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 employs panel data on 413 German counties and cities from 2004 to 2009 to investigate the supply of new single-family housing in local housing markets. New local housing supply is measured by the annual number of construction permits in relation to the existing single-family housing stock. This supply indicator is econometrically related to existing home prices and new housing development costs, which include the costs of housing construction and vacant land in a given location. The results suggest that both higher prices for existing homes and recent increases in development costs are positively associated with local single-family home permit rates. Instead, higher levels of development costs turn out to dampen construction activity. The average local price elasticity of new single-family home supply is considerably less than one, with surprising differences across the urban hierarchy.

Key words: New housing supply, local housing markets, panel data

JEL classification: R12,R31,C31

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1 Introduction

The discipline of housing economics is currently witnessing a dramatic growth of research on housing supply. One of the key parameters of investigation is housing supply elasticity, the sensitivity to which new housing investment responds to (changes in) existing house prices. While older studies mainly use national-level data over long time periods to draw quantitative conclusions about the price elasticity of housing supply, younger publications focus overwhelmingly on regional or local housing market data; recent contributions include Green et al. (2005), Meen (2005), Hwang and Quigley (2006), Goodman and Thibodeau (2008), Glaeser et al. (2008), Ball et al. (2010) and Saiz (2010). The advantage of using local rather than national data in studying housing supply arises from the fact that housing markets are essentially spatially separated, following from the fact that houses are immobile and hence both produced and consumed locally.

As noted by Gyourko (2009), empirical research on the price elasticity of housing supply has recently expanded due to improved data availability, combined with increased interest in local policies like land use control. The economic significance of housing supply elasticity is hardly disputable, given that housing market models and policy recommendations are generally based on explicit or implicit assumptions about the magnitude of this important variable (Malpezzi and Maclennan, 2001). Glaeser et al. (2006) point out that it hinges critically upon the long-term responsiveness of housing supply whether shocks to the demand for a location manifest themselves predominantly in construction shifts and city growth or in rising house prices and wages. The outcome of such processes is of considerable importance to other markets in the economy. Because of their adverse effects on interregional labor mobility, pronounced house price differentials are typically associated with reduced labor market flexibility (Cameron and Muellbauer, 1998; Saks, 2008).[1] It has moreover been argued that an elastic supply of new housing is helpful in smoothing housing cycles and ensuring reasonable levels of housing affordability (Meen, 2005; Glaeser et al., 2006).

While there is general consensus as to the economic importance of housing supply and the variables affecting new construction (prices of existing homes, costs of construction inputs, expectations, time on the market, and so on), the appropriate methodological approach for deriving quantitative estimates of the price elasticity

[1] A recent cross-country study on OECD countries suggests that residential mobility is indeed higher in countries with more responsive housing supply (Sanchez and Johansson, 2011).

of housing supply is less clear-cut.[2] There turns out to be a considerable range of elasticity estimates, sometimes even varying for the same spatial entities depending on the data used.[3] For instance, Goodman and Thibodeau (2008) find an average elasticity of 0.62 for 95 US metropolitan areas with positive elasticity values analyzing data for two time periods, 1990 and 2000. Using comparable data, Saiz (2010) reports a population-weighted average of 1.75 in 2000.

Empirical evidence on housing supply elasticity outside the US is very 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 over 1986 to 1988 in order to estimate long-run supply elasticity in England, obtaining a figure 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. The elasticity range of these two studies is roughly supported by Meen (2005), who finds an average value of 0.42 using 1973-2002 data on nine larger territorial regions for the same country. Analyzing data on 73 administrative authorities over the 1991-2004 period, Grimes and Aitken (2010) derive a mean local supply elasticity of 0.7 for local housing markets in New Zealand.

According to existing evidence, the average responsiveness of housing supply to house prices tends to be greater in the US than in UK or New Zealand.[4] Meanwhile, empirical evidence on the price elasticity of new housing supply in Germany is generally lacking. One main exception is a recent cross-country study by Sanchez and Johansson (2011), who employ national time series data to estimate long-run supply elasticities for several OECD countries. For Germany, Sanchez and Johansson (2011) report a value of 0.4, which indicates housing supply to be inelastic. So far, no attempt has however been made to econometrically quantify the price responsiveness of housing supply using data on local housing markets.

Focusing on the submarket for single-family homes[5], this study presents original

[2]Both the choice of the spatial reference level and the estimation methodology might exert an influence on the magnitude and interpretation of empirical estimates, which is discussed by Meen (2005) and Ball et al. (2010).

[3]For a comprehensive overview over empirical studies examining housing supply elasticity, see Phang et al. (forthcoming).

[4]In contrast to the US, the estimates of average local supply elasticities for the UK and New Zealand are almost invariably less than one. Nonetheless, some metropolitan areas in the US, in particular in New England and coastal California, also seem to be characterized by quite insensitive supply conditions.

[5]Single-family homes are the largest asset single class in which German households are invested, and a vast proportion of these dwellings are owner-occupied. According to 2006 German microcensus data, 80

estimates on new housing supply elasticity in Germany derived from data on 413 counties (*Kreise*) and cities (*Kreisfreie Städte*), spanning the time period 2004-2009. The availability of a balanced panel data set enables the consideration of two important aspects: firstly, it facilitates a quantitative assessment of the respective partial effects of existing home prices and housing development costs on new building activity in a given location, conditional on both unobserved locational characteristics and temporal effects. Secondly, it enables testing for both the effects of levels and recent changes in home prices and housing replacement costs, which helps to distinguish between short- and long-term effects. The results suggest the average local price elasticity of new housing supply to be considerably less than one, supporting casual empiricism as well as Sanchez and Johansson‘s estimate based on national data for total German housing supply.

The remainder of this paper is organized as follows. Section 5.2 below provides some general background on the German market for single-family homes, summarizing recent developments in home prices and new construction and briefly discussing their main underlying causes. Section 5.3 contains a deeper discussion underlying the economic rationale of new housing investment. Section 5.4 is devoted to an explanation of the methodological approach, while Section 5.5 provides a detailed description of the data set. Regression results for alternative specifications of the new housing supply equation are presented in Section 5.6. Finally, Section 5.7 concludes.

2 Background: The German market for single-family homes

2.1 National trends in new homebuilding

Unlike several other countries, Germany has not experienced a pronounced upswing and subsequent bust in single-family home prices in the recent past. New housing construction has meanwhile been displaying a downward trend since the post-reunification construction boom. Measured by the number of new construction permits in relation to the total housing stock, investment in new single-family homes dropped below the critical mark of one per cent on a nationwide basis in 2007, the year after first-time homebuyer subsidies (*Eigenheimzulage*) were abolished by the

per cent of the 16.5 million housing units that were owner-occupied were single-family homes, and their market value totalled about 2 trillion Euros. This underlines the exceptional importance of this type of housing and its long-run supply for wealth accumulation and the creation of homeownership.

German government.[6] The total number of permits issued for new single-family home construction amounted to only 74,810 in the year of 2009, compared to a stock of 11.37 million units. In terms of new construction permits per existing home, this was equivalent to a national "permit rate" of 0.7%.[7]

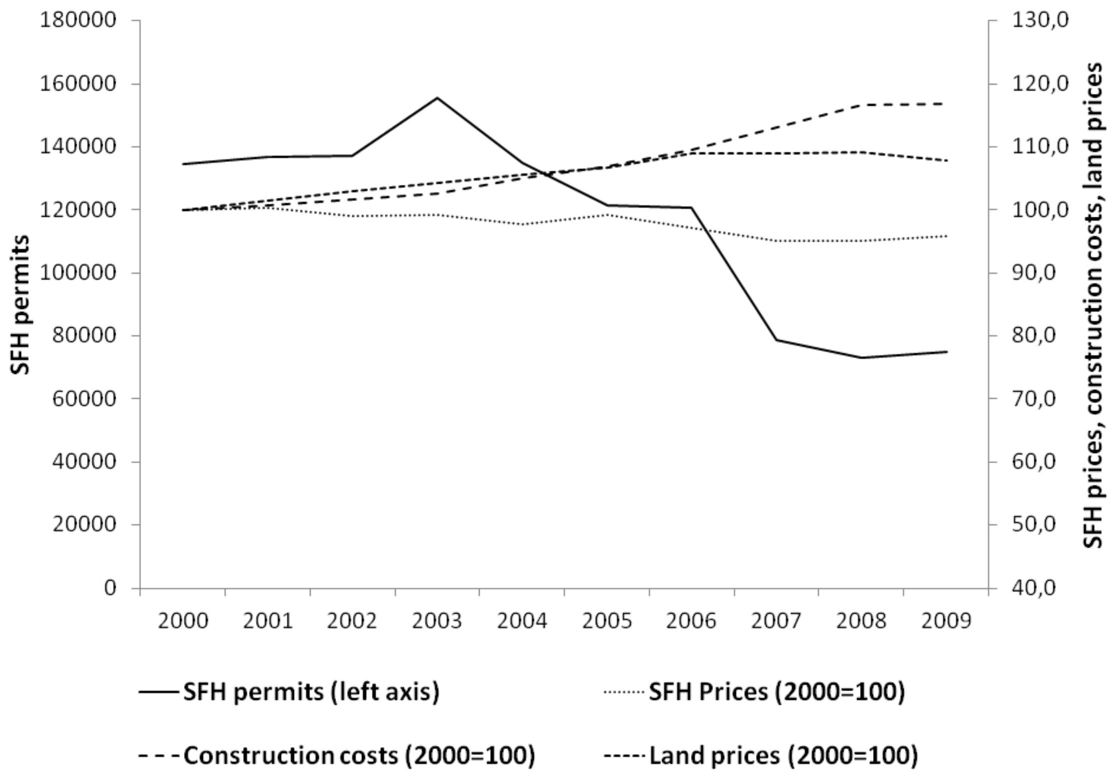

Figure 1: Construction permits, home prices and development costs, 2000-2009

In addition to the total number of new single-family home construction permits issued, Fig. 1 graphs the temporal evolution of existing single-family home prices, construction costs and land prices (all in nominal terms) over the 2000-2009 period for the entire country.[8] The graph illustrates that, simultaneous to the negative

[6]Assuming that residential building have an average lifespan of 100 years, a construction rate of one per cent is typically interpreted as the long-term sustainable rate (Deutsche Bundesbank, 2002).

[7]While many studies use construction starts, this variable has the disadvantage of not being available at the local level in Germany. Construction permits track starts very closely and represent supply intentions more accurately than housing completions, which would be the next-best alternative to permits. Nationally, there is a very close connection between permits and completions in the following year, indicated by a correlation coefficient 0.95 between 1995-2009.

[8]Each time series refers to official housing market statistics by the German Federal Statistical Office.

trend in overall permit activity, potential home builders faced generally deteriorating profitability prospects during the last decade. 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.

Several national-level factors explain the modest development of home prices and construction in the German housing market. The most important are demographic change, general macroeconomic environment, institutional housing market design and housing policy. From experience, demography is one of the key parameters affecting the construction of new single-family houses in the long run (Mankiw and Weil, 1989). Even under the most optimistic immigration projections, significant decreases in population size and simultaneous population ageing will fully unfold their impact on single-family housing demand in Germany within the upcoming decades (Just, 2012). Single-family home prices will be subject to significant downward pressure in regions that decline in size and age rapidly, and potential homebuilders can be expected to refrain from investing in new construction in areas where future depreciation in house values is already anticipated (Maennig and Dust, 2008).[9] Along with the impact of demographic change, the demand single-family home construction has recently been hampered by macroeconomic circumstances. Real household incomes remained almost stable over the observation period, limiting any positive income effects on housing demand. Additionally, it has been argued that interest rates were too high for the German economy over the last decade, considering its slow real economic development and low rates of inflation (Maennig, 2012).

Another factor that has sustainedly impacted the German market for single-family homes is institutional housing market design and housing policy. It is well known that the German housing market is characterized by a competitive and high-quality rental market. German renters benefit from strong legal protection and regulation of rents, which has traditionally dampened the demand for homeownership (Voigtländer, 2009).[10] Since first-time homebuyer allowances were phased out in 2006, the German income tax code also provides only minimal financial incentives

[9]Demographic change obviously not affects regions equally, given that birth rates, life expectancy and internal migration all vary substantially across locations. According to the most recent regional population projection of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), more than 50% of all 413 counties and cities will suffer from a decline in population - although not necessarily in the number of households - by 2025, 100 of them with double-digit rates of decline.

[10]At 43%, the German homeownership rate ranks well below other European countries levels.

in favor of homeownership.[11] Another reason for the low level of additional homebuilding rests in the stability-oriented German mortgage market. German housing loans are still characterized by comparatively low loan-to-value ratios, long-term fixed interest rates, and practically no secondary mortgages (Maennig, 2012). High downpayment requirements tend to generate homebuilding affordability constraints on young and equity-constrained households, most notably in high-priced regions.[12]

2.2 Spatial disparities

A drawback of national figures is that they usually conceal the existence of disparities in single-family homebuilding across local housing markets. Measured again by the annual number of new construction permits per unit of stock, single-family housing permit rates across 413 German counties and cities varied between 0.16% and 3.46% between 2004 and 2009, following a strongly right-skewed distribution (mean value 0.0085, standard deviation 0.0041).[13] Fig. 2 demonstrates the considerable geographical variation in new supply activity across local housing markets, depicting the average number of new construction permits per unit of stock during 2004-2009 (locations are categorized with respect to new building activity, with gradually darker-shaded areas indicating higher permit rates).

Four observations are noteworthy: first, consistent with national figures, the permit rate was low in wide parts of the country. Over 2004-2009, the average permit rate was equal to or smaller than 1% in 312 counties and cities (roughly 75% of the sample), while only eight locations (2% of the sample) had an average permit rate equal or higher than 2%. Second, permit activity was above average in greater cities, as the average permit rate among the 71 cities with at least 100,000 inhabitants reached 1.1%. Third, high permit rates tended to cluster around important economic centers such as Berlin, Hamburg or Munich. Fourth, the average permit rate of the 87 eastern German locations included in the sample (0.9%) exceeded the average permit rate of the 326 western German locations (0.8%) by 0.1 percentage point,

[11] In stark contrast to other countries which treat homeownership more favorably (see, e.g., Glaeser (2011) for the US), the German tax code neither allows mortgage interest deduction nor the deduction of depreciation or running expenses.

[12] For a detailed discussion of the link between relative regional house prices, credit constraints and homeownership, see Lerbs and Oberst (2011a). These authors also discuss the trade-off between mortgage market stability and housing affordability.

[13] Without loss of validity, the permit rate could alternatively be defined as the number of construction permits per household. Compared to permits per household, permits per unit of stock tendentially indicate higher permit rates for areas with low ratios of existing single-family homes per household, typically areas with high shares of multi-family housing and small household sizes.

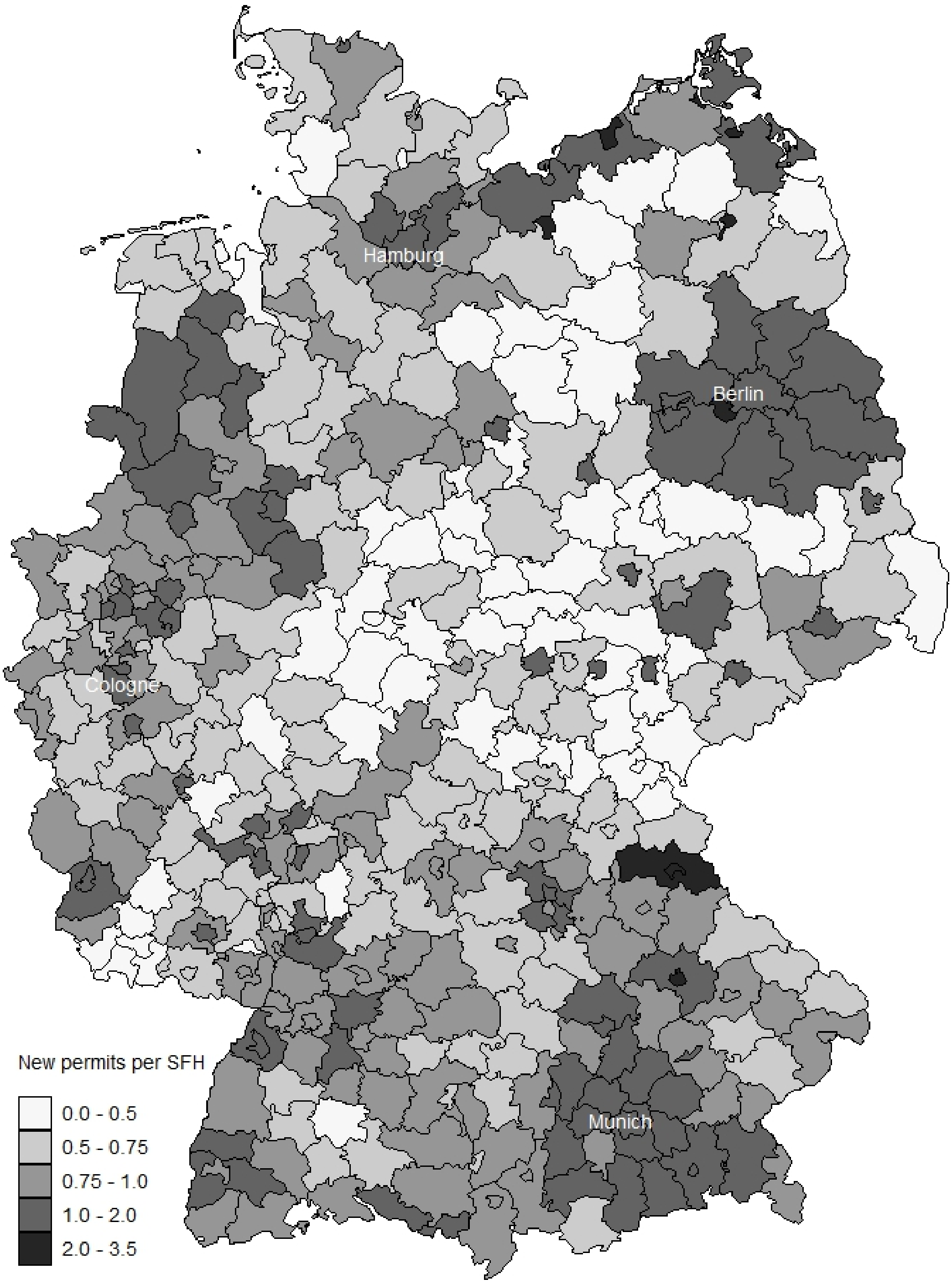

Figure 2: New permits per 100 units of stock, counties and cities, 2004-2009

partially reflecting the ongoing catch-up in single-family homebuilding in eastern Germany.

3 Theory of new local housing supply

New housing production is the outcome of investment decisions taken by private developers. In the case of single-family homes, developers are either private households buying 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.

Standard capital theory suggests that investment in new houses is related to a comparison of the market price of already installed capital - in this case, existing homes - to the marginal cost of replacing capital, the so-called Tobin‘s Q (Tobin, 1969).[14] Holding other factors constant, both higher prices for existing homes and lower costs of new housing development should induce investors to build additional housing in a given location. Theory suggests that additional homebuilding is set forth until the price of vintage houses equals the marginal cost of supplying new housing, including the cost of material, labor and vacant land. In long-run equilibrium, new construction only takes place in order to cover the depreciation of worn-out housing (DiPasquale and Wheaton, 1996; Glaeser, 2008).[15]

To illustrate the mechanics, assume that it takes one period to construct one unit of housing after a new construction permit has been issued, and that existing houses depreciate at a constant rate that is assumed to be equal across locations. With S_t denoting the size of the single-family housing stock at time t in a given location[16], B_t denoting the number of new building permits (equaling the number of buildings under construction) and δ the single-family housing depreciation rate, per identity in each location it holds:

$$S_{t+1} = S_t - \delta S_t + B_t = (1 - \delta)S_t + B_t. \tag{1}$$

[14]Tobin‘Q has been used in other housing supply-related studies, albeit in a national rather than local context. For instance, see Jud and Winkler (2003) and Berg and Berger (2006)

[15]Under exogenous city growth, the same equilibrium condition holds, but new construction net of depreciation will equal the constant annual inflow of additional population.

[16]For sake of simplicity, the location index will be suppressed.

Solving this equation for B_t yields:

$$B_t = S_{t+1} - S_t + \delta S_t. \tag{2}$$

Dividing by S_t on both sides yields the permit rate R_t (the number of permits divided by the current stock) as a function of the percentage difference between the planned stock of houses in the upcoming period and the actual stock (plus the depreciation rate):

$$R_t = \frac{B_t}{S_t} = \frac{S_{t+1} - S_t}{S_t} + \delta. \tag{3}$$

In stationary steady-state equilibrium, the housing stock has to be constant ($S_{t+1} = S_t$), and the permit rate must equal the rate of depreciation ($R_t = \delta$). Based on an equilibrium situation, a positive demand shock in a given location will lead the desired stock of housing in the upcoming period to exceed the current stock, while the opposite is true in the event of a negative demand shock. Therefore, rewrite Eq. 3 in a form where the "desired" permit rate, R_t^*, is a function of the gap between the "desired" and the actual housing stock in a location plus the depreciation rate:

$$R_t^* = \frac{S_{t+1}^* - S_t}{S_t} + \delta. \tag{4}$$

Now consider Q, the ratio of local house prices (P) and the development cost of new houses (C), as a simple index of the profitability of additional homebuilding in a location. A reasonable assumption is that this profitability index depends positively on the percentage difference between the planned and actual housing stock:

$$Q_t = \frac{P_t}{C_t} = 1 + \gamma \left(\frac{S_{t+1}^* - S_t}{S_t} \right) \quad \text{with} \quad \gamma \geq 0. \tag{5}$$

If the demand for homes in a given location exceeds the current stock ($S_{t+1}^* > S_t$), existing home prices will exceed reproduction costs ($Q > 1$) and additional houses are developed, with the responsiveness of supply depending on some exogenous parameter γ. If demand is less than the current stock ($S_{t+1}^* < S_t$), market prices drop below replacement cost ($Q < 1$) and there will be no incentive for investors to build additional homes. In this case, the number of permits will be lower than the number of depreciated units, and the housing stock will decrease. In long-run equilibrium, the difference between the desired and actual stock is zero, and home prices will have converged to marginal development costs ($Q = 1$).

Solving Eq. 5 for the gap between desired and actual housing stock and inserting in Eq. 4 yields:

$$R_t^* = \delta - \frac{1}{\gamma} + \frac{1}{\gamma} Q_t \tag{6}$$

After inserting $Q = \frac{P}{C}$ and taking natural logarithms, one obtains:[17]

$$r_t^* = \ln\left(\delta - \frac{1}{\gamma}\right) + \frac{1}{\gamma} p_t - \frac{1}{\gamma} c_t. \tag{7}$$

Defining $\ln(\delta - \frac{1}{\gamma}) = \alpha$, $\frac{1}{\gamma} = \beta$ and making the equation stochastic yields a basic estimable model for the local housing permit rate:

$$r_t^* = \alpha + \beta_1 p_t - \beta_2 c_t + \varepsilon_t. \tag{8}$$

According to Eq. 8, the single-family housing permit rate in a location depends positively on the prices of existing homes and negatively on new housing development costs in that location. The β_1-coefficient denotes the average responsiveness of the log in local permit activity to the log of local home prices. Thus, it provides an estimate of the price elasticity of new single-family home supply.[18]

In view of previous research on housing supply, the new supply equation developed above deserves some comments. First, the equation defines local permit rates to be determined by the relative *levels* of local home prices and development costs. An important assumption underlying this specification is that, because the annual flow of new housing supply is usually very small compared to the existing housing stock, the market price of existing homes is not affected by new construction permits, and new units can be sold at the market price.[19] Yet, different previous studies indicate that current prices may only be an incomplete predictor of new housing supply (Case and Shiller, 1989; DiPasquale, 1999; Meen, 2005). The reason is that because of search costs, time lags and other market imperfections, housing markets are unlikely to clear immediately in response to a shock. New construction may therefore not only be determined by current levels of home prices and development costs, but also by recent *changes* in prices and costs, as well as further indicators of disequilibrium (Meen, 2005).[20]

[17]Throughout the text, lower case letters of variables will denote natural logarithms.

[18]It should be noted that prices and development costs could in principle be combined into a single profitability variable (Pryce, 1999; Meen, 2005). Including them as separate variables yet allows for more flexibility.

[19]There is indeed considerable evidence that modest rates of new construction hardly affect existing home prices (Meen, 2000; Andrew and Meen, 2003)

[20]Indeed, if existing home prices are sticky and do not fully reflect future expectations, high levels of

In addition to the role of existing home prices, any empirical investigation of new local housing supply requires theoretical assumptions about the role of factor inputs. Many studies analyzing national data assume that the homebuilding industry is composed of many competitive firms facing rising factor cost schedules, but this assumption is usually misleading in the case of local housing markets. Since construction material (bricks, lumber, cement, etc.) capital and labor are tradable across space within a country, these factor inputs are usually shipped towards locations with high levels of homebuilding. As a consequence, the pure cost of supplying housing structure in a given location should largely be independent of current local construction output. For small areas, this implies highly elastic construction supply schedules, a conjecture which has found strong support in the literature (Gyourko and Saiz, 2006; Saiz, 2010).[21] In contrast to the national view, local home construction costs are therefore best thought to be exogenous to local permit levels.

A factor that is widely neglected in national studies but that is specific to the housing market is the relationship between new housing supply and the land market. Several studies have argued that if development costs are included in a model explaining new housing supply, these should include the costs of all inputs that are essential to the development of new houses (DiPasquale and Wheaton, 1994; Mayer and Somerville, 2000). This, of course, includes vacant land that is made available for building.[22] In their influential study, Capozza and Helsley (1989) have argued that only a fully specified model including both construction and land costs together with house prices is theoretically consistent with urban spatial equilibrium, in which house values must converge to the sum of development cost at the margin. From an empirical viewpoint, omitting land costs from the supply equation may therefore cause misspecification and biased estimates of the true price elasticity of supply.[23]

construction may transitionally occur in locations with low prices relative to development costs (for example, this might occur when builders expect house prices and population in an area to grow very rapidly). At the same time, cities characterized by high prices relative to development costs may experience only modest permit activity in the case that house prices are expected to significantly decrease in the future (DiPasquale and Wheaton, 1994; DiPasquale, 1999).

[21] Gyourko and Saiz (2006) conclude that any existent cross-locational variation in the cost of putting up physical structure is almost entirely driven by local differences in unionization rates, energy prices, and the nature of local topography and building regulations. Saiz (2010) additionally notes that the construction industry is highly competitive even at the local level, comprising many small firms that face highly elastic labor supply schedules.

[22] Although it is possible to substitute land for physical structure within a certain range, vacant land is necessary for any new development to proceed.

[23] 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 new supply equation is stationary, new building activity (a stationary variable) cannot be modeled as a function of price and cost levels (which are

So far, there has been very little research as to how the cost of buildable land in a location changes with changing quantities of construction permits issued. While it is often argued that additional construction permits may increase land prices due to speculation, spatial urban theory strongly suggests that vacant land prices depend on the overall size of a location rather than on the level of new construction (Capozza and Helsley, 1989; Glaeser, 2008): since location growth implies an increased scarcity of non-reproducible land, the long-run cost curve of land in a given location must indeed be upward sloping, meaning that land prices rise with location size. However, this increase in land prices occurs in order to restore spatial equilibrium throughout the city, not because of temporarily increased levels of construction. If the size of a location (which is approximately time-invariant for periods of five or six years) is controlled for, land costs are therefore best viewed as another exogenous determinant of local permit rates.

Two final theoretical issues remain. First, investment theory states that new investment should depend on the marginal Q (the relation of home prices to marginal replacement cost), not the average Q in a location. Generally, the data used in this study measures the average Q in a location. This is theoretically consistent if developers in the market for single-family home construction are price takers facing constant returns to scale and given factor prices because in this case, marginal cost equals average cost (Yoshikawa, 1980; Hayashi, 1982). As explained earlier, private developers are generally small and competitive, which justifies the assumption of price-taking behavior and linear homogeneous production functions.

Second, the rationale is based on the assumption that new and existing houses are fully substitutable against each other. While this claim certainly holds in the case of homogeneous financial assets, quality differences between new and vintage houses certainly impede their substitutability in practice even in geographically small markets. This problem is generally hard to resolve, at least, it provides another justification of including housing market disequilibrium indicators in the permit equation (Jud and Winkler, 2003; Berg and Berger, 2006).

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both non-stationary variables), because a variable with a constant mean over time cannot be a function of a variable with a non-constant mean. Only in the case that all relevant cost variables (including the cost of acquiring buildable land) are included in the supply equation together with house prices, this combination of covariates forms a stationary cointegrating vector.

4 Estimation methodology

The remainder of this paper will be focused on exploiting the considerable amount of variation in permit activity, home prices and housing development costs across German locations to draw econometric conclusions on the responsiveness of local housing supply. Following the theoretical considerations of the previous section, the first model specifies local permit rates as depending on local home price and housing replacement cost levels, presuming a causal relationship that runs from higher local Q-ratios (implying higher levels of profitability) to higher local building permit rates. With lower case letters indicating natural logarithms, a basic linear unobserved effects model for new single-family housing permit rates in German counties and cities over 2004-2009 can be written as:

$$r_{it} = \beta_0 + \beta_1 p_{it} + \beta_2 c_{it} + \lambda_i + \mu_t + \varepsilon_{it} \tag{9}$$

where r, p and c denote local permit rates, existing home prices and single-family housing development costs, λ_i and μ_t represent unobserved location characteristics and temporal effects, and ε_{it} is an ordinary idiosyncratic error. As usual, the location fixed effects are expected to account for time-invariant heterogeneity across locations that may affect local permit activity, including location size, topography, building standards and local land use policy. The temporal fixed effects are expected to capture time-varying factors that affect permit activity in a similar fashion across locations, including macroeconomic circumstances like interest rate levels or federal tax reforms. Finally, the idiosyncratic error represents random shocks to local homebuilding activity which vary both across locations and time.

As mentioned earlier, the main advantage of estimating an unobserved effects model is the possibility of quantifying the partial influence of local home prices and housing development costs on local permit rates conditional on unobserved location characteristics and time effects. However, this advantage comes at a certain cost: since the housing supply effect of time-constant policy variables will be captured by the location fixed effects, it will not be possible to identify the causes of local heterogeneity in supply elasticity, which has been the focus of various previous studies (Green et al., 2005; Saiz, 2010).[24] The main focus of the analysis is, however, an unbiased estimate of β_1, the average local elasticity of new housing supply with regard to price.

[24] Since fixed location attributes have no natural unit of measurement, it would be meaningless to estimate their partial effect (Wooldridge, 2006).

It is important to remember that Eq. 9 only includes as regressors local prices and development cost in their levels, but not in their changes. As discussed in the previous section, a theoretical case can be made for either levels or changes, or both.[25] In order to determine which specification best explains local permit rates, two further unobserved effects models were specified. The first model explains local permit rates as a function of recent local price and development cost changes instead of levels (denoted by $\triangle$):

$$r_{it} = \beta_0 + \beta_1 \triangle p_{it} + \beta_2 \triangle c_{it} + \lambda_i + \mu_t + \varepsilon_{it} \tag{10}$$

Following Meen (2005), the second additional specification links permit rates to both levels *and* recent changes in prices and costs:

$$r_{it} = \beta_0 + \beta_1 p_{it} + \beta_2 c_{it} + \beta_3 \triangle p_{it} + \beta_4 \triangle c_{it} + \lambda_i + \mu_t + \varepsilon_{it} \tag{11}$$

Each model is estimated using fixed effects, correcting for heteroskedasticity and serial correlation in the idiosyncratic errors.[26] Allowing the unobserved location effects to be arbitrarily correlated with the included explanatory variables makes intuitive sense, given that unobserved location traits affecting new homebuilding (like local topography or land use policy) are likely to be also correlated with existing home prices and development costs.

In order to be consistent, fixed effects estimation requires the explanatory variables to be strictly exogenous (Baltagi, 2005). Strict exogeneity rules out the possibility that, once levels or changes in home prices and development costs are controlled for along with unobserved location characteristics, random shocks to the permit rate in previous periods affect prices and costs in future periods. Put differently, the explanatory variables have to be uncorrelated with the idiosyncratic errors in each time period, conditional on λ_i (Wooldridge, 2002):

$$E(\varepsilon_{it} \mid \mathbf{x_{it}}, \lambda_i) = 0, \quad t = 1, 2..., T. \tag{12}$$

[25]Ball et al. (2010) conclude that a wide range recent studies (based primarily on stock disequilibrium models) use changes in prices and costs (Blackley, 1999; Mayer and Somerville, 2000; Green et al., 2005; Hwang and Quigley, 2006; Saiz, 2010), whereas earlier work (based primarily on stock-adjustment models) tends to favor levels (Topel and Rosen, 1988; DiPasquale and Wheaton, 1994). The study of Meen (2005) represents one of the rare cases in which both levels and changes are included as explanatory variables in the same equation.

[26]Note that, in estimating Eqs. 10 and 11, one time period is lost due to using one-period changes as additional explanatory variables.

The assumption of zero contemporaneous correlation between the covariates and the idiosyncratic errors (implying orthogonality of ε_{it} and $\mathbf{x_{it}}$) causes no problems, given that random shocks to current permit activity should not affect levels or recent changes of existing home prices and development costs in the same period. However, current shocks to permit activity could potentially feedback onto local prices and costs in future periods, which would result in a situation in which the fixed effects estimator is no longer consistent. In order to check a possible violation of the strict exogeneity assumption, Wooldridge (2002) proposes the following test:

$$r_{it} = \mathbf{x_{it}}\boldsymbol{\beta} + \mathbf{w_{it+1}}\boldsymbol{\xi} + \lambda_i + \mu_t + \varepsilon_{it} \qquad (13)$$

where $\mathbf{x_{it}}$ is the vector of explanatory variables and $\mathbf{w_{it+1}}$ is a subset of $\mathbf{x_{it+1}}$ that includes the potentially endogenous explanatory variables, led by one period. Under strict exogeneity, $\boldsymbol{\xi} = \mathbf{0}$, which can be tested by estimating Eq. 13 using fixed effects. The proposed test was conducted by including both one-period leads of levels and changes in local home prices and development costs, and testing for joint significance of the leaded variables using an F-test. In either case, the null hypothesis of $\boldsymbol{\xi} = \mathbf{0}$ could not be rejected at common significance levels.

5 Data

The empirical analysis in this paper is based on a balanced panel data set including 413 German counties and cities on its cross-sectional dimension (territorial definitions as of 2009/12/31) and annual observations for 2004-2009 on its time series dimension (N=413, T=6). The data were collected from various official sources, which (with the only exception of local single-family home prices) are all publicly available (see Tab. 1).

Local single-family construction permits, single-family home stocks, average construction costs and average costs of vacant building land all refer to official statistics regularly recorded by the statistical offices of the German Laender (*Landesämter für Statistik*). These include construction activity statistics (*Bautätigkeitsstatistik*), housing stock statistics (*Wohnungsbestandsstatistik*) and statistics covering local land markets (*Statistik der Kaufwerte für Bauland*). Local single-family home prices refer to a comprehensive database on regionalized house prices provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (*Bundesinstitut für Bau-, Stadt- und Raumforschung*, BBSR). The database draws

Variable	Description	Source
Construction permits (B)	Number of permits issued for construction of new single-family homes	Bautätigkeitsstatistik
Housing stock (S)	Number of existing single-family homes	Wohnungsbestands-statistik
Permit rate (R)	Construction permits per unit of single-family housing stock	Bautätigkeitsstatistik, Wohnungsbestands-statistik
House price (P)	Median value of standard single-family home in Euros per square metre of floor space	BBSR Wohnungsmarkt-beobachtungssytem, IDN Immodaten
Construction cost (C^{cons})	Average cost of construction (net of land) in Euros per square metre of floor space	Bautätigkeitsstatistik
Land cost (C^{land})	Average selling price of vacant building land in Euros per square metre of lot space	Baulandstatistik

Table 1: Data desriptions and sources

on data from internet platform ads and includes locally representative median prices for standard single-family homes to let. Full spatial coverage is achieved by a large number of observations of more than 1.4 million ads per year (Sigismund, 2005).[27]

Tab. 2 reports mean annual values for local single-family home construction permits (B), single-family housing stocks (S), permit rates (R), home prices (P), new housing development costs (C) and Q-ratios (Q). Construction permits, stock sizes, permit rates and Q-ratios are measured in natural units, while home prices and development costs are both measured in Euros per square metre of floor space. Local development costs are computed as a weighted sum of average local construction costs (costs of construction without costs of land, C^{cons}) per square metre of floor space and average local selling prices of vacant building land (C^{land}) per square

[27] All observations are corrected for double counts and implausible outliers. True market prices may however partially be overestimated, given that listing prices instead of transaction prices are observed. Furthermore, the measurement of prices does not account for quality differences across locations and time (von der Lippe and Breuer, 2010).

metre of lot space.[28] For simplicity, it is assumed that new homes are built with a location-indendent floor-area-ratio (FAR) of 1/3.[29]

	2004	**2005**	**2006**	**2007**	**2008**	**2009**
B_i	327	294	292	191	177	181
	(413)	(413)	(413)	(413)	(413)	(413)
S_i	26411	26688	26971	27198	27373	27526
	(413)	(413)	(413)	(413)	(413)	(413)
$R_i = B_i/S_i$	0.0125	0.0111	0.0109	0.0071	0.0066	0.0066
	(413)	(413)	(413)	(413)	(413)	(413)
P_i	1589.66	1577.00	1566.10	1552.98	1553.10	1542.45
	(413)	(413)	(413)	(413)	(413)	(413)
$C_i = C_i^{cons} + 3C_i^{land}$	1585.25	1604.31	1604.73	1626.38	1626.38	1626.38
	(356)	(387)	(376)	(381)	(395)	(394)
- report.: C_i^{cons}	1230.89	1224.45	1234.06	1254.29	1291.58	1322.79
	(413)	(413)	(413)	(413)	(413)	(413)
- report.: C_i^{land}	119.84	128.47	124.59	124.87	124.56	126.09
	(356)	(387)	(376)	(381)	(395)	(394)
$Q_i = P_i/C_i$	0.99	0.97	0.98	0.95	0.93	0.91
	(356)	(387)	(376)	(381)	(395)	(394)

Table 2: Mean values (by year), number of observations in parenthesis

The statistics reported in Tab. 2 indicate that both average local permit rates and average local builing profitability (measured by local Q-ratios) exhibited a downward trend during the observation period. The decline in Q-ratios was mostly due to a continuous rise in construction costs (net of land), which started around the year of 2005. There was a considerable variation in Q-ratios across counties and cities in each year, indicating substantial spatial and temporal differences in the rentability of additional homebuilding. In line with theory, local differences in Q-ratios are mainly driven by local differences in the prices for existing homes and the price of land instead of pure costs of housing construction. The costs of existing homes and vacant land vary drastically across locations, reflecting different levels of utility

[28] There appeared to be a total of 190 missing observations in the land costs statistic, which were treated as ordinary missings. Thus, the analysis relies on 2288 available observations.

[29] The need for computing input-weighted development costs arises from the fact that the utilized home prices refer to the value of existing structures *together* with the value of their lots per square metre of floor space. A FAR of 1/3 implies that the total size of the site the home is built on (in square metres) is three times as large as total floor space (in square metres), which is a common ratio for single-family homes.

associated with the access to different locations (Roback, 1982; Tabuchi, 2001).[30]

Fig. 3 graphically illustrates the spatio-temporal evolution of new homebuilding profitability across German counties and cities over 2004-2009, as measured by self-computed local Q-ratios. According to the data, new investment ceased to be profitable over time in a large group of locations. At the same time, there was considerable temporal persistence of both high and low Q-ratios in some areas, indicating the existence of persistent local housing market disequilibria. Simple cross-sectional regressions of local Q-ratios against local permit rates for every year indicate a robust positive association between the two variables which even tends to become stronger over time (single-year OLS yields highly significant positive coefficients varying between +1.11 for 2004 and +1.46 for 2007).

6 Results of panel regression analysis

Fixed effects regression results for alternative single-family home supply equations 9-11 are reported in Tab. 3.[31] Estimates for the full model of Eq. 11, which explains local permit rates by local home prices and development costs in terms of both their current levels and recent changes, can be obtained from the third column. The final two columns of Tab. 3 show estimates for two minor extensions of the full model: the first extension (5.11b) amends the model by a group of control variables related to single-family housing demand in a location. The second extension augments the model with interaction terms for local house price levels and various location-type dummy variables (5.11c).

Independent of the precise specification, the estimated coefficients carry the theoretically expected signs, and their magnitudes seem reasonable. Each regression indicates the considerable importance of controlling for unobserved location and time effects on local homebuilding activity, given that both the location fixed effects and the year dummies throughout prove to be significant at high significance levels. If location and time fixed effects were omitted, their influence on local permit

[30] Using 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. The standardized interlocational variation in the cost of land thus exceeds the variation in construction cost by a factor of six. The coefficient of variation for total average development costs (0.226) is comparable to the coefficient of variation for local home prices.

[31] *,**,*** denote statistical significance at the 1%-, 5%- and 10%-significance level, respectively.

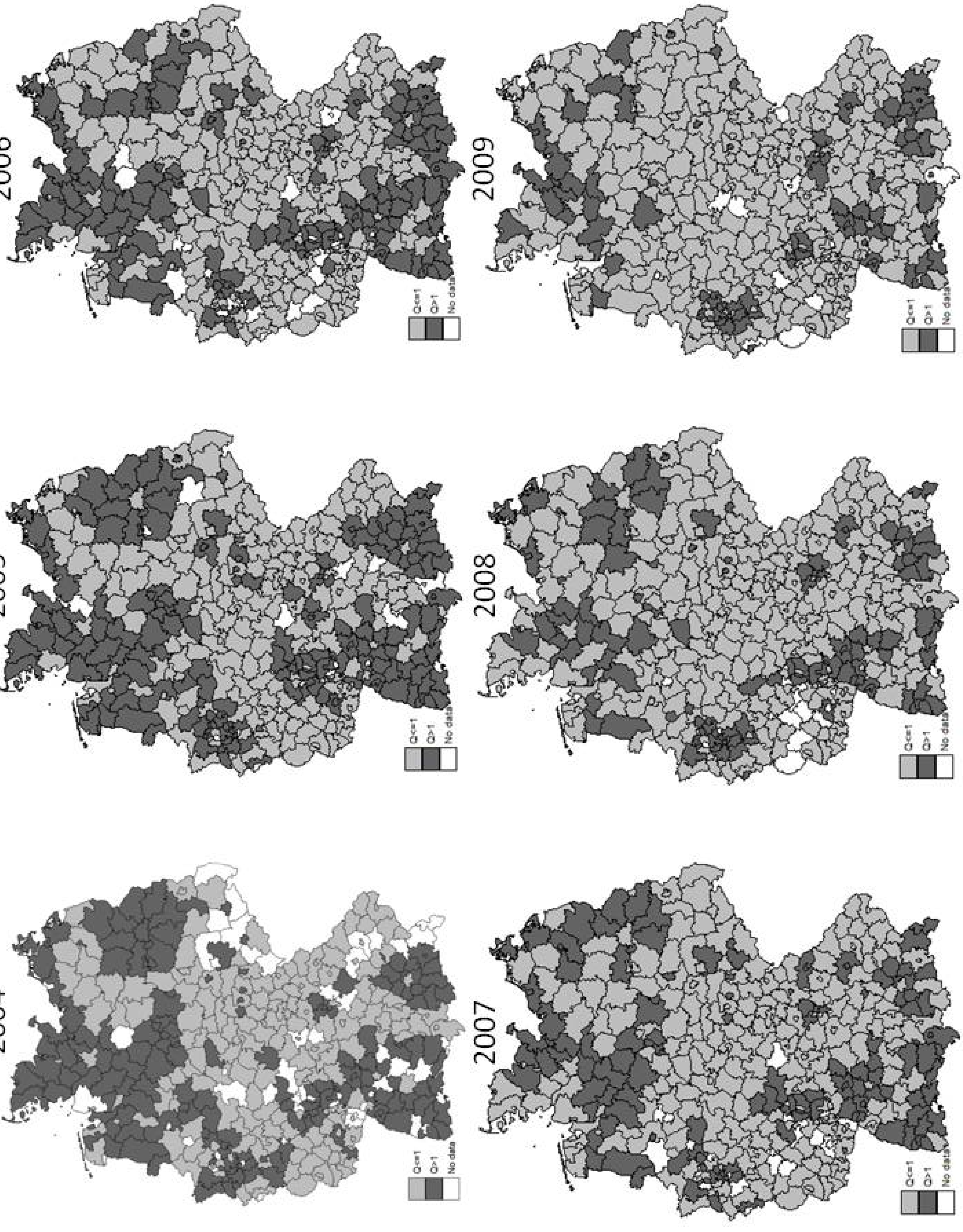

Figure 3: Spatio-temporal development of local Q-ratios, 2004-2009

rates would thus be erroneously attributed to local prices and housing development costs.[32] Common goodness of fit measures reveal that all models are fairly successful in explaining the variation of construction permit rates across counties and cities and also within these markets over time. Both the equation standard error and the Akaike information criterion indicate that the best specification is achieved by including local home prices and development costs in both their levels and recent changes.

Consistent with theory, all estimations show higher prices for existing homes in a location to go along with a higher number of construction permits per unit of stock. Higher levels of housing development costs, including the local cost of purchasing buildable land and putting up physical structure, meanwhile turn out to be associated with lower permit rates. The corresponding coefficients prove to be statistically significant at least at the 5%-level, independent of whether first differences in explanatory variables or other additional covariates are added to the model. There is thus strong empirical evidence that the new supply of single-family housing in German local housing markets closely responds to local levels of existing home prices and development costs.

The evidence regarding the partial effects of recent price and cost changes turns out to be less clear. In the second equation, which only includes changes but no levels, recent home price changes are statistically significant, while the coefficient of recent changes in replacement costs is virtually zero. However, when recent changes in prices and costs enter the equation together with their respective levels, recent home price changes become insignificant, while recent changes in development costs yield a significantly positive coefficient. The latter result implies that, for given levels of home prices and development costs, recent increases in the cost of developing new housing are associated with higher local permit activity. This may be reasonably explained by developers‘s expectations: if recent cost changes can be extrapolated into the future, then (all else constant) investing becomes more attractive if the costs of developing new houses are on the rise in a location.[33] The coefficient on recent price changes carries the expected positive sign, but its statistical insignificance suggests that recent home price developments had practically no effect on local permit rates in the time period analyzed.

[32]The importance of local housing market heterogeneity is underscored by consistently high values for rho (ρ), which indicate how the sample variance in construction permit rates is explained by the variance in location fixed effects.

[33]In fact, the importance of timing in residential construction has found considerable support in previous studies (DiPasquale, 1999; Gyourko, 2009).

Equation	(5.9)	(5.10)	(5.11)	(5.11b)	(5.11c)
$\ln(P)$	0.3631**		0.4654**	0.4916**	1.5220**
	(0.1509)		(0.2013)	(0.2018)	(0.6145)
$\ln(C)$	-0.2333**		-0.5261**	-0.4375**	-0.4640**
	(0.1136)		(0.2204)	(0.2031)	(0.2061)
$\triangle\ln(P)$		0.3181***	0.0842	0.0633	0.1006
		(0.1194)	(0.1536)	(0.1547)	(0.1501)
$\triangle\ln(C)$		-0.0433	0.1745*	0.1744*	0.1928*
		(0.0599)	(0.1130)	(0.1140)	(0.1140)
D_2005	-0.1362***				
	(0.0150)				
D_2006	-0.1572***	-0.0318**	-0.0281**	-0.0128*	-0.0258*
	(0.0158)	(0.0143)	(0.0142)	(0.0228)	(0.1399)
D_2007	-0.6413***	-0.5197***	-0.5111***	-0.4833***	-0.5081***
	(0.0207)	(0.0183)	(0.0181)	(0.0397)	(0.0181)
D_2008	-0.6994***	-0.5889***	-0.5700***	-0.5249***	-0.5674***
	(0.0206)	(0.0175)	(0.0182)	(0.0562)	(0.0183)
D_2009	-0.6571***	-0.5423***	-0.5125***	-0.4491***	-0.5093***
	(0.0203)	(0.0172)	(0.0193)	(0.0717)	(0.0196)
$SH3050$				4.0559	
				(4.0560)	
$\ln(GDP)$				0.0523	
				(0.2032)	
$MIGR$				0.0020	
				(0.0028)	
$\ln(P)*UPE$					-1.0167
					(0.6422)
$\ln(P)*RPE$					-1.0389
					(0.6620)
$\ln(P)*RUR$					-1.4262*
					(0.6588)
No. of obs.	2288	1812	1812	1812	1812
R^2_{within}	0.6839	0.6711	0.6760	0.6765	0.6778
$R^2_{between}$	0.2442	0.0190	0.2075	0.3474	0.0819
$R^2_{overall}$	0.3449	0.2012	0.2974	0.3780	0.0669
ρ (rho)	0.7881	0.8495	0.8334	0.8162	0.9963
Equation SE	0.2202	0.2039	0.2025	0.2026	0.2022
AIC	-880.662	-1076.939	-1100.280	-1095.573	-1104.185

Table 3: Panel regression (fixed effects) results, standard errors in parenthesis

The estimated coefficient on the local home price level, which according to the specification can be interpreted as the average long-term elasticity of single-family home supply with respect to existing home prices, is unambigiously smaller than unity (the only exception is Eq. 5.11c, which requires careful independent explanation). The empirical evidence hence supports the conjecture that local single-family housing supply is widely inelastic to price, as it is often argued by housing market practitioners. According to Eq. 11, which includes prices and costs in terms of both their levels and changes, each one per cent increase in median local house values is associated with a 0.49 per cent increase in local permit rates, all else remaining equal. As a numerical example, this means that if the mean local house value is 200,000 Euros and the mean permit rate is 100 permits per 10,000 existing houses, a 20,000 Euro increase in average house values would generate about five additional permits on each 10,000 houses per year. This estimate is strikingly close to the estimate of Sanchez and Johansson (2011) based on time-series data, even though their study uses data on total housing supply instead of focusing on the supply of single-family homes.

In analogy to the coefficient on home prices, the coefficient estimated on local development costs can be interpreted as the average elasticity of new housing supply with respect to housing replacement costs across the locations included in the sample. Consistent with theoretical expectations, its magnitude is generally close to the price elasticity of supply. Using again Eq. 11 as a reference, each one per cent increase in total housing development costs is associated with a 0.44 per cent decrease in local permit rates.

Before the extended models are commented, it is worth studying the coefficients on the time dummy variables in more detail. The substantial statistical relevance of the year dummies suggests that nationwide factors exerted considerable influence on single-family housing permit activity during the time period analyzed. Regardless of which model is considered, each year dummy obtains a negative coefficient that is statistically significant at least at the 10%-level, which indicates that average permit rates were consistently lower in the years following the base period.[34] Hence, the time fixed effects seem to successfully absorb the general downward trend in permit activity that was discussed earlier in this paper.[35] Finally, it can be inferred from the

[34]Note that the year of 2004 is the base period only for the first specification, while the year of 2005 is the base period for the remaining specifications because first differences in the covariates are included.

[35]According to the year dummies, the most pronounced drop in average local permit activity turns out to have occured in 2007, the year after which first-time home buyer allowances were phased out. While it may seem odd that this drop occured with a one-year delay, this is explained by the fact that all

year dummies that single-family housing permit activity tended to recover during the financial crisis, a phenomenon investigated by Lerbs and Oberst (2011b)

The extensions undertaken in the equations 5.11b and 5.11c serve two different purposes. The purpose of the first extension is to test whether the explanatory power of the supply equation can be augmented by the inclusion of demographic and economic variables that may be related to single-family housing demand.[36] Model 5.11b therefore amends the model by the population share of persons aged 30-50 years (*SH3050*), production per capita (*GDP*) and the net rate of internal immigration in the previous year in each location (*MIGR*). The purpose of the second extension is to test for potential heterogeneity in average supply elasticities across the urban hierarchy. Existing literature has provided evidence that housing supply conditions can vary strongly across different degrees of urbanization (Green et al., 2005; Saiz, 2010). One obvious explanation for this finding is the availability of land: if low elasticities are related to land use constraints, elasticities should on be average lower in densely populated agglomerations than in rural areas that have comparatively abundant land reserves. The hypothesis of equal supply elasticities across location types was tested in model 5.11c by including interaction terms between local house prices and different location-type dummy variables. The estimation distinguishes between core cities (used as the reference type), urban peripheries (*UPE*), rural peripheries (*RPE*) and remote rural areas (*RUR*).[37]

An estimation of Eq. 5.11b reveals that the coefficients on local home prices and development costs are barely affected by the inclusion of demographic and economic variables that are typically associated with the local demand for single-family housing. Neither the share of persons aged 30-50 years in the local population, which is used as a simple indicator of demographic homebuilding potential, nor local output per capita (indicating local purchasing power) and the rate of previous-year immigration (indicating recent inflow of additional population) add significantly to the model. Thus, variables related to local housing demand did not possess independent

households who had already applied for a construction permit were still eligible for the subsidy in 2006.

[36] As argued earlier, local home prices may not fully reflect local housing market conditions due to imperfections in the housing market, which might call for the inclusion of demand indicators in the new supply equation.

[37] The employed area classifications follows BBSR definitions, which are based on the two criteria of accessibility and density. The group of core cities includes cities with at least 100,000 inhabitants, irrespective of population density. The group of urban periphery includes both cities with less than 100,000 inhabitants and counties with a population density of $150/km^2$ or more. The group of rural periphery includes counties with a density of 100-150$/km^2$, while counties with a population density less than $100/km^2$ are classified as remote rural areas.

explanatory power with respect to local dispersion in new single-family housing construction during the observation period, at least after local home prices and housing development costs were already controlled for. This might be interpreted as evidence that local German home prices reflect fundamental conditions in local housing markets to a considerable extent.

Turning to Eq. 5.11c, the estimated coefficients on the three interaction terms for home prices and different types of location indicate that the hypothesis of equal elasticities across the urban hierarchy has to be rejected at least for the difference between core cities and remote rural areas. Since the log-log functional form remains untouched by the inclusion of the interaction terms, the assumption that supply elasticity is the same across all locations in the sample is simply relaxed in favor of the somewhat more realistic assumption that elasticity is the same across all locations in the sample which belong to a certain type of location. Surprisingly, the average elasticity in core cities turns out to be considerably higher than remote rural areas, at the 10%-confidence level. According to the estimated coefficients, the average long-term supply elasticity is 1.55 in core cities but only 0.13 for counties classified as remote rural regions. The average supply elasticity the locations classified as urban and rural periphery also seems to be considerably lower than in core cities, although the hypothesis of statistically significant differences cannot be sustained just at the 10%-confidence level.[38]

One possible explanation for this surprising result may be the fierce competition for residents amongst greater cities (Salmon, 1987; Henderson and Thisse, 2001). In their function as spatial centres of economic activity and growth, German core cities increasingly attract young and usually well educated people, with corresponding effects on the demand and price of single-family housing. Indeed, core cities experienced a markedly positive average migration rate during the observation period (+2%), while remote rural areas faced partly severe levels of outward migration (mean rate of -2%). At the same time, homeownership affordability tends to be a more severe problem in cities than in peripheral counties, where home prices are usually low and stable. Both effects provide core city governments with strong incentives of promoting additional homebuilding, in order to enable prospective homebuyers to invest in their city.[39] Permit rates in many shrinking rural locations meanwhile

[38]For the calculation of these numbers, it has to be remembered that core cities were defined as the reference group. Hence, the coefficient on $\ln(P)$ in Eq. 5.11c refers to core cities, while the remaining coefficients are calculated as $\ln(P)+\ln(P)*DUMMY$.

[39]For an in-depth discussion of this argument, see Glaeser (2008).

tend to be close to their natural floors, implying only very limited responsiveness to existing home prices. In such locations, disequilibrium is more likely to be reduced through abandonment and demolition (Maennig and Dust, 2008).

7 Conclusions

The price responsiveness of housing supply proves to be fundamental to long-term developments in the housing market. This paper has exploited the striking variability in single-family housing construction permits across local housing markets in Germany to compute econometric estimates of the price elasticity of new housing supply. In order to construct an reliable indicator of new local housing supply, annual numbers of new single-family housing permits in 413 counties and cities over 2004-2009 were related to corresponding data on existing single-family housing stocks. This indicator was subsequently linked to current levels and changes in local house prices and new housing development costs, using a panel data framework that allowed to account for unobserved location characteristics and temporal influences.

According to the empirical results, existing home prices and new housing development costs are able to explain a considerable proportion of the variation in new local single-family housing supply both across different areas and within areas over time. Fixed effects estimation showed that higher existing home values in a location go along with a higher number of construction permits per unit of stock, while higher development costs depress local homebuilding activity. The analysis hence provides strong support for the claim that local single-family home markets operate in the way fundamental capital theory suggests. Recent increases in the cost of new developments are another factor stimulating new housing investment, a result that probably reflects adaptive expectations of future cost changes.

For the German housing market as a whole, the empirical findings point to an inelastic responsiveness of new single-family home supply with respect to the price of existing dwellings, which is consistent with both casual empiricism as well as recent empirical findings based on national time-series data. At the same time, the results point to interesting differences in average supply elasticity among the German urban hierarchy. According to the estimates, supply proves to be most elastic (with a supply elasticity greater than one) in core cities of more than 100,000 inhabitants, while inelastic supply is found for urban hinterlands as well as for more remote rural areas.

The findings of this study bear some implications regarding overall housing market developments and housing policy in Germany. Generally, the result of a low price elasticity of supply raises concerns about increasing interlocational house price differentials and lower levels of housing affordability in prosperous regions. These arguments are surely realistic, but some qualifications are necessary. At the beginning of this study, several nationwide trends were sketched which are generally in line with a low average elasticity of new housing supply. Since there is a natural floor to new construction, housing permits should not be expected to be overly responsive to prices in areas that face demographic stagnation or decline, which currently holds true for many parts of the country. Low average elasticities are moreover completely compatible with the rule that new housing should be provided where the demand for new housing construction is the greatest. This study has suggested that new single-family home supply tended to be most price elastic in greater cities, the group of location that is currently experiencing the highest rates of immigration and population growth. German city governments obviously manage the supply of single-family housing to react appropriately to price signals, which is a necessary prerequisite for ensuring affordable housing in economic growth centres.

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