Demand for Owner Occupied Homes in Danish Municipalities – A Spatial Analysis(**).

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PRELIMINARY DRAFT – NOT TO BE QUOTED WITHOUT PERMISSION

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Abstract.

Theories on determinants of demand for owner occupied homes are summarised. An operational model which can be applied for empirical testing of theory is established. The model is estimated using Danish data.

Theoretical determinants of the demand for owner occupied homes include social composition of population (age, social benefit receivers, household composition, civil status, education, nationality), economic ability (income), public regulation (regulation of house rent, housing subsidies, taxation), competition from alternative residence forms (measured by supply of subsidized housing), and population density.

The data to be applied are aggregate data for 270 Danish municipalities, available annually for the period 1994-2004.

An initial model specifies that the effects of the determinants are constant during the period 1994-2004. Presence of non-linearity, time trends, parametric instability and spatial spill-over are investigated and accounted for. Upon these adjustment, the empirical results generally

confirm that the impacts of these determinants correspond to theory. Adjustment for spatial spill-over is further shown to be important, as such spill-over modifies the impact of the determinants.

1. Introduction

The purpose of the present study is to establish a model for demand of owner occupied homes in Denmark for the period 1994 to 2004.

Theories on determinants of demand for owner occupied homes are summarised in Part 2. Theoretical determinants of the demand for owner occupied homes include social composition of population (age, social benefit receivers, household composition, civil status, education, nationality), economic ability (income), public regulation (regulation of house rent, housing subsidies, taxation), competition from alternative residence forms (measured by supply of subsidized housing), and population density.

An operational model which can be applied for empirical testing of theory is established in Part 3. Relevant methodological issues are considered. Issues related to the application of pooled cross sectional data are discussed. This include parametric instability over time and adjustment for dependency caused by repeated observation. Further, issues related to functional form is considered, i.e. linear versus non-linear relationship among variables. Finally, issues related to application of spatial cross sections are considered, i.e. potential presence of spatial spill-over.

Part 4 describes the data to be applied. These are aggregate data for 270 Danish municipalities, available annually for the period 1994-2004.

The empirical models are presented in Part 5. An initial model specifies that the effects of the determinants are common during the period 1994-2004. Within this model, issues of non-linear relations are resolved. Next, parametric instability over time, together with adjustment for dependency across time periods and spatial spill-over is addressed using an SUR model with time-specific parameters. It is found that the parametric instability over time can be ascribed to time patterns in the parameters so that a simplified specification with time interactions can be established.

2. Demand for owner occupied homes.

Demand for owner occupied homes is a fraction of total demand for homes or residential units, the other part being rented homes. The purpose of the present paper is not to estimate the absolute demand for owner occupied homes, but to find determinants for the fraction of owners based on Danish data. The question to be answered is thus which factors significantly influence the home ownership rate and so the choice between owning and renting.

2.1. Theoretical considerations

Basically, individuals or families choose to own the stock from which housing services flow if it is most optimal or welfare maximizing given their specific economic environment. Thus changes of the economic environment may lead to a shift of the optimal choice away from ownership or into ownership. It follows that a listing of the decisive factors in the economic environment will also be a listing of factors that influence the demand for owner occupied homes.

Linneman (1986), Rothenberg, Galster, Butler and Pitkin (1991), and Hansen and Skak (2004) put together give a comprehensive list of potential explanatory variables for home ownership rates.

Typically, a *favourable tax treatment* of homeowners is mentioned first as a very important factor behind homeownership. One should, however, keep in mind that it is the differential tax treatment between housing units that are owned or rented, and between persons that live in owned or rented homes that matters. Concerning the taxation of housing units, a real estate tax in general disfavours housing investments compared to other investment opportunities but plays no role for the choice between renting and owning when it has to be paid both by the home owner and the landlord. In the same way, the possibility of deducting interest payments on loans that finance housing in taxable income does not favour ownership when the interest payments are deductible no matter who lives in the housing unit, an owner or a renter. Concerning the taxation of occupants, the most widespread favourable tax exemption that favours ownership is the low or non existent tax on the imputed and often underestimated value of the flow of housing services to owner-occupiers. This gives owner-occupiers a low net rent compared to non owners, and it is lower the higher is the *marginal tax rate – or tax bracket - of the income earner*. Also landlords may be treated preferentially; i. e. by favourable depreciation rates and/or direct subsidies, which on a competitive market will benefit the renter through lower rent. An owner of an estate can also expect to get a low taxed income through the increase of the market value of the estate that evolves from increased congestion. Typically, the supply of land (of a specific quality) is limited while demand increases due to population growth and this drives prices higher than justified by increasing construction costs. If landlords have to pay full taxation of such capital income while home owners have no or a reduce tax rate, this gives an advantage for home ownership, and more so the higher is the marginal tax rate of the income earner. Finally, is important to stress that landlord gains are only passed fully to renters with an inelastic demand under perfect competition. With a housing market cut into many sub markets, monopolistic competition and oligopoly better characterise the markets and hence, landlord gains are only partly transferred into lower rents.

If, on the other hand, an income subsidy is triggered by renting vs. owning, home ownership rates are reduced. Moreover, if rent control artificially keeps the rent on rented homes below the market equilibrium this also reduces demand for owned housing. Finally, if, e.g. for social reasons, only a fraction of homes can be owned because a big supply of rented homes is wanted, this can potentially reduce home ownership rates, but only if the restriction limits the supply of owned homes compared to a free market.

Another important factor is the *borrowing capacity* of individuals or households. To buy a home is very costly for most persons and is typically done with a combination of a down payment supplemented with a loan to be repaid over a number of years, and with the house or apartment used as collateral. If the person fails to service the debt, the borrower will try to sell the housing unit to recoup the loan. But it is costly to sell a house and the revenue is insecure, and hence the borrower will prefer to give loans to persons with good credit rating. Many people may well prefer to be owner-occupiers, but are unable to buy their homes because of low borrowing capacity. With credit rating or borrowing capacity increasing with the (expected future) annual income level of persons, one can expect ownership rates to increase with *household income*. Other factors that may affect credit rating, and hence ownership rates, are *ethnicity* and *race*, *educational level*, and more generally *personal characteristics* and *former events* that a lender finds important for the credit rating. In countries where institutions require a considerable down payment, wealth will play a corresponding important role relative to (expected future) annual income. This seems to be the case on the American housing market, see Gyourko (2003).

Owning a home is costly not only because of the debt servicing that typically follows after the buying, but also because salaries to real estate agents and lawyers, and document fees make the buying process expensive. Similar costs are low or non existent for a renter, which clearly shows that owning must carry compensating advantages compared to renting. Because the buying or *closing costs* are high for owners and the advantages from owning are part of the annual flow of housing services for owner-occupiers, it follows that the *expected occupation time*, and factors that influence the closing costs will also influence home ownership rates. In example, one would expect students to be primarily renters as they do not expect to stay put for many years. High closing costs furthermore gives a *locking in effect* that reduces geographical mobility as noted by Oswald (1997).

Linneman (1986) also invokes *differences in production efficiency between landlords and owner-occupiers* as an important factor behind ownership rates. In example, landlords internalise externalities that cause problems among neighbours in multi family structures and may be able to use their buying power to reduce maintenance costs. But this higher efficiency of landlords in the supply of housing services may well be more than fully offset by costs from monitoring the renter and limitations on the renters use of the housing unit – and so the housing services that flow from unit. Linneman (1986) holds the opinion that high production efficiency by landlords in high density residences is the reason why ownership rates tend to fall when one travel from the countryside and into city centres. Hansen and Skak (2004) takes the unorthodox view that *persons or households differs with respect to the benefit they gain from individual adaptation of housing units*, i. e. by changing and painting rooms, to suit their preferences. Because of contracting problems, owner-occupiers have much more freedom in adaptation and this potentially offsets the closing costs of owner-occupancy. The model gives a sorting mechanism, where owners are persons with strong preference for individual adaptation of their home. With high rent levels in congested cities, this model also explains why ownership rates tend to fall from the countryside and into city centres. A disadvantage of the model is that it is difficult to identify or rang persons after their preference for individual home adaptation. However, Ærø (2002) shows an exceptional high renovation and repair activity among home owners. A priori, one would also expect self employed to be more individualistic oriented than wage earners and hence have higher ownership rates than wage earners. Also growing families (i.e. families with more than one child) can be expected to demand ownership, because of the need to change the interior of homes when children are born. This has yet to be empirically tested.

Table 1 resumes the variables that, following economic theory, can be expected to influence ownership rates. In addition to economic factors behind demand for owner occupied homes, more sociological relations play a role. Two seem of special relevance. First, a *social heritage* is present; people tend to demand the type of dwelling they used to live in as child and this also counts for their tenure choice. The consequence for the housing market is that tenure patterns may be very persistent and change only slowly over generations. Second, demand may come from the wish of the consumer to manifest himself as a member of a specific social group and lifestyle. Such behavioural patterns could give long lasting bubbles in tenure patterns as modes gather momentum, peaks and decays. The consequence for an econometric analysis of tenure pattern is that ownership rates to day are influenced by yesterday's ownership rates. In a more permanent way, the proportion of singles that want to remain free and movable would tend to lower home ownership rates.

[Table 1 around here]

2.2. Empirical evidence and background.

During the 1980'es and 1990'es, the Danish housing supply improved substantially in quality as well as in quantity. For the first decade, this development was connected to an increase in the demographically related housing need, while the changes in this need was relatively low in the 1990'es as compared to the increase in supply. Thus, the major determinants during the 1990'es are related to changes in request to housing. Three major trends are well identified (Byforum, 2001): First, an increasing number of persons over 18 live together with parents. Second, fewer young families live in owner occupied homes. Third, some of the weak groups have received poorer housing conditions. Apart from retired people, who improved their housing conditions, unemployed, social benefit receivers and immigrants have substantially worsened housing conditions than the population on average.

As compared to other European countries, Denmark has a strong regulation of conditions and prices for private rental homes, and further a price regulation of subsidized housing which is determined by costs and not by market prices or quality concerns. For certain areas, this has led to a mismatch between supply and demand, an excess demand for rental housing, and a reduced mobility (Lejelovskommisionen, 1997; Socialministeriet, 2004; Det Økonomisk Råd, 2001).

3. Methodology.

Based on aggregate data from a sample of 270 Danish municipalities observed annually from 1994 to 2004, a regression model is to be estimated to investigate the effects of determinants on the demand for owner-occupied homes. Due to the nature of the data, some methodological developments are called for. First, as data occur from repeated observation in consequent time periods, adjustment for heterogeneity is necessary, as the residual variance of the regression model may change. Further, adjustment for inter-temporal correlation among observations is necessary. These adjustments are captured using a spatial SUR framework as outlined in Section 3.1. Second, due to the spatial cross-section nature of data, further adjustment of the SUR model for spatial spill-over effects are necessitated in order to obtain consistent and efficient estimates. These adjustments are outlined in Section 3.2.

3.1. The SUR model.

Assuming only one cross-section - i.e. data for only one period – a simple linear model reads as

(1) $$\mathbf{y_t} = \mathbf{X_t}\boldsymbol{\beta}_\mathbf{t} + \boldsymbol{\mu}_\mathbf{t}\ ,\ \ \boldsymbol{\mu}_\mathbf{t} \sim \mathbf{N}(\mathbf{0}, \sigma^2_t\mathbf{I})$$

where $\mathbf{X_t}$ is an n by k matrix of explanatory variables, y an n dimensional vector and $\boldsymbol{\beta}_\mathbf{t}$ a k dimensional coefficient vector. The regression vector $\boldsymbol{\beta}_\mathbf{t}$ is traditionally estimated by means of Ordinary Least Squares (OLS), while $\boldsymbol{\mu}_\mathbf{t}$ is assumed to have a homoscedastic and diagonal variance matrix.

Applying data for T periods leads to T equations, one for each time period, where the T equations will in general be intercorrelated, and the variance for the single cross section will vary over time. The covariance matrix for the full system will thus be heteroscedastic and non-diagonal. The variance- and covariance matrix between any two periods reads as

(2) $$E(\boldsymbol{\mu}_s \, \boldsymbol{\mu}_t') = \sigma^2_{ts}\mathbf{I}_n \,,\; t,s = 1, .. , T$$

The covariance matrix $\boldsymbol{\Sigma}_0$ for the entire system of nT observations is the nT by nT matrix

(3) $$\boldsymbol{\Sigma}_0 = \{\sigma^2_{ts}\mathbf{I}_n\}_{t,s=1,..,T} \;=\; \boldsymbol{\Sigma} \otimes \mathbf{I}_n$$

where $\boldsymbol{\Sigma}$ is the T by T matrix

(4) $$\boldsymbol{\Sigma} = \{\sigma^2_{ts}\}_{t,s=1,..,T}$$

For ease of notation, the equations may be stacked as follows: Let $\mathbf{y}$ be the nT dimensional vector constructed by concatenating $\mathbf{y}_1,..,\mathbf{y}_T$,where $\mathbf{y}_t$ is the dependent variable for period t. Define $\boldsymbol{\mu}$ and $\boldsymbol{\beta}$ in the same way, and define the NT by KT matrix $\mathbf{X} = \text{diag}(\mathbf{X}_1, .. , \mathbf{X}_T)$. The model can now be written in compact form as

(5) $$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\mu} \,,\;\; \boldsymbol{\mu} \sim \mathbf{N}(\mathbf{0},\boldsymbol{\Sigma}_0)$$

The model (5) can be estimated consistently, but not efficiently, by means of OLS. The inefficiency is due to the heteroscedasticity and the nondiagonality of $\boldsymbol{\Sigma}_0$, and causes inflation of the covariance matrix of the estimated parameters, which further inflate any inference based on these OLS results. As an alternative, GLS estimation is used to define the Zellner (1962) SUR estimate for $\boldsymbol{\beta}$, denoted $\boldsymbol{\beta}_{SUR}$, and a feasible GLS procedure applied to obtain a consistent estimate of the covariance matrix (see Appendix A.1 for details on estimation).

Inter-equation correlation and heteroscedasticity of the error term does not necessarily preclude $\boldsymbol{\beta}$ from being constant over time. This opportunity is tested using the Wald test described in Appendix A.1.

If $\mathbf{\beta}$ is found to be constant over time, it is reasonable to redefine $\mathbf{X}$ as the concatenating of $\mathbf{X_1}$, .. , $\mathbf{X_T}$, replace $\mathbf{\beta}$ with a *T* vector, and estimate the model on the form (5) using these. As an alternative, time-varying parameters may be specified to be a function of time, which is obtained by incorporating interaction variables with *T* for these variables.

3.2. SUR models with spatial effects.

The concept of spatial effects is quite intuitive: Assume that the demand for owner occupied homes is high in the municipalities surrounding a specific municipality in question. Then, the prices of owner-occupied homes will rise in these surrounding municipalities, so that their residents will demand owner-occupied homes in the municipality in question. Put another way – the demand for owner occupied homes in one municipality spills over to surrounding municipalities. Apart from such ‘endogenous’ spill-over, ‘exogenous’ spill-over may occur from the explanatory characteristics. For example, rising incomes in a specific municipality may lead to increased demand, not only in the municipality in question, but also in municipalities surrounding it. To make these concepts operational, specify an *n* by *n* matrix $\mathbf{W}$ where w_{ij} equals 1 if municipality *i* and *j* are neighbours ($i \neq j$) and 0 otherwise, and divide each element in $\mathbf{W}$ with the number of non-zero elements in the row it belongs to. Then, the product $\mathbf{W y}_t$ define a variable, which for each municipality holds the average of $\mathbf{y}$ in the neighbouring municipalities, and the endogenous spill-over captured by a spatially autoregressive (SAR) specification on the form (Anselin, 1988)

(6) $$\mathbf{y_t} = \lambda_t \mathbf{W y}_t + \mathbf{\mu}_t,$$

where λ_t is a parameter specifying the degree of spill-over, formally restricted to the interval between (-1) and (+1), but for most practical purposes restricted to be zero or positive (a negative parameter would indicate negative spill-over, i.e. increasing demand leads to 'drain' of demand in neighbouring municipalities). Enlarging the SAR with explanatory variables leads to the SAR-X specification

(7) $\mathbf{y_t} = \lambda_t \mathbf{W}\mathbf{y}_t + \mathbf{X_t}\boldsymbol{\beta}_\mathbf{t} + \boldsymbol{\mu}_t,$

which may finally be enlarged with terms allowing for exogenous spill-over, so that the SAR-X-DL specification (Florax, 1992)

(8) $\mathbf{y_t} = \lambda_t \mathbf{W}\mathbf{y}_t + \mathbf{X_t}\boldsymbol{\beta}_\mathbf{t} + (\mathbf{W}\mathbf{X_t})\boldsymbol{\delta}_\mathbf{t} + \boldsymbol{\mu}_t$

occurs. An interesting special case occurs, if the endogenous and exogenous spill-over are of proportional magnitude, i.e. if the restriction $\boldsymbol{\delta}_\mathbf{t} = \lambda_t \boldsymbol{\beta}_\mathbf{t}$ (the spatial Durbin restriction) holds true. Then, (8) may be rearranged as

(9) $(\mathbf{I}- \lambda_t \mathbf{W})\mathbf{y_t} = (\mathbf{I}-\lambda_t \mathbf{W})\mathbf{X_t}\boldsymbol{\beta}_\mathbf{t} + \boldsymbol{\mu}_t$

or

(10) $\mathbf{y_t} = \mathbf{X_t}\boldsymbol{\beta}_\mathbf{t} + (\mathbf{I}-\lambda_t \mathbf{W})^{-1}\boldsymbol{\mu}_t = \mathbf{X_t}\boldsymbol{\beta}_\mathbf{t} + \boldsymbol{\varepsilon}_t,$

where $\boldsymbol{\varepsilon}_t = (\mathbf{I}-\lambda_t \mathbf{W})^{-1}\boldsymbol{\mu}_t$ represents a spatially autocorrelated error term, which may be equivalently expressed as $\boldsymbol{\varepsilon}_t = \lambda_t \mathbf{W}\boldsymbol{\varepsilon}_t + \boldsymbol{\mu}_t$. The specification (10) – denoted the SAC model – differs conceptually from the SAR-X-DL by specifying the spatial spill-over to be of a residual, rather than a substantial, nature.

These one-period models are easily extended to *T* periods SUR models along the lines in the previous section, using the established notation. Thus, a $\text{SAR-X}_{\text{SUR}}$ specification reads as

(11) $\mathbf{y} = (\boldsymbol{\Lambda}\otimes\mathbf{W})\mathbf{y} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\mu},$

while a $\text{SAR-X-DL}_{\text{SUR}}$ is defined by

(12) $\mathbf{y} = (\boldsymbol{\Lambda}\otimes\mathbf{W})\mathbf{y} + \mathbf{X}\boldsymbol{\beta} + ((\boldsymbol{\Lambda}\otimes\mathbf{W})\mathbf{X})\boldsymbol{\delta} + \boldsymbol{\mu},$

and a SAC_{SUR} as

(13) $\mathbf{y} = \mathbf{X\beta} + (\mathbf{I} - \mathbf{\Lambda} \otimes \mathbf{W})^{-1}\boldsymbol{\mu} = \mathbf{X\beta} + \boldsymbol{\varepsilon}$,

with $\mathbf{\Lambda} = \text{diag}(\lambda_1, .., \lambda_T)$, $\boldsymbol{\varepsilon} = (\mathbf{\Lambda} \otimes \mathbf{W})\boldsymbol{\varepsilon} + \boldsymbol{\mu}$, and $\boldsymbol{\mu}$ defined according to (2)-(5).

Estimation of the spatially adjusted SUR models is performed using Instrument Variables (IV) estimation as outlined in the Appendix. Further, adequacy of the models is addressed using a variety of tests:

- Initially, the SUR model is tested for presence of spatial autocorrelation using a Lagrange Multiplier (LM) pre-test. This test is known to have good power against other specifications of spatial effects, including the SAR, and thus serves as a general proxy of potential spatial spill-over of any form (see Appendix A.2).
- The SAR-XDL_{SUR} is tested for the Durbin restriction using a Wald type Delta post-test applied to each year separately (See Appendix A.3).
- The SAR-XDL_{SUR} is tested for relevance of the additional DL term, using a Wald post-test (see Appendix A.3).
- All spatially adjusted models are tested for relevance of the spatial parametres (i.e. the λ_t 's) as well as constancy of these during the periods, using Wald post-tests (see Appendix A.1-A.3).

4. 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 1994 to 2004. These were collected from three sources: The Statistical Bank at Statistics Denmark, the Key Figure Base [Nøgletalsbasen] at the Ministry of the Interior, and the Ministry of Urban and Housing Affairs' (2000) report on regulation of housing rents. Table 2 presents an overview of the data applied, including variable short-hand, definition and a few descriptive statistics.

[Table 2 around here]

5. Results.

Table 3 shows the results for the pooled OLS model and the adjusted SUR model. High proportions of widowed, divorced and unmarried reduce the proportion living in owner-occupied homes (OOH) as expected. A high proportion of households with children over 18 raises OOH as expected. Proportion of households without children under 18 is not significantly related to proportion living in OOH. Regulations, as measured by proportion living in subsidized housing, housing subsidies and regulation, is, as expected, negatively related to proportion living in OOH. Population density is negatively related to proportion living in OOH. A few effects are not as expected: Proportion with higher education is negatively related, property tax is positively related, unemployment is positively related, and income is negatively related to proportion living in OOH.

[Table 3 around here]

An explanation for these unexpected signed effects may be non-linear relations. We thus tried adding squares of these variables, defined by UNEMP2=UNEMP*UNEMP etc. The resulting OLS and SUR models are further reported in Table 3. Curvature relationships seems to be present for the variables mentioned. For property tax and unemployment U-shaped relations are found, with peaks well beyond the 75 percent quartiles for property tax and unemployment, thus indicating that the suggested negative relationship holds for most of the municipalities. For income, an alike U-shape is found with a peak well below the 25 percent quartile of income, thus indicating that the expected positive relationship is present for most of the municipalities. Finally, an inverted U-shape is found for education, with a top well beyond the 75 percent quartile of income, thus supporting the expected positive relation for the majority of the observations.

Table 4 reports the SUR model, estimated with time-specific coefficients. Beginning with the Wald tests for parametric stability, the impact of the regulation variables (susidized housing, subsidies for housing expenditure, subsidies for rent expenditure, and regulation) and inhabitants from third countries are seen to be unstable over time. Turning next to the estimated coefficients for these variables, distinct patterns are seen to be present. For inhabitants from third countries, there seems to be a shift as the coefficients drop from close to 0 down to significantly negative from 1999 and onwards. For rent subsidies, an alike drop seems to occur from 2000 and onwards. For subsidized housing, the coefficients seem to move slightly upwards from significantly negative toward 0 during the period from 1994 to 2004. For housing expenditure subsidy and regulation, there seems to be an increase from negative and up towards 0 during the period. It is thus suggested to add interaction variables to the model. These are defined as interactions with time (defined as a time trend variable multiplied to the variable in question) for subsidised housing, expenditure subsidy and regulation, while an interaction with levels variables (defined as a dummy variable for the years in question, multiplied to the variable) are suggested for inhabitants from third countries and rent subsidy.

[Table 4 around here]

A SUR model with common coefficients for time periods but with the suggested time interacted variables is thus estimated and reported in Table 5. It is seen that the impact of inhabitants from third countries on owner-occupied housing is negative, and that this impact is further strengthened from 1999 and onwards. For subsidized housing, the impact is negative and gradually strengthened throughout the period from 1994 to 2004. The impact of expenditure subsidies is around 0 in the beginning of the period but gradually moves toward significantly negative throughout the period. Rent subsidies has a negative impact as expected, and this effect is further strengthened in the period from 2000 and onwards. Finally, regulation has the expected negative impact, but this impact is reduced towards 0 through the period.

[Table 5 around here]

Adjustment for substantial spatial spill-over in the demand for OOH is initially performed using the SAR-X_{SUR} specification. The presence of spatial spill-over is evident from the positive λ coefficients, which are significant for the first part of the period from 1994 to 1998. The inconsistency of the SUR without spatial adjustment is further evident, as some determinants, which were found to be significant in the unadjusted SUR, are insignificant in the SAR-X adjusted specification. These are especially some demographic variables, i.e. age composition, inhabitants from third countries, and taxation. When further adjusting for exogenous spill-over applying the SAR-X-DL adjusted specification, some further variables looses significance, including households with children over 18 years, population density and tax base, while some other variables gain significance, including percentage of early retired and percentage of population in subsidized housing. The exogenous spill-over is especially predominant for percentage of divorced, early retired, subsidized housing and tax rate. A distinctive feature is observed, as the spatial lag of some determinants have opposite effects of the determinant itself. This implies that the full effect of the determinant is only obtained, if the municipality is distinctive as compared to the region surrounding it. Consider, as an example, subsidized housing: If a municipality has a high percentage of population receiving subsidies, then the percentage living in OOH is low. But if the percentages of population receiving subsidies are equally high for the surrounding municipalities, then the former negative effect is outperformed. Thus, subsidies does not affect the demand for OOH if the subsidising scheme is equal for an entire region of municipalities. Alike features are observed – with more or less significance – for the other regulation related variables. Thus, regulation fully affects the demand for OOH if it is implemented locally in one municipality, but only partly or not at all if it is implemented equally for a larger region of municipalities. An alike conclusion is obtained for most of the socio-demographic and economic determinants. With a few exceptions, it may thus be concluded that if a set of conditions change equally for a region of municipalities, then the demand for OOH is considerably less affected than if the conditions change only for one municipality.

6. Conclusions.

An economic model describing determination of demand for owner-occupied homes (OOH) is established and partly confirmed by empirical evidence. It is found that regulation reduces the demand. Further, a favourable personal tax treatment increases the demand, while high property taxes reduces it. The impact of borrowing capacity (as measured by income and education) is positive as expected. While age composition of population is mainly found to be insignificant, a positive effect is found from having adult children living at home. Further, singleness (measured as widowed, unmarried and divorced) significantly reduce the demand for OOH. Finally, presence of spatial spill-over is predominant. Specifically, a positive endogenous spill-over is present, implying that high demand in the surrounding municipalities induces demand in the present municipality. Opposed to this positive endogenous spill-over, the exogenous spill-over is of a contra-signed nature, as the sign of the exogenous spill-over is opposite to that of the exogenous effect itself. Especially, the spill-over effect of regulation is of such a nature, so that a full effect of regulation on demand for OOH is only obtained if the municipality deviates from the local surrounding municipalities.

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Appendix.

A.1. Estimation and inference of the SUR model.

GLS estimation is used to define the Zellner (1962) SUR estimate for $\boldsymbol{\beta}$, defined by

(A.1) $\boldsymbol{\beta}_{SUR} = (\mathbf{X}'\boldsymbol{\Sigma}_0^{-1}\mathbf{X})^{-1}\,\mathbf{X}'\boldsymbol{\Sigma}_0^{-1}\mathbf{y}$

with covariance matrix

(A.2) $\mathbf{V}_{SUR}=(\mathbf{X}'\boldsymbol{\Sigma}_0^{-1}\mathbf{X})^{-1}$

which can both be feasibly estimated conditioned on a consistent estimate of $\boldsymbol{\Sigma}$. The latter can be obtained using as an estimate for σ^2_{ts}

(A.3) $s^2_{ts} = \mathbf{u}_t'\mathbf{u}_s / n \quad , \quad t,s = 1, .. , T$

where $\mathbf{u}_t$ is the residual obtained from OLS estimation of (1). Thus, consistent estimates $\mathbf{S}$ for $\boldsymbol{\Sigma}$ and $\mathbf{S}_0$ for $\boldsymbol{\Sigma}_0$ are obtained, and feasible SUR estimates for (7) and (8), denoted $\mathbf{b}_{F\text{-}SUR}$ and $\mathbf{V}_{F\text{-}SUR}$, obtained.

To test the k'th parameter in $\boldsymbol{\beta}_t$, k=1,..,K, for constancy over time, the composite hypothesis

(A.4) H_{0k}: $\beta_{k1} - \beta_{kt} = 0$, $t = 2,..,T$

is respecified as

(A.5) H_{0k}: $\mathbf{R}_k\boldsymbol{\beta} = \mathbf{0}$

by defining $\mathbf{R}_k$ as the (T-1) by (TK) matrix, where the i'th row is defined by letting the element in column k be 1, the element in column ($iK+k$) be (-1) and the remainding elements be 0. The hypothesis can be tested using the Wald test

(A.6) $W_k = (\mathbf{R}_k\mathbf{b}_{F\text{-}SUR})'(\mathbf{R}_k(\mathbf{X}'\mathbf{S}_0\mathbf{X})^{-1}\mathbf{R}_k')^{-1}\,(\mathbf{R}_k\mathbf{b}_{F\text{-}SUR})$

which follows a χ^2 distribution with (T-1) degrees of freedom under H_{0k}. The test is straightforwardly applied to the entire set of explanatory variables, by stacking the $\mathbf{R}_k$'s into one matrix, **R**, and replace $\mathbf{R_k}$ with **R** in (A.6). The resulting Wald test then has *K*(*T-1*) degrees of freedom.

If **β** is constant over time, it is reasonable to redefine **X** as the concatenating of $\mathbf{X_1}, .. , \mathbf{X_T}$, replace **β** with a *T* vector, and estimate the model using these.

A. 2. Estimation and inference in the SAC_{SUR}.

It is well known that presence of spatial autocorrelation in the residuals of a regression model leads to inefficient OLS estimates, so that maximum likelihood (ML) estimation is necessitated (Anselin, 1988). For the SAC_{SUR} model, an ML estimation procedure were outlined by Anselin (1988), leading a test for spatial spill-over. Even though the estimation itself is not applied here, but only the derived pre-test, a brief outline is adequate.

Defining $\mathbf{B} = (\mathbf{I}-(\mathbf{\Lambda}\otimes\mathbf{W}))^{-1}$, the covariance matrix for **μ** becomes $(\mathbf{\Sigma}\otimes\mathbf{I})$, so that the covariance matrix for **ε** is $\mathbf{\Omega}=\mathbf{B}(\mathbf{\Sigma}\otimes\mathbf{I})\mathbf{B}'$. The above SAC_{SUR} model is thus written as

(A.2.1) $\mathbf{y} = \mathbf{X\beta} + \mathbf{\varepsilon}$, $\mathbf{\varepsilon} \sim \mathbf{N}(\mathbf{0},\mathbf{\Omega})$

The parameters to be estimated are **β**, **Σ** and **Λ**. The maximum likelihood function for **y** becomes (Anselin, 1988)

(A.2.2) $L = (-1/2)\ln(|\mathbf{\Omega}|) – (1/2)(\mathbf{y} – \mathbf{X\beta})' \mathbf{\Omega}^{-1}(\mathbf{y} – \mathbf{X\beta})$,

which, using the block-diagonality of **Ω**, becomes (Anselin, 1988)

(A.2.3) $L = (-n/2)\ln(|\mathbf{\Sigma}|) + \Sigma_{t=1..T} \ln(|\mathbf{I}- \lambda_t\mathbf{W}|) – (1/2)(\mathbf{y} – \mathbf{X\beta})' \mathbf{\Omega}^{-1}(\mathbf{y} – \mathbf{X\beta})$.

The first order condition for maximizing the likelihood function with respect to **β** gives (Anselin, 1988)

(A.2.4) $\mathbf{\beta} = (\mathbf{X}'\mathbf{\Omega}\mathbf{X})^{-1}\mathbf{X}'\mathbf{\Omega}^{-1}\mathbf{y}$

while for $\mathbf{\Sigma}$ the ML estimate becomes (Anselin, 1988)

(A.2.5) $\mathbf{\Sigma} = \mathbf{Z}'\mathbf{Z} / n$

where $\mathbf{Z}$ is an n by T matrix $\mathbf{Z} = [\mathbf{z_1}, .. , \mathbf{z_T}]$ obtained with $\mathbf{z_t} = (\mathbf{I}-\lambda_t\mathbf{W})\mathbf{e}_t$, $t = 1, .. , T$. The ML estimate for $\mathbf{\Lambda}$ is provided by the non-linear equation system (Anselin, 1988)

(A.2.6) $\mathrm{tr}(\mathbf{W}(\mathbf{I}-\lambda_t\mathbf{W})^{-1}) = \Sigma_{s=1,..,T}\, \sigma^{ts}(\mathbf{e}_t\mathbf{W}'(\mathbf{I}-\lambda_s\mathbf{W})\mathbf{e}_s)$, $t = 1 , .. , T$.

where σ^{ts} is the(t,s)'th element in $\mathbf{\Sigma}^{-1}$.

Consistent pseudo maximum likelihood estimates for $\boldsymbol{\beta}$, $\mathbf{\Sigma}$ and $\mathbf{\Lambda}$ may be obtained using the following calculations (Anselin, 1988):

1. Let $\mathbf{\Lambda}=\mathbf{0}$. Determine the OLS-estimate for $\boldsymbol{\beta}$, $\mathbf{b}=(\mathbf{X'X})^{1}\mathbf{X'y}$. Let $\mathbf{e}$ be the estimated OLS-residuals.
2. Determine the estimate for $\mathbf{\Sigma}$ using (15).
3. Determine the ML estimate for $\boldsymbol{\beta}$ using (14). Update $\mathbf{e}=\mathbf{y}-\mathbf{X}\boldsymbol{\beta}$.
4. Determine $\mathbf{\Lambda}$ by solving (16), update $\mathbf{\Sigma}$ using (15), $\boldsymbol{\beta}$ using (14), and $\mathbf{e}=\mathbf{y}-\mathbf{X}\boldsymbol{\beta}$.

While consistent pseudo maximum likelihood estimates (which satisfies for most practical purposes) are obtained using these calculations, efficient maximum likelihood estimates may be obtained by iterating step 4. until convergence (Anselin, 1988). The significance of the estimated parameters – as well as any hypothesis involving these - are tested using Wald tests based on the second order conditions of the likelihood function (see Anselin, 1988).

Clearly, it is computationally involved to estimate the $\mathrm{SAC}_{\mathrm{SUR}}$ model. Therefore, it is convenient to perform a pre-test for absence of spatial spill-over, which does not involve the estimation of $\mathbf{\Lambda}$. Anselin (1988) derived the following LM test for $H_0 : \mathbf{\Lambda} = \mathbf{0}$, which requires the estimation of a feasible SUR model only. The test is asymptotically distributed as χ^2 with T degrees of freedom and reads as

(A.2.7) $LM = \mathbf{i}'(\mathbf{\Sigma}^{-1}\#\mathbf{U}'\mathbf{W}\mathbf{U})(T_2\mathbf{I} + T_1\mathbf{\Sigma}^{-1}\#\mathbf{\Sigma})^{-1}(\mathbf{\Sigma}^{-1}\#\mathbf{U}'\mathbf{W}\mathbf{U})'\mathbf{i}$

where $T_1 = tr(\mathbf{W}'\mathbf{W})$, $T_2 = tr(\mathbf{W}^2)$, $\mathbf{i}$ is a vector of ones, $\mathbf{U}$ is an n by T matrix with the $\mathbf{e_t}$'s from the feasible SUR as columns, and # denotes the Hadamard product. For an investigation of the finite-sample performance of the LM test, see Lauridsen (2005a).

A. 3. Estimation and inference in the SAR-X_{SUR} and SAR-X-DL_{SUR}.

The SAR-X_{SUR} were suggested by Anselin (1988), who provided the log likelihood function

(A.3.1) $L = (-n/2)\ln(|\mathbf{\Sigma}|) + \ln(|\mathbf{A}|) - (1/2)\mathbf{v}'\mathbf{v}$,

where $\mathbf{A} = \mathbf{I}-(\mathbf{\Lambda}\otimes\mathbf{W})$ and $\mathbf{v}'\mathbf{v} = (\mathbf{Ay}-\mathbf{X\beta})'(\mathbf{\Sigma}^{-1}\otimes\mathbf{I})(\mathbf{Ay}-\mathbf{X\beta})$. Using the block-diagonal structure of $\mathbf{A}$ and the notation $\mathbf{A}_t = \mathbf{I}- \lambda_t\mathbf{W}$, this simplifies to (Anselin, 1988)

(A.3.2) $L = (-n/2)\ln(|\mathbf{\Sigma}|) + \Sigma_{t=1..T} \ln(|\mathbf{A}_t|) - (1/2)\mathbf{v}'\mathbf{v}$.

Further, Anselin (1988) outlined a consistent Instrument Variable estimation routines for the estimation of $\mathbf{\Lambda}$ and $\mathbf{\beta}$. Specifically, the IV estimator for $\mathbf{b} = (\mathbf{\lambda}',\mathbf{\beta}')$ is obtained conditioned on $\mathbf{\Sigma}$ as (Anselin, 1988)

(A.3.3) $\mathbf{b_{IV}} = \{\mathbf{Z}'\mathbf{Q}[\mathbf{Q}'(\mathbf{\Sigma}\otimes\mathbf{I})\mathbf{Q}]^{-1}\mathbf{Q}'\mathbf{Z}\}^{-1}\mathbf{Z}'\mathbf{Q}[\mathbf{Q}'(\mathbf{\Sigma}\otimes\mathbf{I})\mathbf{Q}]^{-1}\mathbf{Q}'\mathbf{y}$

with asymptotic covariance matrix

(A.3.4) $\mathbf{b_{IV}} = \{\mathbf{Z}'\mathbf{Q}[\mathbf{Q}'(\mathbf{\Sigma}\otimes\mathbf{I})\mathbf{Q}]^{-1}\mathbf{Q}'\mathbf{Z}\}^{-1}$

where $\mathbf{Z} = [\mathbf{Wy_{1(0)}}, .., \mathbf{Wy_{T(0)}}\ \ \mathbf{X}]$, using the notation $\mathbf{Wy_{t(0)}}$ to denote an nT vector, where the elements for period t are $\mathbf{Wy_t}$, and the remaining elements 0. The matrix $\mathbf{Q}$ holds the instruments for $\mathbf{Z}$. Naturally, $\mathbf{X}$ serves as an instrument for itself. For each of the $\mathbf{Wy_t}$, the suggestion of Anselin (1988) to apply the spatial lag of the predicted values from a regression of $\mathbf{y_t}$ on $\mathbf{X_t}$ is adopted (see Anselin, 1988, for discussion of alternative choices of instruments).

An iterative estimation of $\mathbf{b_{IV}}$ consists of the steps:

1. Estimate an equation for each time period separately (by replacing $\mathbf{\Sigma}$ with $s^2\mathbf{I}$). Obtain residuals $\mathbf{e_t}$. Obtain estimates of elements s^2_{ts} of $\mathbf{\Sigma}$ as $s^2_{ts} = \mathbf{e_t}'\mathbf{e_s}/n$.

2. Obtain the estimate $\mathbf{b_{IV}}$ for $\mathbf{b}$ conditioned on $\mathbf{\Sigma}$. Obtain residual $\mathbf{e} = \mathbf{y} - \mathbf{Zb_{IV}}$. Update $\mathbf{\Sigma}$.

3. Repeat step 2. until convergence.

The SAR-X-DL_{SUR} is estimated completely along the lines as for the SAR-X_{SUR} specification by simply enlargening $\mathbf{X}$ to consist of $\mathbf{X}$ as well as the spatial lag of these variables, excluding the constant term. Specifically, writing $\mathbf{X}$ as $[\mathbf{i}\ \mathbf{X_0}]$, where $\mathbf{i}$ is a column of ones, and $\mathbf{X_0}$ denotes the variables in $\mathbf{X}$ apart from the constant term, the variables to enter the SAR-X specification are $\mathbf{X} = [\mathbf{i}\ \mathbf{X_0}]$, while those entering the SAR-X-DL specification are $\mathbf{X} = [\mathbf{i}\ \mathbf{X_0}\ \mathbf{WX_0}]$.

It is of relevance to examinate constancy over time of the λ_t ‘s. This is easily performed in the SAR-X_{SUR} as well as the SAR-XDL_{SUR}, using a Wald post-test defined along the lines as for the constancy over time of the coefficients in the SUR model, see Appendix A.1.

Further, it is relevant to test the non-linear Durbin restrictions on the SAR-X_{SUR} in order to determine whether this model is necessary or whether the simpler SAR_{SUR} satisfies. Wald-type Delta post-tests are obtained by specifying the Durbin restriction as

(A.3.5) $H_0 : \mathbf{f}_t(\boldsymbol{\theta}_t) = (\boldsymbol{\delta}_t - \lambda_t\boldsymbol{\beta}_t) = \mathbf{0}$

with $\boldsymbol{\theta}_t = (\boldsymbol{\beta}_t',\boldsymbol{\delta}_t',\lambda_t)'$, and using a first-order Taylor approximation of the covariance matrix of $\mathbf{f}(\boldsymbol{\theta}_t)$ provided by

(A.3.6) $\mathbf{V}_{\mathbf{f}t} = (d\,\mathbf{f}_t(\boldsymbol{\theta}_t)/d\boldsymbol{\theta}_t)'\mathbf{V}_{\boldsymbol{\theta}t}\,(d\mathbf{f}_t(\boldsymbol{\theta}_t)/d\boldsymbol{\theta}_t)$

where $\mathbf{V}_{\boldsymbol{\theta}t}$ is the covariance matrix of $\boldsymbol{\theta}_t$, a Wald type Delta test is obtained for the Durbin restriction in period t as

(A.3.7) $W = (\mathbf{f}_t(\boldsymbol{\theta}_t))' \, \mathbf{V}_{\mathbf{f}t}^{-1} \, (\mathbf{f}_t(\boldsymbol{\theta}_t))$

which follows a χ^2 distribution with K degrees of freedom.

The IV estimation procedure as well as the tests are asymptotically justified. For an investigation of their finite-sample properties, see Lauridsen (2005b).

Table 1: Variables affecting home ownership rates

Variable	Explanation
Favourable tax treatment of homeowners 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 (-)	Homeownership 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.
Borrowing capacity income (+) ethnicity race educational level (+) other personal characteristics special life events (e.g. bequest, lottery)	With asymmetric information on financial markets, various indicators of borrowers (homeowners) 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 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 (-) lagged ownership rates (+)	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 short-hand	Definition	25% quartile	Median	75% quartile
PSHOOH	% of population living in owner-occupied homes	63.00	72.00	78.00
PSH716	% of population aged 7-16	11.80	12.80	13.70
PSH1725	% of population aged 17-25	8.43	9.68	10.78
PSH2635	% of population aged 26-35	12.05	13.19	14.19
PSH3666	% of population aged 36-66	39.84	41.63	43.69
PSH67+	% of population aged 67 and over	12.00	13.50	15.10
PSHWIDOW	% of population widowed	5.95	6.68	7.45
PSHDIV	% of population divorced	4.72	5.67	7.25
PSHUNMARR	% of population unmarried	42.05	43.57	44.88
PHCHO18	% of households with children over 18	7.93	9.13	10.36
PHWCHU18	% of households without children under 18	0.00	3.18	5.78
PSHEDU	% of population with further education	11.20	13.20	16.00
PSHEARLYR	% of population on early retirement benefit [førtidspension]	6.30	7.50	8.90
PSHSOCBEN	% of population receiving social benefits [kontanthjælp]	6.90	8.30	9.80
PSHUNEMP	% of population (17-66 year) unemployed	3.90	5.00	6.60
PSH3C	Number of citizens from countries outside EU, Scandinavia and North America per 10,000 inh.	8.10	14.30	21.90
PSHSUBHOU	% of population living in subsidized housing	5.00	9.00	17.00
PSHHSUB	% of households receiving housing subsidies [boligydelse]	8.80	10.80	13.30
PSHRSUB	% of 15-66 year old receiving rent subsidies [boligsikring]	4.00	6.00	8.70
POPDEN	Inhabitants per square kilometre	48	69	145
PROPTAX	Real Property Tax (in 0/00) [Grundskyldspromille]	7.50	10.00	15.00
TAXRATE	Municipal + county tax rate (in %) [Udskrivningsprocent]	19.80	20.50	21.20
TAXBASE	Taxbase [beskatningsgrundlag] per inhabitant (100.000 DKK)	9.08	11.74	13.31
REGUL	Housing Regulation Act [Boligreguleringsloven] asssumed by 2000 (1=yes, 0=no)	-	-	-

Table 3. Initial OLS and SUR models with common parameters.

	Only linear terms:		Nonlinear terms added:	
Variable	OLS:	SUR:	OLS:	SUR:
Intercept	164.354***(12.34)	142.587***(9.830)	152.661***(12.35)	144.129***(9.867)
PSH716	-0.111 (0.170)	0.106 (0.101)	-0.030 (0.167)	0.117 (0.103)
PSH1725	-0.997***(0.131)	-0.347 (0.104)	-1.030***(0.129)	-0.391 (0.105)
PSH2635	0.261 (0.185)	-0.049 (0.123)	0.402** (0.183)	0.004 (0.125)
PSH3666	-0.559***(0.127)	-0.275 (0.112)	-0.228* (0.135)	-0.186 (0.114)
PSH67+	-0.440***(0.143)	-0.729***(0.117)	-0.251* (0.142)	-0.665***(0.118)
PSHWIDOW	-1.454***(0.156)	-0.469***(0.147)	-1.419***(0.152)	-0.520***(0.148)
PSHDIV	-0.796***(0.103)	-1.015***(0.108)	-0.746***(0.101)	-1.012***(0.109)
PSHUNMARR	-0.864***(0.070)	-0.717***(0.072)	-0.696***(0.071)	-0.677***(0.073)
PHCHO18	0.837***(0.074)	0.381***(0.049)	0.881***(0.074)	0.381***(0.049)
PHWCHU18	-1.847 (1.198)	0.012 (0.491)	-2.250* (1.168)	-0.077 (0.508)
PSHEDU	0.055***(0.019)	-0.049 (0.033)	0.381***(0.064)	0.017 (0.108)
PSHEARLYR	0.008 (0.057)	-0.005 (0.070)	-0.145** (0.059)	-0.033 (0.070)
PSHSOCBEN	0.194***(0.048)	0.013 (0.033)	0.201***(0.048)	0.009 (0.033)
PSHUNEMP	0.249***(0.039)	0.109***(0.028)	-0.439***(0.132)	-0.260***(0.072)
PSH3C	-0.031***(0.006)	-0.027***(0.006)	-0.026***(0.007)	-0.027***(0.006)
PSHSUBHOU	-0.45*** (0.012)	-0.535***(0.018)	-0.446***(0.011)	-0.524***(0.017)
PSHHSUB	-0.354***(0.040)	-0.154***(0.038)	-0.331***(0.039)	-0.154***(0.037)
PSHRSUB	-0.873***(0.064)	-0.558***(0.056)	-0.793***(0.065)	-0.547***(0.057)
POPDEN	-6.355***(1.332)	-4.759***(2.303)	-6.517***(1.336)	-5.195***(2.376)
PROPTAX	0.088***(0.014)	0.019 (0.016)	-0.107** (0.053)	-0.129***(0.056)
TAXRATE	0.046 (0.062)	0.034 (0.059)	-0.002 (0.062)	0.039 (0.060)
TAXBASE	-0.491***(0.059)	-0.252***(0.053)	-2.453***(0.201)	-1.220***(0.164)
REGUL	-0.306** (0.148)	-0.800***(0.329)	-0.225 (0.147)	-0.735***(0.331)
PSHEDU^2			-0.009***(0.002)	-0.002 (0.003)
PROPTAX^2			0.007***(0.002)	0.005***(0.002)
UNEMP^2			0.034***(0.008)	0.021***(0.004)
TAXBASE^2			0.066***(0.006)	0.033***(0.005)
R-square(OLS)	0.926		0.929	
LogL	-4873.96	-1987.34	-4795.70	-2001.81
AIC	9797.92	4154.68	9649.40	4191.62
LM for SAC in SUR		594.51***		580.19***

Note. Standard deviations in parentheses. Significance indicated by *** (1%), ** (5%), * (10%).

Table 4. SUR model with time-specific coefficients

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Wald (df=10)
Constant	131.35***	143.76***	121.37***	133.81***	135.04***	132.40***	126.87***	136.72***	137.86***	140.18***	140.29***	3.21
PSH716	-0.08	-0.07	0.25	0.07	0.02	0.01	0.16	-0.03	0.05	-0.17	-0.35	7.41
PSH1725	-0.73***	-0.77***	-0.6 ***	-0.61***	-0.77***	-0.60***	-0.41***	-0.44***	-0.42***	-0.40**	-0.52***	5.67
PSH2635	-0.46	-0.61***	-0.24	-0.59***	-0.45**	-0.18	-0.10	-0.23	-0.20	-0.23	-0.24	6.78
PSH3666	-0.13	-0.37*	-0.02	-0.11	-0.09	-0.16	-0.17	-0.22	-0.24	-0.21	-0.22	6.06
PSH67O	-0.51**	-0.65***	-0.47***	-0.62***	-0.54***	-0.70***	-0.70***	-0.84***	-0.95***	-1.08***	-1.12***	8.18
PSHWIDOW	-0.26	-0.15	-0.14	-0.20	-0.27	-0.85***	-0.79***	-0.85***	-0.65***	-0.71***	-0.60***	9.75
PSHDIV	-1.02***	-0.70***	-0.93***	-0.93***	-0.75***	-0.64***	-0.65***	-0.50***	-0.54***	-0.37***	-0.41***	17.52*
PSHUNMARR	-0.29***	-0.47***	-0.42***	-0.40***	-0.35***	-0.40***	-0.50***	-0.51***	-0.62***	-0.57***	-0.55***	7.64
PHCHO18	0.36***	0.43***	0.25***	0.13	0.20**	0.41***	0.39***	0.37***	0.28***	0.38***	0.47***	15.05
PHWCHU18	0.50	0.02	-1.26	-0.30	1.28	1.50	0.45	-0.13	-1.35	-0.04	-1.03	6.60
PSHEDU	0.04	0.04	0.17	0.11	0.16	-0.02	0.01	0.10	0.10	0.02	0.07	8.08
PSHEARLYR	0.07	0.06	-0.07	-0.10	-0.11	-0.26***	-0.29***	-0.22***	-0.20**	-0.34***	-0.28***	14.78
PSHSOCBEN	0.07	0.07	0.03	0.02	0.00	0.01	-0.01	-0.03	-0.04	0.04	0.05	3.86
UNEMP	-0.54*	-0.36*	-0.29	-0.40	-0.40	-0.03	0.11	0.32	0.63	-0.01	0.03	7.92
PSH3C	-0.01	-0.02**	0.00	0.00	0.00	-0.03***	-0.02**	-0.04***	-0.04***	-0.06***	-0.05***	24.81***
PSHSUBHOU	-0.58***	-0.59***	-0.56***	-0.55***	-0.55***	-0.53***	-0.51***	-0.50***	-0.49***	-0.46***	-0.44***	28.57***
PSHHSUB	-0.51***	-0.50***	-0.40***	-0.39***	-0.45***	-0.10*	-0.03	-0.12**	-0.14***	-0.01	-0.09	64.78***
PSHRSUB	-0.21***	-0.20***	-0.30***	-0.44***	-0.39***	-0.51***	-0.72***	-0.67***	-0.63***	-0.81***	-0.79***	32.99***
POPDEN	-4.79*	-5.40**	-6.27***	-5.14*	-6.49***	-5.29*	-6.86***	-6.58***	-7.18***	-10.35***	-9.72***	7.86
PROPTAX	0.07	0.12	-0.02	-0.05	-0.10	-0.12	-0.19**	-0.17*	-0.17*	-0.25***	-0.21**	15.24
TAXRATE	0.09	0.14	-0.03	0.06	0.10	0.04	0.06	0.17	0.22**	0.27**	0.28***	11.65
TAXBASE	0.02	0.68	0.11	0.24	-0.52	-0.39	0.17	-0.44	-0.17	-0.21	-0.12	10.99
REGUL	-1.21***	-1.53***	-1.40***	-1.25***	-1.49***	-0.60	-0.37	-0.34	-0.34	-0.31	-0.22	22.09***
PSHEDU^2	-0.01	-0.01	-0.01*	-0.01*	-0.01**	0.00	0.00	-0.01*	-0.01	0.00	0.00	9.53
PROPTAX^2	0.00	0.00	0.00	0.00	0.00**	0.00	0.01**	0.01*	0.01*	0.01***	0.01**	14.84
UNEMP^2	0.03**	0.02*	0.02	0.03*	0.04	-0.02	-0.02	-0.04	-0.08**	-0.01	-0.02	9.66
TAXBASE^2	-0.02	-0.04	-0.01	-0.02	0.01	0.01	-0.01	0.02	0.01	0.01	0.01	10.93
Wald (overall;df=280)												2590.68***

Note. Significanse indicated by *** (1%), **(5%), *(10%)

Table 5. SUR and spatial SUR models adjusted for time trends

	SUR		SAR-X-SUR		SAR-XDL-SUR			
					X		WX	
Constant	148.159***	(9.993)	48.891	(87.29)	64.047	(171.14)		
PSH716	-0.001	(0.107)	0.844	(0.881)	0.208	(0.848)	-0.494	(1.573)
PSH1725	-0.565***	(0.105)	-0.278	(0.890)	-0.495	(0.857)	-0.016	(1.553)
PSH2635	-0.196	(0.125)	1.151	(0.885)	0.095	(0.864)	-0.219	(1.612)
PSH3666	-0.241**	(0.114)	0.792	(0.879)	0.370	(0.843)	-0.703	(1.587)
PSH67O	-0.770***	(0.118)	0.669	(0.881)	-0.115	(0.851)	0.510	(1.594)
PSHWIDOW	-0.545***	(0.148)	-1.390***	(0.355)	-1.128***	(0.360)	-0.387	(0.858)
PSHDIV	-0.931***	(0.109)	-0.681***	(0.233)	-1.559***	(0.310)	2.673***	(0.502)
PSHUNMARR	-0.589***	(0.078)	-0.539***	(0.184)	-0.460**	(0.193)	0.483	(0.351)
PHCHO18	0.347***	(0.049)	0.724***	(0.160)	0.262	(0.175)	0.292	(0.426)
PSHWCHU18	-0.021	(0.493)	-2.266	(1.857)	-2.126	(1.761)	0.744	(3.979)
PSHEDU	0.001	(0.107)	0.186	(0.156)	-0.217	(0.169)	0.381	(0.329)
PSHEARLYR	-0.085	(0.070)	-0.189	(0.136)	-0.393**	(0.157)	0.519**	(0.241)
PSHSOCBEN	0.007	(0.033)	0.055	(0.101)	0.039	(0.107)	-0.238	(0.178)
PSHUNEMP	-0.334***	(0.072)	-0.923***	(0.265)	-1.320***	(0.339)	1.009*	(0.532)
PSH3C	-0.013**	(0.006)	-0.013	(0.016)	-0.023	(0.016)	0.004	(0.031)
PSHSUBHOU	-0.654***	(0.023)	-0.566***	(0.037)	-0.405***	(0.041)	0.183	(0.182)
PSHHSUB	0.099**	(0.050)	-0.185*	(0.109)	-0.554***	(0.113)	0.547**	(0.218)
PSHRSUB	-0.461***	(0.057)	-0.680***	(0.150)	-0.688***	(0.153)	0.515	(0.339)
POPDEN	-6.571***	(2.363)	-5.914*	(3.685)	3.887	(5.453)	2.010	(10.21)
PROPTAX	-0.119**	(0.055)	0.000	(0.122)	-0.132	(0.127)	0.332	(0.223)
TAXRATE	0.113*	(0.060)	0.211	(0.147)	0.272*	(0.154)	-0.982***	(0.302)
TAXBASE	-0.851***	(0.168)	-1.853***	(0.473)	-0.966*	(0.559)	-0.935	(0.971)
REGUL	-2.049***	(0.417)	-1.319***	(0.485)	-1.263***	(0.492)	1.113	(1.116)
PSHEDU^2	-0.002	(0.003)	-0.006	(0.004)	0.002	(0.004)	-0.006	(0.009)
PROPTAX^2	0.004***	(0.002)	0.003	(0.004)	0.006	(0.004)	-0.013*	(0.007)
PSHUNEMP^2	0.022***	(0.004)	0.054***	(0.013)	0.075***	(0.017)	-0.053*	(0.027)
TAXBASE^2	0.022***	(0.005)	0.044***	(0.013)	0.010	(0.016)	0.034	(0.028)
PSH3C*T	-0.029***	(0.006)	0.001	(0.011)	-0.007	(0.012)	-0.005	(0.016)
PSHSUBHOU*T	0.020***	(0.002)	0.020***	(0.004)	0.004	(0.004)	0.014	(0.010)
PSHHSUB*T	-0.044***	(0.005)	-0.035***	(0.012)	0.015	(0.014)	-0.064**	(0.026)
PSHRSUB*T	-0.057***	(0.013)	-0.060	(0.075)	0.008	(0.075)	-0.042	(0.109)
REGUL*T	0.202***	(0.004)	0.197***	(0.058)	0.122**	(0.060)	-0.095	(0.126)
LAMBDA(1994)			0.062**	(0.031)	0.712**	(0.291)		
LAMBDA(1995)			0.066**	(0.030)	0.722**	(0.289)		
LAMBDA(1996)			0.058**	(0.029)	0.733**	(0.290)		
LAMBDA(1997)			0.059**	(0.029)	0.744***	(0.289)		
LAMBDA(1998)			0.073**	(0.029)	0.760***	(0.284)		
LAMBDA(1999)			0.013	(0.030)	0.752**	(0.302)		
LAMBDA(2000)			0.024	(0.030)	0.769***	(0.296)		
LAMBDA(2001)			0.022	(0.030)	0.781***	(0.296)		
LAMBDA(2002)			0.026	(0.031)	0.795***	(0.295)		
LAMBDA(2003)			0.039	(0.032)	0.809***	(0.292)		
LAMBDA(2004)			0.037	(0.033)	0.812***	(0.292)		
LogL	-1941.28		-1939.81		-2227.59			
AIC	4080.56		4101.64		4743.19			
LM for SAC	420.42***(df=11)							
Wald for equal gamma's			417.65***(df=10)		11.26 (df=10)			
Wald for DL in SAR-XDL-SUR					119.02***(df=32)			

Wald tests for Durbin restrictions in SAR-XDL-SUR (df=32):

1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
66.99***	66.87***	66.30***	65.96***	65.93***	64.32***	64.16***	63.71***	63.32***	63.16***	63.05***

Note. Significanse indicated by *** (1%), **(5%), *(10%)