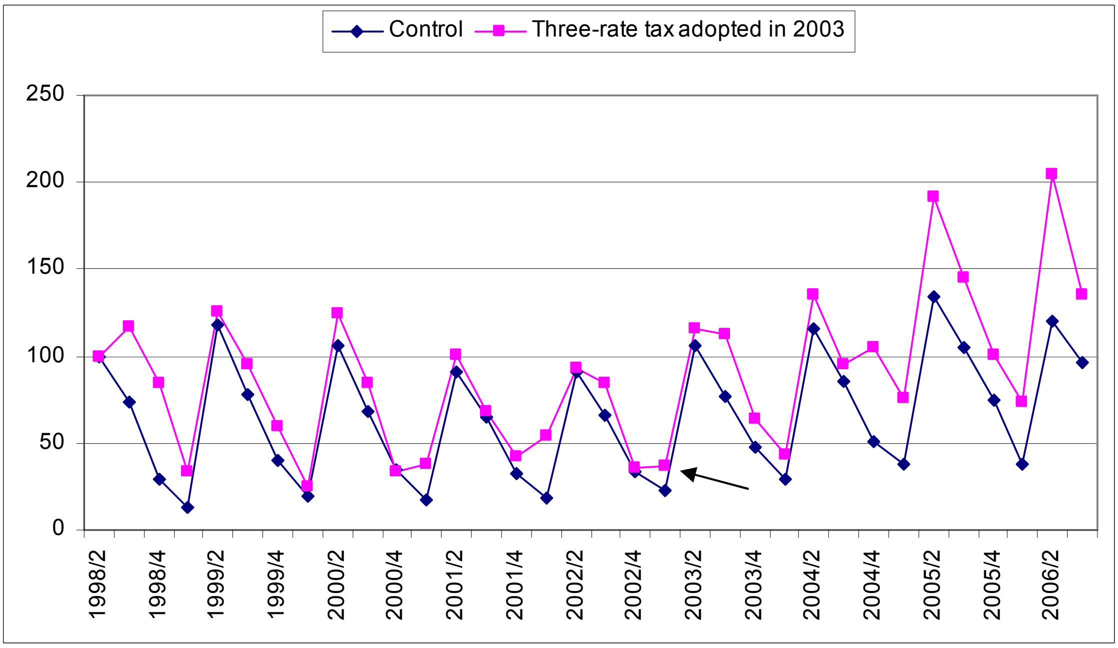
Graph 1a. Single-family housing starts in three-rate (system introduced in 2001) and two-rate municipalities (Index, 1998/2=100)



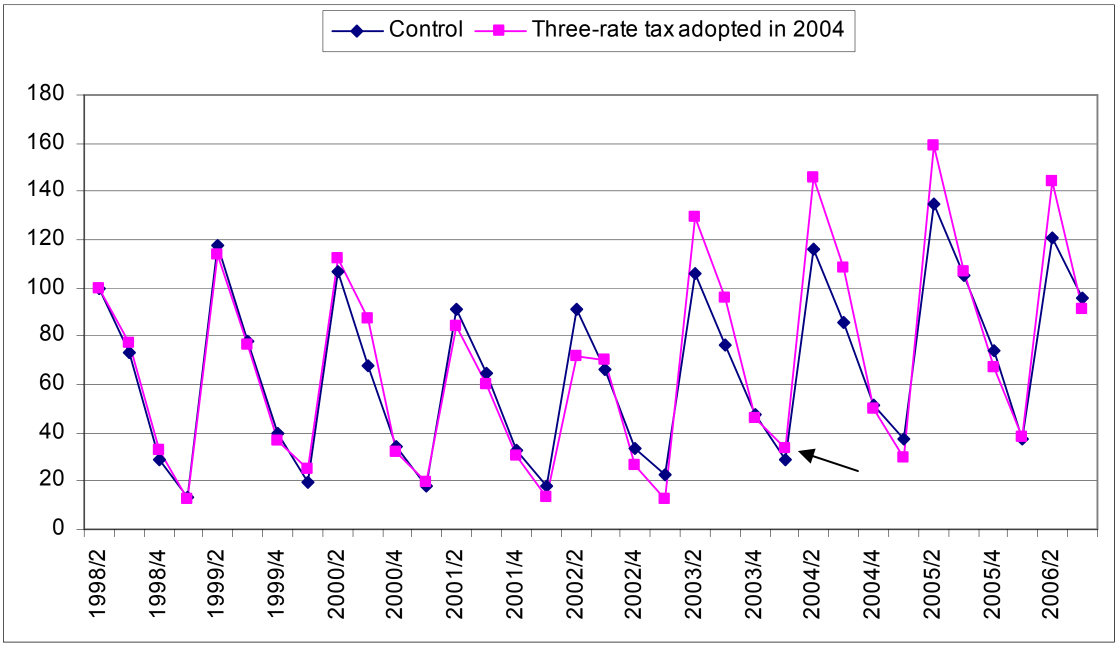
Graph 1b. *Single-family housing starts in three-rate (system introduced in 2002) and two-rate municipalities (Index, 1998/2=100)*



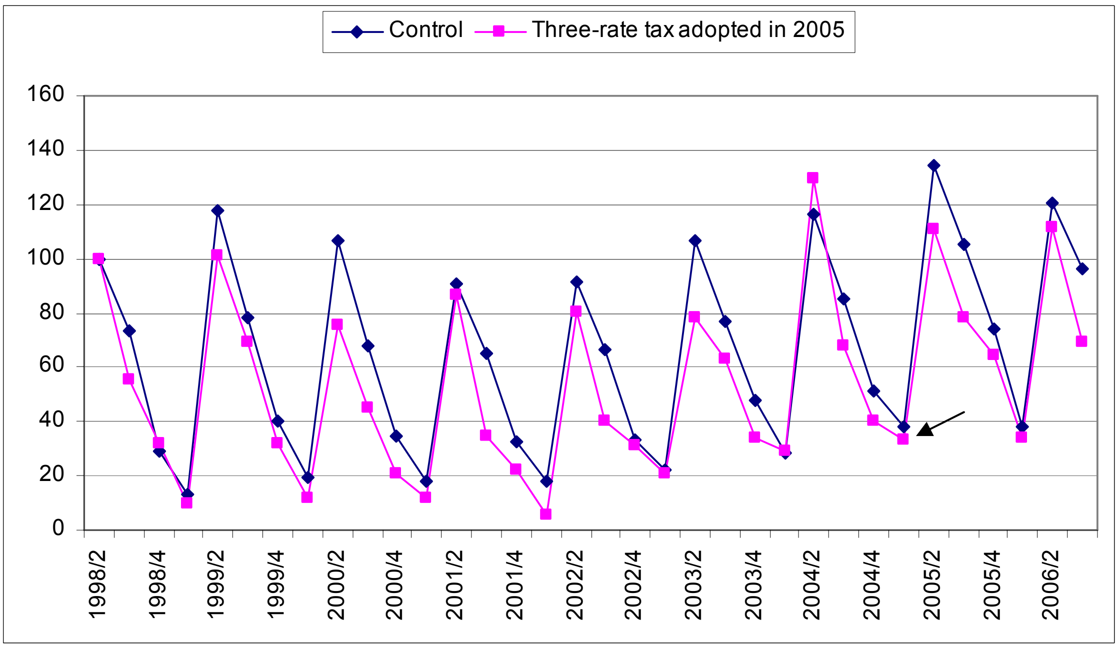
Graph 1c. *Single-family housing starts in three-rate (system introduced in 2003) and two-rate municipalities (Index, 1998/2=100)*



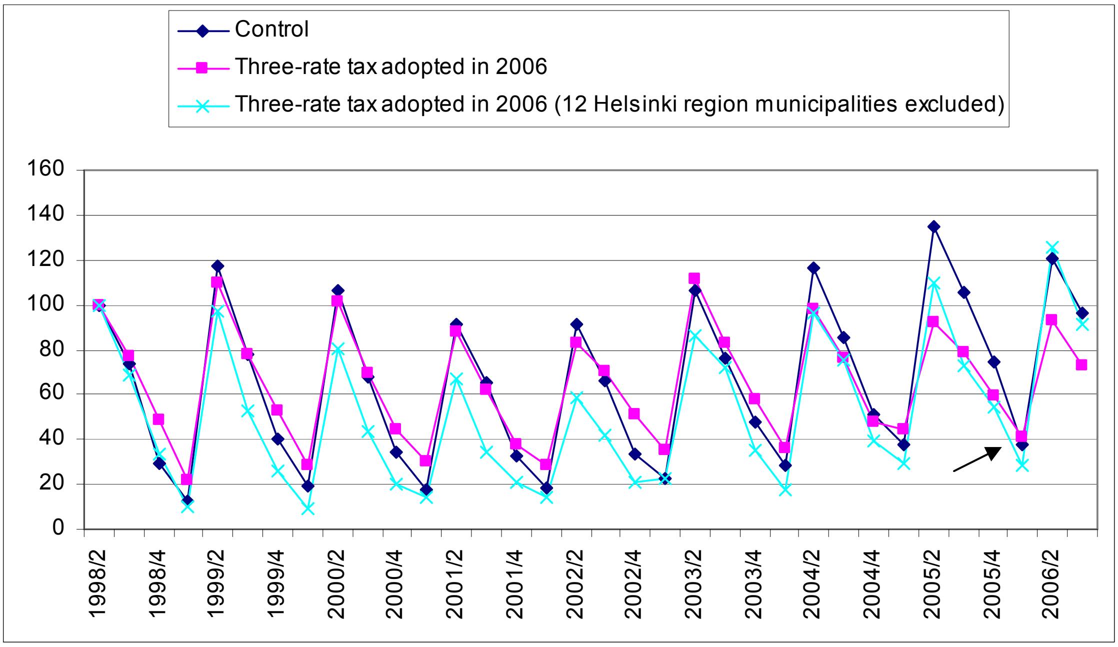
Graph 1d. Single-family housing starts in three-rate (system introduced in 2004) and two-rate municipalities (Index, 1998/2=100)



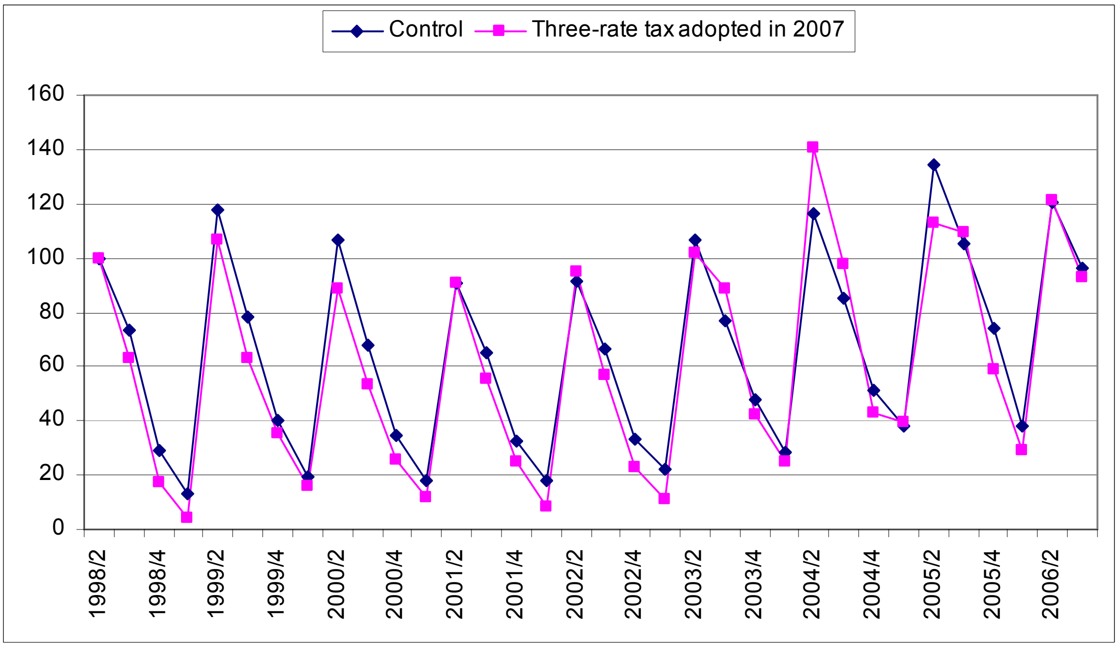
Graph 1e. Single-family housing starts in three-rate (system introduced in 2005) and two-rate municipalities (Index, 1998/2=100)



Graph 1f. *Single-family housing starts in three-rate (system introduced in 2006) and two-rate municipalities (Index, 1998/2=100)*



Graph 1g. *Single-family housing starts in three-rate (system introduced in 2007) and two-rate municipalities (Index, 1998/2=100)*



The descriptive Graphs 1a–1g suggest that three-rate taxation leads to more single-family housing starts. Furthermore, the coming switch to the three-rate system seems to increase starts already in the preceding year. Accordingly, the econometric model is built so that it allows for this anticipatory effect. The upward shift in housing starts seen when a three-rate system is introduced, which seems quite strong, particularly in Graphs 1c and 1d, may naturally be due to other factors affecting housing starts, such as housing prices. In the fixed-effects Poisson model, we control not only for property taxes but also for some other municipality attributes thought to affect housing starts. Note that the fixed-effects Poisson estimates of the effects of property taxes are based on variation within municipalities, not between municipalities. Thus, the two-rate municipalities labeled as the control group in the graphs do not serve as the control group for three-rate municipalities in the econometric part.

Fixed-effects Poisson estimations

In the econometric estimations, single-family housing starts and all housing starts are studied separately because single-family housing starts are likely to be more market-driven and more affected by land taxes than all housing starts, which include social housing built with government-subsidized loans. Apartment blocks and row houses are also more often built on lots rented by the municipality, in which case the developer does not pay land taxes. It is not possible to separate market-driven starts from government subsidized starts. Single-family units are built by private households or construction firms and they are more often on owned lots than larger units.

The econometric models have two aims: 1) to estimate the effect of property taxes on the number of housing starts, which reflects the development timing considerations of individual land owners; 2) to estimate the effect of property taxes on the volume (in cubic meters) of started buildings, which is thought to reflect the joint effect of timing and development density considerations. For single-family housing, the number of dwellings is used as a measure of new single-family units since the number of buildings includes supplementary buildings, such as garages. For all housing starts, the number of buildings is used. The volume of started buildings in cubic meters is used to measure the joint effect of the intensity of construction activity and development density, even though volume is not directly compatible with capital used in construction, which is the land owner's decision variable in the theory part.[6] Thus, the analysis of development density in the empirical part differs somewhat from the theory part. Volume is used since data on the value of housing construction are not available. Differences in the coefficients of tax variables for the number of started dwellings (or buildings) and for volume give some indication of how taxes affect the density of development. For all housing starts, however, the interpretation of the difference in the coefficients of the number of starts model and the volume model is not clear. If three-rate taxation affects mainly the number of single-

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[6] Nor do we have information on lot sizes, which would make it possible to measure density as volume per unit of land.

family housing starts, the estimated effect of three-rate taxation on the volume of all housing starts is weaker than on the number of buildings, even if the development density chosen by each land owner is unaffected. In Finland, land use plans define the kind of building that can be built on each site, and thus it is not possible for multi-dwelling starts to be substituted with single-family housing starts.

The tax rate relevant to construction decisions is the effective tax rate, i.e. the ratio of tax liabilities to the market value of the property. However, because of the lack of data on the taxable values of properties relative to market values, the effective tax rate cannot be measured accurately. Statutory tax rates are used instead. The ratio of taxable value to market value is likely to be lower in areas where housing prices and land prices have grown faster because the assessment regulations allow concessions when prices are rising. Thus the measurement error between statutory and effective tax rates is likely be correlated with a major determinant of housing construction. Therefore, property taxes are included in the model in two different ways. The effect of property taxation is estimated first by means of a dummy variable indicating whether the municipality has a three-rate or two-rate tax system and then by using a complete set of tax rates and their interactions with the tax system dummy. The three-rate dummy model does not suffer from measurement errors in tax rates but it gives a less detailed view of the effects of property taxes than the tax rate models.

In their study of two-rate property taxes, Plassman et al. (2000) only include in their data municipalities in economic distress since municipalities that adopted the two-rate system in the study period were all in economic distress. They argue that including all municipalities with different economic conditions would weaken the reliability of their results through their effect on time dummies. We report the results of three-rate indicator models both with data including all municipalities and excluding municipalities that did not introduce the three-rate system in 2001–2007. Since the results seemed to be slightly different with the two sets of data, the remaining models were estimated with data including only the 118 municipalities that adopted the three-rate system in the period of the study. In Plassmann et al. (2000), the inclusion of cities similar to the cities of interest is necessary since they have only 15 cities contributing to the estimate of the tax rate difference.

Table 5 reports the results of fixed-effects Poisson regressions of single-family housing starts on a three-rate regime dummy variable and the control variables. The three-rate regime dummy is given a value of one if the municipality has a three-rate property tax system and also in the year preceding the introduction of the system. The coefficients are semi-elasticities, or elasticities if the explanatory variable is in logs. The reported standard errors are robust. According to the results obtained with data including all municipalities, a three-rate tax system increases single-family housing starts measured as the number of dwellings by

9.4 per cent per unit of time. The coefficient is significant at the 5 per cent level. The effect on volume is roughly the same, indicating that the density of development is not affected by three-rate taxation. Land use restrictions may play a role here. If the optimal density is above the limit of the town plan, density is not affected by three-rate taxation. When only municipalities that adopted the three-rate system are included, the estimated effect of three-rate taxation on both the number of dwellings and volume in cubic meters is roughly 1 percentage point higher.

Table 5. FE-Poisson results with a tax system dummy (single-family housing starts)

Dep. var. number of dwellings	*All municipalities included*			*Only three-rate municipalities included*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Dummy(three-rate system)	0.094	0.041	0.021	0.105	0.054	0.054
ln(housing price)	0.776	0.299	0.009	0.887	0.399	0.026
ln(housing stock/population)	-1.344	0.466	0.004	-0.520	0.479	0.278
Time dummies	yes			yes		
Log-likelihood	-28227			-10557		
Observations	13265			4130		

Dep. var. cubic meters	*All municipalities included*			*Only three-rate municipalities included*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Dummy(three-rate system)	0.091	0.038	0.017	0.106	0.049	0.033
ln(housing price)	0.710	0.276	0.010	0.743	0.384	0.053
ln(housing stock/population)	-1.003	0.447	0.025	-0.267	0.484	0.581
Time dummies	yes			yes		
Log-likelihood	-6966245			-2658124		
Observations	13265			4130		

Housing price has a positive effect on starts since higher housing prices make development more lucrative. The price elasticity of housing starts varies from 0.71 to 0.89. The ratio of dwelling stock to population is thought to capture the scarcity of housing not necessarily reflected in housing prices. The elasticity of housing starts in respect of dwellings per capita is negative as expected but insignificant when municipalities that stayed in the two-rate system are excluded. The explanatory variables also include 34 quarterly time dummies capturing the effect of nationwide factors, such as interest rates and common business cycle effects (and expectations regarding them). The quarterly dummies also control for seasonal variation, which was seen to be quite strong in Graphs 1a – 1g.

Table 6 shows the results with all housing starts as the dependent variable. The estimated effect of three-rate taxation on all housing starts is lower than on single-family housing starts. The effect of three-rate taxation on the number of starts (buildings) is 6.7 percent when all municipalities are included and significant at the 10 per cent level. When only three-rate municipalities are included, the coefficient is roughly the same but insignificant.

Table 6. FE-Poisson results with a tax system dummy (all housing starts)

Dep. var. number of buildings	*All municipalities included*			*Only three-rate municipalities included*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Dummy(three-rate system)	0.067	0.039	0.085	0.065	0.045	0.146
ln(housing price)	0.436	0.297	0.142	0.264	0.419	0.529
ln(housing stock/population)	-1.397	0.438	0.001	-0.769	0.466	0.099
Time dummies	yes			yes		
Log-likelihood	-32930			-11980		
Observations	13265			4130		

Dep. var. cubic meters	*All municipalities included*			*Only three-rate municipalities included*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Dummy(three-rate system)	0.027	0.037	0.466	0.041	0.045	0.363
ln(housing price)	0.454	0.287	0.114	0.199	0.404	0.622
ln(housing stock/population)	-1.013	0.377	0.007	-0.058	0.415	0.888
Time dummies	yes			yes		
Log-likelihood	-11016373			-4528113		
Observations	13265			4130		

The coefficient of the three-rate dummy for the volume of starts in cubic meters is lower than for the number of buildings, suggesting that three-rate taxation may have led to lower development density, which is compatible with the case of increasing returns on housing investment in the theoretical model. However, there are also other possible explanations for this observation. Firstly, the perceived weaker effect of three-rate taxation on volume than on the number of buildings may be due to the fact that the pre-development land tax affects a smaller share of multi-dwelling construction than of single-family construction. A large share of apartment blocks and row houses are government-subsidized and are also more often built on lots rented from the municipality than single-family units. A stronger increase in single-family housing starts than in multi-dwelling starts naturally leads to lower volume per building. We also estimated a model with multi dwelling unit starts as the dependent variable, but the coefficients were very unstable and insignificant. Secondly, part of the effect may be due to changes in zoning policy related to the choice of tax system. Endogeneity issues are discussed more thoroughly later in this section. The price-elasticity of all housing starts is lower than in Table 5, reflecting the fact that all housing starts include social housing which is not as strongly market-driven as privately funded housing. The coefficient of dwelling stock per population is negative and varies from -0.06 and insignificant to -1.40 and highly significant.

Table 7 reports the results of the regressions of single-family housing starts on property tax rates and the control variables. Now only municipalities that adopted the three-rate system in the studied time period are included. The effect of pre-development tax is modeled through the difference between pre- and post-development tax (general property tax) since no value can be assigned to the pre-development tax rate under a two-rate system. The tax rate difference is given a value of zero under the two-rate system and a positive value under the three-rate system. In order to take into account the effect of the typical one-year transition period between the decision to switch to a three-rate system and its actual introduction, the following year's tax rate difference is used in the year preceding the introduction of the system. The effect of the tax rate difference can be estimated more accurately than the effects of building tax and general property tax, since there is more within variation in the tax rate difference than in the two latter tax rates (see Table A2 in the appendix).

In Model 1 of Table 7, where tax rates are not interacted with the tax system dummy, the effect of the difference between pre-development land tax and post-development land tax on starts measured as dwellings is 5 per cent and is significant at the 5 per cent level. Building tax has a negative sign but is insignificant and the general property tax is positive and significant. In the lower panel, where volume in cubic meters is the dependent variable, the estimates are roughly the same as in the upper panel, suggesting that property taxes do not affect the size of new single-family units. Even though the coefficients of building tax and general property tax are much higher than that of the tax rate difference, the estimated effects of a one standard deviation change in each of them are of the same magnitude. Based on Model 1 in the upper panel and Table A2 in the Appendix, the effect of a one standard deviation increase in the tax rate difference is 4.6 percent. For building tax the corresponding effect is -2.5 per cent and for general property tax 7.4 percent.

Model 2 in Table 7 includes the interaction between the tax system and tax rates since the theoretical model suggested that the effects of the same statutory taxes may differ by tax system. The result that building tax has a stronger negative effect on starts under a three-rate system than under a two-rate system is in line with the finding in Chapter 3 that the timing distortion of building tax is magnified by switching to a three-rate system. The positive interaction term of general property tax is in contrast with theory. However, neither of the two interaction terms is insignificant, thus Model 1 is taken to be adequate.

Table 7. FE-Poisson results with tax rates (single-family housing starts)

Dep. var. number of dwellings	*Model 1*			*Model 2*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Pre-development – post-development tax %	0.051	0.023	0.029	0.020	0.034	0.563
Building tax %	-0.411	0.578	0.477	-0.357	0.725	0.622
Dummy(three-rate)*building tax				-0.033	0.612	0.957
General property tax %	0.495	0.199	0.013	0.424	0.252	0.093
Dummy(three-rate)*general property tax				0.129	0.260	0.619
ln(housing price)	0.950	0.420	0.024	0.962	0.423	0.023
ln(housing stock/population)	-0.496	0.488	0.310	-0.506	0.504	0.316
Time dummies	yes			yes		
Log-likelihood	-10546			-10541		
Observations	4130			4130		

Dep. var. cubic meters	*Model 1*			*Model 2*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Pre-development – post-development tax %	0.056	0.022	0.010	0.031	0.033	0.346
Building tax %	-0.538	0.523	0.304	-0.457	0.641	0.476
Dummy(three-rate)*building tax				-0.092	0.530	0.863
General property tax %	0.411	0.193	0.033	0.342	0.223	0.125
Dummy(three-rate)*general property tax				0.126	0.229	0.582
ln(housing price)	0.783	0.400	0.051	0.793	0.405	0.050
ln(housing stock/population)	-0.223	0.488	0.647	-0.222	0.499	0.657
Time dummies	yes			yes		
Log-likelihood	-2651955			-2650205		
Observations	13265			4130		

Table 8 shows the results of models with all housing starts as the dependent variable and tax rates as explanatory variables. As in Table 7, the interaction terms in Model 2 are insignificant. In Model 1, the effect of the difference between pre-development and post-development land tax on started buildings is 4.5 percent and significant, but only by 1.7 per cent and insignificant in the lower panel with volume as the dependent variable. Comparisons of the upper and lower panels of Tables 6 and 8 suggest that density distortions may have crowded out part of the positive effect of pre-development tax on housing construction. The result that the effect of three-rate taxation on the number of starts is weaker than on volume is in line with the comparative static results of the theoretical model in the case where returns on housing investment are rising. However, the results for single-family starts in Tables 5 and 7 give a different picture.

Table 8. FE-Poisson results with tax rates (all housing starts)

Dep. var. number of buildings	*Model 1*			*Model 2*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Pre-development – post-development tax %	0.045	0.020	0.023	0.042	0.028	0.132
Building tax %	-0.585	0.476	0.219	-0.555	0.576	0.335
Dummy(three-rate)*building tax				-0.045	0.432	0.918
General property tax %	0.338	0.205	0.100	0.324	0.230	0.160
Dummy(three-rate)*general property tax				0.026	0.200	0.896
ln(housing price)	0.296	0.418	0.479	0.297	0.421	0.481
ln(housing stock/population)	-0.734	0.444	0.099	-0.727	0.448	0.105
Time dummies	yes			yes		
Log-likelihood	-11963			-11963		
Observations	4130			4130		

Dep. var. cubic meters	*Model 1*			*Model 2*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Pre-development – post-development tax %	0.017	0.033	0.604	0.009	0.036	0.809
Building tax %	-0.287	0.574	0.617	-0.943	0.689	0.172
Dummy(three-rate)*building tax				1.095	0.603	0.070
General property tax %	-0.054	0.359	0.881	0.147	0.387	0.704
Dummy(three-rate)*general property tax				-0.379	0.298	0.203
ln(housing price)	0.152	0.725	0.834	0.135	0.689	0.845
ln(housing stock/population)	-0.029	0.648	0.964	-0.229	0.648	0.724
Time dummies	yes			yes		
Log-likelihood	-4527342			-4514863		
Observations	4130			4130		

Time pattern of the effect of three-rate taxation

The time pattern of the effect of three-rate taxation is of interest since the initial effect may be different from the longer-term effect. One would expect the initial shock to be strong and then to weaken over time as the stock of vacant land decreases over time due to faster development. Due to the lack of data, land stock was not included in the set of control variables.

In Table 9, the time pattern of the effect of three-rate taxation on single-family housing starts (dwellings) is explored by estimating a model with separate dummy variables for the year preceding the introduction of the three-rate system and for six years after the introduction. When all municipalities are included, the coefficient of the three-rate dummy varies from roughly 9 per cent to 11 per cent from the year prior to the introduction until the fourth year after introduction and seems to diminish thereafter. When municipalities that stayed in the two rate system are excluded, the effect seems to weaken earlier. The control variables again have the expected signs.

Table 9. *Time pattern of the effect of three-rate taxation on single-family housing starts*

Dep. var. number of dwellings	*All municipalities included*			*Only three-rate municipalities included*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Year before	0.086	0.041	0.036	0.089	0.050	0.076
1st year	0.110	0.050	0.028	0.110	0.066	0.096
2nd year	0.090	0.057	0.116	0.072	0.082	0.380
3rd year	0.093	0.054	0.086	0.054	0.086	0.531
4th year	0.107	0.071	0.136	0.046	0.102	0.654
5th year	0.077	0.110	0.483	0.004	0.145	0.978
6th year	0.051	0.081	0.531	0.031	0.118	0.793
ln(housing price)	1.201	0.301	0.011	0.877	0.406	0.031
ln(housing stock/ population)	-2.188	0.469	0.004	-0.476	0.467	0.307
Time dummies	yes			yes		
Log-likelihood	-28224			-10553		
Observations	13265			4130		

Endogeneity issues

The data used in this study do not come from a natural experiment since municipalities get to choose the tax system and tax rates applied in their particular municipality. Hence it may be that the perceived positive effect of three-rate taxation on housing starts is partly attributable to other policy measures taken simultaneously with the introduction of the three-rate system. Apart from property taxes, the main instrument through which a municipality can affect housing construction is zoning. The municipality has a zoning monopoly over all land within its borders. New residential land comes to the market mainly through the municipality. Typically, the municipality buys raw land from private land owners or from the government, then the municipality draws up a plan for the purchased area and sells or rents the lots to households or developer firms. The municipality has the responsibility to provide infrastructure for the zoned area. Alternatively, the municipality can make a land use contract with a landowner (typically a large developer) owning raw land. Land use contracts typically obligate the landowner to build infrastructure in the area in exchange for zoning. The former alternative is far more common.

It may be that in conjunction with the introduction of the three-rate system, the municipality changes its zoning policy. It is ambiguous a priori whether a three-rate system can be expected to be accompanied by more or less zoning. Three-rate taxation may form part of an expansive land use policy, which could include increasing the supply of residential land through increased zoning and land sales. On the other hand, the municipality might use three-rate taxation as an instrument to get existing zoned residential areas fully developed, and hence existing infrastructure more efficiently utilized. A policy of getting existing areas developed may be reinforced by refraining from zoning new areas.

Being able to control for the stock of vacant residential land zoned for different types of housing could solve the potential endogeneity problem related to simultaneous changes in zoning policy and property taxation. Alas, land stock data are not available. However, the relation between the choice of property tax system and zoning can be examined indirectly by utilizing land transaction data.

Annual municipality-level data on transactions of single-family housing lots are available for the period 2002–2005.[7] Table 10 reports the results of fixed-effects Poisson regression of the number of single family lots sold by the municipality on the three-rate system indicator and three year dummies. 2002 is the reference year. The sample size is much smaller than when studying housing starts since the dependent variable is annual and available only for four years. Because of missing observations, the cross-sectional sample size also declined from 118 to 111. Only three-rate municipalities are included in the data.

The first three columns show the results obtained with data including all three-rate municipalities. The coefficient of the three-rate dummy indicates a 15 per cent increase in the number of lots sold by the municipality as the three-rate system is introduced, but the coefficient is not significant. Exploring the data revealed that the coefficient was strongly driven by one municipality (city of *Turku)*, which adopted the three-rate system in 2003 and sold over 130 lots in the same year. In the other years in the data, the number of lots sold varied from 10 to 30. The three last columns report the results when the influential outlier is dropped from the data. The coefficient of the three-rate dummy is now zero.

[7] The data are provided by the National Land Survey Authority of Finland.

Table 10. *FE-Poisson results for the linkage between property tax system and land sales (dep. var. single-family lots sold by the municipality)*

Dep. var. single-family lots sold by the munici-pality	*All three-rate municipalities*			*One influential outlier excluded*		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Dummy (three-rate)	0.150	0.191	0.433	0.001	0.148	0.995
2003	-0.375	0.132	0.005	-0.393	0.132	0.003
2004	-0.025	0.126	0.845	-0.127	0.089	0.153
2005	-0.137	0.096	0.153	-0.129	0.098	0.188
Log-likelihood	-1100.8			-1026.3		
Observations	448			444		

Table 10 does not support the hypothesis that the choice of property tax system is strongly linked with more expansive zoning policy. Even if the insignificance of the results is partly driven by the small sample size, the results support the view that the observed positive effect of three-rate taxation on housing starts is indeed a causal effect of the tax system. However, the results for the effect of three-rate taxation cannot be generalized to apply to all municipalities since the choice of the tax system may be related to the unobserved potential effect of introducing the three-rate system. For example, municipalities that adopted the three-rate system voluntarily may differ from the other municipalities in whether renting or selling lots is the primary method of bringing zoned land to the market. Some municipalities rent lots to developers instead of selling them. The developer does not pay property taxes on rented lots, and therefore development projects on rented lots should not be directly affected by changes in property tax rates on land. The data do not include information on the proportion of rented lots. Thus the effects of property taxes on land are estimated for a municipality with an average proportion of rented lots.

A survey conducted by the Ministry of the Environment and the Association of Finnish Local and Regional Authorities provides some additional evidence that the tax system indeed has a causal effect. The survey asked representatives of 41 three-rate municipalities whether development of lots affected by pre-development land tax had increased. In total, 66 per cent of respondents said that development had increased.

Overall effect of three-rate taxation

In order to evaluate the overall significance of three-rate taxation for housing construction in Finland, estimates of the average effect of three-rate taxation from Tables 5 and 6 are utilized to calculate estimates of the total effect in 2005. The insignificance of some of the coefficients is ignored here.

Table 11. Total effect of three-rate taxation in 2005

		Obs.	Total starts	Average effect %	Total effect (starts)
Single-family housing starts					
Dwellings	All municipalities	414	14912		
	Three-rate municipali-ties	82	4111	10.5	390
Volume (1000 cubic me-ters)	All municipalities	414	8809.8		
	Three-rate municipali-ties	82	2390.4	10.6	228
All housing starts					
Buildings	All municipalities	414	19719		
	Three-rate municipali-ties	82	5309	6.5	326
Volume (1000 cubic me-ters)	All municipalities	414	13700		
	Three-rate municipali-ties	82	3544.3	4.1	140

Table 11 reports the estimated total effect of three-rate taxation in terms of the number of buildings, dwellings or volume (in 1000 m^3) separately for single-family starts and all housing starts. It is seen that the impact of three-rate taxation on total housing construction is relatively small. According to the results, three-rate taxation led to 390 additional single-family housing starts (dwellings) in 2005, which corresponds to a two per cent increase in total single-family housing construction. In terms of volume, the total effect was 228,000 cubic meters. As regards all housing starts, the total effect implied by the estimates in Table 6 is even weaker. The estimated total effect was 326 additional buildings or 140,000 cubic meters.

6. Conclusions

This paper builds a theoretical model of the impact of Finnish type three-rate property taxation on landowners' development decisions and estimates the effect of property taxes on construction activity using Finnish data. The discussion following the theoretical model in Chapter 3 underlines the potential difficulties in estimating the effects of property taxes on construction activity. According to the theoretical model, the effects of property taxes on the timing and density of development depend crucially on future returns on housing investment, which are difficult if not impossible to measure. This complexity of the effects of property taxes on development has not been adequately acknowledged in earlier empirical studies. However, the effect of the Finnish-type tax on undeveloped land can be estimated more reliably than the effects of uniform land tax and building tax because the qualitative effect of the pre-development land tax does not depend on market conditions.

The results of the fixed-effects Poisson estimations suggest that taxing undeveloped land at a higher rate than developed land has the desired positive effect on single-family housing starts. The impact of three-rate taxation on the volume of single-family housing starts is the same as on the number of dwellings, indicating that the density of development is not affected. The results of the models containing all housing starts suggest that as a side effect of more development, the density of development might decrease somewhat, attenuating the positive effect of faster development. This result is consistent with the theoretical result that, when returns on housing investment are rising, higher pre-development tax hastens development but leads to lower density by moving projects to a time with lower optimal density. There are, however, also alternative explanations for the perceived reduced density. We think that it is more plausible that the weaker effect of three-rate taxation on the volume than on the number of buildings (all starts) mainly reflects the asymmetric effects of taxes on single-family housing starts and multi-dwelling starts.

The lack of data on the stock of land zoned for different uses reduces the reliability of the empirical results. The simultaneity of changes in land use policy and property taxation was studied by estimating a model where single-family housing lots sold by the municipality were regressed on a tax system indicator. The effect of the tax system was insignificant, supporting the view that the econometric models identify the causal effects of property taxation.

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Appendix

Table A1. Descriptive statistics: all municipalities

Variable		Mean	Std. Dev.	Min	Max	Observations
Single family housing starts (dwellings)	*overall*	5.8	11.2	0	196	N = 13265
	between		8.5	0.2	76.1	n = 379
	within		7.3	-59.3	125.7	T = 35
Single family housing starts (cubic meters)	*overall*	3343	6522	0	112993	N = 13265
	between		4965	74	42801	n = 379
	within		4236	-35073	73534	T = 35
All housing starts (buildings)	*overall*	8.5	14.8	0	234	N = 13265
	between		11.9	0.2	106.3	n = 379
	within		8.8	-68.8	136.2	T = 35
All housing starts (cubic meters)	*overall*	5187	14329	0	268566	N = 13265
	between		12589	74	144361	n = 379
	within		6873	-88188	149639	T = 35
Dummy (three-rate)	*overall*	0.152	0.359	0	1	N = 13265
	between		0.266	0	0.771	n = 379
	within		0.242	-0.619	1.067	T = 35
Pre-development – post-development land tax	*overall*	0.22	0.60	0	2.78	N = 13265
	between		0.44	0	1.95	n = 379
	within		0.41	-1.73	2.76	T = 35
Building tax	*overall*	0.27	0.06	0.1	0.5	N = 13265
	between		0.05	0.19	0.40	n = 379
	within		0.04	0.10	0.49	T = 35
General property tax	*overall*	0.60	0.15	0.2	1	N = 13265
	between		0.12	0.43	0.98	n = 379
	within		0.08	0.24	1.06	T = 35
Housing price index (y2000=100)	*overall*	105.0	10.6	79.8	147.5	N = 13265
	between		2.4	99.7	110.4	n = 379
	within		10.4	74.9	142.6	T = 35
Dwellings/population	*overall*	0.456	0.050	0.216	0.829	N = 13265
	between		0.044	0.307	0.595	n = 379
	within		0.024	0.240	0.807	T = 35

Table A2. *Descriptive statistics: municipalities that adopted three-rate system in 2001–2007*

Variable		Mean	Std. Dev.	Min	Max	Observations	
Single-family housing starts (dwellings)	*overall*	8.6	13.5	0	117	N =	4130
	between		9.7	0.3	45.7	n =	118
	within		9.5	-29.0	84.9	T =	35
Single-family housing starts (cubic meters)	*overall*	4973	7932	0	72485	N =	4130
	between		5728	202	26263	n =	118
	within		5511	-18116	54783	T =	35
All housing starts (buildings)	*overall*	12.2	17.5	0	163	N =	4130
	between		13.4	0.5	67.8	n =	118
	within		11.3	-40.1	108.9	T =	35
All housing starts (cubic meters)	*overall*	7550	14478	0	151905	N =	4130
	between		11762	203	77424	n =	118
	within		8510	-48843	100232	T =	35
Dummy (three-rate)	*overall*	0.489	0.500	0	1	N =	4130
	between		0.250	0.085714	0.771	n =	118
	within		0.434	-0.282	1.404	T =	35
Pre-development – post-development land tax	*overall*	0.71	0.90	0	2.78	N =	4130
	between		0.52	0.055714	1.95	n =	118
	within		0.74	-1.25	3.25	T =	35
Building tax	*overall*	0.27	0.06	0.1	0.45	N =	4130
	between		0.05	0.19	0.39	n =	118
	within		0.04	0.12	0.41	T =	35
General property tax	*overall*	0.62	0.15	0.2	1	N =	4130
	between		0.12	0.43	0.95	n =	118
	within		0.08	0.27	0.88	T =	35
Housing price index (y2000=100)	*overall*	104.7	10.2	81.0	142.9	N =	4130
	between		2.3	99.7	110.4	n =	118
	within		9.9	77.6	139.5	T =	35
Dwellings/population	*overall*	0.450	0.052	0.216	0.647	N =	4130
	between		0.046	0.346	0.559	n =	118
	within		0.023	0.234	0.571	T =	35

Table A3. Correlation matrices of variables used in the regressions

All municipalities

		1	2	3	4	5	6	7	8	9	10
1	**Single-family housing starts (dwellings)**	1									
2	**Single-family housing starts (cubic meters)**	0.989	1								
3	**All housing starts (buildings)**	0.970	0.975	1							
4	**All housing starts (cubic meters)**	0.825	0.840	0.879	1						
5	**Dummy (three-rate)**	0.154	0.156	0.139	0.088	1					
6	**Pre-development – post-development land tax**	0.182	0.186	0.168	0.114	0.865	1				
7	**Building tax**	-0.036	-0.032	-0.036	-0.031	0.191	0.136	1			
8	**General property tax**	0.174	0.184	0.187	0.182	0.170	0.157	0.388	1		
9	**Housing price index (y2000=100)**	0.135	0.145	0.111	0.088	0.186	0.181	0.292	0.310	1	
10	**Dwellings/population**	-0.021	0.002	0.014	0.086	0.040	0.017	0.200	0.447	0.311	1

Only municipalities that introduced three-rate system included

		1	2	3	4	5	6	7	8	9	10
1	**Single-family housing starts (dwellings)**	1									
2	**Single-family housing starts (cubic meters)**	0.989	1								
3	**All housing starts (buildings)**	0.968	0.972	1							
4	**All housing starts (cubic meters)**	0.848	0.868	0.901	1						
5	**Dummy (three-rate)**	0.087	0.094	0.067	0.041	1					
6	**Pre-development – post-development land tax**	0.157	0.166	0.140	0.113	0.801	1				
7	**Building tax**	-0.028	-0.024	-0.030	-0.037	0.351	0.215	1			
8	**General property tax**	0.242	0.250	0.252	0.261	0.215	0.194	0.347	1		
9	**Housing price index (y2000=100)**	0.174	0.188	0.146	0.143	0.471	0.421	0.306	0.322	1	
10	**Dwellings/population**	0.028	0.052	0.065	0.155	0.212	0.132	0.130	0.503	0.294	1

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