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EXPLAINING REGIONAL VARIATION IN EQUILIBRIUM REAL ESTATE PRICES AND INCOME

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Explaining Regional Variation in Equilibrium Real Estate Prices and Income*

Abstract: We combine the real estate model of POTEPAN (1996) with the spatial equilibrium approach of ROBACK (1982) to prove the interdependency of housing prices, rental prices, building land prices and income via one simultaneous equilibrium analysis. Using unique cross-sectional data on the majority of German counties and cities for 2005, we estimate the equations in their structural and reduced form. The results show significantly positive interaction effects of income and real estate prices. Moreover, we can confirm model predictions concerning the majority of exogenous determinants. In particular, expectations about population development seem to be among the most important determinants of price and income disparities between regions in the long term.

Keywords: Regional Housing Markets, Spatial Equilibrium Analysis, Simultaneous Equation, Germany
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1 Introduction

Until now, regional equilibrium analyses of real estate markets have been characterized by two qualities. First, these analyses rely on theoretical approaches that exclusively, and explicitly, reflect the interactions between individual real estate sectors. Relationships to the labor market and possible interdependencies between income and housing prices have not been examined thus far. Second, in empirical evaluations, only markets in the US or in Canada have been examined. Thus, equilibrium studies investigating model valuation for European markets, for example, are lacking.

Initial work on regional housing markets in a steady state is presented by FORTURA & KUSHNER (1986), MANNING (1989) and ROSE (1989), who estimate demand and supply models in their reduced forms. OZANNE & THIBODEAU

* We thank Alexander Schürt from the Federal Office for Building and Regional Planning (BBR) for providing housing price and rental price data and Arne Feddersen for providing the geographic shapefile of German districts to obtain the spatial weights matrix. We also thank Wolfgang Maennig for helpful comments and suggestions.

(1983) develop the first theoretically-based approach for describing the mechanisms of real estate sectors. It consists of two sectors: the rental market and the owner-occupied market. The rental market is the environment for the housing services consumed by tenants and owners in equal measure, where the rental price reflects the price of housing. In contrast, the owner-occupied market depicts the production side of housing, where the housing price equals the amount that landlords and owners have to pay when purchasing habitable living space. The long-term relationship between both sectors is ensured by no arbitrage conditions. Despite the small number of degrees of freedom, they are able to classify the age structure and land-use restrictions as the most important price determinants in their reduced-form approach.

POTEPAN (1996) introduces an extension of this concept by including the market for building land in his attempt to describe the process of providing housing space in more detail. To do so, he decomposes the real estate sector into three fields. The first sector describes land provision, the second, housing production and the third housing consumption. Using a two-stage least squares procedure, POTEPAN (1996) estimates a three-equation system for the majority of U.S. metropolitan areas. He finds that infrastructure quality, property taxes, population size and land-use restrictions matter most in explaining regional price disparities.

Although this three-equation system represents a complete model, connections to the labor market remain unexplored. According to the spatial equilibrium approach of ROBACK (1982), household living and firms' production decisions depend fundamentally on the level of local amenities. Those amenities determine housing environment and house prices, but they also affect production and income. Because the supply of amenities is limited, the market process leads to adjustments in location decisions of households and firms given preferences and production strategies. Therefore, direct and indirect effects of amenities, prices and income become capitalized. With regard to empirical evaluation, the result is that no spatial autocorrelation should exist when the market adjustment is completed. In equilibrium, no further arbitrage opportunities exist and market agents at the margin are indifferent across space (BERGER, BLOMQUIST, & PETER, 2008;

EBERTZ & BUETTNER, 2009; GLAESER & GOTTLIEB, 2009; RAPPAPORT, 2008; WINTERS, 2009).[1] However, if competition for the most productive and highest quality location is neglected, the results may be one-sided and biased (GLAESER & GYOURKO, 2008).

Admittedly, OZANNE & THIBODEAU (1983) and POTEPAN (1996) hint at the possible endogeneity of income, but they do not pursue a deeper investigation of this concept. Income is generated by the labor market, which is affected by location decisions according to the spatial equilibrium approach. Market agents, in turn, orient themselves based on real estate prices, income and amenities according to their individual strategy. In sum, from a theoretical point of view, the spatial equilibrium model yields a justification for the interdependent relationship between income and housing prices.[2]

Because dominantly U.S. data have been used in the research conducted so far, applying the model to another housing market environment provides a method to validate the model. The U.S. market exhibits an owner-occupied rate of approximately 66% (U.S. CENSUS BUREAU, 2008). With such a high owner-occupant rate, that specific housing demand is automatically reflected in the price structure. In contrast, housing markets characterized by a more symmetric distribution of preferences could provide new insight into long-term price factors; e.g., in Germany, only approximately 42% of all households are owner-occupied (ECB, 2005).

In this paper, we extend the three-equation system of POTEPAN (1996) with an additional income equation to capture interactions between the real estate market and the labor market in steady state, but also to control for local externalities between regions. For our empirical evaluation, we use cross-sectional data covering approximately 95% of all independent cities and counties in Germany for the

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1 Analyses that incorporate migration flows as a key driver to explain market processes are made by, e.g., JEANTY *et al.* (2010), POTEPAN (1994) and VERMEULEN & VAN OMMEREN (2009), while in HWANG & QUIGLEY (2006) the aspect of market regulation is stressed.

2 A long-term relationship between income and house prices using U.S. time-series data is presented in HOLLY *et al.* (2006), whereas no relationship is detected by GALLIN (2006).

year 2005. In the first step, we estimate the four-equation system consisting of housing prices, rental prices, building land prices and income via a three stage least squares regression to clarify the structural relationships at play. In the second step, we estimate the reduced form separately for each equation to detect the total effects of exogenous price determinants. Thereby, regardless of the theoretical setting, which already considers externalities across space, we present additional estimates to account for spatial correlation due to the nature of data to make our findings as robust as possible.

The remainder of this paper is organized as follows: Section two presents the theoretical background. Section three describes the data and the empirical methods. Section four discusses the results, first presenting the structural form estimations, followed by the reduced form estimations. Section five concludes the paper.

2 Theoretical Background

This paper begins with the real estate model of POTEPAN (1996). That model describes the entire value-added chain of housing from production to consumption to analyze regional disparities in steady states. The setting consists of three subsectors, each delineating one aspect of housing. They are sequentially linked by no-arbitrage conditions; therefore, rational agents can equally reflect demand and supply in consecutive submarkets. We convert prices, costs and income to real terms using a regional price index to investigate market processes in the absence of money illusion (or in terms of relative prices).

Starting at the top of the model, the market for housing services depicts the consumption of housing services. In such a market, tenants and owners determine the housing demand together, where the price for housing services is the rental price. Just as tenants transfer their payments to landlords during each period, homeowners implicitly do the same for themselves. Thus, there exists one unified market price for all households. In equilibrium, under the user-cost of capital approach, households are indifferent regarding the choice between the two options for tenure choice, renting or owning.

The demand function HS^D can be generally described as follows:

$$HS^D = HS^D(r, inc, am, immobility, t, structure, size), \qquad (1)$$

where:

$\frac{\partial HS^D}{\partial r} \leq 0$; $\frac{\partial HS^D}{\partial inc} \geq 0$; $\frac{\partial HS^D}{\partial am} \geq 0$; $\frac{\partial HS^D}{\partial immobility} \leq 0$; $\frac{\partial HS^D}{\partial t} \leq 0$; $\frac{\partial HS^D}{\partial structure} \leq 0$; $\frac{\partial HS^D}{\partial size} \leq 0$.

If housing is a normal good, the willingness to consume housing services will decrease with a higher rental price, r, but rise with higher income, inc. The same change is expected to manifest when the quality of local amenities, am, is higher.

Both studies also include the absolute level of the population as the demand factor. In our opinion, the long-term model attempts to abstractly define rational decisions that depend on already-captured economic factors. By applying the spatial equilibrium approach, which internalizes network externalities via population size, we keep population from becoming an exogenous factor.

Instead, we account for population mobility within one district using $immobility$, the number of people above the age of 65. The number of elderly persons is assumed to decrease housing demand in Germany (KEMPER, 2004) because, following GABRIEL & NOTHAFT (2001), lower mobility lowers the natural vacancy rate and thus equilibrium rental prices in the long-term.[3] The price effect of property tax, t, is expected to be negative because the tax burden on landlords, which depends on the price elasticity of demand, can be transferred to tenants (TSOODLE & TURNER, 2008). To account for demand differences in population according to ownership (BORJAS, 2002) and according to housing stock quality due to discrimination (BOSCH, CARNERO, & FARRÉ, 2010), we include the number of foreigners, $structure$, which we assume to induce a relatively lower price impact compared

[3] This causal relationship holds true ceteris paribus even though the natural rate of vacancy is not considered here. As WHEATON (1990) points out, changes in living preferences can occur in the equilibrium state as well, but, consistent with our approach, this can only happen *within* the same district.

to natives since they tend to occupy lower quality rental apartments. Finally, we use $size$ to consider the declining effect on demanded living space with increased household size.

The supply side comprises landlords and homeowners who provide housing services in the same way. This assumption may appear too strong due to the different housing quality and types they each offer. However, the lower ownership ratio in Germany may balance these disparities in regard to the total supply effects in the rental and in the owner-occupied market. The rent-maximum strategy, HS^S, is modeled as follows:

$$HS^S = HS^S(r, p, i, t, exp), \quad (2)$$

where:

$$\frac{\partial HS^S}{\partial r} \geq 0; \quad \frac{\partial HS^S}{\partial p} \leq 0; \quad \frac{\partial HS^S}{\partial i} \leq 0; \quad \frac{\partial HS^S}{\partial t} \leq 0; \quad \frac{\partial HS^S}{\partial exp} \geq 0.$$

In the observation of price effects, the elasticity of housing supply is expected to be less than perfectly elastic and to vary across districts, due to, e.g., restrictions on housing affordability (GLAESER, GYOURKO, & SAKS, 2006; GREEN, MALPEZZI, & MAYO, 2005; QUIGLEY & SWOBODA, 2010).

Rising costs in housing production lead to disincentives to invest; hence, the price of housing capital, p, and the mortgage interest rate, i, ought to decrease housing services. Because the latter depends almost solely on contract length in Germany and on the amount of equity, it is assumed to be equal across cities and counties in Germany. Therefore, the interest rate enters in the intercept.

The correlation between the property tax rate, t, and the housing service supply is generally expected to be negative in general. Of course, as we have mentioned above, the tax can be imposed on tenants, but only when the contract between tenant and landlord provides for this tax. Otherwise, taxes are costs of housing supply costs.

Whether positive expectations about future returns on housing capital due to appreciation in housing, exp, are expected to increase the quantity of housing

services depends on the agents' degree of market information.[4] As CAPOZZA & HELSLEY (1989) show in their theoretical long-term model of urban land conversion, perfect foresight lead to the full capitalization of all necessary determinants and thus to an insignificant effect of population growth. The opposite becomes true when urban growth is unexpected (CAPOZZA & SCHWANN, 1989).[5]

In total, the market equilibrium for housing services reduces to the following:

$$r = r(p, inc, am, i, t, exp, structure, immobility, size). \quad (3)$$

The link to the second subsector, which is the market for housing capital, can be found in the equation for the user-cost of owning. As in any other equilibrium analysis of housing, all market agents need not have further arbitrage opportunities in changing their tenure choices or in renting or ownership investments (HENDERSON & IOANNIDES, 1983; POTERBA, 1992):

$$r = (i + t - exp) * p. \quad (4)$$

The market for housing capital ensures the supply of housing services. The "good" in this market is the habitable housing stock that is immediately suitable for renting or buying. Landlords or homeowners must purchase residential buildings in advance when offering living space in the market for housing services. Therefore, owners and renters also reflect the demand side of this market, HC^D, where the same implications for fundamentals apply:

$$HC^D = HS^S = HC^D(r, p, i, t, exp). \quad (5)$$

Housing capital is produced by housing developers who convert building land and construction materials:

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4 Appreciation in housing capital or in residential buildings is associated with less frequent reinvestments and thus with lower demand for construction materials and lower prices.

5 DUST & MAENNIG (2008) can empirically prove asymmetric house price reactions to population shrinkage in Germany.

$$HC^S = HC^S(p, l, c,), \tag{6}$$

where

$$\frac{\partial HC^S}{\partial p} \geq 0; \quad \frac{\partial HC^S}{\partial l} \leq 0; \quad \frac{\partial HC^S}{\partial c} \leq 0.$$

As in the market for housing services, supply is expected not to be perfectly elastic. Incentives to supply should emerge with higher returns, p, but disincentives should occur with higher building land prices, l. Similarly, housing capital supply should decline with higher construction costs c because it is unlikely that developers will be able to impose the entire cost burden on homeowners and landlords.

The steady-state relationship in the market for housing capital, including the relationships described in (5) and (6), results in the following:

$$p = p(r, i, t, e, l, c). \tag{7}$$

The connection between the market for housing capital and the third sector, the market for building land, is given in equation (8). The average return of housing capital, p, must be equal to the space unit cost of the production of housing capital separated into construction costs c and building land costs, l:

$$p = (c + l). \tag{8}$$

The market for building land is related to the space available for construction. Unlike agricultural land, building land is already connected to the public infrastructure system.

Housing developers take on the position of demand, so that their payment reserve equals its calculation in (6) with identical outcomes:

$$BL^D = HC^S = BL^D(p, l, c). \tag{9}$$

The land, including natural amenities, is initially owned by landowners (or, to be more precise, by public authorities) so that the landowners enter as suppliers:

$$BL^S = BL^S(l, ar, m, arliving), \tag{10}$$

where:

$$\frac{\partial BL^S}{\partial l} \geq 0; \quad \frac{\partial BL^S}{\partial m} \leq 0; \quad \frac{\partial BL^S}{\partial ar} \geq 0; \quad \frac{\partial BL^S}{\partial arliving} \leq 0.$$

Unlike the two previous studies, we make no further direct price distinction between kinds of land (such as building, rural or agriculture). Based on the smaller total land surface and higher population density of Germany compared to the U.S., the conversion of agricultural areas is assumed to be less price-intensive.

Supply elasticity is assumed to be less than perfectly elastic, so quantity should increase with price, l. In turn, legal land use restrictions, m, decrease the building land supply. A larger total surface per district, ar, might offset topographical limitations such as those represented by rock or water landscapes. However, when the proportion of building land is marginally increased, which creates a larger area already settled by households and firms as well as a larger public thoroughfare, $arliving$, depicts natural restrictions in new housing construction that diminish the opportunity for public permission to release building land in the future.

In equilibrium, the price function that implies all marginal effects of (9) and (10) mentioned above is as follows:

$$l = l(p, c, ar, m, arliving). \tag{11}$$

This is the limit of model POTEPAN's (1996) model, but there is room for further extension. Further embedding in a regional framework is possible. For example, according to ROSEN (1979) and ROBACK (1982), spatial equilibrium arises when households and firms have no further incentive to move. The economic intuition behind this model is relatively simple but noteworthy. Assuming a market environment characterized by perfect factor mobility and no moving costs, households and firms compete for a limited supply of land and amenities because these natural resources can fundamentally influence living quality and production; the effects become visible in housing prices and wages or, in our case, in the price for

housing services and in income. A steady state is achieved when direct and indirect (externalities) effects over time and, in particular, across space are fully capitalized into local prices and wages. If and only if this circumstance holds true, market agents do not have incentives to change their location decisions.

Following GLAESER *et al.* (2006), the spatial equilibrium condition can be stated:

$$U + r = w + I + a. \tag{12}$$

Substituting labor income w and non-labor income I with household income inc and treating individual utility U as uniform, the spatial equilibrium model is part of the housing services model and vice versa. Because a long-term interaction exists between income and housing prices, equation (12) acts as an equilibrium bridge like the other two conditions, (4) and (8).

To model an income equation, we specify the labor market as simply as possible. We expect that income is predominantly generated by labor[6]:

$$L^D = L^D(inc, productivity), \tag{13}$$

where:

$$\frac{\partial L^D}{\partial inc} \leq 0, \quad \frac{\partial L^D}{\partial productivity} \geq 0.$$

Firms will naturally hire more workers when the costs of labor, inc, are lower. Amenities, am, can make the production process more efficient, so that the marginal product of capital increases, while the marginal product of labor simultaneously decreases ceteris paribus. However, those effects are already captured in the $productivity$ variable, so amenities are redundant for explaining income. Regardless, a higher level of labor productivity increases recruitment by the non-perfectly elastic labor supply.

Labor supply is depicted as follows:

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[6] We ignore income from financial capital investments, so the differences between income and wages are due to net tax excess or to social transfer payments.

$$L^S = L^S(inc, r, children, am), \tag{14}$$

where:

$$\frac{\partial L^S}{\partial inc} \geq 0; \quad \frac{\partial L^S}{\partial r} \leq 0; \quad \frac{\partial L^S}{\partial children} \leq 0; \quad \frac{\partial L^S}{\partial am} \geq 0.$$

Once again, market supply is assumed to be less than perfectly elastic but still positive in regard to returns, inc. In contrast, higher prices for housing services, r, force individuals to move and hence reduce the region-specific labor supply. Moreover, the labor supply also depends on its (potential) quantity starting as a rule at the age of 18, $children$. A higher proportion outside of that range ought to lead to a relatively lower supply. Despite controlling for the prices of housing services and income, the influence of the amenity level on labor supply is positive because otherwise households would not settle in that district and thus would not supply labor as the spatial equilibrium condition implies.

Combining labor demand (13) and supply (14), the equilibrium in the labor market becomes the following:

$$inc = inc(productivity, r, am, children). \tag{15}$$

3 Data & Empirical Strategy

In our paper, we use a comprehensive data set for independent cities and counties in Germany for the year 2005. As Figure One shows, we cover the majority of districts, corresponding to approximately 95% of all districts or 418 sample units; the district boundaries were dated on 12/31/2006.[7]

Data for residential rents per square meter of living space, r, are provided by the Federal Office for Building and Regional Planning (Bundesamt für Bauwesen und

[7] For descriptive statistics, including sources, see Table 1.

Raumordnung - BBR)[8], which records basic, freely financed supply rents offered in daily newspapers and via popular internet platforms. They were compiled only for multi-apartment houses with at least three dwelling units. Thus, no information about single-family houses is available, but this limitation has a negligible impact within our framework.

We also receive housing supply prices, p, from the BBR. The BBR exclusively analyzes data for single-family houses that feature living space between 100 and 150 m². The associated lot size for properties in large cities amounts to 200 to 650 m²; in surrounding areas, the span extends from 250 to 700 m², and in rural districts it runs from 300 to 850 m². Nevertheless, data only exist in absolute terms. To convert this data into information on relative prices, we assign each district a respective average value in accordance with the classification established by the BBR.[9]

One limitation must be noted. Because there were few offers in some districts, relevant data for 2005 and 2006 are bundled. Similar restrictions also hold for building land prices, l, published by the BBR. The average purchase prices per m² for building land are presented for 2003-2005 and are available in the published data set INKAR 2007.

We use the same source to receive the majority of amenities, am.

[8] The BBR has separated housing data by district for Brandenburg, distinguishing between narrow and broad-integration areas. For a more appropriate comparison, we use data for broad areas. For rental prices see http://www.bbr.bund.de/cln_015/nn_23744/BBSR/DE/Raumbeobachtung/GlossarIndikatoren/indikatoren__dyncatalog,lv2=104776,lv3=290854.html and for house prices see http://www.bbr.bund.de/cln_015/nn_23744/SharedDocs/GlossarEntry/P/PreisStandardhaus.html.

[9] The BBR divides the regions into four so-called WIM-district types (metropolitan districts, large city districts, surrounding districts, and rural districts) to account for different patterns of development in real estate markets. For metropolitan and large-city districts, the assigned average is 425m² ; for surrounding districts, the average is 475m²; and for rural areas, the average is 575m². A map of classification is available on the BBR homepage: http://www.bbr.bund.de/nn_499850/BBSR/DE/WohnenImmobilien/Wohnungsmarkt/MethodenWerkzeuge/Fachbeitraege/WIMKreistypen/WIMKreistypen.html.

To measure some sort of public amenities, but also the geographic location of one district, we include $commuting\ time$, which measures the average travel time in minutes by public trains to the three nearest agglomeration centers.[10]

The average number of persons per household is displayed via $size$, while the number of registered $doctors$ per 1000 capita is used to describe the health care of one region. In contrast to OZANNE & THIBODEAU (1983) and POTEPAN (1996), who use recent population growth as a predictor of expected future returns in housing capital, exp, we use the calculated forecast value for population growth between 2004 and 2020. This indicator relies on past information about natural population changes and movements.

Using the same source, the total area of settlement and public thoroughfare, $arliving$, is provided in a relative scale per capita, which we recalculate for our analysis in absolute terms.

To deflate prices, costs, productivity and income, we pull a regional price level index from the online platform for the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR).[11] It measures disparities in cost of living for the year 2009, whereby it reflects a relative scale (given that Bonn is set as the reference category).

The other major data source that we make use of is the free online database provided by the statistical offices of the German federal government and the German states. This data source is used to calculate proxies of economic activity.

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[10] The following agglomeration centers within and around of Germany are considered: Berlin, Bremen, Dresden, Essen, Frankfurt, Hamburg, Hannover, Köln, Leipzig, Mannheim, München, Nürnberg, Stuttgart, Amsterdam, Antwerpen, Basel, Brüssel, Den Haag, Eindhoven, Genf, Kopenhagen, Liège, Lille, Lodz, Lyon, Mailand, Paris, Prag, Rotterdam, Stettin, Straßburg, Turin, Utrecht, Venedig, Wien and Zürich.

[11] http://www.bbr.bund.de/nn_335560/BBSR/DE/Aktuell/Medieninfos/2009/Ablage__Medieninfos/PM__Berichte30.html (click on « Preisindex aller Kreisregionen Deutschlands ») or see BBSR (Hrsg.): Regionaler Preisindex. Bonn 2009. = Berichte, Bd. 30, Anhang 3.

To create income, inc, we use disposable income per person in an average household, which incorporates the salaries of employees and the net excess of social payments and taxes.

Defining labor productivity, $productivity$, we calculate the ratio according to the gross-domestic product and the volume of work expressed according to the working hours of the entire labor force. In addition, because labor productivity depends on the degree of human capital which in turn essentially depends on agglomeration effects (CICCONE & HALL, 1996; COMBES, DURANTON, & GOBILLON, 2010; ROSENTHAL & STRANGE, 2004) and thus on factors eventually being not included in our model, we circumvent the problem of omitted variable bias by specifying it as endogenous. We take female population,$women$, as an instrumental variable because of the different supply elasticities of gender (HIRSCH, SCHANK, & SCHNABEL, 2006) and the different sum of man-years.

The aforementioned administrative bodies also provide data on the population below the age of 18, $children$, above the age of 65, $immobility$, the female population, $women$, the number of foreigners, $structure$, total area size, ar, and the property tax, t. Legal land use restrictions, m, are proxied by a dummy variable that is one if the district is an independent city. While in German independent cities there is one superior public administrative body, in German counties, public decisions are predominantly made in the municipality.

To consider the negative externalities of landfills on residential property values following REICHERT *et al.* (1992), we incorporate the number of $landfill$s.

The two additional amenity variables, $nursery$ and $tourism$, are the total number of places in day nurseries for children under the age of 14 and the number of beds in tourist accommodations. By including $nursery$, we attempt to capture the ability of the publicly provided child care system to provide households with the flexibility to participate in the labor market (DOIRON & KALB, 2005). The variable $tourism$ acts as a rough proxy for districts' opportunities for private activities including cultural events, sports, shopping etc., proceeding from the assumption

that tourism services are predominantly offered in areas characterized by a relatively high quality and quantity of local (private) amenities.

Construction data, c, are very scarce in Germany and do not exist on the county level. However, the German Federal Office of Statistics documents total revenue and working hours in the residential construction sector for each month and each state. Thus, we calculate the average ratio and assume an uniform cost distribution for each state. Material costs are omitted, but a more suitable indicator of cost differences is not available. To avoid misspecification through errors in variables, we specify construction costs as an endogenous variable instrumentalized by the number of construction firms available for each district for the year 2006. To ensure orthogonality to white noise, we assume a perfectly competitive market environment where each firm makes zero profits.

To examine the structural approach combining (3), (7), (11) and (15), ensuring consistent and efficient estimators, we choose the three-stage least squares method (ZELLNER & THEIL, 1962). The system of equations can be simply formulated as follows when assuming linear market functions:

$$\mathrm{YA} + \mathrm{XB} = \mathrm{U} \qquad \text{with } i = 1, \dots, n \text{ observations} \tag{16}$$

where $Y^T = [r_i \; p_i \; l_i \;\; inc_i]^T$ is a 4 x n vector of endogenous variables, X is a n x k matrix of the corresponding exogenous covariates k and the error vector U has the dimension n x 4. In this specification, errors have a zero conditional mean and are conditionally homoskedastic but are cross-correlated. The first diagonal parameter matrix A is 4 x 4 and depicts the interdependencies among all four endogenous variables, while the second parameter matrix B has dimension k x 4 , containing the marginal effects of all exogenous covariates.

Afterwards, we obtain the reduced form for each equation that can be individually estimated by ordinary least squares:

$$\mathrm{Y} = \mathrm{XBA}^{-1} + \mathrm{UA}^{-1} = \mathrm{X\Pi} + \mathrm{V} \tag{17}$$

or in our case to circumvent misleading calculations, according to AIGNER *et al.* (1984), by two-stage least squares.

The differences between equations (16) and (17) are largely theoretical. In general, the reduced form results from the solution for endogenous interactions and is appropriate whenever the total impact of the exogenous variables is of main interest. By contrast, estimating structural or simultaneous equation models makes it possible to consider the interdependencies in its entirety. These calculations are generally closer to theoretical and causal predictions.

4 Results

4.1 Structural Form Estimation

The estimation results for the system equations – of the extended and the baseline models – are shown in Table 2. In principle, our further comparisons refer to his study even when no explicit remark is made to that effect. Moreover, because almost all variables are transformed into their natural logarithms (with the exception of population forecasts, property tax, and landfills),[12] we can interpret the coefficients as price or income elasticities.

First, we find empirical evidence for the interdependence of real estate prices and income. They exhibit a significant effect associated with their expected sign. Without an endogenization of household income as the reference setting shows, remarkable changes in coefficient magnitudes and significances in the housing services equation become obvious, primarily in terms of income.

Because this analysis focuses on Germany, the results lend additional support to the underlying framework; the analysis does not work exclusively for the U.S. market. For all four equations, the model explains between 27% and 51% of the

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12 We do not take the logarithm of these three variables because population forecasts and property tax are already in relative scale and no fullfills exist in approximately 20% of all districts.

variance and the covariates are always jointly significant, as the chi statistic clearly indicates.

Concerning the endogenous variables for each equation, price elasticity of housing services, r, with respect to housing capital, p, is positive and statistically significant. This result confirms the hypothesis that homeowners or landlords reduce their housing service supply when faced with higher investment costs for housing capital. In comparison, the price elasticity value of approximately 0.37% is below the 0.49% detected in the U.S. market. The lower degree of price sensitivity in Germany might be due to the lower (real) central bank discount rate in 2005, which reduced the opportunity costs of housing capital, e.g., by increasing incentives for capital net exports.

The opposite is true for income, inc. Income has a positive and significant influence of 0.33% on German housing demand and reflects a relatively higher level of preference regarding housing services than the 20% for U.S. households. Compared to the baseline model, where income is specified as exogenous, the elasticity is significantly negative, meaning that housing is an inferior good. That outcome clearly indicates misspecification in the baseline model, at least when it is applied to the German case. Omissions of relevant determinants for income, as the spatial equilibrium model suggests, automatically lead to inconsistencies and inefficiencies in the estimations. However, assumptions of initial exogeneity on the district level, as seen in MAYO (1981), might be not applicable to the entire structure of local economic interrelations.

In the market for housing capital, we can confirm almost all model predictions for the endogenous variables. Although higher returns in the housing services market, as depicted by higher rental prices, coincide with an increase in the homeowners' and landlords' incentives to enlarge the supply by approximately 0.02%, that finding is not significant at any conventional level. However, this lack of significance may be due to the fewer degrees of freedom and the complex estimation method at play.

However, housing capital supply is determined by housing developers, who use the price of land, l, to determine their course of action. The larger the expenditures required to secure suitable land, the lower the available market quantity should be. This effect is why the price of building land exhibits a positive and highly statistically significant coefficient of approximately 0.40, which is roughly close to the figure of 0.32 for the U.S. sector.

Similarities also appear in the market for building land. In relation to housing capital, building land prices are elastic. A one-percent increase in housing capital revenue increases demand by developers and ultimately leads to an average increase in building land price of almost 3.16% compared to the 2.33% in the U.S. case. Thus, the price increase suggests indirectly that there are comparatively large profit margins for housing developers and land owners across the markets of various nations.

The fourth equation presents the market for labor and earnings. The highly significant coefficient of the housing services price variable in the amount of 0.33% supports our conjecture about income endogeneity because household location choices (or, equivalently, household labor supply) are significantly influenced by the price of housing services as well.

Turning toward the exogenous determinants, as equation four suggests, property tax expenses, t, indicate higher costs for housing capital followed by lower demand for housing capital and a lower supply of housing services. Comparing the model forecasts with the estimates, we conclude that landlords are predominantly able to pass the tax burden onto tenants. Therefore, property taxes play no further role in the housing capital market.

Referring to condition (4) again, and bearing in mind that there are no financial barriers across space in Germany, expectations about future returns on housing capital are also important to investments and consumption choice decisions. Thus, higher rates of expected future population growth, exp, should raise demand for housing capital while increasing housing services supply. In each case,

the estimates are insignificant for both sectors, so the results confirm the certainty model of CAPOZZA & HELSLEY (1989), at least for the structural form.

Following equation (8), construction costs determine developers' investment strategy in the market for housing capital and building land in a fundamental way. As mentioned above, developers reduce their demand for building land and their supply of housing capital when construction costs, c, are higher. In contrast to POTEPAN (1996), we obtain a significantly positive impact on housing prices and a negative impact on building land prices, which is in line with the theoretical framework.

Subject to the spatial equilibrium approach in equation (12), amenities, am, that increases living quality raise the value of housing services and simultaneously decrease production output. Therefore, all (dis-)amenities appear in the housing services and in the labor market equally.

For almost all amenity variables, which reflect the quality of public services, geographical location, leisure opportunities and health care, the results provide individual evidence for each according to model predictions.

In addition to amenities, housing services demand also depends on housing stock heterogeneity and on the composition of its demanders. By $structure$, which exerts a distinctly negative effect on the average price for housing services, we can sustain the thesis about disparities in housing among ethnic groups. We also detect that household mobility or apartment changes within districts are remarkable even in equilibrium because $immobility$ is significantly negative. Moreover, the results also confirm the negative relationship between the demand for living space and average household size for the German housing market by the negative outcome of $size$.

When considering the labor market, $productivity$ reflecting labor efficiency and $children$ presenting a factor that affects labor quantity are included. By comparison, an increase of $children$, as per the assumption, reduces labor supply and thus increases wages or income relatively; in our case, by approximately 0.07%

holding all other factors constant, while $productivity$ increases earnings by 0.55%. For the German labor market, one can therefore conclude that quality effects outweigh quantity effects. This finding is in line with SUEDEKUM (2008) or ARNTZ (2010), who detect regional convergence for human capital, especially for well-educated people in Germany, and is in contrast to BERRY & GLAESER (2005) for the U.S. Given the equal distribution of education level in a steady state, income disparities mainly emerge in terms of differences in labor efficiency.

Finally, with regard to the building land market, disparities between our observation units, independent cities and counties declared by m, are not present. Instead, larger area size, ar, significantly lowers the value of building land by approximately 0.08%. Conversely, the larger the housing sprawl, $arliving$, the larger the shortage of new building land and the more expensive is its relative price; in our case, 0.10%. Nevertheless, both outcomes points to an inelastic reaction indicating that there is still sufficient building land for new construction in the average German district.

4.2 Reduced Form Estimation

Now we turn to the reduced form elasticities of all exogenous price drivers. A prior analysis of the structural form is difficult because interactions between the endogenous variables obscure the issue. In addition to presenting the results using two stages least squares (2SLS) methods, thereby specifying construction costs and productivity as endogenous, calculations controlling for error terms and omitted variables that might be correlated across space (ANSELIN, 1988) and that

are addressed by spatial autoregressive models (SAR) are also shown.[13] Despite using the spatial equilibrium model, which captures spatial correlation from a theoretical perspective, we ensure robustness using a various set of empirical outcomes. Tables 3 and 4 present the results for the reduced forms with or without modeling household income interdependencies with real estate prices in addition to spatial correlations.

Referring to the tests of DURBIN (1954), of WU (1974), of HAUSMAN (1978) and of WOOLDRIDGE (1995), all of which determine whether variables are indeed endogenous as specified, except for the housing capital sector, they clearly support our presumption of the joint endogeneity of productivity and construction costs due to omitted variable bias and to errors in variables. Even at the 1% significance level, they allow us to reject the null hypothesis of exogeneity.

As the results of the Wald test and the Lagrange multiplier test for the spatial autoregressive parameter show, at least from an empirical perspective, it might be preferable to control for further spatial externalities. From a theoretical perspective, the model is expected to be fully specified and to account for spatial externalities by definition; a contradiction therefore emerges between theoretical and empirical predictions. Two possible and opposed explanations exist: First, that the empirical spatial outcomes are spurious and second, that the model specification is not sufficient. While either explanation could be generally valid, the problem of omitted variables correlated across space can empirically exist without leading to inconsistent and inefficient estimations assuming that those

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[13] To choose the appropriate spatial pattern, we obtain the robust Lagrange multiplier test for the spatial lag and the spatial error model following ANSELIN & BERA (1996). While for each reduced form equation for the spatial error approach the robust Lagrange multiplier test confirms our model assumption of no misspecification due to spatial correlation at the one percent significance level, for the spatial lag approach the same test reveals the opposite. Therefore, we only present results for the spatial lag approach. Using equation (17), the model becomes to: $Y = \rho WY + X\Pi + V$ with ρ denoting the spatial autoregressive parameter rho and with W denoting the spatial weights matrix. As KELEJIAN & PRUCHA (1998) prove, the pure 2SLS procedure, which we apply in this paper, is consistent, but not fully efficient compared to their suggestion of a generalized spatial two-stage least squares (GS2SLS) procedure. Because we focus our interpretation on variables that are significant at least at the five percent level, this asymmetry in standard errors can be mitigated asymptotically.

neglected effects are uncorrelated to our model parameters, as stated earlier in section 3. Because our degrees of freedom correspond to 400, the estimates can also be interpreted in asymptotical terms. Closely linked, even though the majority of determinants in Table 3 are accounted as insignificant, as the Wald χ^2-statistic respectively shows, the joint explanation power of all determinants matters.

Comparing Tables 3 and 4, three general facts become obvious. First, more variables are significant under the spatial 2SLS method than in the pure 2SLS. Second, the majority of coefficient disparities between both methods are relatively small when estimation uncertainty is small. Third, all variables that are significant in the 2SLS models are also relevant in the spatial 2SLS models. Thus, there are similarities in the findings that follow the theoretical and empirical lines, especially for housing capital and the labor market. Therefore, we will now focus on the parameters in Table 3, which are significant at the 10% level at least.

Beginning with the housing service market, on average, those districts with the best health care systems, $doctors$, and the highest expected population trends, exp, induce relative price increases by 0.29% and 0.57%, respectively. The positive sign of the latter might be counterintuitive in regard to the user cost of capital approach in equation (4). However, under the structural estimates, the impact of housing capital on housing services is larger than the reverse effect, so the first outweighs the second.

In the market for housing capital, expectations about future population development also matter likewise. Contrary to the findings above, we detect a significant impact that reveals partial information uncertainty among market agents. Nevertheless, this diametrality in evidence clearly reveals the necessity to present structural and reduced forms, especially when the information set is limited and the equation system is complex. In sum, the findings for Germany rather supports the results of CAPOZZA & SCHWANN (1989). The positive causality between $immobility$ and the price for housing capital seems to be a further contradiction to the structural estimates. Bearing in mind that a larger proportion of population above the age of 65 can reflect average household wealth as well, as far as in-

come determinants are insignificant due to collinearity, in this case, that effect can be also interpreted as an indirect signal for higher returns in the market for housing services. To explain the negative coefficient of area settlement, $arliving$, and the positive of area size, ar, one have to consider the interrelations of markets again. A shortage of free building land given total area size pushes up the price, reduces the incentive for housing developers to invest and thus decreases capital production. Moreover, housing capital is significantly more expensive in independent cites than in counties, as the parameter for m shows. The higher price may be due to the administrative structure, under which planning decisions in large cities are made centrally and are probably more restrictive than in counties due to the stronger limitations on available land.

Concerning the market for building land, only expectations about future population development are important according to the pure 2SLS, while almost all determinants are highly significant when following the spatial 2SLS approach. The remarkable price response confirms the value of expectations for agents' decisions in the housing market. Similar to the causality line highlighted for the other significant determinants above, this outcome can be explained via the positive real estate price interdependencies.

To say something about the finding in the labor market is quite more difficult. The positive impact of household size might be due to its correlation to $children$, which is supposed to have a positive influence on income. Because the latter is highly insignificant, $size$ may capture a large proportion of $children$'s effectiveness.

5 Conclusion

We adopt the equilibrium model of POTEPAN (1996) to analyze long-run differences in rental prices, housing prices, building land prices and income levels for the overwhelming majority of German counties and independent cities using one closed structural model. We include the spatial equilibrium approach of (ROBACK, 1982) to provide theoretical justification for the interdependent relationship be-

tween income and real estate prices. We can show that the link between the two models can be found in the market for housing services.

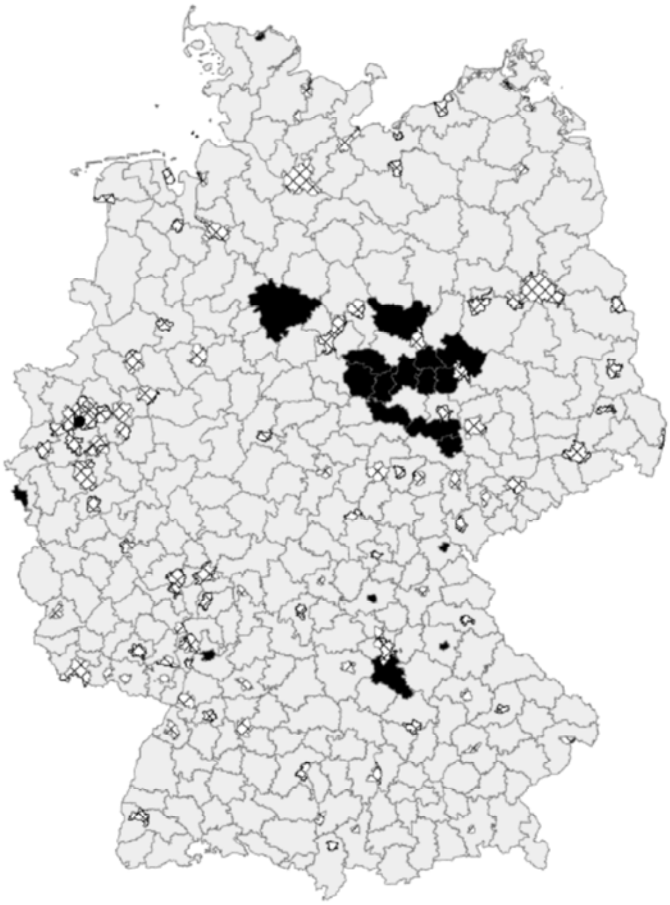
Structurally estimating the four-equation system via a three-stage least squares analysis, we find clear evidence to support the extension of our model. The interactions of real estate prices and income are predominantly significant and positive, and thus completely compliant with model predictions. Without specifying income as endogenous as the baseline model does, for Germany, we even find a completely diametral, significantly negative impact of income on housing prices. This finding might suggest that housing is an inferior rather than a normal good. However, in view of the theoretical framework and the empirical outcomes, this result instead indicates an omission of important income determinants.

To investigate the total impacts of exogenous factors on prices and income, we also present reduced form results. In addition to pure 2SLS regressions, 2SLS spatial lag models are shown due to the origin nature of data. While the empirical tests confirm the utility of such a procedure, from a theoretical perspective, spatial externalities are already accounted for via the spatial equilibrium model. However, independently from the specific estimation method, expectations about population development in particular exert a positive influence on real estate prices and income. This significance result reveals that regional variation in equilibrium real estate prices depends on agents' expectations about future market trends.

Future research should focus on examining the model in regard to time variation. Because our theoretical approach is specified in real terms, it is possible to verify the framework over time. To ensure robust results, it is important to know how model predictions satisfy the relevant requirements over a longer time span. Here, a closely linked dynamic structural approach might be appropriate. Concentrating entirely on the reduced form occludes the underlying theoretical relationship that is most often the starting point in similar research. Another area for further exploration has to do with our modeling of the labor market. Theoretical and empirical expansion is possible here and, indeed, is necessary to verify the previous model setting.

Appendix

Fig. 1 Sample Units - 2005



Source: This image was made by Gabriel Ahlfeldt.

Notes: Shaded districts display independent cities, grey districts display counties and black districts display units that are not included. The district boundary is dated on 12/31/2006.

Tab. 1 Data Overview

Variable	Scale	Source	Mean	Std. Dev.	Min	Max
Real Rental Price, r	€/m²	BBR	5.91	0.80	4.50	9.19
Real Housing Price, p	€/m²	BBR	445.55	135.86	223.75	881.19
Real Building Land Price, l	€/m²	INKAR 2007	128.95	100.14	12.79	657.77
Real Income, inc	€/person (in average house-hold)	vgrdl.de; bbr.de	18912.1	1998.1	14656	27584
Population Fore-cast, exp	Relative Change, 2004- 2020	INKAR 2007	-0.013	0.079	-0.302	0.219
Population -18, $children$	total	regionalstatis-tik.de	4325.22	4545.0	794	74834
Population +65, $immobility$	total	regionalstatis-tik.de	36478.18	38977.4	7538	585313
Regional Price Index	Relative scale to Bonn	bbsr.bund.de	0.9089	0.0486	0.83	1.14
Time to Centers $Commuting\ time$	in minutes	INKAR 2007	101.20	36.22	24	228
Number of Beds, $Tourism$	total	regionalstatis-tik.de	6064.90	8036.7	230	81779
Health care, $doctors$	per 1000 capita	INKAR 2007	1.539	0.515	0.69	3.71
Child care, $nursery$	total	regionalstatis-tik.de	7464.28	8475.4	1180	126168
Foreign Popula-tion, $structure$	total	regionalstatis-tik.de	16849.2	34547.	572	466518
Property Tax, t	in 100 %	regionalstatis-tik.de	3.5996	0.6200	2.37	6.6
Real Construc-tion Costs, c	€/h	https://www-genesis.destatis.de	82.30	10.56	56.33	124.63
Independent city, m	Dummy	own calculation	0.263	0.441	0	1
Area surface, ar	km²	regionalstatis-tik.de	824.86	596.91	35.7	3058.1
Area of settle-ment, $arliving$	km²	INKAR 2007, own conversion	106.52	73.31	12.97	880.73
Real $productivity$	€/h	vgrdl.de	41.58	5.68	27.81	70.75

Landfills	total	regionalstatis-tik.de	4.6	7.4	0	67
Female population, *women*	total	regionalstatis-tik.de	97010.1	111884	18105	1731180
Household *size*	total	INKAR 2007	2.17	0.175	1.74	2.74
Construction firms	total	regionalstatis-tik.de	855.6	899.8	39	13931

Source: Based on data described in 3.

Notes: Data are shown in their original form. Data for income and productivity were retrieved on 08/08/2008 before data according to the restructuring in Saxony in 2008 has been published.

Tab. 2 Structural Form

3SLS	Extended Model				Baseline Model		
	Housing Services	Housing Capital	Building Land	Labor Market	Housing Services	Housing Capital	Building Land
	Rental Price	Housing Price	Land Price	Income	Rental Price	Housing Price	Income
Rental Price	-	0.016 (0.13)	-	0.327*** (4.34)	-	-0.043 (-0.38)	-
Housing Price	0.321*** (4.35)	-	3.159*** (25.17)	-	0.424*** (6.85)	-	3.189*** (24.81)
Land Price	-	0.296*** (10.64)	-	-	-	0.303*** (11.45)	-
Income	0.332** (2.39)	-	-	-	-0.178*** (-3.60)	-	-
Nursery	0.1567*** (6.87)	-	-	-0.092*** (-3.43)	0.118*** (7.25)	-	-
Population Forecast	0.102 (1.29)	0.043 (0.61)	-	-	0.156** (2.19)	0.058 (0.87)	-
Size	-0.233** (-2.59)	-	-	-	-0.182** (-2.17)	-	-
Property Tax	-0.038*** (-4.06)	-0.009 (-1.01)	-	-	-0.056*** (-6.89)	-0.015* (-1.78)	-
Construction Costs	-	0.399*** (3.43)	-1.140*** (-3.44)	-	-	0.368*** (3.22)	-1.166*** (-3.49)
Independent Cities	-	-	0.014 (0.26)	-	-	-	0.058 (1.27)
Area Surface	-	-	-0.083** (-2.27)	-	-	-	-0.064* (-1.91)
Area of Settle-ment	-	-	0.100*** (2.72)	-	-	-	0.092*** (2.64)
Productivity	-	-	-	0.550*** (9.22)	-	-	-
Children	-	-	-	0.071*** (2.61)	-	-	-
Immobility	-0.077*** (-3.13)	-	-	-	-0.061*** (-2.77)	-	-
Landfills	-0.003*** (-4.86)	-	-	0.001 (1.41)	-0.002*** (-3.48)	-	-
Structure	-0.053*** (-3.91)	-	-	-	-0.030** (-2.11)	-	-
Commuting time	-0.027** (-2.01)	-	-	0.010 (0.60)	-0.026** (-2.03)	-	-
Tourism	0.024*** (4.37)	-	-	-0.001 (-0.10)	0.019*** (3.51)	-	-

Doctors	0.106*** (4.40)	-	-	-0.041** (-2.17)	0.101*** (4.25)	-	-
Intercept	-3.594*** (-2.98)	2.951*** (5.14)	-9.461*** (-7.21)	7.404*** (29.15)	1.108** (2.27)	3.180*** (5.74)	-9.621*** (-7.34)
N	418	418	418	418	418	418	418
R^2	0.2817	0.5136	0.2699	0.3415	0.2545	0.5152	0.2584
Chi^2- Statistic	468.94***	848.19***	726.61***	291.29***	466.62***	846.21***	712.79***

Notes: All variables are converted into the natural logarithm except property tax, landfills and population forecast. The endogenous variables are rental price, housing price, building land price, productivity and construction costs. In addition to the exogenous variables, female population and the number of construction firms are used as further instrumental variables in the extended version, while for the baseline model, the female population is neglected. Estimations are made using the three stage least squares method. Z-statistics are in parentheses; the asterisks ***, ** and * denote significance at the one percent, five percent and ten percent levels.

Tab. 3 Reduced Form

2SLS	Extended Model				Baseline Model		
	Housing Services	Housing Capital	Building Land	Labor Market	Housing Services	Housing Capital	Building Land
	Rental Price	Housing Price	Land Price	Income	Rental Price	Housing Price	Land Price
Nursery	-0.026 (-0.13)	0.013 (0.08)	-0.220 (-0.21)	-0.034 (-0.20)	-0.027 (-0.41)	-0.176 (-1.14)	-0.020 (-0.73)
Population Forecast	0.566** (1.99)	0.518** (2.23)	3.558*** (2.63)	0.380 (1.59)	0.394*** (3.80)	0.295 (1.54)	2.579*** (7.15)
Size	-0.116 (-0.24)	0.266 (0.57)	-0.735 (-0.30)	1.087** (2.42)	0.151 (0.78)	0.459 (0.98)	0.918 (1.11)
Property Tax	0.047 (0.50)	0.010 (0.12)	0.302 (0.60)	0.065 (0.78)	-0.028* (-1.83)	-0.014 (-0.47)	-0.066 (-1.08)
Construction Costs	-0.918 (-0.83)	-0.064 (-0.06)	-1.889 (-0.33)	-0.322 (-0.34)	-0.986** (-2.17)	-0.969 (-1.01)	-2.749 (-1.55)
Independent cities	-0.0109 (-0.12)	0.167** (2.01)	0.407 (0.90)	-0.047 (-0.60)	-0.079* (-1.85)	0.111 (1.30)	0.813 (0.50)
Area surface	0.130 (1.26)	0.161* (1.88)	0.624 (1.23)	0.113 (1.28)	-0.020 (-0.49)	0.025 (-0.31)	-0.163 (-1.15)
Area of settle-ment	-0.281 (-1.41)	-0.407** (-2.38)	-1.690 (-1.57)	-0.251 (-1.43)	-0.002 (-0.03)	-0.066 (-0.46)	-0.206 (-0.88)
Productivity	2.380 (1.14)	0.919 (0.50)	12.020 (1.10)	2.193 (1.18)	-	-	-
Children	0.322 (0.95)	-0.088 (-0.30)	1.807 (1.00)	0.151 (0.49)	-	-	-
Income	-	-	-	-	0.279* (1.72)	0.467 (1.44)	1.857*** (2.95)
Immobility	-0.069 (-0.70)	0.232** (2.71)	-0.036 (-0.07)	0.101 (1.14)	-0.085** (-2.09)	0.035 (0.53)	-0.049 (-0.36)
Landfills	-0.005 (-1.33)	0.005 (1.38)	-0.026 (-1.41)	-0.004 (-1.12)	0.002 (1.14)	0.008** (2.57)	0.008 (1.32)
Structure	-0.069 (-0.70)	0.099 (0.69)	-0.710 (-0.83)	-0.121 (-0.81)	0.104*** (3.50)	0.186*** (3.17)	0.519*** (4.75)
Commuting time	-0.055 (-1.06)	-0.002 (-0.05)	-0.310 (-1.24)	-0.033 (-0.72)	-0.017 (-0.70)	0.006 (0.12)	-0.076 (-0.91)
Tourism	0.079 (1.35)	-0.012 (-0.23)	0.314 (1.01)	0.044 (0.85)	0.032*** (2.84)	-0.012 (-0.58)	0.086* (1.86)
Doctors	0.287* (1.88)	-0.007 (-0.05)	0.770 (1.00)	0.199 (1.48)	0.183*** (5.14)	-0.034 (-0.39)	0.235 (1.55)
Intercept	-3.626 (-0.71)	0.866 (0.19)	-36.180 (-1.40)	1.966 (0.44)	3.430*** (3.27)	- 25.82*** (-6.34)	-3.020 (-0.78)
Wald Chi2-Statistic	89.***	581.***	172.***	288.***	609.***	684.***	1734.***

Durbin Robust Chi2- Statistic	18.79***	0.32	29.63***	4.96*	4.04**	0.06	2.91*
Wu-Hausman Robust F-Statistic	9.39***	0.15	15.22***	2.39*	3.92**	0.06	2.82*
Wooldridge Robust F-Statistic	7.64***	0.15	13.66***	2.75*	3.27*	0.07	2.20

Notes: All variables are converted into natural logarithm except property tax, landfills and population forecast. The endogenous variables are rental price, housing price, building land price, productivity and construction costs. Besides the exogenous variables, female population and the number of construction firms are used as further instrumental variables in the extended version, while for the baseline model female population is neglected. Estimations are made using the 2SLS method with heteroskedasticity robust standard errors. Z-statistics are in parentheses, the asterisks ***, ** and * denote significance at the one percent, five percent and ten percent levels, respectively.

Tab. 4 Reduced Form Spatial Lag Approach

2SLS Spatial Lag	Extended Model: Housing Services – Rental Price	Extended Model: Housing Capital – Housing Price	Extended Model: Building Land – Land Price	Extended Model: Labor Market – Income	Baseline Model: Housing Services – Rental Price	Baseline Model: Housing Capital – Housing Price	Baseline Model: Building Land – Land Price
Nursery	0.003 (0.71)	-0.012 (-0.09)	-0.030 (-0.12)	-0.050 (-1.26)	0.069** (2.33)	-0.002 (-0.02)	0.262* (1.68)
Population Forecast	0.319*** (3.96)	0.442** (2.23)	2.722*** (7.93)	0.153** (2.13)	0.203*** (2.85)	0.445** (2.20)	1.920*** (5.58)
Size	-0.230** (-1.97)	0.113 (0.29)	-1.157** (-2.04)	0.226* (1.68)	-0.087 (-0.81)	-0.151 (-0.44)	-0.331 (-0.61)
Property Tax	0.023 (0.73)	0.012 (0.13)	0.211 (1.22)	0.051 (1.64)	-0.025* (-1.72)	-0.042 (-0.98)	-0.098 (-1.32)
Construction Costs	-0.243 (-0.51)	-0.235 (-0.15)	-0.076 (-0.03)	-0.406 (-0.99)	-0.135 (-0.31)	0.503 (0.39)	0.568 (0.24)
Independent cities	0.013 (0.45)	0.182** (2.15)	0.431*** (3.56)	-0.063** (-2.14)	-0.025 (-0.93)	0.192** (2.43)	0.235* (1.89)
Area Surface	0.100*** (2.62)	0.136 (1.35)	0.566*** (3.40)	0.040 (1.01)	0.010 (0.57)	0.100* (1.73)	-0.015 (-0.17)
Area of Settle-ment	-0.205*** (-2.70)	-0.320* (-1.77)	-1.422*** (-4.18)	-0.111* (-1.69)	-0.042 (-1.42)	-0.253*** (-2.82)	-0.343** (-2.31)
Productivity	1.598** (2.22)	1.001 (0.50)	10.45*** (2.96)	1.260* (1.81)	-	-	-
Children	0.240** (2.10)	-0.034 (-0.12)	1.565*** (3.09)	0.047 (0.46)	-	-	-
Income	-	-	-	-	0.026 (0.31)	0.148 (0.59)	0.676 (1.48)
Immobility	-0.052 (-1.57)	0.203*** (2.67)	-0.055 (-0.46)	0.110*** (3.20)	-0.032 (-1.31)	0.105* (1.75)	0.041 (0.40)
Landfills	-0.004*** (-2.95)	0.004 (0.97)	-0.025*** (-4.10)	-0.002 (-1.08)	-0.001 (-1.05)	0.005** (2.39)	-0.001 (-0.41)
Structure	-0.125*** (-2.28)	0.044 (0.30)	-0.735*** (-2.98)	-0.077 (-1.45)	0.010 (0.78)	0.099*** (2.75)	0.114* (1.83)
Commuting Time	-0.053*** (-3.06)	0.006 (0.12)	-0.269*** (-3.24)	-0.016 (-0.82)	-0.021** (-1.96)	0.003 (0.09)	-0.054 (-1.15)
Tourism	0.045** (2.49)	-0.008 (-0.15)	0.238** (2.47)	0.021 (1.26)	0.013* (1.84)	-0.031 (-1.52)	0.035 (0.96)
Doctors	0.214*** (6.06)	0.086 (0.07)	0.789*** (4.62)	0.113*** (2.75)	0.146*** (6.72)	-0.045 (-0.59)	0.310*** (2.99)
Intercept	-4.187** (-2.17)	-0.277 (-0.05)	-31.74*** (-3.65)	1.528 (0.85)	0.406 (0.96)	0.900 (0.66)	-6.697* (-3.36)

N	418	418	418	418	418	418	418
Pseudo R^2	0.782	0.591	0.878	0.574	0.777	0.589	0.877
Wald Chi2- test (rho=0)	297.17***	33.96***	119.48***	54.65***	284.52***	36.63***	136.33***
LM Chi2- test (rho=0)	190.32***	34.69***	142.74***	43.82***	185.91***	38.04***	148.74***

Notes: All variables are converted into the natural logarithm except property tax, landfills and population forecast. The endogenous variables are rental price, housing price, building land price, productivity and construction costs. In addition to the exogenous variables, the female population and the number of construction firms are used as further instrumental variables in the extended version, while for the baseline model female population is neglected. Estimations are made using the 2SLS method for spatial lag models with heteroskedasticity robust standard errors. The elements of the spatial weights matrix are 1 if two districts have the same border, otherwise the elements are 0. Z- statistics are in parentheses, the asterisks ***, ** and * denote significance at the one percent, five percent and ten percent levels, respectively.

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