House Prices, Housing Development Costs, and the Supply of New Single-Family Housing in German Counties and Cities

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Abstract

This paper investigates the determinants of new single-family housing supply in local housing markets in Germany, using construction permits as the dependent variable. The empirical estimations are based on a rich panel data set for 413 German counties and cities over the time period of 2004-2010. Employing dynamic panel data analysis, the findings suggest that the local ratio of existing home prices to housing development costs and past local permit rates act as main drivers of new local housing investment. The average long-run price elasticity of new single-family housing supply is less than one, but sizable differences exist across the urban hierarchy.

Key words: Housing supply, local housing markets, difference GMM

JEL classification: R31, C33

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1 Introduction

Urban and regional economics currently witnesses a rapid growth of empirical research on the supply of housing in small geographic areas. Among others, recent important contributions include Green et al. [2005], Hwang and Quigley [2006], Goodman and Thibodeau [2008], Glaeser et al. [2008], Ball et al. [2010], Saiz [2010] and Meen and Nygaard [2011]. As Gyourko [2009] notes, the recent growth in quantitative research on the supply side of local housing markets can be explained by improvements in data availability and an increased interest in the economic and non-economic factors that shape land allocation.\footnote{For example, Malpezzi and Maclennan [2001] point out that many multiple-region macroeconomic models provide policy recommendations that are based on implicit (empirically driven) assumptions about the magnitudes of regional (or local) housing supply elasticities.}

A typical objective of many empirical studies is the estimation of the price elasticity of new housing construction. This grounds in the high importance that the size of housing supply elasticity carries for the long-term development of cities and regions, as well as for the entire economy. The responsiveness of which new housing supply reacts to (changes in) existing home prices strongly influences whether shocks to the demand for a location manifest themselves in construction shifts and city growth, or in rising house prices and wages [DiPasquale and Wheaton, 1996, Gibb and Hoesli, 2003, Glaeser et al., 2006]. The outcome of the housing supply process is of considerable importance to other markets as well: by aggravating house price differentials across regions, low housing supply elasticities may impede the interregional mobility of labor [Cameron and Muellbauer, 1998, Saks, 2008]. Price-inelastic supply of housing may also amplify the amplitude of housing cycles and constrain housing affordability in prospering places [Muellbauer and Murphy, 2008].

The central aim of the present article is to derive reliable estimates for the price elasticity of new housing supply in local housing markets in Germany. The paper focuses on the submarket for single-family housing. The econometric analysis is based on a comparatively rich panel data set, covering all 413 German counties (Kreise) and urban municipalities (Kreisfreie Städte) on its cross-sectional dimension and the time period of 2004 to 2010 on its temporal dimension. The paper’s motivation for analyzing single-family housing supply in German local areas stems from two main reasons. First, a substantial advantage of using local rather than national data in studying housing supply arises from the fact that housing markets are intrinsically separated in space. Homes are produced, distributed and consumed locally. This means that national (and even regional) level information systematically conceals important information that may be obtained from structural housing market disparities across smaller-sized geographic areas. Second, there has been very little research on housing supply in Germany, in particular regarding the submarket for single-family homes. Considering the micro-level wealth effects of new residential construction, the single-family home submarket is, however, of considerable importance. The majority of single-family homes in Germany is owner-occupied, which implies that new supply largely determines how much housing capital is accumulated by private households.\footnote{Single-family homes are currently the largest single asset class in which German households are invested. According to German Census data for the year of 2010, owner-occupied housing accounted for 50 per cent of net household wealth, and 65 per cent of all 16.5 million}
As an important innovation, this paper is one of the first to apply dynamic stationary panel data techniques to local housing market data. In order to distinguish between the short- and the long-run elasticity of new local housing supply, a dynamic stationary panel model is estimated which allows to account for systematic temporal inertia in the reaction of new supply to (changes in) local home building profitability. The empirical setting also helps identifying whether there is significant discrepancy in the responsiveness of housing supply in different markets, such as major cities, urbanized areas, and rural counties. Additionally, the use of two-way fixed effects facilitates to account for unobserved local heterogeneity as well as for unobserved time effects on local housing investment. In this manner, the paper contributes original evidence on the nature of adjustment processes in the German market for single-family housing.

The remainder of the article is organized as follows. Section 2 reviews the main results of existing empirical research on local housing supply from different countries. Section 3 provides relevant background information on the German market for single-family homes. Based on a formal description of the economic rationale underlying new single-family housing investment, Section 4 serves to discuss the econometric specification of a housing supply equation. Section 5 contains a detailed description of the data set and a discussion of stationarity issues. Panel regression results are presented in Section 6. Finally, Section 7 concludes.

2 Literature overview

Economists have come to general consensus as to the economic importance of housing supply in general as well as to the variables affecting new construction (prices of existing homes, costs of construction inputs, expectations, time at the market, and so on). The appropriate methodological approach to derive quantitative estimates of the price elasticity of supply is, however, less clear-cut. Following DiPasquale [1999] and others, the methods of econometric modelling mainly used in empirical studies can be classified in three main approaches: (i) the estimation of reduced form equations, obtained from a system of simultaneous equations, (ii) the estimation of equations that directly link a supply variable on (changes in) house prices and further variables, and (iii) the estimation of error correction models that allow for adjustment dynamics or time-changing deviations from the equilibrium house price.

Reflecting different approaches to empirical modelling, as well as differences in the choice of spatial reference level and time period, existing studies on housing supply offer a considerable range of elasticity estimates [Ball et al., 2010]. Elasticity estimates even vary for the very same spatial entities, depending on methodology and the years for which supply is observed. For instance, Goodman and Thibodeau [2008] find an average price elasticity of 0.35 for 95 US owner-occupied housing units were single-family houses. The total of 10.75 million single-family homes accounted for an estimated market value of about two trillion Euros, which corresponds to an average value of 186,000 Euros per home.

In view of the voluminous literature, this section does not review existing research on housing supply in depth. Excellent surveys are provided by DiPasquale [1999] and Gyourko [2009].
metropolitan areas with population over 500,000 in the 2000 US Census, analyzing the change in metropolitan housing stocks between 1990 and 2000. Using a comparable set of cities and data on housing stock change between 1970 and 2000, Saiz [2010] reports a population-weighted average elasticity of 1.75.4

Empirical evidence on local housing supply elasticity outside the US is generally scarce, with the UK and New Zealand as major exceptions. An early study by Bramley [1993] employs cross-sectional data on 90 local authority districts in England over 1986 to 1988 to estimate long-run supply elasticity, obtaining a value of 0.31. Pryce [1999] also uses cross-sectional data at the English district level, comparing local elasticities of supply between 1988 (a period of housing boom) and 1992 (a period of housing slump). He derives estimates of 0.58 in 1988 and 1.03 in 1992. A more recent paper by Meen [2005] roughly supports the elasticity range of the two previous papers, reporting an average elasticity size of 0.42 for nine larger territorial regions in the same country during 1973 and 2002. Analyzing data for 73 administrative local authorities in New Zealand over the 1991-2004 period, a recent study by Grimes and Aitken [2010] finds a mean supply elasticity of 0.7.

Empirical evidence on the price elasticity of new housing supply in Germany is widely lacking. This is particularly true considering evidence based on spatially disaggregated information. Referring to all forms of housing and the national level, two recent cross-country studies by Sanchez and Johansson [2011] and Gattini and Ganoulis [2012] estimate long-run elasticity of supply based on time series analysis. The two studies use different methodological approaches and time periods, but both indicate the price elasticity of new housing supply in Germany to be smaller than one.6 To the best of our knowledge, no attempt has so far been made to quantify the price responsiveness of housing supply based on local housing market information in this important national economy.

3 The market for single-family housing in Germany

National patterns of new home building

In contrast to other economies, Germany did not experience a pronounced upswing and subsequent bust in single-family house prices over the recent past. Meanwhile, new construction of single-family homes has been generally on the downturn. Measured by the number of new construction permits in relation to the total housing stock, national investment in new single-family homes dropped below the annual rate of one per cent in 2007.7 In 2010, the number of single-

Note that Goodman and Thibodeau [2008] also report the average elasticity for metropolitan areas for which the authors estimate positive elasticity values, which is 0.62.

Following the evidence, the responsiveness of new housing supply to (changes in) home prices in US locations tends to be greater than in the UK or New Zealand. Nonetheless, some metropolitan areas in the US, in particular in New England and coastal California, are also characterized by quite insensitive supply conditions.

For long-run elasticity, Sanchez and Johansson [2011] derive a point estimate of about 0.4, while Gattini and Ganoulis [2012] derive a point estimate of about 0.9.

The sharp drop in construction activity after the year of 2006 was largely caused by the phase-out of public first-time homebuyer allowance (Eigenheimzulage), which was ruled out by the German government after that year.
family home permits totalled 78,557, compared to a stock of 11.43 million existing dwellings. In terms of permits issued per existing home, this was equivalent to a national ‘permit rate’ of 0.69 per cent.

Three main macro-level factors are discussed in the literature to explain the moderate level of single-family housing investment activity in the German housing market. These are demographic change, the business cycle environment, and institutional housing market design and policy. Demographic change is the key parameter affecting the construction of single-family housing in the long run [Mankiw and Weil, 1989]. For Germany, there is little doubt that a shrinking and ageing population is going to demand less living space in single-family houses within the upcoming decades. Anticipating future declines in housing demand, many prospective home buyers refrain from investments in order to avoid future losses in home values [Maennig and Dust, 2008].

Along with demography, the demand for single-family housing construction has been hampered by the general business cycle environment. Real disposable household incomes only grew slightly, while real mortgage rates developed sidewardly at comparably high levels [Maennig, 2012].

Regarding regulation and policy, the German market for home loan financing is strongly regulated. Mortgage loans with high down payments and long-term fixed interest rates are common, while banks refinancing their loans are regulated to use highly standardized and low-risk products. After first-time home buyer allowances were phased out in 2006, the German income tax code also provides little financial incentives in favor of home ownership, while tenants benefit from strong legal protection and effective price regulation of existing rents [Voigtlander, 2009].

In addition to the broader trends outlined above, cyclical housing market developments have affected the overall downturn in new single-family housing construction as well. While both the costs of putting up physical structure and the cost of vacant land rose almost continuously during the observation period, average existing home prices slightly declined even in nominal terms, implying deteriorating profitability prospects for potential home builders during the observation period. Figure 1 depicts the temporal evolution of national-level existing single-family home prices, housing construction costs (including costs of material, labor, and energy), and buildable land prices along with national numbers of annual building permits over the 2000-2010 period.

*Place Figure 1 about here*

**Local housing market disparities**

A substantial drawback of national figures is that they do not account for the profound structural disparities in single-family home markets across local areas. In order to illustrate the substantial level of spatial housing market heterogeneity, Figure 2 below depicts the average annual number of new single-family home permits per unit of existing stock across German counties and cities during the period of 2004-2010. Local areas are categorized with respect to the relative

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8 Single-family housing permit rates across all 413 German counties and cities averaged between 0.16 and 3.46 per cent between 2004 and 2010, following a strongly right-skewed distribution (mean value 0.0085, standard deviation 0.0041).
level of permit activity, with gradually dark-shaded areas indicating higher permit rates.

Place Figure 2 about here

Considering spatial variation in permit rates, four main observations are noteworthy. First, in accordance to national figures, the 2004-2010 average annual permit rate was quite low in wide parts of the economy. The average permit rate equalled one or less per cent in 312 counties and cities (roughly three quarters of the sample), while only eight locations (two per cent of the sample) had an average permit rate equal or higher than two per cent. Second, permit activity was comparatively strong in greater cities, as the average annual permit rate among the 71 major cities of at least 100,000 inhabitants included in the sample reached 1.1 per cent. Third, high permit rates tend to cluster in demographically and economically prospering metropolitan areas, such as the wider regions around Berlin, Hamburg, or Munich. Fourth, the average annual permit rate of the 87 eastern German counties and cities included in the sample (0.9 per cent) exceeded the average permit rate of their 326 western German counterparts by 0.1 percentage points. This possibly reflects the ongoing catch-up process in single-family home building in eastern German locations.

Permits vs. completions

It is sometimes argued that construction permits are not equivalent to new residential investment, given the time lag that occurs between receiving the permission to build, the start of the construction process and the completion of a new dwelling [McDonald and McMillen, 2000]. Indeed, the time lag between the three stages of the development process can reach several years, and not every permit eventually leads to a completion.

The methodological appeal of using construction permits rather than completions is that permits reflects the current state of the market better than completions, which are the outcome of economic decisions taken in the (distant) past. Indeed, developers applying for a new permit are likely to do so because the current market situation renders new construction of single-family housing profitable. However, it may also be the case that developers apply for a permit and then wait for the best point of time to start construction, which then means that construction starts would be the best variable to indicate new supply.

Since local-level data on housing starts is not available in Germany, this study draws on permits as the supply indicator. Yet, construction permits can be shown to track actual investment very closely in the German housing market. Using national data for single-family home completions and permits from 2001 onwards, Figure 3 illustrates the close link between single-family home permits and completions in the following year, plotting current permits and completions on a joint time axis. The time series indicate that the vast majority of single-family home construction projects was started quite shortly after a construction permit has been issued. At the level of counties and cities, correlation coefficients between current single-family home permits and one-year leaded completions lie in a range of 0.80 to 0.95 for the time period of 2001-2010.

Place Figure 3 about here
4 Methodology

In the case of single-family housing, new investment is the outcome of decisions taken by private developers. Developers are either private households who buy construction services from firms, or operative builders who construct new properties on their own account and sell them directly to their customers. In either case, land and physical structure are transformed into durable housing capital that provides additional flows of housing services in future periods.

Assuming arbitrage between the markets for new and existing housing, standard capital theory suggests that the level of investment in new houses is related to the ratio of the market price of already installed capital - in this case, the market price of existing homes - to the marginal cost of capital replacement, in this case, the cost of new housing development [Tobin, 1969, Jud and Winkler, 2003]. Ceteris paribus, higher prices for existing homes and/or lower costs of new housing development will induce investors to build additional housing in a given location. Under perfect market conditions, additional home building in a local housing market is set forth until the price of vintage houses equals the marginal cost of developing new housing capital, including the cost of construction and the cost of vacant land [Capozza and Helsley, 1989, Mayer and Somerville, 2000, Glaeser, 2008].

To illustrate this, assume that it takes one period to construct a constant size and quality single-family house after a new construction permit has been issued, and that existing houses depreciate at a constant rate (assumed to be equal across locations). With $S_{it}$ denoting the size of the single-family housing stock in location $i$ in time period $t$, $B_{it}$ denoting the number of new construction permits (set equal to the number of dwellings under construction), and $\delta$ denoting the annual scrappage rate of single-family housing, per identity in each location it holds:

$$S_{i,t+1} = S_{it} - \delta S_{it} + B_{it} = (1 - \delta)S_{it} + B_{it}$$

(1)

Solving this equation for $B_{it}$ yields:

$$B_{it} = S_{i,t+1} - S_{it} + \delta S_{it}$$

(2)

Dividing by $S_{it}$ on both sides yields the local annual permit rate, $R_{it}$, which is a function of the percentage difference between the current stock of houses and the stock in the upcoming period, and the depreciation rate:

$$R_{it} = \frac{B_{it}}{S_{it}} = \frac{S_{i,t+1} - S_{it}}{S_{it}} + \delta$$

(3)

In long-run (stationary) equilibrium, new construction will only take place in order to cover the depreciation of worn-out housing. In such a situation,
the housing stock is constant in each location \((S_{i,t+1} = S_{it} \quad \forall \quad i, t)\), which implies that the annual permit rate equals the annual rate of depreciation \((R_{it} = \delta \quad \forall \quad i, t)\). Based on such an equilibrium situation, a random shock to housing demand in a given location (e.g., caused by an unforeseen rise in household income or in the number of households) lets the desired size of the housing stock in this location differ from its current size. Therefore, rewrite the equation in a form where the ‘desired’ permit rate, \(R^*_{it}\), is a function of the relative gap between the ‘desired’ and the actual housing stock, plus the depreciation rate:

\[
R^*_{it} = \frac{S^*_{i,t+1} - S_{it}}{S_{it}} + \delta
\]  

(4)

Now consider \(Q\), the ratio of existing local home prices \((P)\) and the local replacement cost of new housing \((C)\), as a simple index of the profitability of additional home building in a location.\(^\text{11}\) A reasonable assumption is that this profitability index depends positively on the relative gap between the desired and the actual housing stock:

\[
Q_{it} = \frac{P_{it}}{C_{it}} = 1 + \gamma \left( \frac{S^*_{i,t+1} - S_{it}}{S_{it}} \right) \quad \text{with} \quad \gamma \geq 0
\]  

(5)

If the demand for single-family homes in a given location exceeds the current stock \((S^*_{i,t+1} > S_{it})\), existing home prices will exceed replacement costs \((Q_{it} > 1)\) and additional homes will be developed, with the responsiveness of supply depending on some exogenous parameter \(\gamma.\(^\text{12}\) If the demand for units in the upcoming period falls short of the current stock \((S^*_{i,t+1} < S_{it})\), home values drop below replacement costs \((Q_{it} < 1)\), and there is no incentive to develop additional homes. In this case, the number of permits will be lower than the number of depreciated units, and the local housing stock will decrease. In long-run equilibrium, the difference between the desired and the actual stock will again be zero, and home prices have converged to (marginal) replacement costs \((Q_{it} = 1)\).

Solving Eq. (5) for the relative gap between the desired and actual housing stock and inserting in Eq. (4) yields the following expression:

\[
R^*_{it} = \delta - \frac{1}{\gamma} + \frac{1}{\gamma} Q_{it}
\]  

(6)

After taking natural logarithms, one obtains (with lower case letters denoting log-level terms):

\[
r^*_{it} = \ln \left( \delta - \frac{1}{\gamma} \right) + \frac{1}{\gamma} q_{it}
\]  

(7)

After defining \(\ln \left( \delta - \frac{1}{\gamma} \right) = \alpha, \frac{1}{\gamma} = \beta\) and making the equation stochastic, one obtains a basic estimable model for the local single-family housing permit rate:

\[^{11}\text{Note that the notation is used because the ratio of the market price of capital and capital replacement has widely become known as Tobin’s } Q \text{ in the literature.}\]

\[^{12}\text{For sake of simplicity, this parameter is also assumed to be homogeneous across locations. This somewhat strict assumption can be relaxed by estimating location-type-specific regressions, for which results are presented in the Results Section.}\]
\[ r_{lt} = \alpha + \beta q_{lt} + \epsilon_{lt} \] (8)

In Eq. (8), the coefficient \( \beta \) denotes the average response of the local permit rate (which is measured as a percentage) in log-level form to a change in the log-level local Q-ratio (which is also measured as a percentage). Thus, the coefficient of \( \beta \) corresponds to the expected average percentage change in the local permit rate in response to a one per cent increase in existing home values relative to housing development costs. This implies that \( \beta \) can be readily interpreted as average price elasticity of new local housing supply.

Model specification

Some implicit assumptions and shortcomings of Eq. (8) need to be discussed before a reasonable model can be estimated. Four main points are noteworthy. First, standard capital theory suggests that new housing investment depends on marginal \( Q \) (the ratio of existing home prices to marginal replacement cost), not average \( Q \) in a location. Generally, the data used in this study measures average \( Q \). This is, however, theoretically consistent if developers in the market for single-family home construction are price takers facing constant returns to scale and exogenously given factor prices [Hayashi, 1982]. In this case, marginal costs equal average costs. Since the market for residential construction is generally atomistic even at the local level, price-taking behavior and constant returns to production are quite reasonable assumptions [Gyourko and Saiz, 2006, Saiz, 2010].

Second, Eq. (8) defines local permit rates to be determined by the relative level of home prices to housing development costs. A subtle but important implication of this assumption is that new houses can be sold at the market price of existing houses [DiPasquale, 1999]. This may be reasonable because the annual flow of new housing construction is usually very small compared to the existing housing stock. It may however be objected that current relative prices may only be an incomplete predictor of permit activity. Since adjustment to shocks in the housing market is costly, housing markets are unlikely to clear immediately in response to a shock [DiPasquale, 1999, Green et al., 2005]. Because of temporal inertia in supply activity, current permit rates should not only be determined by current relative house prices, but also by past levels of permit activity, which implies that short-run price elasticity of supply should systematically differ from long-run elasticity [Topel and Rosen, 1988, DiPasquale, 1999].

Third, the local level of new single-family housing supply is likely to be affected by factors other than current profitability and past supply levels. There is considerable evidence that markets for single-family homes are not information efficient [Case and Shiller, 1989, 2003]. This implies that several latent local and non-local variables affecting the demand for new single-family housing construction may not be fully incorporated in existing local home values. In order to control for observable latent, time-varying variables, we augment our model by average (actual) disposable household income, the annual percentage change in population, and the rate of unemployment in each location. To control for unobserved time-varying variables at the level of the national economy, we also include time indicator variables that do not vary across individual locations. Unobservable local variables affecting new supply are captured via the inclusion
of local fixed effects.

Fourth and finally, a point can be raised for spatial interactions between locations. While the units of observation used in this study are administrative areas, 'true' functional housing markets may well exceed across administrative borders [Meen, 2001]. Neglecting spatial interdependence in housing market conditions between spatially contiguous locations therefore lead to bias and inconsistence in our estimates, since permit rates in one location would no longer be independent of relative home prices in neighboring locations [Pace and LeSage, 2010]. In order to account for potential spillover processes across administrative borders, a spatial lag in local $Q$-ratios is included in the model, expecting that the level of investment activity in a given location is negatively affected by higher levels of home building profitability in spatially adjacent locations.\footnote{Note that a spatial lag in the dependent variable is not included in the model, presuming that the permit rate in a given location does not systematically depend on the permit rate in spatially contiguous locations once our included covariates are valid.}

Based on the prior considerations, a dynamic linear two-way unobserved effects model for new single-family housing permits in German counties and cities over 2004-2010 can be specified as follows:

\begin{equation}
\begin{split}
{r}_{it} &= \rho r_{i,t-1} + \beta q_{it} + \xi \sum_{j=1}^{N} w_{ij}q_{jt} + z_{it}\delta + \lambda_i + \mu_t + \epsilon_{it} \\
\end{split}
\end{equation}

In Eq. (9), $r_{it}$ denotes log-level local permit rates in location $i$ during time period $t$, $q_{it}$ denotes log-level $Q$-ratios, $w_{ij}$ represents the elements of a row-standardized first-order binary spatial weights matrix which indicates whether units of observation are considered neighbors\footnote{The reported results are based on a spatial distance matrix using a maximum range of 40 kilometres between location centroids to define locations as neighbors. The chosen distance band is the minimum distance which still ensures that all included locations have at least one neighbor. The use of alternative specifications for the spatial weights matrix had no notable effect on the results.}, $z_{it}$ is a row vector of unit- and time-specific observations drawn from a matrix $z$ containing a set of time-varying control variables (including the local income level, the population growth rate, and the local rate of unemployment), $\lambda_i$ denotes unobserved location effects and $\mu_t$ denotes unobserved time or year effects. The $\rho$, $\beta$, $\xi$ and $\delta$ are (vectors of) coefficients to be estimated. Finally, $\epsilon_{it}$ is a serially uncorrelated idiosyncratic error with non-constant variance and zero mean:

\begin{equation}
\begin{split}
E(\epsilon_{it}) = 0, & \quad E(\epsilon_{it}\epsilon_{js}) = \sigma_{\epsilon}^2 \quad \text{if} \quad i = j \quad \text{and} \quad t = s, \\
E(\epsilon_{it}\epsilon_{js}) &= 0 \quad \text{otherwise.}
\end{split}
\end{equation}

As usual, unobserved location effects are expected to account for unobserved time-invariant heterogeneity across locations, such as variation in topography, the rigity of building regulations, or household propensity towards single-family housing. Importantly, the unobserved location effects are allowed to be correlated with the time-varying independent variables included in the equation. The set of time indicator variables is expected to capture unobserved influences that are time-variant but do not differ across locations, such as mortgage rates, the
general business cycle environment, or federal tax reforms. Finally, the idiosyncratic error represents shocks to local permit rates that vary unsystematically both across space and time.

An important feature of the dynamic specification is that it allows to differentiate between the short- and the long-run price elasticity of supply. While $\beta$ measures the short-run effect of local home building profitability on the local single-family housing permit rate conditional on all other right-hand side variables (i.e., the effect to be realized within the same period), the long-run partial effect can be recovered by the term $\beta - \rho$. The adjustment parameter $\rho$ is expected to be positive and smaller than one, given that the long-run elasticity of supply should exceed short-run elasticity.\(^{15}\)

5 Data

The estimations are based on a panel data set covering all 413 German counties and cities (territorial definitions as of 2010/12/31) on its cross-sectional dimension and annual observations for 2004-2010 on its time series dimension ($N=413, T=7$). The data was gathered from various official sources. Local single-family housing permits, housing stock sizes, construction costs and land prices were obtained from official statistics that are regularly recorded by the statistical offices of the German Laender (Landesämter für Statistik). These include residential construction activity statistics (Bautätigkeitssstatistik), statistics on the residential housing stock (Wohnungsbestandsstatistik) and statistics covering transaction activity on local land markets (Statistik der Kaufwerte für Bauland). Data on local single-family home prices refer to a comprehensive database containing spatially disaggregated housing prices provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (Bundesinstitut für Bau-, Stadt- und Raumforschung, BBSR). The observed prices refer to locally representative median listing prices for standard single-family homes advertised through internet platforms and newspapers.\(^{16}\) Data on local disposable household income, population growth and unemployment was obtained from federal income accounting, population statistics and labor market statistics (Volkswirtschaftliche Gesamtrechnung der Länder, Bevölkerungsstatistik der Länder, Bundesagentur für Arbeit).

Table 1 lists arithmetic mean values for single-family home permit rates, median existing home prices, average construction, land and total development costs, Q-ratios and control variables. Permit rates, Q-ratios, unemployment and population growth rates are reported as dimensionless real numbers. Annual average disposable household income is given in Euro. Construction costs are given in Euro per square metre floor space, land costs in Euro per square metre.

\(^{15}\)It is worth noting that home prices and housing development costs could, in principle, enter the equation as two separate variables. Including them in the form of a single profitability index allows to reduce multicollinearity problems, especially because land prices are included in total housing development costs. From urban land theory, omitting land costs in the relative profitability measure may cause miss-specification and biased estimates of the true price elasticity of supply.

\(^{16}\)See Sigismund [2005] for closer details on the database. Local representativity is achieved by a large number of observations (more than 1.4 million ads per year). However, the observed listing prices are not corrected for size and quality differences in houses listed across locations and time. Furthermore, the reported median listing prices may partially overstate true median sales prices.
lot space. Local home prices and development costs are each expressed in Euro per square metre floor space. In addition to figures referring to the entire sample, reported mean values are grouped by different years and three main types of location: major cities, urbanized counties, and rural counties.

A quick glance at the conditional mean values reveals that home and land prices vary drastically across major cities, urbanized counties and rural counties. This variation reflects the different level of utility that households associate with having access to locations of different centrality and amenity value [Tabuchi, 2002]. In line with theory, the cost of housing construction proves to be much less sensitive to differences in location type than the prices of immovable property and land. Since construction materials, capital and labor are cheaply tradable across small geographical areas as they are used in this study, these inputs can be easily shipped towards counties and cities experiencing higher levels demand for single-family housing construction. As a consequence, the cost of supplying pure physical structure in a given location turns out to be largely independent of current local supply activity, a conjecture that has found strong support in previous studies.

Figure 4 graphically illustrates the spatio-temporal evolution of local home building profitability across German counties and cities over 2004-2010, as measured by local Q-ratios according to Table 1.

Stationarity tests

Several authors cast doubt on specifications in which indicators of new construction are linked to house prices and costs, at least if the variables enter in their levels rather than in first differences. The reason is that time series of supply indicators, such as permits or completions, are generally stationary, while time series of house prices and development costs are typically non-stationary [Mayer and Somerville, 2000, Jud and Winkler, 2003]. In a time series context, Mayer and Somerville [2000] argue that except in the special case that a linear combination of the explanatory variables included in the supply equation is stationary, new construction activity cannot be modelled as a function of price

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17Local development costs are computed as a weighted sum of local construction costs per square metre of floor space and average land costs per square metre of lot space. For sake of simplicity, it is assumed that new homes are built under an average floor-area-ratio (FAR) of 1/3, which is a common ratio for German single-family homes.

18The classification of different types of location follows the official classification given by BBSR: Urban municipalities are classified major cities if they have a size of at least 100,000 inhabitants, irrespective of population density. Urbanized counties include urban municipalities of less than 100,000 inhabitants as well as counties with average population density of at least 150 people per square kilometre. The group of rural counties includes counties with population density less than 100 people per square kilometre.

19Using pooled sample means and standard deviations, the coefficient of variation for average local construction costs is only 0.152, compared to 0.289 for median home values and even 0.903 for average land prices.

20For the US, Gyourko and Saiz [2006] conclude that any cross-sectional variation in the cost of putting up physical structure across US MSAs is almost entirely driven by differences in unionization rates, energy prices, topography and building regulations.
and cost levels, because a variable with a constant mean over time cannot be a function of a variable with a non-constant mean. In order to be consistent, the dynamic panel data estimation technique applied in this study indeed requires stationarity in both permit rates and $Q$-ratios.

In contrast to existing home prices and development costs in levels, the ratio of prices and development costs should generally form a stationary series, given that existing home prices cannot trend far away from building costs over a sufficiently long time period. In the presence of arbitrage between housing and other forms of capital in the economy, the same argument is true for housing permit rates. The conjecture of panel stationarity for both local permit rates and $Q$-ratios is confirmed by three common tests for panel unit root in small-$T$, large-$N$ panels [Maddala and Wu, 1999]. Respective test statistics for both the log-level local permit rate and the log-level $Q$-ratio are reported in Table 2. For both variables, all three tests strictly reject the null hypothesis of non-stationary series in the panel in favor of the alternative that the series included in the panel are stationary.

Place Table 2 about here

6 Empirical Results

Equation (9) was estimated using the two-step difference GMM estimator proposed by Arellano and Bond [1991]. Windmeijer-finite sample correction was used to correct for downward bias in the estimated standard errors [Windmeijer, 2005]. GMM estimation is the appropriate technique since, in the dynamic model, the unobserved location effects are correlated with the lagged dependent variable, which makes standard techniques inconsistent [Arellano and Bond, 1991, Baltagi, 2009]. Difference GMM was favored over system GMM in order to avoid additional restrictions on the initial conditions of the process governing the dependent variable.

Empirical results for alternative specifications of the permit rate equation are reported in Table 3. The model is apparently successful in relating local levels of home building profitability to the dynamics in the local single-family housing permit rate. Independent of which specification is considered, the coefficient estimated for the local $Q$-ratio is positive and highly statistically significant, confirming the hypothesis of a close and positive link between the ratio of existing home prices to new housing development costs and the level of new housing supply activity. Hence, the results confirm standard capital theory propositions regarding the operation of the market for single-family housing supply in German counties and cities.

Place Table 3 about here

21 The only exception is the special case that a linear combination of the included covariates forms a stationary cointegrating vector.

22 Arellano and Bond [1991] show that the two-step difference GMM estimator is asymptotically consistent and efficient in the presence of heteroscedastic idiosyncratic error terms, such as assumed in our model. A potential weakness of the Arellano-Bond estimator is that lagged levels may be poor instruments for first-differenced variables if the variables included in the model are close to a random walk [Arellano and Bover, 1995, Blundell and Bond, 1998].
Along with this important result, there is considerable evidence in favor of the hypothesis that local single-family home permit rates only gradually adjust to shocks in local home building profitability and other time-varying variables. As expected in the presence of adjustment costs, the estimated coefficient on lagged permit rates is positive and significantly smaller than one. This immediately implies that the average long-run price elasticity of new single-family housing supply across German counties and cities is significantly greater than average short-run elasticity: given a size of roughly 0.35 for the adjustment parameter, long-run elasticity is estimated to exceed short-run elasticity by a factor of almost 1.6.

From theory of housing demand, both higher income levels and higher levels of population growth in a location should be positively associated with new local housing supply. This conjecture is also widely confirmed by our model, as significantly positive coefficients are found for both local disposable household income and the local population growth rate. This suggests that local household purchasing power (possibly working through the credit constraint channel in home mortgage financing) and demographic shocks put direct pressure on the demand for single-family housing construction. As the partial effects of income and population growth go beyond the partial effect of local home building profitability, the findings can be interpreted as further evidence in favor of the single-family housing market inefficiency postulate put forward by Case and Shiller [1989, 2003]. Meanwhile, contrasting theoretical expectations, neither the local rate of unemployment nor home building profitability in spatially contiguous locations add significantly to the fit of the model.

In order to interpret the estimated coefficients appropriately, it is important to remember that the coefficient on local $Q$-ratios reflects the expected average percentage change in the permit rate (the number of permits on each 100 existing dwellings) in response to a one per cent increase in home building profitability (a one per cent rise in existing home prices while development costs remain constant). The coefficient estimated for the final specification (including the complete set of control variables) has a size of 0.2467, which means that, on local average, a ten per cent rise in local home values relative to development costs generates an about 2.5 per cent rise in construction permits within the same period. Using the coefficient of 0.3465 estimated for the lagged dependent variable, the corresponding average long-run elasticity turns out to be about 0.38. This estimate for long-run elasticity is strikingly close to the estimate of Sanchez and Johansson (2011), although their estimate is based on time series analysis for all forms of housing.

Compared to the partial short- and long-run effect of local home building profitability, the partial short- and long-run effects of household income and population growth on local permit rates prove to be comparatively strong. According to the estimates derived from the final specification, a one per cent rise in average disposable household income increases permits by about 1.46 per cent in the same period and 2.23 per cent in the long run, while a one percentage point increase in the population growth rate increases permits by about 0.51 per cent in the short and 0.78 per cent in the long run.\textsuperscript{23}

\textsuperscript{23}Note that the population growth rate appears in absolute form instead of the log form because the sample contains negative population growth rates.
it is worthwhile to discuss the estimation results for the included unobserved time effects. The time period dummy variables are jointly significant and negatively signed in each specification. Consistent with the national patterns in home building activity discussed earlier in this paper, this indicates that unobserved national factors (such as changes in mortgage rates, the business cycle environment, or federal tax policy) exerted some downward influence on housing supply activity in German counties and cities during the observation period. Expectedly, the most pronounced drop in average permit rates occurred during the year of 2006, which marked the year when first-time home buyer allowances were abolished by the German government. An important message from these results is that national-level factors can play a significant role in explaining the evolution of housing permit activity in local markets over time.

Type of location-specific elasticities

In addition to temporal heterogeneity, existing literature provides strong evidence that housing supply conditions vary substantially across locations and different levels of urbanization [Evenson, 2002, Green et al., 2005, Saiz, 2010, Meen and Nygaard, 2011]. For example, if the responsiveness of new housing supply to existing home prices is inversely related to the severity of land use or building regulations, one would typically expect price elasticity to be lower in large and densely populated major cities than in sparsely populated rural counties, which are usually characterized by abundant land reserves.

The nature of the panel data analysis carried out in this paper does not allow to calculate reliable individual location elasticities. In order to test for potential heterogeneity in average supply elasticities, the estimations were instead repeated for three different subsamples corresponding to different types of location, using the classifications made in the Data Section (major cities, urbanized counties, rural counties). Table 4 reports estimation results for the three location-type subsamples. The estimations indeed suggest that the hypothesis of equally sized supply elasticities across the urban hierarchy has to be strongly rejected. Surprisingly, however, the estimated coefficients indicate that the average short and long run elasticity of new single-family housing supply in major cities and urbanized counties considerably exceeds the average price elasticity of supply in rural counties. Indeed, the local ratio of home prices and development costs is even indifferent from zero at common significance levels in the set of rural counties.

One possible explanation for this surprising result is the idea of a kinked supply curve for new residential housing put forward by Glaeser and Gyourko.

---

24 Note that the year of 2005 serves as the base period for each specification because the dynamic model uses a lag length of one for the dependent variable.

25 Among others, Evenson [2002], Green et al. [2005], Saiz [2010] and Meen and Nygaard [2011] derive local elasticities for US MSA, identifying population size, land area, the historical growth rate, the geographic region, January temperature, the age of housing stock and the incentive to regulate housing as important elasticity size determinants.

26 Cross-sectional and temporal variation in single-family home permit rates within rural counties is instead mainly driven variation in local household income and aggregate time effects.
The idea of a kinked supply curve is associated with thought that housing supply reacts differently to positive and negative shocks in housing demand. While additional homes can be put up comparably easily to restore long-run equilibrium in growing markets (as long as there are no strong restrictions to essential factor inputs, most notable land open for building), housing market disequilibrium in constantly shrinking markets can only be reduced by abandonment and demolition instead of (further) reductions in new supply. This means that, albeit declining areas tend to be less restrictive to new building, housing permits may not be responsive to relative prices once prices are permanently decreasing [Maennig and Dust, 2008].

Permit rates in most rural counties included in the sample have indeed been quite low since the beginning of the sample period, which naturally implies very limited potential to react to (further) decreases in home values relative to new housing development costs. Many rural counties faced partially severe population loss, while major cities experienced mostly positive household population growth rates during the observation period. In their function as spatial centres of economic activity and growth, German major cities (and their immediate surroundings) increasingly attract young and highly-educated workers. At the same time, single-family housing affordability tends to be a more severe problem in cities than in rural counties, where home prices and price-to-income ratios are generally much lower. Both the influx of population and affordability problems may provide city governments with strong incentives to promote additional home building in order to allow prospective home buyers to invest in their city [Glaeser, 2008]. Future research could be aimed at a deeper investigation of the exact causes of the supply elasticity differences across locations in the German housing market.

7 Conclusions

For Germany as a whole, the findings of this study point to an inelastic responsiveness of new single-family housing supply with respect to the price of existing single-family homes. The estimated elasticity proves to be less than unity both in the short and in the long run, with a long-run value of about 0.4. This finding is generally consistent with both casual empiricism provided by practitioners as well as with recent empirical research based on national time-series data for all housing. At the same time, the results point towards striking differences in average supply elasticity across the German city system. According to the estimates, new supply of single-family housing proves to be most responsive to changes in home prices in cities of more than 100,000 inhabitants. New supply is found to be somewhat less price-elastic in urbanized areas and even completely inelastic with regard to existing house prices in rural counties.

The results bear a couple of implications regarding housing policy and land development in the German housing market. First, the results confirm that the supply of new single-family housing systematically reacts to shocks in fundamental market conditions in a way that ensures prices and quantities to tend back towards long-run equilibrium. In the presence of intrinsically stable markets,

27 Population growth has an apparently strong effect on the demand single-family housing in major cities, which is suggested by the significant and large coefficient estimated on the population growth rate for this subsample.
discrete policy interventions may distort market behavior and lead to socially suboptimal outcomes. Under such low price elasticities as they are estimated in this paper, however, this adjustment process takes a substantial period of time. This in turn may make a case for reducing restrictions to supply in local housing markets, most notably land markets in prospering cities and their immediate surroundings. Local authorities might aim to promote a quicker and more sizable reaction of new single-family housing construction to (shocks in) profitability, for example by designating sufficient land for building or by allowing for optimized lot sizes [Quigley and Rosenthal, 2005]. Second, as an implication of existence of quite asymmetric housing supply reactions across the urban hierarchy, German central-state policy makers should at least consider three broad types of location (major cities, urbanized counties, and rural counties) when formulating home ownership policy.
Tables and figures

Figure 1: Single-family housing permits, existing home prices, construction costs and land prices, 2000-2010 (national values). Source: Federal Statistical Office, own calculations.
Figure 2: Annual single-family housing permits per 100 units of existing stock (2004-2010 averages) in 413 German counties and cities. Source: Federal Statistical Office, own calculations.
Figure 3: Temporal evolution of single-family housing permits and housing completions, 2001-2011 (national values). Source: Federal Statistical Office, own calculations.
### All locations (413)

<table>
<thead>
<tr>
<th>Year</th>
<th>Permit rate</th>
<th>House value</th>
<th>Construction cost</th>
<th>Land price</th>
<th>Tot. devel. cost</th>
<th>Q-ratio</th>
<th>Disposable income</th>
<th>Population growth</th>
<th>Unemployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>0.0125</td>
<td>1589.66</td>
<td>1230.89</td>
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<td>0.9859</td>
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<td>0.1166</td>
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<td>0.1284</td>
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<td>2007</td>
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<td>1254.29</td>
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<td>0.9081</td>
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<td>0.0028</td>
<td>0.0792</td>
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### Major cities (71)

<table>
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<tr>
<th>Year</th>
<th>Permit rate</th>
<th>House value</th>
<th>Construction cost</th>
<th>Land price</th>
<th>Tot. devel. cost</th>
<th>Q-ratio</th>
<th>Disposable income</th>
<th>Population growth</th>
<th>Unemployment</th>
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<tbody>
<tr>
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<td>1835.67</td>
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<td>1952.11</td>
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<td>0.1024</td>
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<td>1953.93</td>
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<td>0.9377</td>
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<td>0.0330</td>
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### Urban counties (161)

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<th>Construction cost</th>
<th>Land price</th>
<th>Tot. devel. cost</th>
<th>Q-ratio</th>
<th>Disposable income</th>
<th>Population growth</th>
<th>Unemployment</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.0118</td>
<td>1700.93</td>
<td>1252.45</td>
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<td>2007</td>
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### Rural counties (181)

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<th>House value</th>
<th>Construction cost</th>
<th>Land price</th>
<th>Tot. devel. cost</th>
<th>Q-ratio</th>
<th>Disposable income</th>
<th>Population growth</th>
<th>Unemployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>0.0126</td>
<td>1376.85</td>
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<td>0.8802</td>
<td>17851.93</td>
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<td>0.0831</td>
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Table 1: Arithmetic mean values for all variables, grouped by year and type of location
### Table 2: Stationarity tests for local single-family housing permit rates and \( Q \)-ratios.

<table>
<thead>
<tr>
<th>Test</th>
<th>Log. permit rate</th>
<th>Log. ( Q )-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harris-Tzavalis-Test [Harris and Tzavalis, 1999]</td>
<td>( t = 0.3956^{***} )</td>
<td>( t = 0.3515^{***} )</td>
</tr>
<tr>
<td>Im-Pesaran-Shin-Test [Im et al., 2003]</td>
<td>( \tilde{z}_t = -9.0060^{***} )</td>
<td>( \tilde{z}_t = -4.6979^{***} )</td>
</tr>
<tr>
<td>Fisher-type-Test [Choi, 2001]</td>
<td>( p = 1417.5842^{***} )</td>
<td>( p = 1242.1689^{***} )</td>
</tr>
</tbody>
</table>

*** indicate rejection of the null hypothesis (non-stationarity) at the 1%-significance level.
Figure 4: Spatio-temporal evolution of local $Q$-ratios, 2004-2010 (1). Source: own calculations.
Figure 5: Spatiotemporal evolution of local $Q$-ratios, 2004-2010 (continued). Source: own calculations.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>p-value</th>
<th>Coeff.</th>
<th>p-value</th>
<th>Coeff.</th>
<th>p-value</th>
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<tbody>
<tr>
<td>$r_{t-1}$</td>
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<td>0.000</td>
<td>0.3589</td>
<td>0.000</td>
<td>0.3465</td>
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<tr>
<td></td>
<td>(0.087)</td>
<td></td>
<td>(0.087)</td>
<td></td>
<td>(0.083)</td>
<td></td>
</tr>
<tr>
<td>$q$</td>
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<td></td>
<td>(0.087)</td>
<td></td>
<td>(0.091)</td>
<td></td>
<td>(0.089)</td>
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</tr>
</tbody>
</table>

Control variables

- **Spatial lag q**
  - 0.0200 | 0.856 | 0.0395 | 0.722 |
  - (0.111) |         | (0.111) |         |

- **Disp. income**
  - 1.4615 | 0.009 |
  - (0.556) |         |

- **Pop. growth**
  - 0.5090 | 0.043 |
  - (0.330) |         |

- **Unemp. rate**
  - -0.1517 | 0.853 |
  - (0.819) |         |

Time effects

- $y_{2006}$
  - -0.4490 | 0.000 |
  - (0.025) |         |

- $y_{2007}$
  - -0.2717 | 0.000 |
  - (0.058) |         |

- $y_{2008}$
  - -0.3281 | 0.000 |
  - (0.060) |         |

- $y_{2009}$
  - -0.2576 | 0.000 |
  - (0.065) |         |

- $y_{2010}$
  - -0.2302 | 0.000 |
  - (0.056) |         |

Diagnostics

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<td>$\chi^2(7)$=2784.99</td>
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<td>Hansen-J-Statistic</td>
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<td>$z = -0.676$</td>
<td>0.220</td>
<td>0.278</td>
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Table 3: Two-step difference GMM results for alternative specifications of housing supply equation (9). Windmeijer [2005]-finite sample corrected standard errors are given in parentheses, significant coefficients at the 5%-level or better in bold.
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<th>Variable</th>
<th>Coeff.</th>
<th>p-value</th>
<th>Coeff.</th>
<th>p-value</th>
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<th>p-value</th>
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<td>Rural counties</td>
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<td>$r_{t-1}$</td>
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<td>0.023</td>
<td>0.2250</td>
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<td></td>
<td>(0.109)</td>
<td></td>
<td>(0.077)</td>
<td></td>
<td>(0.070)</td>
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<tr>
<td>$q$</td>
<td>0.4615</td>
<td>0.046</td>
<td>0.3141</td>
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<td>0.1244</td>
<td>0.263</td>
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<td>(0.251)</td>
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<td>(0.116)</td>
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<td>(0.111)</td>
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<td>Control variables</td>
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<tr>
<td>Spatial lag $q$</td>
<td>0.3180</td>
<td>0.658</td>
<td>0.2131</td>
<td>0.260</td>
<td>-0.0539</td>
<td>0.711</td>
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<tr>
<td></td>
<td>(0.717)</td>
<td></td>
<td>(0.189)</td>
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<td>(0.146)</td>
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<td>Disp. income</td>
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<td>(0.752)</td>
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<td>-0.4879</td>
<td>0.507</td>
<td>-0.0825</td>
<td>0.908</td>
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<td>(0.735)</td>
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<td>(0.712)</td>
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<tr>
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<td>(3.456)</td>
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<td>(1.192)</td>
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<td>(1.074)</td>
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<td>Time effects</td>
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<td>$y_{2006}$</td>
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<td>$y_{2007}$</td>
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<td>-0.4269</td>
<td>0.000</td>
<td>-0.3964</td>
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<td>-0.5240</td>
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<td></td>
<td>(0.182)</td>
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<td>(0.088)</td>
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<td>(0.094)</td>
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<tr>
<td>$y_{2009}$</td>
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<td>0.031</td>
<td>-0.4538</td>
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<td></td>
<td>(0.219)</td>
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<td>(0.092)</td>
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<td>(0.104)</td>
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<td>$y_{2010}$</td>
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<td>0.011</td>
<td>-0.4172</td>
<td>0.000</td>
<td>-0.3694</td>
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Diagnostics

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<td>AR(1)-Test $z$</td>
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<td>AR(2)-Test $z$</td>
<td>-0.301</td>
<td>-0.491</td>
<td>-0.983</td>
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</table>

Table 4: Two-step difference GMM estimation results for type of location-specific subsamples. Windmeijer [2005]-finite sample corrected standard errors are given in parentheses, significant coefficients at the 5%-level or better in bold.
References


