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Dynamic and Geographic Patterns of Home Ownership (**)

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Abstract.

Determination of the demand for home ownership is analysed. Determinants include prices and short- and medium-term price changes, public regulation (regulation of house rent, housing subsidies, taxation), competition from alternative residence forms (measured by supply of subsidized housing), social composition of population (age, social benefit receivers, household composition, civil status, education, nationality), economic ability (income), and congestion (measured by population density and degree of urbanisation). Danish aggregate data for 270 Danish municipalities, available annually for the period 1999-2004. The study applies a spatially adjusted SUR approach, so that dynamic as well as spatial patterns are controlled for simultaneously. It is revealed that ignorance of controlling for spatial spillover strongly skews conclusions regarding effects of determinants, as determination of housing market behaviour is not restricted within municipalities, but rather spills over across municipalities.

JEL Classification: C21; C33; P25; R21; R31.

Keywords: Housing market; Demand for home ownership; SUR; Spatial spillover; spatial autoregression; spatial distributed lag

Word count: 6165.

1. Introduction

Over the last decades there has been growing attention about the aggregate home ownership rate in industrialized countries. Recent economic studies of determinants for home ownership emphasize the complexity of the basic housing tenure choice between owning and renting whereas earlier time series studies such as Rosen et al (1984) and Henderson and Ioannides (1983) mainly focused on user cost of home ownership and rents, and the fluctuations over time in these variables as decisive factors for variations in home ownership. More recent empirical work points to a range of economic as well as socio-economic and demographic factors as important determinants for the aggregate home ownership rate. Rather than constituting an alternative explanation in understanding tenure choice, however, such factors can be seen as complementary to the traditional user-cost factors.

One reason for the increased attention in home owning is the generally higher focus of portfolio analysis of private households in these years, and thus a broader portfolio choice explanation has emerged to tenure choice that basically considers real estate assets as an integrated part of portfolio investment in households. This issue is studied in the context of price hedging, rent risk and income risk under various individual and structural conditions. See for example Brueckner (1997), Goetzmann (1993), Ortalo-Magne and Rady (2002), and Sinai and Souleles (2003). Sinai and Souleles (2003) provide a summary of the literature on the relation between portfolio choice and tenure choice.

In addition, within social capital research there is interest in identifying the linkages between the physical environment and social interactions of individuals, and among other issues the impacts of home ownership on social connection is examined. For more reasons home owners appear to have a high stake in protecting the local community and they therefore put more effort in the upkeep and appearance of a neighbourhood. For instance, home owners, unlike renters, have made a financial

investment in the dwelling and they also appear more stationary than renters. This again may lead to activities and behaviour that serves to reduce vandalism, theft and other crimes in the area and generally increases social interaction and responsibility between residents. Several studies document a range of positive effects from ownership. They include, among others, Glaeser and Sacerdote (1999), Perkins et al. (1996), Rohe and Basolo (1997) and White (2001).

The present paper can be seen as extending the literature on demand for home ownership by accounting for an understudied element in empirical analysis of home ownership. All empirical studies of home ownership rates (at least to the knowledge of the authors) ignore important issues related to spatial variation of the data applied. It is well known from studies concerning small area variation that it is necessary to control for spatial spillover in order to obtain proper conclusions regarding effects of determinants (Anselin, 1998; Anselin and Bera, 1998; Anselin, 2000). This evidence typically pertain to housing studies insofar as housing markets are not restricted to act within the borderlines of single small areas. Rather, market conditions and market behaviour of contiguous areas may be expected to spill over between the jurisdictions. Thus, solely assuming the housing market behaviour of a (small area) to be conditioned on the determining factors of this small area alone may well lead to skewed conclusions.

Specifically, it is the purpose of the present study to relate our results to the findings in Lauridsen et al. (2006). This study established an econometric model for the fraction of homes that are owner occupied in Denmark for the period 1999 to 2004. Theoretical determinants included prices and short- and medium-term price changes, public regulation (regulation of house rent, housing subsidies, and taxation) along the lines of the user cost approach. Moreover the study tested for factors such as competition from alternative residence forms (measured by supply of subsidized housing), social composition of population (age, social benefit receivers, household composition,

civil status, education, and nationality), economic ability (income), and congestion (measured by population density and degree of urbanisation). Issues related to the application of pooled cross sectional data were further discussed. Lauridsen et al. (2006) included parametric instability over time, adjustment for dependency caused by repeated observation, and identification of the effect of prices on home ownership rates. It was found that parametric instability over time could be mostly ascribed to time trends in the parameters so that a simplified specification with common parameters across time, combined with time interactions, could be established.

By analysing the determinants of home ownership while controlling simultaneously, not only for dynamic patterns as done by Lauridsen et al (2006), but also for spatial spillover effects, the present analysis provides an opportunity to formalise and analyse geographical aspects of home ownership in a small area setup. One such aspect is endogenous spillover, which implies that high ownership rates in one area induce high ownership rates in neighbourhood areas. Another aspect is exogenous spillover, which implies that factors determining the home ownership rate in one area also affect home ownership in surrounding areas.

Part 2 of the present study briefly summarises the theoretical foundations from Lauridsen et al. (2006) regarding determinants of home ownership rates. The applied data are briefly described in Part 3, upon which Part 4 outline methodological aspects. As pooled data are applied, a Seemingly Unrelated Regression (SUR) framework is advocated in order to capture dynamic patterns efficiently. Further, potential spatial spillover is controlled for by extending the SUR with spatial autoregression (SAR) and spatial distributed lag (SDL) specifications. Next, Part 5 outlines the estimation results and throughout demonstrates the fallacies of not simultaneously controlling for dynamic patterns and spatial spillover, as conclusions regarding effects on home ownership rates of

determinants varies heavily across the adjusted and non-adjusted specifications. Finally, Part 5 rounds off with a few comments and suggestions.

2. Demand for owner occupied homes in Denmark

We address the basic household choice of owning or renting a residence, focusing on home ownership by considering the demand for owner occupied residential units relative to total demand for these units. Based on Danish data, empirically significant determinants for this fraction are identified. Theoretically speaking, a household choose to own a dwelling if 'owning' is the outcome of its utility maximization given specific economic conditions for this household. The following discussion on determinants for home ownership draws on theoretical findings by among others Linneman (1986), Rothemberg et al (1991), Hansen and Skak (2005), and Elsinga and Hoekstra (2004).[1]

In general, house prices and property values impact on ownership rates as mainly low income groups may be expected to reduce or delay demand for ownership occupation when rising prices occur. As price changes over longer periods also lead to changing price expectations this may again affect demand of dwellings, the consequence being that there is no unique relationship between owner occupations and house prices, but rather distinctive short term and a medium to long term relationships.

Various forms of government intervention in housing markets via taxation and subsidization tend to capitalize in market prices and may as well affect relative price expectations for owned and rented dwellings. These interventions may therefore play a significant role for the choice of tenure type. The most important tax and subsidy measures in the Danish housing market will be tested for

[1] For a broader discussion of the theoretical basics see Lauridsen et al (2006). In addition Atterhög (2005) surveys recent empirical studies on home ownership determinants from various countries.

directly or indirectly as explanatory factors in the analysis. We thus include the real property tax rate. Further, as rent subsidies are commonly offered to renters, we test for the influence of this policy by considering the share of households and the share of the population receiving rent subsidies.

In industrialised countries mortgage loans typically constitute the major share of real estate finance. Mortgage terms and credit rating of households by lender institutions are likely to depend on a variety of individual characteristics. Chiuri and Japelli (2004) provide empirical evidence from 14 countries that the mortgage availability affects home ownership distribution across age groups primarily due to income differences between the groups. Further, Canner and Smith (1991) find that ethnicity matters for mortgage availability. Other factors that may affect credit rating are educational level and job perspectives. In the analysis we test for such characteristics.

Comparing advantages and disadvantages of ownership relative to rented dwellings may help identifying further potential determinants for the analysis. In more respects there are additional costs of owning rather than renting. The theoretical literature points to disadvantages of owners as to switching costs of moving (salaries to real estate agencies and lawyers, uncertainty about sales prices etc.) which thereby cause relatively low geographical mobility of owners. This indicates that individuals being more inclined to move (such as younger people, unmarried people, younger couples without children) may choose rented dwellings. In addition Linneman (1986) points out that high production efficiency by landlords (i.e. as to maintenance costs) in high density areas is an important reason why ownership rates tend to fall from country side to urban areas. We seek evidence for this hypothesis by testing the significance of population density. One advantage of ownership is the wide scope for individual adaptation of the residence, and households clearly put different value on such an option. Preferences for housing autonomy may differ with age and career

position as younger couples plan to have (more) children and educated people expect increasing future income. Further, one can argue that self employed people may be more individualistic oriented than employees and for that reason prefer home ownership.

It appears from these reasonings, however, that incentives for choosing tenure type are mixed for some of these groups. For instance, while younger couples may evade switching costs of moving by being renters they may on the other hand prefer ownerships for reasons of housing autonomy (which in some sense can provide the same services as obtained from moving to a new residence). The same arguments in principle also apply to divorced people (anticipating future marriage).

In all these considerations lead us to test the variables shown in Table 1 for empirical significance in explaining home ownership rates in Denmark.

[Table 1 around here]

3. Data

The data to be applied are aggregate cross section data observed for 270 Danish municipalities (5 municipalities on the island of Bornholm were omitted due to data problems) annually from 1997 to 2004. Data were collected from five sources: The Statistical Bank at Statistics Denmark, the Key Figure Base [Nøgletalsbasen] at the Ministry of the Interior, the Ministry of Urban and Housing Affairs' (2000) report on regulation of housing rents, and the Danish Tax Authority's [Told & Skat] (2004) report on property sales prices. Table 2 presents an overview of the data applied, including variable short-hands, definitions and a few descriptive statistics.

[Table 2 around here]

Figure 1 shows the distribution of the variables (averaged over years) across municipalities. Several indications of spatial clustering are observed for the home ownership rates as well as for the explanatory variables. Thus, spatial spillover may potentially be present and needs to be adjusted for.

[Figure 1 around here]

4. Methodology

The point of departure is the linear regression model defined for the *N*=270 municipalities by

(1) $$y_t = X_t\beta + \upsilon_t, \quad \upsilon_t \sim N(0, \sigma^2 I)$$

where X_t is an *N* by *K* dimensional matrix of *K* explanatory variables, y_t an *N* dimensional vector of endogenous observations, and β a *K* dimensional coefficient vector. While pooled data for *T* years are applied, the residuals between years are correlated, and the variances within each year will vary across years, i.e., between any two years, the residual covariance reads as

(2) $$E(\upsilon_t'\upsilon_s) = \sigma_{ts}^2 \quad t, s = 1,..,T\,.$$

Thus, to obtain efficient estimates of β, Lauridsen et al. (2006) applied Feasible Generalised Least Squares (F-GLS) estimation to obtain the Zellner (1962) Seemingly Unrelated Regression (SUR) estimates for β. Further, to allow for variation of β across years, they further added interaction terms between some of the X_t variables and a time trend *T*.

As the model is estimated with regional data, dependencies between the cross-sections have to be taken into account. It is intuitively clear that the housing market is not restricted to realise itself

within a single municipality, but rather flows over the municipality borderlines. Operationally, the home ownership rate (y_t) may not only be determined by the explanatory variables in the municipality itself (X_t), but also by values of X_t in the surrounding municipalities, i.e., *exogenous spatial spillover* may occur. Further, if the demand for home ownership in the surrounding municipalities is high, this demand may spill over and induce demand in the municipality in question, i.e. *endogenous spatial spillover* may occur. Alike any other omission of relevant variables, ignorance of spatial spillover may bias the results obtained (Anselin, 1988). Traditionally, control for spatial spill-over is obtained by adding spatial parameters to the model in question (Paelinck and Klaassen, 1979; Cliff and Ord, 1981; Anselin, 1988; Florax, 1992; Anselin, 2000). Operationally, endogenous spatial spillover may be controlled for by adding the average of y_t in the neighbourhood municipalities (denoted by y_t^W) as an explanatory variable in (1) to obtain the *spatially autoregressive* (SAR) specification (Anselin, 1988)

(3) $$y_t = y_t^W \lambda + X_t \beta + \upsilon_t ,$$

where λ is a parameter specifying the magnitude of spill-over, formally restricted to the interval between (-1) and (+1), but for most practical purposes restricted to be non-negative. Likewise, exogenous spatial spillover may be controlled for by adding the averages of X_t in the neighbourhood municipalities (denoted X_t^W) as explanatory variables in (1) to obtained the *spatially distributed lag* (SDL) specification (Florax, 1992)

(4) $$y_t = X_t \beta + X_t^W \delta + \upsilon_t ,$$

while both types of spillover may be controlled for simultaneously by simply adding both y_t^W and X_t^W to obtain a combined SAR-SDL specification. One further approach commonly applied is to

defer the entire matter to be a *residual spatial spillover* by respecifying (1) as the *spatially autocorrelated* (SAC) specification (Anselin, 1988)

$$(5) \qquad y_t = X_t\beta + \varepsilon_t\,,\ \varepsilon_t = \lambda\varepsilon_t^W + \upsilon_t\,,$$

but this specification is merely a special case of the SAR-SDL obtained by imposing restrictions on the λ and δ parameters, and will therefore not be applied here. All these specifications are easily integrated with the SUR framework, so that spatial spill-over and dynamic patterns are controlled for simultaneously (Anselin, 1988; Florax, 1992)[2].

Finally, an issue related to *identification* was considered by Lauridsen et al. (2006): The prices of home ownership depress the demand for owner-occupied housing. At the same time a shift in the demand function will affect the equilibrium prices in the same direction as the shift. Hence, prices and home ownership are simultaneously determined, so that any of the above estimation will yield biased results (Greene, 2003). A proper solution is to use instrumental estimation (Greene, 2003) where a supply-side variable is applied as an instrument for prices. As such an instrument, Lauridsen et al. (2006) applied the amount of finished buildings per capita. The present study will follow this approach throughout and thus apply instrumentalised prices.

To provide devices for comparison of alternative models, some quantities are applied. One is a pseudo-R-square (R^2), calculated as the square of the correlation between y and its predicted values. This measure is readily calculated for the SUR and the SUR-SDL models, but it is not

[2] One difficulty of these spatial SUR specifications is related to estimation. While the SDL adjusted SUR specification can be consistently estimated using the F-GLS procedure by simply adding X_t^W to the explanatory variables, the SAR and the SAR-SDL adjusted SUR specifications cannot be estimated consistently by the F-GLS due to the contemporaneous correlation among the observations in y_t (Anselin, 1988). Consistent estimates are obtained using the following Maximum Likelihood approach: We did a grid search of the relevant values of λ from -1 to +1. Conditioned on each λ, the F-GLS procedure was performed using $(y_t - \lambda y_t^W)$ instead of y_t. Finally, the set of results which maximized the log likelihood function (Anselin, 1988) was selected.

defined for the SUR-SAR specification. A second device applied is the familiar Akaike Information Criterion (AIC) calculated as (-2LogL + 2*K*). Finally, nested models are tested against each other using Likelihood Ratio (LR) test, calculated as twice the difference between the values of the log likelihoods of the two models.

5. Results

Table 3 repeats in the second column the SUR model established by Lauridsen et al. (2006). It is especially noticed that the effects of prices as well as of short- and medium-term price changes have the expected signs, although the price is insignificant. As demonstrated by Lauridsen et al. (2006), some of the determinants exerted an effect on home ownership rate which decreased or increased through years. For subsidized housing, the impact is negative but gradually reduced throughout the period from 1999 to 2004 as indicated by the interaction term with time. The impact of housing subsidies is positive in the beginning of the period but gradually moves toward significantly negative throughout the period as shown by the time interaction. Rent subsidies has a negative impact as expected, and the interaction with time show that this effect is gradually strengthened in the period from 1999 and onwards. Rent regulation has the expected negative impact, but this impact is gradually reduced through the period as illustrated by the interaction term. For urbanisation and proportion of divorced, the effects are negative, but their interaction terms with time illustrate that they significantly reduce toward zero over time. Considering proportion of 7-16 year olds, the effect is gradually moving from insignificantly positive/negative to significantly negative during the period as shown by the interaction with time. Thus, these demographic variables share a common feature of having an effect on home ownership rate, which is significant, but mostly reduced in magnitude during the period. The remaining determinants were not found to exert time-varying effects on home ownership. With a few exceptions, the signs of these effects

corresponded to prior expectation. As exceptions, property taxes and proportion of unemployed exerted significantly positive effects, while proportion with further education exerted a negative effect.

[Table 3 around here]

To benchmark the SUR results, a simple OLS, which is not adjusted for dynamic patterns alike the former, is provided in the first column of Table 3. With the exception of proportion of social disability pensioned, for which the effect changes from significantly negative to significantly positive, none of the effects exert a significant shift in sign, but it is evident that several determinants loose explanatory significance. Further, the log likelihood as well as the AIC and the LR test strongly favour the SUR for the OLS specification. Thus, the inefficiency occurring if ignoring dynamic patterns is clearly demonstrated.

Next, attention is turned to the spatially adjusted models, which are reported in the remainder of Table 3. For the SAR-SUR (3), which controls for endogenous spatial spillover by adding a spatial lag of home ownership rates to the SUR specification, it is first of all noticed that the LR test for the SAR-SUR versus the unadjusted SUR (2) does not reject the latter in favour of the former. This conclusion is supported by the insignificance of the spatial lag of home ownership rates and by the log likelihood and AIC values, which are practically equal for the two specifications. Further, a quick look through the estimated effects of determinants reveals that neither the signs nor the magnitude or the significance levels of these deviate across the two specifications.

A different picture is obtained when comparing the unadjusted SUR (2) to the SDL-SUR (4) which adjusts for spatial spillover of the determinants (i.e. the terms X_t^W of equation (4)). The LR test of (4) versus (2) strongly rejects the unadjusted SUR in favour of the SDL-SUR. This conclusion is

supported by the log likelihood and AIC values, which are larger and smaller, respectively, for the SDL-SUR than for the unadjusted SUR. A closer look at the effects of determinants, reported in the first column of (4), reveals substantial differences as compared to the unadjusted effects of (2). It is especially noticed that the effects of short- and medium-term price changes are no longer significant. Thus, the effects of local price dynamics seem to be overestimated when ignoring control for spatial spillover occurring from the supra-municipal nature of the housing market. On the other hand, several effects of determinants capturing population structure seem to be overestimated by the unadjusted SUR. This is especially the case for population proportions of divorced, educated, early retired, social benefit receivers, and inhabitants from third countries. Thus, it is clearly demonstrated that ignorance of controlling for spatial spillover (occurring from a discrepancy between the small area or intra-municipal nature of the data and the large area or supra-municipal nature of the housing market) leads to seriously skewed conclusions regarding effects of important determinants of home ownership rates.

The second column of the SDL-SUR (4) reports the effects of spatial lags of determinants. Though it should be kept in mind that these effects are not of explicit interest, but rather added as controls to ensure proper conclusions regarding effects of the determinants, interesting information regarding the functioning of the housing market may be obtained. Thus, a weakly positive effect of spatially lagged prices is found. This indicates that high prices in the surrounding municipalities may – ceteris paribus – lead to increased homeownership rates in the municipality. An alike positive spill-over effect is exerted by high property taxes in surrounding municipalities. As the direct property tax effect is positive, the positive spill-over reflects some clustering of municipalities with relatively high home ownership. Applying municipal cross section data, this clustering phenomena is not surprising given that planned localisation of owned dwellings in the past (mainly one-family house areas) as well as the localisation of apartment complex areas has not followed municipal borders of

today. The positive spill-over effect could also be the result of a tendency at local policy-makers (which in Denmark decide on real property taxes) to follow the levels of taxes imposed in the region the purpose being to pre-empt tax evasion from own locals into surrounding locals.

The significantly *positive* spillover exerted by the population proportions of divorced and inhabitants from third countries appear less intuitive, given that the direct effect on homeownership of these variables are both *negative*. As to the divorce factor, a possible explanation appears from a combination of the facts that home owners getting divorced on the one hand tend to give up ownership (partly for direct economic reasons as two formerly mutual incomes need to finance two future households, and partly for lowering expected future residential switching costs following from a higher likelihood of a future change from single status to new marital status). On the other hand, people's preferences for staying in a region after divorce may remain and they therefore prefer to settle down in less expensive rented dwellings in nearby areas. This would explain the countervailing spatial effect on the direct divorce effect. A similar movement pattern for immigrants may in fact be behind the positive spatial spillover for 3rd countries. The Danish Integration Act give municipalities responsibility for integration of refugees, and for the purpose of achieving a more equal distribution of refugees among municipalities, newly arrived refugees are generally required to remain in their allocation municipality in a three-year introduction period. Presumably to follow ethnic network, there is however a clear tendency for refugees to move to rented dwellings in nearby larger cities with larger populations of immigrants[3].

To round off the analysis of spatial spillover, the SAR-SDL-SUR (5) controls for endogenous as well as exogenous spillover simultaneously. Looking through the effects of the determinants as well as their spatial lags reveals no practical differences as compared to the SDL-SUR. Thus, the

[3] See Nielsen and Blume (2006) for a thorough statistical description of settlement patterns and mobility of refugees in Denmark.

conclusions from the treatment of the SAR-SUR and the SAR-SDL separately are confirmed, i.e. it is spatial spillover of determinants rather than endogenous spillover which matters when focus is on proper evaluation of determinants of home ownership rates. On the other hand, the effect of endogenous spillover is significantly positive in the SAR-SDL-SUR, which it was not in the SAR-SUR, and the LR test of (5) versus (4) as well as the log likelihood and AIC values slightly prefer the SAR-SDL-SUR for the SDL-SUR. Thus – just as a bypass – it may be seen that in order to obtain a proper picture of spatial spillover effects, one has to control for … spatial spillover. However, whether the full SAR-SDL-SUR or the restricted SAR-SDL specification is preferred, the central message is unchanged: The necessity of controlling for spatial spillover, in order to obtain proper conclusions regarding the effects of determinants on home ownership rates, is urgent.

6. Conclusions

The present investigation of determinants of home ownership rates adds to previous knowledge and suggests revision of traditional modelling practice (like application of OLS estimation). It is confirmed that adjustment for inter-temporal residual correlation and heterogeneity is essential in order to obtain efficient estimation of the effects of explanatory characteristics on home ownership rates, when applying pooled small area cross sections. Further, the necessity of controlling for spatial spill-over effects is demonstrated. Endogenous spatial spill-over is found to be of some – but less – relevance, while exogenous spatial spill-over matters seriously. Especially, the effects of price dynamics seem to be heavily overestimated if control for spatial spill-over is ignored, while the effect of several population characteristics seem to be strongly underestimated. Finally, it is demonstrated that the spatial spillover effects in themselves may contain valuable information regarding the functioning of the housing market. In particular, the spatial lags of prices were found to induce demand for home ownership. Thus, the urgency of simultaneously adjusting for the cross

sectional nature as well as the dynamic properties of the data when analysing (large area) housing market behaviour using pooled (small-area) cross section data is clearly illustrated.

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Table 1. Variables affecting home ownership rates

Variable	Explanation
Prices Actual price (-) One-year price change (-) Three-year average price change (+)	High prices and short-run price increases make it difficult to buy home. Medium-term price changes stimulate the expectation of future increasing prices and thus the propensity to buy.
Favourable tax treatment of home owners Tax bracket (+)	A favourable tax treatment triggered by ownership tends to raise ownership rates; such treatment, e.g. a low imputed rent, is typically more valuable for higher income tax brackets.
Rent subsidy (-) Rent control (-) Urban restriction on ownership (-)	Home ownership rates are reduces if an income subsidy is triggered by renting vs. owning. If rent control artificially keeps the rent on rented homes below the market equilibrium this also reduces demand for owned housing. If, e.g. for social reasons, only a fraction of homes can be owned, this potentially reduce home ownership rates.
Financial capacity Income (+) Nationality (?) Educational level (+) Other personal characteristics Special life events (e.g. divorce, bequest, lottery)	With asymmetric information on financial markets, various indicators of borrowers (home owners) repayment ability will influence home ownership rates.
Expected occupation time Age (-) Rate of "under education" (-) Job type	Ownership starts with closing or contracting costs that have to be balanced against benefits in each occupation year. If the expected number of occupation years is low, ownership rates tend to fall. Expected occupation years may also fall with some job types.
Production efficiency for landlords vs. owner-occupiers Congestion (-)	Where many live together landlord scale economies for production of housing services may be pronounced.
Households differs in benefit from adapting their home Self employed (+) More than one child (+) High rent area (-)	Idiosyncratic variations in the benefit households or individuals get from individual adaptation of homes leads to a market screening where owners benefit most. High rents reduce net benefit most for owners and squeeze some owners into renters.
Social heritage Parents tenure choice	People tend to demand the type of dwelling they used to live in as child.
Lifestyle Rate of single households (-)	Modes of living, e.g. free single life vs. tied family life influence ownership rates.

Note: A (+) indicates a positive correlation between the variable and the home ownership rate.

Table 2. Data applied

Variable	Definition	25% quartile	Median	75% quartile
Home ownership (dependent variable	% of housing units occupied by owner (cooperative housing and student hostels omitted)[(1)]	62.00	71.00	76.00
Price	Average sales price (real DKK) per square meter of one-family houses[(4)]	51.86	55.73	73.48
Short term price change	Defined as ($Price_{i,t} - Price_{i,t-1}$) / $Price_{i,t-1}$	0.034	0.055	0.079
Medium term price change	Defined as ($Price_{i,t} - Price_{i,t-3}$) / $Price_{i,t-3}$	0.095	0.225	0.285
Subsidized housing	of population living in subsidized housing [*almennyttige boliger*] [(2)]	5.00	9.00	17.00
Housing subsidy	% of households receiving housing subsidies [*boligydelse*] [(2)]	8.90	10.90	13.25
Rent subsidy	% of 15-66 year old receiving rent subsidies [*boligsikring*] [(2)]	2.90	4.00	5.90
Regulated	Rent Regulation Act assumed by 2000 (1=yes, 0=no) [(3)]	Proportion "yes"=0.556		
Property tax	Real Property Tax (in 0/00) [*Grundskyldspromille*] [(2)]	8.00	12.00	15.00
Tax rate	Municipal + county tax rate (in %) [*Udskrivningsprocent*] [(2)]	20.20	20.80	21.30
Tax base	Tax base [*beskatningsgrundlag*] per inhabitant (100.000 DKK) [(2)]	9.94	10.97	12.10
Population density	Inhabitants per square kilometre (10000 [(2)]	48	69	147
Urbanisation	% of population living in urban areas[(2)]	61.00	71.00	86.00
7-16 year	% of population aged 7-16[(1)]	11.90	12.90	13.90
17-25 year	% of population aged 17-25[(1)]	8.07	9.09	10.21
26-35 year	% of population aged 26-35[(1)]	11.74	12.82	13.89
36-66 year	% of population aged 36-66[(1)]	40.55	42.33	44.27
67+ year	% of population aged 67 and over[(1)]	12.00	13.50	15.00
Widowed	% of population widowed[(1)]	5.91	6.61	7.37
Divorced	% of population divorced[(1)]	4.86	5.82	7.40
Unmarried	% of population unmarried[(1)]	41.91	43.54	44.80
Adult children	% of households with children over 18[(1)]	7.68	8.76	9.88
No children	% of households without children under 18[(1)]	0.00	3.06	5.62
Educated	% of population with higher education[(2)]	11.50	13.60	16.45
Social Disability Pension	% of population on social disability pension [*førtidspension*] [(2)]	6.25	7.40	8.80
Social Benefit receivers	% of population receiving social benefits [*kontanthjælp*] [(2)]	6.70	8.00	9.60
Unemployed	% of population (17-66 year) unemployed[(2)]	3.60	4.40	5.40
3rd countries	Number of citizens from countries outside EU, Scandinavia and North America per 10,000 inh. [(2)]	10.60	15.70	23.60
Finished new buildings	Finished new buildings (m^2 per capita)[(1)]	0.84	1.37	2.06

Sources: [(1)] Statistics Denmark; [(2)] The Key Figure Base; [(3)] The Ministry of Urban and Housing Affairs; [(4)] The Danish Tax Authority.

Table 3. OLS and SUR models

Variable	(1) OLS	(2) SUR	(3) SAR-SUR	(4) SDL-SUR		(5) SAR-SDL-SUR	
Constant	183.72***(14.36)	149.81***(10.44)	150.04***(10.41)	125.88***(22.75)		107.99***(22.97)	
Price	0.061***(0.014)	-0.005 (0.004)	-0.005 (0.004)	-0.005 (0.004)	0.014* (0.007)	-0.005 (0.003)	0.014** (0.007)
Short term price change	-5.220* (2.840)	-2.222***(0.589)	-2.249***(0.591)	-1.521 (0.976)	-0.819 (1.105)	-1.536 (0.973)	-0.476 (1.103)
Medium term price change	5.196** (2.201)	1.678** (0.714)	1.679** (0.715)	1.495 (1.131)	0.848 (1.360)	1.527 (1.128)	0.577 (1.355)
Subsidized housing	-0.504***(0.038)	-0.567***(0.031)	-0.569***(0.030)	-0.571***(0.031)	-0.017 (0.043)	-0.562***(0.030)	0.043 (0.045)
Housing subsidies	-0.732***(0.104)	-0.127***(0.047)	0.128***(0.047)	0.127***(0.048)	0.041 (0.058)	0.105** (0.047)	0.043 (0.057)
Rent subsidies	-0.577***(0.183)	-0.115 (0.098)	-0.114 (0.097)	-0.085 (0.099)	-0.092 (0.107)	-0.102 (0.098)	-0.049 (0.107)
Regulated	-1.052** (0.493)	-2.725***(0.568)	-2.722***(0.565)	-3.193***(0.535)	0.227 (0.725)	-3.181***(0.530)	0.490 (0.728)
Property tax	0.141***(0.015)	0.036** (0.018)	0.036** (0.017)	0.028 (0.018)	0.098***(0.032)	0.026 (0.017)	0.093***(0.032)
Tax rate	-0.166** (0.077)	-0.036 (0.071)	-0.034 (0.070)	-0.005 (0.070)	-0.017 (0.133)	-0.008 (0.069)	-0.016 (0.132)
Tax base	-0.696***(0.065)	0.008 (0.047)	0.007 (0.046)	-0.015 (0.050)	0.101 (0.090)	-0.014 (0.049)	0.096 (0.089)
Population density	-18.25***(1.469)	-25.03***(3.066)	-25.77***(3.294)	-26.78***(5.318)	-22.90***(8.775)	-26.05***(5.333)	-19.92** (8.814)
Urbanisation	-0.037** (0.018)	-0.099***(0.018)	-0.099***(0.018)	-0.089***(0.018)	0.035 (0.029)	-0.088***(0.017)	0.043 (0.028)
7-16 year	-0.190 (0.218)	-0.049 (0.117)	-0.047 (0.116)	0.011 (0.119)	-0.338* (0.205)	0.004 (0.18)	-0.313 (0.203)
17-25 year	-0.894***(0.147)	-0.561***(0.106)	-0.558***(0.106)	-0.553***(0.107)	-0.060 (0.205)	-0.551***(0.106)	0.028 (0.204)
26-35 year	-0.306 (0.201)	-0.391***(0.125)	-0.387***(0.125)	-0.406***(0.125)	0.294 (0.245)	-0.413***(0.124)	0.345 (0.243)
36-66 year	-0.485***(0.150)	-0.223* (0.115)	-0.217* (0.114)	-0.261** (0.114)	0.053 (0.224)	-0.263** (0.113)	0.084 (0.222)
67+ year	-0.654***(0.162)	-0.829***(0.126)	-0.822***(0.124)	-0.907***(0.127)	0.332 (0.250)	-0.908***(0.126)	0.437* (0.250)
Widowed	-0.892***(0.175)	-0.353** (0.152)	-0.348** (0.151)	-0.276* (0.151)	0.034 (0.301)	-0.267* (0.149)	0.093 (0.299)
Divorced	-0.817***(0.195)	-0.965***(0.142)	-0.969***(0.142)	-1.194***(0.146)	0.687***(0.222)	-1.162***(0.144)	0.737***(0.220)
Unmarried	-0.953***(0.091)	-0.525***(0.081)	-0.520***(0.080)	-0.467***(0.082)	0.157 (0.162)	-0.474***(0.081)	0.228 (0.162)
Adult children	0.483***(0.093)	0.195***(0.049)	0.194***(0.049)	0.178***(0.049)	0.024 (0.098)	0.177***(0.049)	-0.014 (0.097)
No children	2.507** (1.109)	0.531 (0.410)	0.533 (0.410)	0.278 (0.411)	-1.545* (0.874)	0.313 (0.408)	-1.561* (0.868)
Educated	0.042* (0.023)	-0.035 (0.038)	-0.036 (0.037)	-0.104** (0.042)	0.098 (0.067)	-0.104** (0.042)	0.099 (0.067)
Social Disability Pensioned	0.117* (0.061)	-0.184** (0.076)	-0.179** (0.076)	-0.209***(0.079)	0.005 (0.139)	-0.212***(0.078)	0.020 (0.138)
Social benefit receivers	0.026 (0.054)	-0.116***(0.042)	-0.114***(0.041)	-0.147***(0.042)	0.034 (0.080)	-0.151***(0.041)	0.042 (0.079)
Unemployed	0.014 (0.073)	0.118***(0.046)	0.119***(0.046)	0.087 (0.054)	0.095 (0.080)	0.082 (0.053)	0.079 (0.079)
3rd countries	0.004 (0.020)	-0.020* (0.012)	-0.020* (0.012)	-0.027** (0.012)	0.054***(0.016)	-0.028** (0.011)	0.057***(0.015)
Time*Subsidized housing	0.012** (0.006)	0.015***(0.003)	0.015***(0.003)	0.016***(0.003)		0.014***(0.003)	
Time*Housing subsidies	-0.029 (0.017)	-0.043***(0.008)	-0.043***(0.008)	-0.044***(0.009)		-0.040***(0.008)	
Time*Rent subsidies	-0.052* (0.029)	-0.046***(0.013)	-0.046***(0.013)	-0.053***(0.014)		-0.047***(0.013)	
Time*Regulated	0.131 (0.084)	0.160***(0.042)	0.161***(0.042)	0.174***(0.041)		0.164***(0.040)	
Time*Urbanisation	0.009***(0.003)	0.003* (0.002)	0.003* (0.001)	0.005***(0.002)		0.004***(0.001)	
Time*7-16 year	-0.001 (0.013)	-0.020***(0.007)	-0.020***(0.007)	-0.024***(0.008)		-0.021***(0.008)	
Time*Divorced	0.056* (0.029)	0.063***(0.014)	0.064***(0.013)	0.063***(0.015)		0.055***(0.014)	
Time*3rd countries	-0.005 (0.004)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)		-0.001 (0.001)	
Home ownership (spatial lag)			-0.012 (0.018)			0.122***(0.026)	
R-Square	0.961	0.932	-	0.944		-	
LogL	-2361.73	-655.18	-656.36	-611.97		-605.68	
AIC	4797.46	1426.35	1428.74	1391.94		1381.37	
LR (2)-(5) versus (1)		3413.10***	3410.74***	3499.52***		3512.1***	
LR (3)-(5) versus (2)			2.36	86.42***		99.00***	
LR (5) versus (3)-(4)			101.36***	12.58***			

Note. Significance indicated by ***(1%), **(5%), *(10%). Standard errors in parentheses. Second columns of (4) and (5) are coefficients of exogenous spatial lags.

Figure 1. Geographical distribution of variables (average 1999-2004).

Figure 1 (continued)

Figure 1 (continued)