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Border Effects in House Prices

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Abstract

We estimate the effect of the Dutch-German border on house prices. In the last 40 years the development of house prices in the Netherlands and Germany has been substantially different. While the Netherlands have been hit by two real estate cycles, prices in Germany have been extraordinary stable. We develop a model for studying house prices and the impact of the border. Then we study the development of Dutch house prices close to the German border in the period 1985-2013. Next, combining German and Dutch real estate datasets, we study the jump in the housing price occurring at the border. Using different estimation strategies, we find that ask prices of comparable housing drop by about 16% when one crosses the Dutch-German border. Given that price discounts from the last observed asking price are substantially larger in Germany, we interpret our findings as indicating the willingness of Dutch households to pay up to 26% higher house prices to live among the Dutch.

JEL classification: R31, F15, R21

Keywords: house prices, European integration, border effects

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1 Introduction

House prices can differ substantially between countries and between metropolitan areas within a country. The impact of locally differentiated variables like amenities such as infrastructure, income and the elasticity of housing supply may dominate that of global determinants of house prices like the long run interest rate on the international capital market, which should be expected to have an equalizing effect. Roback (1982) has shown that substantial differences between house prices in different areas are compatible with interurban equilibrium when they compensate for differences in productivity or amenities.

For locations close to each other, differences in productivity and amenities are usually small and therefore less important and, unless barriers to mobility exist, the limited distance offers possibilities for arbitrage that will be exploited by households. One should therefore expect differences in house prices to be limited between locations that are close to each other, although the possibilities for arbitrage in housing markets is hampered by the substantial costs of moving (Glaeser and Gyourko 2007).

In the case of national borders, there may also be differences in amenities – like the common language spoken by people, the educational or the law system – that limit arbitrage. It has been found that national boundaries matter substantially for international trade even in case of the Canada-US border, which may be qualified as 'relatively innocuous' (McCallum 1995, p. 622). For instance, in a seminal paper, Engel and Rogers (1996) find that 'crossing the border is equivalent to 1,780 miles of distance between cities' in terms of price dispersion of similar goods (Engel and Rogers 1996, p. 1120). The explanation of this finding is that arbitrage is substantially less powerful when a national boundary has to be crossed to make it effective. People are reluctant to cross the boundary and willing to forego some benefits by avoiding it. This suggests that they are also willing to stay in their home country even if a move over a short distance across the border would offer them the benefit of a substantially lower house price. For the case of the European Union, where national economies are arguably even more integrated than those of Canada and the US, Cheshire and Magrini (2009) conclude that national borders still have a significant impact on property prices. Indeed, they find that cities within the Union still form national urban systems rather than a single European-wide system. Jacobs-Crisoni and Koomen (2014) show that national borders still affect the spatial urban pattern in northern Europe.

In this paper we argue that house prices may reveal interesting information about the importance of boundaries within the European Union. In particular, we argue that, under conditions that will be clarified below, a jump in the housing price occurring exactly at the border reveals the importance that households attach on staying within their own country.

As far as we know, there is no research that investigates the possible presence of discontinuities of house prices across country boundaries. In this paper we aim to fill this gap in the literature by considering house prices on both sides of the German-Dutch border. Germany and the Netherlands are both Western European countries sharing a border of approximately 500 km length.[1] The Dutch economy is closely connected to the – much larger – German economy. Long before the Euro was established, the currencies of the two countries were already closely tied to each other by coordination of the monetary and, more generally, macro-economic policies in both countries. However, as will be documented in the next section, the development of house prices in the two countries differed substantially over the past decades. In short, Dutch house prices were volatile and at one stage more than doubled in real terms, whereas German house prices remained essentially constant over the whole period 1985-2013. Since the distance from the Dutch Randstad – the economic center of the Netherlands – and the Ruhrgebiet – the German metropolitan region closest to the Netherlands – is less than 250 km, this raises the question if these large differences in the general level of house prices between the two countries persist in regions close to their common border and to which extend arbitrage is able to diminish them.

Differences between country-wide average house prices in the Netherlands and Germany do not necessarily have to be reflected in price differences in the border regions of both countries. Just like houses prices in American metropolitan areas can differ substantially without any discontinuity in the price as a function of the distance between these areas, the Dutch Randstad and the German Ruhrgebiet can differ in their housing market situation without a significant border effect. If arbitrage is sufficiently strong it will prevent such a discontinuity to occur unless there is a discontinuity in amenities.

It is important to note, however, that such a difference in amenities does not necessarily have to show up in a discontinuity in house prices. If Dutch and German households are willing to pay a premium for living in their own country instead of across the border – even if they live very close to that border – and housing conditions are similar in both countries, the price of comparable housing may be almost identical on both sides of the border. It is for this reason that the substantially different development of housing prices in the two countries is of special interest. As we will document below, the strong increase in house prices in the Netherlands that occurred since the mid-1980s was not restricted to the core area in the west, but has also been observed in the border area. This strong increase in house prices on the Dutch side of the border provides an ideal test case for the extent of housing market arbitrage between the two countries. If integration of the

[1] This is the total length of the border line. The Euclidean distance between the most northern and the most southern point is approximately 300 km.

two countries were complete, we would not expect to see a discontinuity in prices since the Dutch households would be essentially indifferent between living on either side of the border. However, if integration is incomplete, the reluctance of Dutch households to benefit from the lower house prices in Germany is revealed by a discontinuity in house prices. That is, it reveals the willingness to pay of these households to stay in a Dutch environment.

The differences between countries in the European Union that may manifest themselves in border effects can probably be interpreted to a large extent as cultural factors. It has been shown that culture can affect a variety of economically important variables (Guiso et al. 2006) or outcomes (Döhrn 2000; Bredtmann and Otten 2013). The most obvious cultural discrepancy is the difference in language. The emergence of nation-states in the 19th century has contributed to sharp discontinuities in the language spoken on both sides of national borders while previously there was often a more or less continuous change in local dialects. This was the case for large parts of the Dutch-German border as the dialects (*nedersaksisch*) spoken in the eastern parts of the Netherlands were very close to the *plattdüütsch* that was common on the other side of the boundary. The official languages which are now also the common language for most people show more substantial differences. It is well documented in the international trade literature, e.g. Melitz (2008), that sharing a common language increases the volume of traded goods and services between two countries. Lazear (1999) transfers this finding of increased interactions between countries with a common language to the individual level. He develops a model of a multi-lingual society where trading partners are required to speak a common language and shows that individuals have a preference to live in neighborhoods where the own language is common.

However, the impact of culture seems to be far more subtle than the existence of a common language. Falck et al. (2012) show that even given a common language, cultural similarities still affect economic outcomes. They study cross-regional migration in Germany in the time period 2000-2006 and find that historical dialect similarity still has an important effect. This finding endorses the view that a move across the border implies a significant change in social environment even if it concerns the 'relatively innocuous'[2] border of the Netherlands and Germany. Associated with the switch in language is – at least to some extent – a switch in culture as the language spoken is associated with the use of television, radio, newspapers, books, et cetera.

Related to these cultural differences are the differences in spatial planning on both sides of the border. Tennekes and Harbers (2012) have recently documented the differ-

[2] We borrowed this term from McCallum (1995) who used it as a qualification for the border between the US and Canada.

ences in urbanization style between the Netherlands and its neighboring countries. Briefly, the main difference they observe between the Netherlands and Germany is that extensions to existing settlements in the Netherlands are usually larger, reflecting the stronger population growth in the Netherlands in the post-war period, and more planned in the sense that there is limited variety in the types of housing. Associated with this is a stronger emphasis on terraced housing and apartments in the Netherlands.

In summary, there are strong reasons to believe that a move across the German-Dutch border also implies a jump in local amenities that will probably limit housing price arbitrage. The implication is that a discontinuity in the housing prices indicates the value of the amenities that Dutch households give up when they choose to reside in Germany. Measuring this gap is the main purpose of the paper.

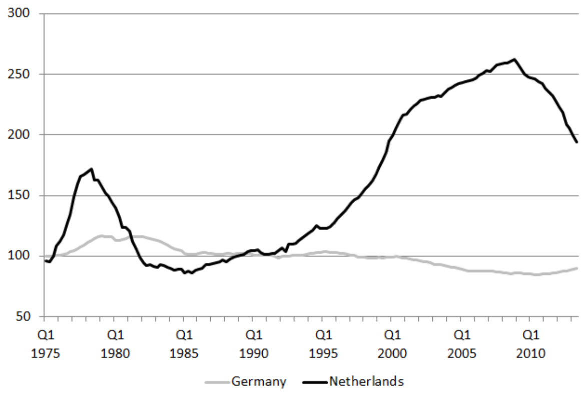
This paper is structured as follows: Section 2 discusses institutional differences for the housing market in the two countries. Section 3 develops a theoretical model for house prices that motivates the empirical work that follows. Section 4 documents the development of house prices in the Dutch border region in the past 25 years. Section 5 presents the combined data that are used to investigate the border effect. Section 6 describes the results of this analysis. Section 7 concludes.

2 House Prices and Housing Markets in Germany and the Netherlands

2.1 No Convergence

Vansteenkiste and Hiebert (2011), who recently considered the relationship between the development of house prices in Euro area countries, mention three reasons for expecting international co-movement of house prices. The first one is the common development in housing market fundamentals like income and interest rates. For instance, as Germany and the Netherlands are both members of the EMU, the uniform monetary policy should transmit into similar interest rates in the two countries. The second reason is the parallel introduction of capital and mortgage market innovations. However, the fiscal treatment of owner-occupiers differs considerably between the two countries and the mortgage market in the Netherlands has reacted to specific features of the Dutch income tax system, which suggests that convergence of house prices might not be complete. We will return to this issue below. As a third reason for expecting co-movement these authors mention "[...] housing-specific factors, notably related to some convergence of housing risk premia associated with returns on housing as an asset (beyond its role as a consumption good)" (Vansteenkiste and Hiebert 2011, p. 299). The increasing integration of the two economies and the establishment of the single financial market should have led to a convergence of risk premiums.

Figure 1: Real House Prices in Germany and the Netherlands 1975-2013 (1975=100)



Source: Mack and Martinez-Garcia (2011), International House Price Database Dallas Fed.

Figure 1 shows that the development of real house prices in Germany and the Netherlands differed considerably between 1975 and 2013. Whereas German real house prices remained more or less constant over the sample period, Dutch house prices showed substantial peaks in 1978 and 2008. At the second peak, Dutch real house prices were almost three times as large as in 1985. These differences are remarkably large, especially for countries that are as close, geographically as well as in terms of economic structure and policy, as Germany and the Netherlands.

2.2 Differences in Population Growth and Housing Policy

The first things that come to mind when looking for explanations for differences between the housing markets in both countries are population growth and mortgage interest deductibility. In many European countries, the post World War II baby boom was soon followed by a substantial decrease in birth rates. This decrease has been especially pronounced in Germany, which has one of the lowest birth rates in the EU, whereas birth rates in the Netherlands remained relatively high until the late 1960s. This difference in population growth had significant implications for the housing market. While demand pressure remained rather strong in the Netherlands, it was much less of an issue in Germany (at least at the national level). These differences in the development of housing demand do not necessarily imply stronger price increases or higher house prices in the Netherlands than in Germany: much depends on the elasticity of housing supply and the (de)centralization of employment and (other) amenities.

However, there also appears to be an important difference between the two countries with respect to housing supply. Vermeulen and Rouwendal (2007) find that the price elasticity of housing supply in the Netherlands is virtually equal to zero, whereas Lerbs (2014) finds significant (both statistically and economically) effects of house prices on construction activity in Germany. In other words: housing supply is more elastic in Germany, which has a stabilizing effect on house prices. On the other hand, the combination of growing demand and inelastic supply was probably an important driver of increasing house prices in the Netherlands.

In addition to the difference in supply elasticities, there is an important difference in the tax treatment of owner-occupation in the two countries that may play an important role. Ever since the introduction of an income tax in the Netherlands in the early 20th century interest paid on mortgage loans was deductible from taxable income.[3] Initially, this was motivated by the aim of treating owner-occupiers in the same way as homeowners who rent out their property. That is, the rent foregone because of owner-occupation had to be added to taxable income, and the mortgage interest paid was regarded as the cost associated with the realization of this income-in-kind. Later on the motivation changed. Imputed rental income was deliberately determined at a very low level to stimulate homeownership, while at the same time (and for the same reason) mortgage interest deductibility was fully maintained. This is in stark contrast to Germany where mortgage interest payments on owner-occupied housing are not tax deductible.[4] In Germany, deductibility of interest paid is restricted to non-owner occupied real estate. Mortgage interest deductibility in itself does not necessarily lead to higher house prices. It stimulates housing demand, but if supply reacts swiftly, the price level does not have to change. However, in combination with extremely price inelastic housing supply in the Netherlands this tax facility has probably contributed substantially to the higher price level.

To complete the picture, some other factors have to be added. Both countries substantially differ in the way home ownership is stimulated. In the Netherlands the national mortgage guarantee (abbreviated in Dutch as NHG) implies that the Dutch state guarantees repayment of accepted mortgage loans to the lender. There is a one-time premium for this insurance to be paid by the household, but it is very low and since mortgage suppliers offer a slightly lower interest rate for insured loans, it typically is paid-back within a few

[3]Since approx. 2000 Dutch workers living in Germany can opt for the Dutch income tax system, which implies that they continue to be able to benefit from mortgage interest deductibility. See Section 4. Until recently this was possible with any type of mortgage, but at present mortgage interest deductibility for new contracts has been restricted to fixed price and linear mortgages.

[4]Imputed rents also do not have to be added to taxable income in Germany, but we noted already that in the Netherlands they are determined at a very low level. The tax rules in the Netherlands ensure that the net effect of subtracting mortgage interest paid and adding imputed rent can never result in a higher taxable income.

years.[5] If a household qualifies for the guarantee, loan to value (LTV) ratios larger than 1 become possible – and are indeed common – as not only the full sales price of the house but also the transaction costs involved can be financed by the insured mortgage loan. The essential eligibility requirement is that the ratio between the mortgage payments and household income should not be too high – typically the threshold is around 30% – and that the workers in the household have job tenure.[6]

To see how this could contribute to the development of Dutch house prices shown in Figure 1, consider for simplicity a household that takes an interest-only mortgage loan. The maximum size L of the loan is given by the equation: $iL = cY$, where i is the (net) interest rate, Y is household income from tenured jobs and c is the critical share of mortgage payment in household income. Clearly, the maximum bid a household can make for a house is equal to cY/i, a decreasing function of the interest rate i. In the 1970s interest rates were relatively low and households could pay large amounts of money for their houses. Around 1980 there was a shift towards a much tighter monetary policy and initially the effect was that interest rates increased considerably, implying much lower borrowing (and bidding) capacity of Dutch households.[7] In the course of the 1980s and 1990s interest rates gradually decreased, while the increasing share of double earner households[8] and economic growth lead to significant increases in household income. These developments contributed to the substantially higher borrowing capacity of Dutch households. Since housing supply was essentially inelastic, the increased bidding capacity did not lead to better or more luxury houses, but predominantly to higher prices for the same houses. Note that in this analysis the possibility to realize high LTVs – which exists in the Netherlands, but not in Germany – is essential, since the necessity to invest – say – 20% of the value of the house from other sources (such as savings) would have made it much more difficult for first-time Dutch buyers to pay the high prices.

In Germany the government encourages saving for house purchases through fiscal measures.[9] There exists a contractual savings system allowing households to pin down future interest rates on contracts for future lending for house purchases. Due to government

[5] This means that the premium is so low that the lower interest rate banks are willing to offer in return for the disappearance of the default risk is more than sufficient to pay it. This may raise doubts about the appropriateness of the level of the premium. The fact is that even in the current crisis the number of defaults has remained low and the NHG funds accumulated from past premiums paid have been sufficiently large.

[6] There is also an upper limit on the price of the house.

[7] For the negative effect of monetary policy shocks on house prices, see e.g. Iacoviello (2005) and Iacoviello and Neri (2010).

[8] In the Netherlands the increase in female labor force participation occurred relatively late. Many working women have a part-time job. Only in the course of the 1990 banks started taking into account the income of the second worker when determining a household's borrowing capacity.

[9] Up till 2006 the government subsidized the first real estate purchase for all taxpayers. However, this subsidy has been abolished in 2006.

subsidies these contracts offer favorable conditions compared to other types of lending. On the other hand such subsidized contracts are conditional on the commitment to save before obtaining the loan, reducing the required size of the loan and decreasing the LTV ratio due to higher equity, which arguably has a stabilizing effect on house prices.

In addition, the difference in accessibility of the rental market between the two countries may have contributed further to the differential development of house prices. In Germany the rental sector is large – 56% of households do not own their main residence – and open to all households. In the Netherlands the rental sector is somewhat smaller – 43% of all households rent their main residence – and it consists predominantly of social rental housing, which is rent-controlled. There is severe excess demand for social rental housing, especially in the larger cities, and since the rationing systems favor lower incomes, households with higher incomes are therefore practically unable to rent. Unlike in Germany, renting is therefore not a real alternative to owning for many Dutch households. Note that this contributes to making demand less price elastic than it would be if the rental market offered a good substitute to owner-occupied housing.

3 The Model

3.1 The Model and its Implications for the Border Effect on House Prices

To motivate the empirical work that follows, we now formulate a simple model that incorporates some of the stylized facts discussed in the previous section. Assume that Dutch workers are dispersed over a line with its origin in the center of the Dutch Randstad. A position on the line is indicated by x, the residential location, or y, the location of the worker's job, and refers to the distance to the center of the Randstad. The line stretches eastward and crosses the border with Germany in $\bar{x}$. Jobs are present everywhere on the line, and the density of labor demand $g\left(x, w\left(x\right)\right)$ for Dutch workers is a decreasing function of x until the German border.[10] The decreasing density of labor demand reflects that the Randstad is the urban heart of the Netherlands.

The density of housing at a particular location x is assumed to be an increasing (housing supply) function $s^{i}\left(p\left(x\right)\right)$ of the local housing price $p\left(x\right)$, with i equal to N on the Dutch side of the border and equal to G on the German side.[11] We assume that housing supply is less elastic in the Netherlands than in Germany. We interpret the

[10] That is $\partial g/\partial x < 0$.

[11] This formulation implies that the housing supply function is identical everywhere in a given country. We discuss the implication of less elastic housing supply close to the Randstad toward the end of this section.

housing price – in line with the economic literature – as the price of one unit of housing services or – equivalently – as the price of a house with a given set of characteristics.[12] The number of housing services consumed refers in this setup to the quality of housing relative to that of the reference house.

The housing price $p(x)$ refers to the value of all present and future housing services and must be distinguished from the payment for user cost during one period, which are known as the user cost. We adopt a simple formulation in which the user cost is the product of the housing price and the net interest rate. In Germany the net interest rate equals the gross rate since there is no mortgage interest deductibility, but in the Netherlands the net interest rate is equal to the gross rate multiplied by one minus the marginal income tax rate. We thus define the user cost of housing in Germany as $uc^G(p(x)) = \rho\, p(x)$, where ρ is the mortgage interest rate, and in the Netherlands as $uc^N(p(x)) = (1-\tau)\,\rho\; p(x)$, where τ is the marginal income tax rate.

Worker utility is determined by the wage $w(y)$ where y denotes the worker's job location, the user cost of housing $uc^i(p(x))$, where x denotes the residential location, the commuting distance $d(x, y)$ and a dummy variable $f(x, y)$ that indicates that the commute crosses the border: $u = u(w(x), uc^i(p(x)), d(x), f)$. We consider the distribution of a given population of Dutch workers over jobs that are located in the Netherlands and residential location in the Netherlands and – perhaps – also in Germany. We assume throughout the paper that jobs in the Netherlands are all occupied by Dutch workers, and that jobs in Germany are all occupied by German workers. An equilibrium in this model is a distribution of the Dutch workers over job locations in the Netherlands such that:

a) All Dutch workers are employed and housed.

b) The number of workers equals the demand for labor at the prevailing wage at each location.

c) The number of houses equals the supply of housing at the prevailing user cost/housing price.

d) All workers reach the same utility at the chosen residential and job location.

e) No worker is able to improve his utility by changing job location, residential location, or both.

The first and second characteristics imply that we must have $\int_0^{\bar{x}} g(y, w(y))dy = B$, where B is the given size of the Dutch labor force. The first and third equations imply:

[12] The concept 'housing services' was introduced by Muth, Muth (1969).

$\int_0^{\bar{x}} s^N (p(x))dx + \int_{\bar{x}}^{\hat{x}} s^G (p(x))dx = B$, where $\hat{x}$ denotes the extent of the Dutch settlement in Germany. If all Dutch workers live in their own country, $\bar{x} = \hat{x}$.

Suppose some Dutch workers live in Germany. Compare the worker who lives on the Dutch side of the border, at $\bar{x} - dx$, where dx is a small positive number, with the one who lives at the German side at $\hat{x} + dx$. Since neither should be able to gain from changing their jobs their wages-net-of-commuting costs must be equal. The requirement that both reach the same level of utility thus implies that the negative impact of crossing the border must be completely compensated by the housing price. That is, the housing price must show a discontinuity at the border that reveals the willingness to pay of a Dutch worker to live in the Netherlands instead of Germany.

The jump in the housing price that occurs at the border has of course consequences for the quantity of housing services demanded, which should increase. The value of the house is affected by two components, quantity as indicated by the number of housing services and price per unit of housing services. The border does affect both components differently. At the border the price per unit of housing services decreases, and this affects the quantity of these services demand by the households. If housing services are a normal good, the two effects point in opposite direction and the sign of the net effect is undetermined. However, the downward jump in the unit price should be expected to increase the number of units consumed, which implies a better quality (=a larger number of housing services) of housing at the German side of the border. It may also be noted that the impact of the border on population density is indeterminate as the effect of the lower housing price and the more elastic supply counteract each other.

3.2 Some Properties of the Equilibrium

In this subsection we explore some properties of an equilibrium when utility is Cobb-Douglas:[13]

$$u = \ln (w(y) - td(x,y)) - \alpha \ln \left(uc^i(x) \right) - \beta f(x,y) \tag{1}$$

with $\alpha, \beta > 0$. A stylized fact of commuting behavior in the Netherlands is that commutes are predominantly into the Randstad area. This suggests that in equilibrium we should have:

$$\int_0^x g(z, w(z))dz \geq \int_0^x s(p(z))dz \tag{2}$$

[13]With these preferences, households spend a given share of their budget on housing services. Their behavior is therefore similar to what happen if a constraint imposed on the share of housing in total expenditure – imposed, for instance, by mortgage insurance – is valid.

for all x, $0 \leq x \leq \bar{x}$. Workers should therefore reach their highest possible utility when commuting in western direction. A convenient way of modeling such a situation is to assume that all workers – at any residential location – are indifferent between all jobs located between their residential location and the Randstad center.[14] It is easy to verify that this is the case if the wage function satisfies:

$$w(y) = w(0) - t\,y. \tag{3}$$

We require also that for any job location a worker is indifferent between all residential locations that are further to the east. Standard calculations[15] then show that:

$$p(x) = \frac{c\,(w(0) - tx)^{1/\alpha}}{(1-\tau)\,\rho} \qquad 0 \leq x \leq \bar{x} \tag{4}$$

where c is a constant of integration. The analysis of the previous section implies that Dutch workers who live in Germany should pay:

$$p(x) = \frac{c\,(w(0) - tx)^{1/\alpha}\, e^{-\beta/\alpha}}{(1-\tau)\,\rho} \qquad \bar{x} \leq x \leq \hat{x} \tag{5}$$

It can be verified that with these wage and housing price equations the conditions d) and e) for equilibrium are fulfilled. In order to verify the validity of the other three conditions, observe that labor demand in all locations is decreasing in $w(0)$. We can therefore find a labor market equilibrium in which all workers have a job and demand for labor is satisfied at each location by choosing an appropriate value for $w(0)$.

For housing we follow a similar approach. We assume that housing supply can be described by a log-linear supply function:

$$Q^N(x) = \sigma_0^N p(x)^{\sigma_1^N} \tag{6}$$

Here Q refers to the number of housing services supplied. In order to find the density of households we divide by individual demand for housing services, as follows from out Cobb-Douglas utility function:

$$s^N(x) = Q^N(x) \,/\, \frac{\alpha\,(w(0) - tx)}{(1-\tau)\,\rho\, p(x)} \tag{7}$$

If all Dutch workers live in their own country, we must have:

[14] Compare the urban model with decentralized unemployment of Hamilton and Röell (1982).

[15] Compare the monocentric model in which consumers have Cobb-Douglas preferences. The housing price function (4) follows from the Muth condition $\partial p/\partial x = -t/s(p(x))$. Substitution of the housing demand function and solving the resulting differential equation gives the result.

$$\int_0^{\bar{x}} s^N (p(x))dx = B \ . \tag{8}$$

This condition allows us to compute the value of the constant of integration c in the housing price Equation (4):

$$c = 1/ \left[\frac{1}{B} \frac{\sigma_0}{(1+\sigma_1)\, t} \frac{1}{(\rho(1-\tau))^{\sigma_1}} \left[w(0)^{\sigma_1/\alpha} - (w(0) - t\bar{x})^{\sigma_1/\alpha} \right] \right]^{1/(1+\sigma_1)} \tag{9}$$

After substituting this expression into the price function (4), we arrive at a price equation that gives the local housing prices that solve the model conditional upon the value of $w(0)$ that equilibrates the labor market. In this equilibrium inequality (2) must be satisfied, as is suggested by the stylized fact discussed above.

It can be shown that these local housing prices are everywhere increasing in the total number of workers B, the equilibrium wage $w(0)$ and the marginal tax rate τ, and decreasing in the interest rate ρ. The model is thus consistent with the story told above about the pressure put on Dutch house prices. If house prices in an initial situation are close on both sides of the border, all Dutch workers will live in their own country. If the housing price on the Dutch side of the border increases relative to that on the German side, nothing happens until the threshold that reflects the reluctance of the Dutch workers to live among the Germans is exceeded. Then Dutch workers start buying houses in Germany and the German housing price immediately across the border is described by (5).

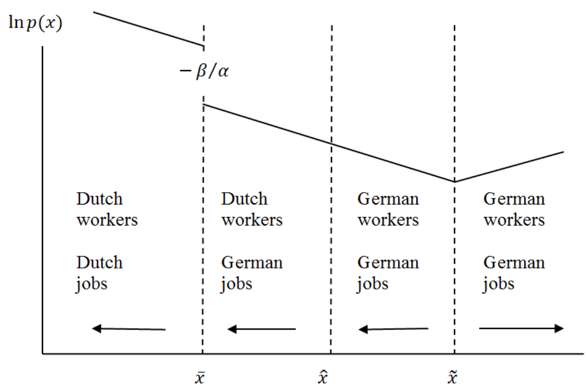
3.3 Extending the Model to Germany

A similar model as outlined for the Netherlands is assumed to hold on the German side as well, for instance, the Ruhrgebiet playing the same role as the Randstad. Differences between the countries are that the elasticity of housing supply, σ_1, is higher in Germany and that there is no mortgage interest deductibility. Depending on the parameters of the model, the German housing price may be close to the Dutch one at the border, or differ from it.

A major new element is, of course, that for Germany we should consider the possibility of Dutch workers 'invading' the country. This situation will only occur, of course, if the ratio of the Dutch and German housing price exceeds $\exp(\beta/\alpha)$. Dutch workers will then enter and overbid German workers close to the border. The consequence is that (at least) close to the border the initial equilibrium is disturbed. All German workers now have to be housed in a smaller amount of space, which calls for higher house prices. Some German workers now have to commute in reverse direction, that is towards the Dutch border. That means that – at least close to the border – the equilibrium will be qualitatively different from that discussed in the previous section does not exist.

Unless the spatial pattern of house prices changes, the displaced German workers now have to pay a higher housing price or face a longer commute. Interest in jobs close to the Dutch border will therefore disappear unless wages become higher, but this means that the number of jobs will decrease. The geographical distribution of German jobs will therefore change. It is possible that an equilibrium emerges in which the German workers can be divided into two groups: group 1 commutes in the direction of the Dutch border, whereas group 2 commutes in the opposite direction. For group 2 the equilibrium is similar to that in the situation in which no Dutch workers live in Germany. For group 1 the equilibrium is close to that on the Dutch side of the border: all workers are indifferent between all jobs that are between their residential location and the Dutch border because the wage compensates the commuting cost. However, in contrast to the situation in the Netherlands, the density of jobs is increasing if one moves from west to east. This situation is illustrated in Figure 2.

Figure 2: House Prices, Location Patterns and Commuting close to the Border



Note: The arrows show the direction of the commutes. $\bar{x}$ location of the border. $\hat{x}$ extent of Dutch workers living in Germany. $\tilde{x}$ German workers living in Germany.

This figure shows that to the left of the Dutch/German border at $\bar{x}$ Dutch workers commute in the direction of the Randstad, as is indicated by the arrow. To the right of the German border Dutch households live until $\hat{x}$, and they commute to jobs in the Netherlands. The jobs that are located between $\bar{x}$ and $\hat{x}$ are occupied by German workers who live between $\hat{x}$ and $\tilde{x}$, they commute in the direction of the Dutch border. The workers who live in that area between $\hat{x}$ and $\tilde{x}$ also occupy all jobs that are located there. This means that the presence of Dutch workers in Germany results in an extension of the Dutch commuting and housing price patterns to a wider area then where the Dutch workers are actually settled. Only to the right of $\tilde{x}$ the pattern that is present everywhere in the German part of the Figure when the Dutch do not cross the border still holds.[16]

Finally, we note that a crucial property of the model developed in this section is that commuting costs are linear in distance. Although we think this is a useful approximation for most commutes, it is unlikely to be true for longer commutes. For instance, there will hardly be any Dutch worker living close to the German border who is happy to accept a job in Amsterdam. After a certain threshold – often thought to be close to 45 minutes travelling – commuting costs increase more than proportional with distance. This means that the rent gradient may become steeper if workers start to live further from their jobs, possibly on the other side of the German border.

4 Development of Dutch House Prices close to the German Border

With house prices more or less stable in Germany and rapidly increasing in the Netherlands over much of the aforementioned period, we are especially interested in the developments of real estate prices on the Dutch side of the border and whether price increases vary with the distance to the Dutch-German border. Therefore, we estimate a hedonic price function on Dutch housing transactions in the period January 1985-June 2013 within 50 km of the German border. The data refer to transactions handled by members of the Dutch Association of Real Estate Brokers, abbreviated in Dutch as NVM. We use a large number of transaction and housing characteristics to control for differences in housing quality (e.g., surface area, quality of maintenance, house type). Further, we use municipality-dummies to control for all kinds of local characteristics that remain constant over time as 'fixed effects', the distance to the German border to see if house prices are lower close to the border, and time dummies.

After cleaning the data $853,807$ transactions remain available for our semi-logarithmic regression analysis.[17] Table 1 lists the descriptive statistics of the dataset. Estimation results for the time dummies and their interaction with the distance to the border are shown in Figure 3. The dependent variable is the log of the transaction price. The full set of estimation results is reported in Table A1.

[16]The figure assumes that commuting costs are identical for Dutch and German workers. Many Dutch employers reimburse commuting costs, whereas this practice does not seem to be present in Germany. If commuting costs are higher in Germany, the German housing price function would be steeper, but qualitatively nothing would change in the Figure.

[17]We started with $1,001,757$ observations and removed observations with missing and/or incorrect variable values, as well as building lots, garage boxes, house boats, caravans, recreational property, countryside estates, partially rented houses, not permanently occupied objects and real estate investments objects.

Table 1: Descriptive Statistics for all Variables in the 50km wide Study Area (Period: 1985–2013)

Variable	Min	Max	Median	Mean	Std. Dev.
Transaction price (x 1,000 Euros)	*10*	*2200*	*158*	*182*	*121*
Transaction price corrected for inflation (x 1,000 Euros)	*11*	*2596*	*192*	*221*	*134*
Surface area (m^2)	*26*	*537*	*120*	*128*	*45*
Transaction price per square meter (x 1,000 Euros/m2)	*0.079*	*5*	*1.387*	*1.413*	*0.691*
Parcel size (m^2)	*0*	*99845*	*206*	*536*	*2108*
Number of rooms	*1*	*30*	*5*	*4.602*	*1.354*
Distance to Germany (km)	*0*	*50*	*27.449*	*26.108*	*14.947*
Nat. log of Trans. price corr. for inflation (x 1,000 Euros)	9.348	14.77	12.163	12.161	0.537
<u>Transaction characteristics</u>					
Annual time dummies: see below	0	1			
Free of transfer tax (0=no/1=yes)	0	1	0	0.0155	0.1234
<u>Structural characteristics</u>					
Natural log of surface area (m^2)	3.258	6.286	4.787	4.802	0.323
Natural log of parcel size (m^2) (0 in case of apartment)	0	11.511	5.328	4.786	2.22
Natural log of number of rooms	0	3.401	1.609	1.483	0.304
Heating system: present (0/1)	0	1		0.970	0.170
Garden: absent (0/1)	0	1		0.020	0.140
Garden: present (0=no/1=yes, simple or normal)	0	1		0.652	0.476
Garden: present (0=no/1=yes, well-kept)	0	1		0.328	0.470
Parking place: absent (0/1)	0	1		0.473	0.499
Parking place: present (0/1)	0	1		0.047	0.212
Parking place: garage and/or carport present (0/1)	0	1		0.480	0.500
Inside maintenance: bad to moderate (0/1)	0	1		0.004	0.059
Inside maintenance: mediocre to fair (0/1)	0	1		0.118	0.323
Inside maintenance: good to excellent (0/1)	0	1		0.878	0.327
Outside maintenance: bad to moderate (0/1)	0	1		0.003	0.056
Outside maintenance: mediocre to fair (0/1)	0	1		0.104	0.305
Outside maintenance: good to excellent (0/1)	0	1		0.893	0.309
Isolation: absent (0/1)	0	1		0.183	0.387
Isolation: 1 or 2 types present (0/1)	0	1		0.447	0.497
Isolation: 3 or more types present (0/1)	0	1		0.370	0.483
Building age dummies (0/1), ranges: 1500-1905; '06-'30; '31-'44; '45-'59; '60-'70; '71-'80; '81-'90; '91-2000; >2000					
House type dummies (0/1), indicating any of the 15 possible types (8 types of houses, 7 types of appartments)					
<u>Spatial characteristics</u>					
Municipality dummies	0	1		-	-
Year dummies (range 1985–2013) * dist. to Germany (km)	0	50		-	-

Variable	Mean	Std. Dev.	Variable	Mean	Std. Dev.	Variable	Mean	Std. Dev.
1985	0.014	0.117	1995	0.029	0.167	2005	0.056	0.230
1986	0.017	0.128	1996	0.033	0.179	2006	0.057	0.232
1987	0.017	0.128	1997	0.037	0.189	2007	0.059	0.235
1988	0.017	0.130	1998	0.043	0.203	2008	0.050	0.218
1989	0.018	0.132	1999	0.043	0.204	2009	0.038	0.190
1990	0.017	0.129	2000	0.045	0.206	2010	0.039	0.193
1991	0.018	0.135	2001	0.050	0.218	2011	0.036	0.186
1992	0.019	0.138	2002	0.050	0.219	2012	0.038	0.191
1993	0.022	0.146	2003	0.051	0.220	2013	0.015	0.121
1994	0.021	0.144	2004	0.052	0.222			

Note: italic variables are not used in the regression model

Figure 3: Development of the Dutch Housing Price near the German Border

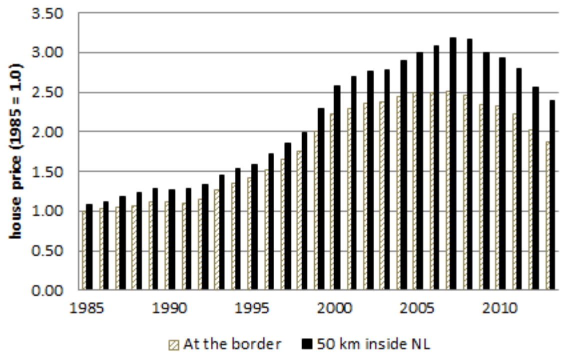


Figure 3 shows the development of Dutch house prices close the border as implied by the estimation results.[18] House prices at the border, indicated by the time dummy coefficients, have increased considerably over time with a peak in 2008, when the financial-economic crisis started to affect the Dutch housing market. House prices 50 km inside the Netherlands are always higher than at the border, which is in line with our model. However, around 2000 the discrepancy between the two series is growing, probably reflecting the stronger impact of the proximity to the German border as we discuss below.

Figure 4 illustrates the development of the price gradient over time.[19] It shows that the gradient remained more or less constant between 1987 and 2004, then increased until 2008, probably in reaction to the migration of Dutch households to Germany, and has stabilized at this higher level since then. The model developed in the previous section suggests that this gradient reflects commuting costs, but the shift to a higher level since 2005 must probably be interpreted as a short or medium run reaction to the higher numbers of Dutch workers moving across the border and thus relieving pressure on the Dutch house prices close to that border.

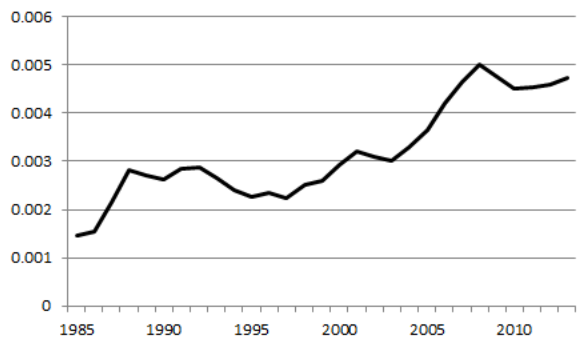
Since Germany and the Netherlands are both members of the European Union and both have signed the Schengen Treaty, the border between the two countries is easy to cross. Moreover, since 2001 Dutch citizens who have a job in the Netherlands can opt for the Dutch income tax even if they live across the border in Germany.[20] This means that Dutch migrants can take the mortgage interest deductibility with them as

[18]Figure 3 is based on the coefficients for the time dummies as reported in (the southeast part of) Table A1. The price index is constructed as $exp\left(co\left(year\right)\right)$, where $co\left(year\right)$ is the estimated coefficient for the time dummy referring to the year.

[19]Figure 4 gives the coefficients of the time * distance interactions reported in (the southwest part of) Table A1.

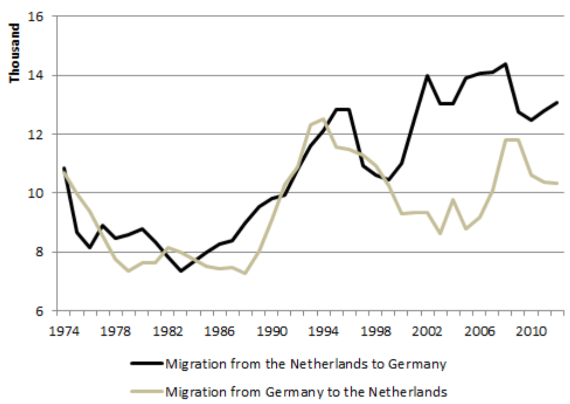
[20]This is also the case for Dutch households living in Belgium and other countries. The general principle follows from jurisprudence at the European level in the 1990s according to which workers living abroad must (have the possibility to) be taxed in the same way as those living in the country in which their job is located. The so-called 'keuzeregeling' (choice possibility) is included in article 2.5 of the Dutch income tax law of 2001.

Figure 4: Change in Price Gradient within 50 km of the Dutch-German Border



long as their job remains in the Netherlands. This change in tax treatment facilitates arbitrage considerably. Figure 5 shows the development of cross county migration between the Netherlands and Germany in the period 1974-2012. It is striking that there is a considerable net migration from the Netherlands to Germany starting in the early 2000s, when Dutch house prices increased rapidly and it became possible for Dutch workers to take advantage of mortgage interest deductibility even when moving across the border. This development is in line with numerous newspaper reports in the early 2000s concerning Dutch citizens who had moved just across the German border to live in a much larger house for the same or even a lower price. After a temporary drop, net migration to Germany increased again in 2010.

Figure 5: Bilateral Migration, Netherlands and Germany, 1974-2012



Source: Destatis.

Summarizing, it may be stated that Dutch house prices in the border region increased substantially in the period 1985–2013, but less in areas that were close to the German border and least at the border itself. Especially since 2000 the Dutch seem to have become aware of the potential attractiveness of moving across the German border, and this has contributed to the divergence between house prices at the border and at a 50 km distance of the border.

5 Data on House Prices on Both Sides of the Border 2007-2011

In this section we compare house prices on both sides of the border. As information on German house prices is available starting in 2007 we restrict the analysis to the years 2007-2011.[21] In Germany we observe houses that were offered on the website of ImmobilienScout24. This website allows realtors as well as private sellers to offer their real estate for sale or rent. It is the largest and most frequented internet real estate market place in Germany. ImmobilienScout24 estimates that about 50% of all real estate objects offered for sale or rent in Germany are offered via their website Georgi and Barkow (2010). Since transaction values are not observed, we use the last price for which the house was offered on this website.

In the Netherlands we observe houses that were offered on the FUNDA website by realtors that are members of the NVM. FUNDA is the largest website for houses in the Netherlands. It only registers houses offered for sale via members of NVM, which means that approximately 70% of the national supply is offered on this website. However, this share differs across regions. To make the data comparable with those available for Germany we do not use information on transaction values, but only the last observed price on the FUNDA website. Moreover, for the same reason we add information about Dutch houses that have been withdrawn from the FUNDA website without being sold.

Using ask prices instead of observed transaction prices is of course an additional source of uncertainty. To our knowledge, there is one study investigating the difference between the last observed ask price of objects advertised at ImmobilienScout24 and actual transaction price in Germany. For rural regions in Rhineland-Palatine Dinkel and Kurzrock (2012) find a difference of about 15%. To relate this to the Dutch dataset, where the transaction price is available to us, we compute the difference between the last ask price and the transaction price for all objects within 10km to the German border. In the Netherlands the discount seems to be substantially smaller, only about 5% of the transaction price.[22]

Using this dataset, we employ a method proposed by (Black 1999) to measure the impact of the border on house prices by concentrating on the border region. We only include objects located within a distance of 10km of the German-Dutch border in our analysis to guarantee that objects far away from the border do not distort the analysis.

[21]For a description of the dataset see an de Meulen et al. (2014).

[22]In the computation of the average percentage price difference we exclude the highest and lowest one percent to eliminate faulty entries.

Table 2: Descriptive Statistics

	Netherlands		Germany		Difference	
	0–5 km	5–10 km	0–5 km	5–10 km	0–5km	5–10 km
Observations	117,992	52,711	13,656	9,561		
Price	241,723	261,446	218,740	218,377	22,983***	43,069***
	(393)	(617)	(867)	(1077)	(952)	(1241)
Living space (m^2)	140	143	145	145	-5.21***	-2.50***
	(0.14)	(0.22)	(0.38)	(0.48)	(0.41)	(0.52)
Number of rooms	5.4	5.3	5.2	5,2	0.19***	0.11***
	(0.0048)	(0.007)	(0.0131)	(0.0151)	(0.014)	(0.0200)
Lot size (m^2)	642	635	683	628	-41.15***	6.94
	(3.92)	(5.85)	(5.8)	(5.78)	(7.00)	(8.22)
Year of construction (in percent)						
1500-1905	3.51	4.41	2.39	3.01	1.12***	1.40***
					(0.0014)	(0.0020)
1906-1930	9.65	10.52	6.44	5.61	3.21***	4.92***
					(0.0023)	(0.0027)
1931-1944	5.82	7.84	2.78	2.53	3.04***	5.31***
					(0.0016)	(0.0020)
1945-1959	12.11	9.74	11.46	9.47	0.65**	0.28
					(0.0029)	(0.0033)
1960-1970	16.44	16.91	13.88	13.43	2.56***	3.48***
					(0.0031)	(0.0039)
1971-1980	22.62	17.18	13.57	13.12	9.05***	4.07***
					(0.0032)	(0.0038)
1981-1990	11.84	11.81	9.97	9.25	1.86***	2.57***
					(0.0027)	(0.0033)
1991-2000	10.62	12.82	13.91	15.08	-3.28***	-2.26***
					(0.0031)	(0.0039)
2001-present	7.39	8.76	25.6	28.51	-18.21***	-19.75***
					(0.0038)	(0.0048)
Last observed in (in percent)						
2007	23.31	23.38	15.95	17.3	7.36***	6.08***
					(0.0034)	(0.0043)
2008	21.91	22.29	18.91	22.13	3.00***	0.15
					(0.0036)	(0.0046)
2009	18.19	19.07	21.54	18.7	-3.34***	0.37
					(0.0037)	(0.0043)
2010	17.95	18.2	21.19	21.52	-3.25***	-3.33***
					(0.0037)	(0.0045)
2011	18.64	17.07	22.41	20.34	-3.77***	-3.27***
					(0.0037)	(0.0044)
House type						
Terraced house	38.03	37.44	9.18	10.99	28.86***	26.45***
					(0.0028)	(0.0038)
Corner house	19.35	19.89	25.45	28.79	-6.10***	-8.91***
					(0.0039)	(0.0049)
Detached house	42.62	42.67	65.37	60.21	-22.75***	-17.54***
					(0.0043)	(0.0054)

Notes: *, **, *** indicate differences are significant at the 10%, 5% and 1% level. Standard deviations reported in brackets. Observations have been excluded if: price, living space, lot size, number of rooms < 1. Additionally to that, the top and bottom 1% of price, living space and lot size as well as the top 1% for the number of rooms have been excluded.

The number of observations on the Dutch side of the border is substantially higher: the portion of Dutch houses to German ones in the datasets is about 7 : 1. This large difference might be due to several causes. First, market coverage of ImmobilienScout24 in Germany is about 50%, which is lower than the one of the NVM in the Netherlands (70%). Second, it might be due to differences in the average time till a given object is offered for sale again. In Germany house owners are incentivized to hold on to their properties, as they have to pay taxes on speculative gains, if a house is sold within ten years of the purchase. Third, because of the large rental market in Germany, potential buyers that are not sure about their future household size or whether they will stay in the same city might be tempted to rent instead of buy as renting is associated with lower costs of relocation. In the Netherlands, this mechanism does not work because entrance to the social rental sector is limited, and a private rental market is virtually absent. Finally, there could be differences in population density on both sides of the border. To investigate the latter issue we have collected data on population density which is presented in the map in Figure A1. It appears that for most parts of the border population densities are comparable on the German and the Dutch side.

Apart from the last observed list price, the two datasets provide information about several other housing characteristics. Included in both datasets are living space, lot size (both in square meters), number of rooms, year of construction[23], house type[24], the last time an object has been advertised, and the location. We report some descriptive statistics for these variables in Table 2. There, we divide the dataset for objects that are located within 5 kilometer distance to the German-Dutch border as well as objects further away (5km-10km) for both countries.

The descriptive statistics show the presence of statistically significant price differences between houses on both sides of the border. On average house prices of objects within a boundary of five kilometers to the Dutch-German border are about 23 thousand Euros more expensive in the Netherlands than in Germany. The difference is larger if we also consider houses at a distance between 5 and 10 km, because Dutch house prices are higher in that area. Additionally to that, houses in the Netherlands are slightly smaller (in terms of living space and lot size) and less recently build, implying that the price mark up for identical houses might be even more pronounced.

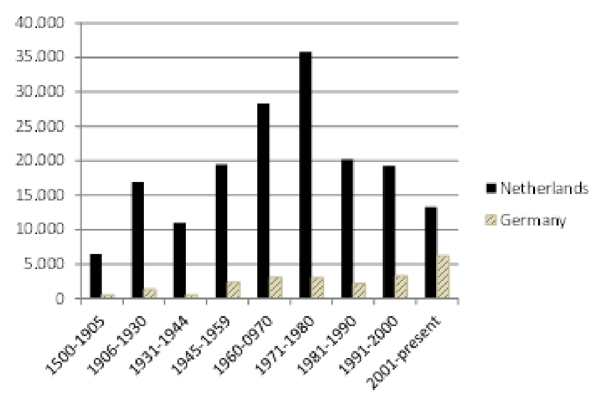
The differences in the amount of living space and lot size are consistent with the urbanization patterns on both sides of the boundary documented in Tennekes and Harbers

[23]The year of construction is available for 9 time periods. These consist of the years from '1500-1905', '1906-1930', '1931-1944', '1945-1959', '1960-1970', '1971-1980', '1981-1990', '1991-2000', and '2001 until presenT'.

[24]Due to differences in house types in Germany and the Netherlands we include the categories *terraced house*, *corner house*, and *detached house*.

(2012). The explanation for the difference in the year of construction, shown in Figure 6, is less clear. One explanation could be the longer holding period for German home owners. Given each object is first observed when it is sold after construction has finished, a longer holding period implies that houses appear less frequent on the market resulting in a relatively larger share of newly build houses.

Figure 6: Number of Observations by Year of Construction



Source: FUNDA, ImmobilienScout24, own calculations.

6 Analysis

In this section we report the results of three analyses, each one tackling a different aspect of the problem. We start with a hedonic price function analysis. Then we consider regression discontinuity analysis. And finally we carry out a spatial matching analysis. In Section 6.4 we discuss the development of the border gap over the period 2007–2011, in Section 6.5 we analyze regional differences.

6.1 Hedonic Price Analysis

Hedonic theory implies that the quality of a good is determined by the bundle of its defining characteristics. By estimating a hedonic function we are able to extract the implicit value of each characteristic of a house.

$$\ln p = Z\beta_Z + L\beta_L + f\beta_G + \varepsilon \tag{10}$$

In Equation (10) $\ln p$ is a vector of logarithmic house prices, Z a matrix of the individual houses' characteristics as described in Section 5 and β_Z the characteristics' implicit prices. The matrix L represents location specific information, which consists of two components. First, there is a dummy variable indicating a border segment. As the

Dutch-German border stretches out over about 500km, house prices might differ substantially with respect to the location within one country. For instance, house prices on the southern end of the border, with the employment centers Maastricht and Aachen, might be higher than in the less densely populated regions in the north. We have therefore divided the border into segments of 1km length[25] and we include a dummy indicating the nearest border segment into the regression equation. Second, we include the distance to the border in polynomial form to deal with the possible impact of proximity to the border on housing prices in a flexible way. In Table 3 below we report the estimation results for the specification with polynomials up to the power four. Figure 7 shows the results of the different estimated price effects of the distance to the boundary. The vector f contains dummy variables that are equal to 1 for houses located in Germany and zeroes for Dutch houses. The coefficient β_G is the price markdown for objects in Germany and the coefficient of interest in this analysis. We estimate the equation including all houses within ten kilometers to the Dutch-German border.

All estimation results reported in Table 3 are in line with the intuition. Larger houses are more expensive than small ones. A one percent increase in living space increases house prices by about 0.6%. The price increase for one percent additional lot size is considerably smaller (0.2%). The house type also has a substantial impact on the price. Given the reference category, detached houses, corner houses are subject to a price markdown of about 20%, terraced houses an even larger markdown of about 25%. Houses that have been built most recent are the most expensive. The price markdown for older houses increases monotonically till 1940. The markdown for objects build in the intra war period is less pronounced.

The estimated coefficient for the dummy variable β_G, which indicates whether or not the object is located in Germany, is highly significant. Houses in Germany are roughly 15% cheaper than their counterparts of identical quality on the Dutch side. Additionally to this direct effect, the border seems to impact house prices in another way. In the Netherlands, house prices decrease with decreasing distance to the German border.

To illustrate this we report the impact of the distance to the Dutch-German border on house prices in Figure 7. The different lines represent the impact based on the different estimations. First, assuming a linear relationship only, then stepwise including an additional polynomial. This convergence on the Dutch part seems robust to the inclusion of additional polynomials. However, it cannot be found on the German side, as one might have expected prices to increase with decreasing distance to the Netherlands.

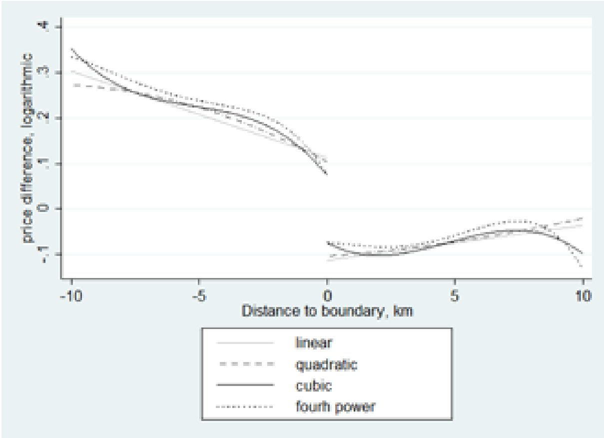
[25]This results in a total of 490 border segments with a length of 1km in the estimation of Equation (10).

Table 3: Hedonic Regression

	linear	Quadratic	cubic	quartic
Average border effect (β_G)	-0.2279***	-0.2102***	-0.1500***	-0.1510***
	0.0046	0.0062	0.0081	0.0101
Distance Germany	0.0078***	0.0047*	-0.0315***	-0.0018
	0.0008	0.0027	0.0065	0.0129
Distance Netherlands	-0.0192***	-0.0309***	-0.0697***	-0.0962***
	0.0004	0.0012	0.0027	0.0053
(Distance Germany)^2		0.0004	0.0101***	-0.004
		0.0003	0.0016	0.0055
(Distance Netherlands)^2		-0.0014***	-0.0117***	-0.0237***
		0.0001	0.0007	0.0022
(Distance Germany)^3			-0.0007***	0.0017*
			0.0001	0.0009
(Distance Netherlands)^3			-0.0007***	-0.0027***
			0.00005	0.0003
(Distance Germany)^4				-0.0001***
				0.00005
(Distance Netherlands)^4				-0.0001***
				0.00002
Living space	0.5899***	0.5901***	0.5898***	0.5899***
	0.0021	0.0021	0.0021	0.0021
Lot size	0.1859***	0.1860***	0.1859***	0.1858***
	0.0009	0.0009	0.0009	0.0021
Number of rooms	0.0085***	0.0085***	0.0086***	0.0086***
	0.0003	0.0003	0.0003	0.0003
Terraced house	-0.2469***	-0.2467***	-0.2463***	-0.2466***
	0.0017	0.0017	0.0017	0.0017
Corner house	-0.2001***	-0.2000***	-0.1996***	-0.1998***
	0.0016	0.0016	0.0016	0.0016
Adj R-squared	0.8262	0.8263	0.8265	0.8266
Observations	193920	193920	193920	193920

Note: *, **, *** indicate significance at the 10%, 5% and 1% level. Additional control variables are the year of construction (8 dummy variables: ‘1500-1905’; ‘1906-1930’; ‘1931-1944’; ‘1945-1959’; ‘1960-1970’; ‘1971-1980’; ‘1981-1990’; ‘1991-2000’; reference category is ‘built after 2000’) and dummy variables for the border-segment (a total 490, each one with a length of 1km).

Figure 7: Price Effect of Distance to Boundary



Note: Negative values for distance indicate the Dutch side of the border, positive values the German one. Source: FUNDA, ImmobilienScout24, own calculations.

6.2 Regression Discontinuity Design

A potentially attractive alternative to a hedonic analysis would be the regression discontinuity analysis (see e.g. Imbens and Lemieux (2008)).[26] The sharp regression discontinuity design (SRD)[27] is especially useful to estimate causal effects of a treatment, assigned on the basis of an observable forcing variable, in our case the German-Dutch border. However, an important condition for the SRD to uncover the causal effect of – in our case – the border is that all other variables that have an impact on house prices, notably housing characteristics, are continuous functions of the distance to the border. Discontinuities in such variables at the border imply a violation of the key assumption of SRD, viz. that the treatment and the counterfactual are identical with respect to all other variables. Since Tennekes and Harbers (2012) and the descriptives provided in Table 2 above suggest the presence of structural differences in the housing markets of the two countries that are probably reflected in discontinuities at the border, we first investigate this issue.[28]

It is conventional to present figures for the control variables to check the validity of the continuity assumption. Since this would result in a large number of graphs, we only used SRD as a descriptive device to investigate the presence of discontinuities in control variables at the border. The results are reported in Table 4. Each line of this table gives the impact of the border in a separate SRD regression.[29] For instance, the first line refers to a regression of the log of living space, the second to a similar regression on the log of

[26]See Keele and Titiunik (2013) for a discussion of RDD in a spatial context.
[27]For a discussion of RD in economics see Lee and Lemieux (2010).
[28]To estimate the boundary effect by SRD we use the code by Nichols (2007).
[29]The bandwidth is computed according to Imbens and Kalyanaraman (2012). Similar to the estimation of the hedonic price function we only include observations within 10 km to the boundary.

the lot size, et cetera. The table shows that for most of the variables that we used in the hedonic regression there is a significant discontinuity at the border, which confirms the differences in land use on both sides of the border that were observed by Tennekes and Harbers (2012).

Table 4: SRD for Covariates

Variable	Boundary effect	Standard error
Log (living space)	0.0331***	0.0081
Log(lot size)	0.4876***	0.0328
Number of rooms	-0.2407***	0.0329
House type		
Terraced house	-0.2804***	0.0109
Corner house	0.02767*	0.0157
Detached house	0.2487***	0.022
Year of construction		
1500-1905	-0.0504***	0.0087
1906-1930	-0.1063***	0.0136
1931-1944	-0.0289***	0.0064
1945-1959	-0.0056	0.0128
1960-1970	0.0446***	0.0101
1971-1980	0.0364	0.0235
1981-1990	0.0499***	0.0097
1990-2000	-0.0117	0.0088
2000-2011	0.1090***	0.0127
Log (price)	0.0192	0.0127

Note: *, **, *** indicate significance at the 10%, 5% and 1% level. Positive coefficients indicate that houses on the German side do exhibit more units of the respective variable. For the binary variables, house type and the year of construction, positive coefficients indicate that the variety is more probable to be found in Germany.

Frölich (2007) has investigated situations like the one encountered here where some housing characteristics differ between treated and non-treated objects and suggests controlling for additional covariates to reduce estimation bias. We therefore estimate the boundary effect on house prices using SRD controlling for various covariates[30] using the STATA code by Nichols (2007).[31] Doing so, we find a jump in house prices at the bound-

[30]The included covariates are: Log(lot size), log(living space), nine dummy variables for the year of construction, three dummy variables for the house type, five dummy variables for the year of transaction, and 56 dummy variables for the border segment closest to the individual house. The 56 border segments represent border bits, each of ten kilometers length.

[31]As we expected, results including covariates differ substantially from the results excluding them. This differs from the general experience in which covariates are continuous in the forcing variable, see Section 5.2 of Imbens and Kalyanaraman (2012). If we don not include covariates we do not find a significant effect of the border.

ary of 16.5%, as shown in the line with the bold figures in Table 5. The effect is highly significant and very similar in magnitude to that found in the hedonic analysis when the impact of the distance to the boundary is taken into account in a flexible way. To test whether this discontinuity is unique at the border or potentially artificial to the datasets we repeat the estimation setting spurious cutoff points. We estimate the equation for the spurious cutoffs 2 km, 4 km, and 6 km on both sides of the border. The results, which are also reported in Table 5, confirm that the discontinuity is unique to the border.

Table 5: Estimation Results SRD with Covariates

Distance to cutoff	Boundary effect	Standard error
6 km on the Dutch side	0.0059	0.005
4 km on the Dutch side	0.0082*	0.0045
2 km on the Dutch side	0.0017	0.0046
Border	**-0.1650*** **	**0.0088**
2 km on the German side	0.0164	0.011
4 km on the German side	-0.0027	0.0097
6 km on the German side	0.0086	0.0098

Note: *, **, *** indicate significance at the 10%, 5% and 1% level. Positive coefficients indicate higher prices in Germany. The included covariates are: Log(lot size), log(living space), nine dummy variables for the year of construction, three dummy variables for the house type, five dummy variables for the year of transaction, and 56 dummy variables for the border segment closest to the individual house. The 56 border segments represent border bits, each of ten kilometers length.

We have also carried out an SRD analysis on the housing prices close to the border without controlling for housing characteristics. We then find an insignificant effect of the border. This tells us that the value of houses on both sides of the border is essentially equal, suggesting that the negative impact of the border on the housing price is fully compensated by the increase in the quantity of housing services consumed. This result is consistent with the Cobb-Douglas specification of preferences used in Section 3.

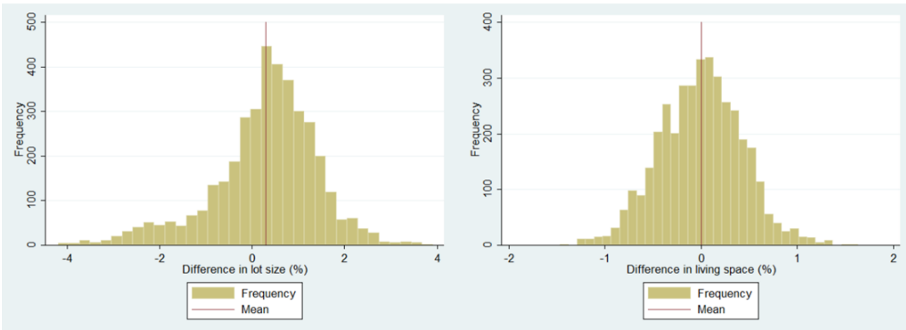
6.3 Spatial Matching

Even though we only include objects within a certain threshold distance to the boundary in the hedonic analysis, a concern one may have is that it refers to the whole German-Dutch border and thus compares houses that may be hundreds of kilometers apart. Our use of fixed effects for small border segments may not be sufficient to capture regional differences correctly. Therefore we use matching techniques as an additional device to test for the presence of border effects, as this allow for a comparison of objects that are more or less directly adjacent. In a first step we match all objects on the German side to its closest geographical neighbor on the Dutch side. We do this separately for each year to exclude the impact of price differences between Dutch and German houses over time.[32]

Using these pairs of observations we compute differences for all explanatory variables. We subtract the characteristics of the Dutch houses from their closest German counterpart, positive values indicating that e.g. floor size in the German houses is larger than in the Dutch ones.[33]

We test if these differences in quality persist even when looking at objects that are spatially close. Figure 8 shows the percentage differences for the continuous explanatory variables living space and lot size. While differences in living space do not seem to be driven by the country, lot sizes of spatially close objects are substantially larger in Germany. This implies that even spatially close houses that were observed in the same year, need to be quality adjusted when compared, as we did in our regression discontinuity analysis.

Figure 8: Difference in Lot Size and Living Space



Notes: Houses within 3km distance. Source: FUNDA, ImmobilienScout24, own calculations.

We estimate the hedonic price function:

$$\Delta \ln p = \beta_G + \Delta Z \beta_x + \varepsilon \tag{11}$$

where $\Delta \ln p$ represents a vector of log price differences and matrix Z differences in the two matched objects' characteristics. Negative values for the coefficient β_G indicate that prices in Germany are lower than in the Netherlands. ε is an error term. We report the estimation results in Table 6.

[32]The Stat module GEONEAR (Picard 2010) has been used.

[33]For the variables in price, living space and lot size we build the log difference. For the three dummy variable representing the house type we build three new variables, one for a matched pair consisting of a terraced house and a corner house, one for a pair of a terraced house and a detached house and one for a pair of a corner house and a detached house. For pairs of similar house types the all of the three variables are assigned zero. For differences in the year of construction, we only observe time periods we can control for by dummy variables for the Dutch side, we subtract the time periods means. For the dummy representing houses built before 1906 we set the value to 1900.

Table 6: Matched Pair Regression

Difference in	1km	2 km	3km
Average border effect (β_G)	-0.18***	-0.17***	-0.17***
	(0.06)	(0.03)	(0.02)
Living space	0.61***	0.38***	0.60***
	(0.11)	(0.06)	(0.04)
(Living space)^2	-0.34**	0.02	-0.03
	(0.14)	(0.07)	(0.05)
Lot size	0.24***	0.34***	0.34***
	(0.06)	(0.02)	(0.02)
(Lot size)^2	-0.05*	-0.06***	-0.07***
	(0.03)	(0.01)	(0.01)
Number of rooms	0.0002	0.0098**	-0.0032
	(0.0077)	(0.0043)	(0.0031)
Year of construction	0.0087***	0.0071***	0.0072***
	(0.0013)	(0.0006)	(0.0004)
(Year of construction)^2	-0.000063***	-0.000036***	-0.000042***
	(0.000018)	(0.000008)	(0.000006)
Terraced, corner house	-0.18***	-0.09***	-0.18***
	(0.05)	(0.03)	(0.02)
Terraced, detached house	-0.42***	-0.26***	-0.30***
	(0.04)	(0.02)	(0.02)
Corner, detached house	-0.18***	-0.17***	-0.14***
	(0.05)	(0.02)	(0.01)
Distance to match	-0.08	-0.01	-0.03***
	(0.08)	(0.02)	(0.01)
Adj R-squared	0.65	0.67	0.67
Observations	391	1631	3842

Note: *, **, *** indicate significance at 10%, 5%, and 1% level. Standard errors in brackets underneath.

Houses on the Dutch side seem to be about 17% more expensive than otherwise comparable houses in Germany. The results are robust to altering the maximum distance between two houses. Also,the estimated price effect of about 17% is perfectly in line with the result of the hedonic regression (about 15%) and the SRD analysis (16%). The values of the other coefficients are also in line with intuition. Larger houses, in terms of lot size and living space, and newer houses are more expensive. The hierarchy of different house types is detached houses, corner houses, and terraced houses with detached houses the ones most favored.

6.4 House Price Development over Time

In the previous three subsections we have presented a consistent set of results that show the presence of a considerable gap between quality-adjusted house prices on both sides of the Dutch-German border. Earlier we suggested interpreting this difference as reflecting the value of remaining in the Dutch social and cultural environment. If this interpretation is correct, one would expect the boundary gap to be relatively constant over time as long as the house price difference between the Netherlands and Germany remains substantial. The reason is that the cultural differences change only slowly over time.

Figure 1, which depicts the all-country price indices in (Mack and Martinez-Garcia 2011), shows that real house prices in the Netherlands started to decline substantially in 2008, while prices in Germany slightly increased. Figure 3 makes evident that this also holds true for Dutch houses close to the German border. If our interpretation is correct, we thus would expect the price difference at the border to be constant despite the decreasing trend in the Dutch house prices.

By allowing for time variation in the price markup of Dutch houses over the years and re-estimating Equation (11), we find that the price difference at the border has been relatively stable (Table A2). Depending on the estimation sample, the absolute change in the price difference has been 10% for the estimation using all objects within 1km and 2km. For the estimation using all houses within 3km, which considerably increases sample size and this way also the reliability of the results, the difference between the highest and the lowest estimate for the price markup is only 6%. This is substantially lower than what the development of the all country indices would imply. Assuming the price markup is by about 17% on average, the price markup for Dutch houses should have decreased from about 23% in 2008 to 9% in 2011, resulting in an absolute change of the price difference of about 14%.

6.5 Regional Differences

Let us finally take a look at differences in house prices at different locations. We therefore divide the border into three segments. If we follow the border starting in the north, the first segment consists of the first 200km, the second one of the next 200km and the third one of the remaining 156km. We then assign each of the matched pairs as explained in Section 6.3 to a border segment, depending on the closest segment of the house located in Germany. Table 7 shows the number of matched pairs in the different groups for the three samples of all objects within 1km, 2km, and 3km. This shows that the number of observations in the North is substantially lower than in the more urban environment in the South, which also has been indicated by Figure A1.[34]

Table 7: Number of Observations in Different Border Groups

	1km	2km	3km
0km - 200km	23	130	279
200km - 400km	70	272	1,230
400km - 556km	297	1,220	2,318

In our regional analysis we focus on the 3km sample as the number of observation in the Northern group seems too low to get reliable estimates for the price effect in the 1km and 2km samples of matched pairs. We re-estimate Equation (11) allowing for different price effects for the three border segments. The results show the price difference is substantially more pronounced in the Northern part of the border (Table 8). One explanation for these different effects of the national border on house prices might be that living in a foreign country is substantially less harmful in an urban environment where the level of infrastructure is high and crossing the boundary, e.g. to work in a different country, is less of an issue. Additionally to that, cultural diversity in urban environments is higher which might reduce disutility from living in a foreign country. In a rural environment, crossing the boundary typically is more time consuming as border crossings are less frequent.

To test whether differences in population density are one factor driving price differences, we include the difference in population densities as control variable in a second regression.[35] While differences in population densities have a significant effect on the house price differences, regional differences hardly seem to be affected by this. One explanation for this might be that the differences in population density are not as pronounced

[34] As not all houses could be matched information on population densities the number of observations is slightly lower than in the analysis in Section 6.3.

[35] We use population densities based on a 1km grid available from Eurostat. The variable is defined as the log difference between the population density in Germany and in the Netherlands. This way, a positive coefficient for the difference in population density means that an increase in population density in the Netherlands c.p. increases the (already negative) price difference.

Table 8: Matched Pair Regression with Regional Differences

Difference in	3km	3km
0km-200km	-0.34***	-0.34***
	(0.03)	(0.03)
200km-400km	-0.19***	-0.21***
	(0.02)	(0.02)
400km-556 km	-0.14***	-0.13***
	(0.02)	(0.02)
Difference in population density		0.04***
		(0.00)
Living space	0.602***	0.61***
	(0.04)	(0.04)
(Living space)^2	-0.06	-0.08
	(0.05)	(0.05)
Lot size	0.33***	0.32***
	(0.02)	(0.02)
(Lot size)^2	-0.07***	-0.06***
	(0.01)	(0.01)
Number of rooms	0.0011	0.0013
	(0.0031)	(0.0030)
Year of construction	0.0072***	0.0072***
	(0.0004)	(0.0004)
(Year of construction)^2	-0.000041***	-0.000040***
	(0.000006)	(0.000006)
Terraced, corner house	-0.17***	-0.17***
	(0.02)	(0.02)
Terraced, detached house	-0.29***	-0.30***
	(0.02)	(0.02)
Corner, detached house	-0.14***	-0.14***
	(0.01)	(0.01)
Distance to match	-0.03***	-0.04***
	(0.01)	(0.01)
Adj R-squared	0.68	0.69
Observations	3827	3827

Note: *, **, *** indicate significance at 10%, 5%, and 1% level. Standard errors in brackets underneath.

as one might have expected. Comparing densities of spatially close objects, we find that in the Northern border segment, the average difference in population density is 1.3%, in the middle segment the difference is about 1.6% and in the South the difference is only 0.3%.

7 Conclusion

This paper has investigated the considerable difference between house prices in Germany and the Netherlands while focusing on the difference at the border. We find that during the period 1985-2007 house prices on the Dutch side of the border increased in real terms, but less than in the Netherlands as a whole. The substantial increase in house prices in the Netherlands has made a move just across the border increasingly attractive to Dutch households. Moreover, after around 2000 we observe an increasing discrepancy between house prices in the border region and objects located 50 km away from the border. All this is suggestive of Dutch workers taking into account the possibility to live in Germany to take advantage of lower house prices and still benefiting from mortgage interest deductibility. These findings are consistent with data on migration of Dutch households to Germany.

Although arbitrage is relatively easy, a sharp discontinuity in the quality-adjusted house prices on both sides of the border remained present in the period 2007-2011. Notwithstanding the progress made in the unification of the European Union and the fact that there is no 'natural' border between the two countries, the Dutch are still reluctant to live among the Germans and appear to be willing to forego a substantial benefit. While there are regional differences, the price difference seems to be substantially more pronounced in the North in comparison to the more urban Southern border region, the difference in ask prices seems to be about 16% of the price of a house, or approximately 38,000 Euros. Given that the price discount from the last ask price seems to be substantially higher in Germany, Dutch households might be paying as much as 26% higher house prices to live among their own people.

These conclusions are based on the analysis of a combined datasets on real estate prices in both countries. Using various techniques we find similar values of the jump at the border. Moreover, the gap at the border remained relatively stable and has been less volatile than implied by the all country indices.

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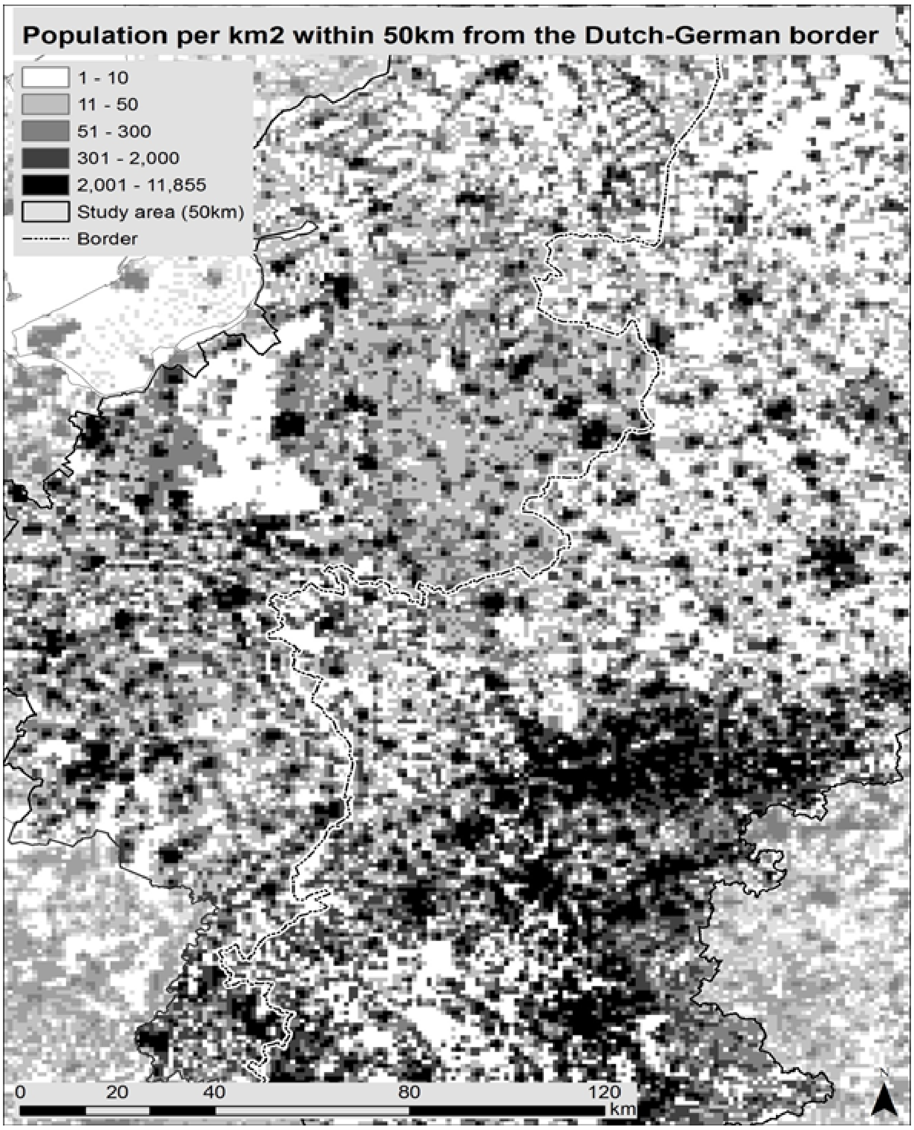
A Appendix

Table A1: Development of Dutch House Prices close to the German Border

Variable	Coef.	Std. Err.	t-value	Variable	Coef.	Std. Err.	t-value
Constant	7.5428	0.0079	951.37	Building period			
Natural log of surface area (m^2)	0.5787	0.0011	507.85	1906-1930	-0.0437	0.0014	-31.49
Natural log of parcel size (m^2)	0.0915	0.0003	313.17	1931-1944	-0.0152	0.0015	-10.45
Natural log of number of rooms	0.0603	0.0010	59.48	1945-1959	-0.0428	0.0015	-29.15
House type: Terraced house	0.0636	0.0011	55.46	1960-1970	-0.1121	0.0014	-81.43
House type: Canal side house	0.3779	0.0115	32.94	1971-1980	-0.0982	0.0014	-72.27
House type: Mansion	0.2045	0.0013	151.51	1981-1990	-0.0522	0.0014	-36.25
House type: Farm	0.2031	0.0020	103.15	1991-2000	0.0288	0.0015	19.41
House type: Bungalow	0.3324	0.0015	214.53	>2000	0.0756	0.0019	40.73
House type: Villa	0.4053	0.0019	215.6	Inside maintenance			
House type: Country house	0.3884	0.0021	180.79	Mediocre to fair	0.0958	0.0051	18.95
House type: Apartment	0.4968	0.0024	209.82	Good to excell.	0.1665	0.0051	32.59
House type: Ground-floor flat	0.4632	0.0022	208.28	Outside maintenance			
House type: Upstairs flat	0.4203	0.0027	153.45	Mediocre to fair	0.0558	0.0053	10.44
House type: Maisonette	0.5165	0.0020	256.02	Good to excell.	0.1041	0.0054	19.3
House type: Porch flat	0.4785	0.0021	231.97	Isolation			
House type: Gallery flat	0.0557	0.0048	11.49	1 or 2 types	0.0256	0.0006	40.42
House type: Old people's home	0.4375	0.0065	67.27	3 or more types	0.0476	0.0008	61.77
Heating system present (0/1)	0.0180	0.0013	13.72	Garden			
Parking place present (0/1)	0.0632	0.0011	59.9	Simple or normal	0.0517	0.0016	31.81
Garage and/or carport (0/1)	0.1316	0.0005	248.34	Well-kept	0.095	0.0017	57.29
Free of transfer tax	0.0563	0.0020	27.94				
Year 1985 * distance to Germany (km)	**0.00145**	0.0002	9.32	Year 1985 (reference value)			
Year 1986 * distance to Germany (km)	**0.00155**	0.0001	10.57	Year 1986	**0.0295**	0.005	5.91
Year 1987 * distance to Germany (km)	**0.00214**	0.0001	14.55	Year 1987	**0.0587**	0.005	11.83
Year 1988 * distance to Germany (km)	**0.00282**	0.0001	19.25	Year 1988	**0.0676**	0.005	13.65
Year 1989 * distance to Germany (km)	**0.00270**	0.0001	18.78	Year 1989	**0.1080**	0.0049	22.1
Year 1990 * distance to Germany (km)	**0.00263**	0.0001	18.04	Year 1990	**0.1082**	0.0049	22.05
Year 1991 * distance to Germany (km)	**0.00286**	0.0001	20.13	Year 1991	**0.1039**	0.0048	21.44
Year 1992 * distance to Germany (km)	**0.00287**	0.0001	20.57	Year 1992	**0.1453**	0.0048	30.43
Year 1993 * distance to Germany (km)	**0.00264**	0.0001	19.35	Year 1993	**0.2371**	0.0047	50.34
Year 1994 * distance to Germany (km)	**0.00241**	0.0001	17.73	Year 1994	**0.3069**	0.0047	64.75
Year 1995 * distance to Germany (km)	**0.00227**	0.0001	17.94	Year 1995	**0.3523**	0.0045	78.5
Year 1996 * distance to Germany (km)	**0.00235**	0.0001	19.11	Year 1996	**0.4264**	0.0044	96.78
Year 1997 * distance to Germany (km)	**0.00224**	0.0001	18.65	Year 1997	**0.5049**	0.0043	116.87
Year 1998 * distance to Germany (km)	**0.00251**	0.0001	21.6	Year 1998	**0.5648**	0.0042	133.55
Year 1999 * distance to Germany (km)	**0.00261**	0.0001	22.34	Year 1999	**0.6955**	0.0042	164.82
Year 2000 * distance to Germany (km)	**0.00292**	0.0001	25.22	Year 2000	**0.8026**	0.0042	190.57
Year 2001 * distance to Germany (km)	**0.00320**	0.0001	28.15	Year 2001	**0.8328**	0.0041	200.91
Year 2002 * distance to Germany (km)	**0.00311**	0.0001	27.32	Year 2002	**0.8594**	0.0042	206.89
Year 2003 * distance to Germany (km)	**0.00300**	0.0001	26.44	Year 2003	**0.8691**	0.0041	209.57
Year 2004 * distance to Germany (km)	**0.00329**	0.0001	29.23	Year 2004	**0.8975**	0.0041	217.02
Year 2005 * distance to Germany (km)	**0.00364**	0.0001	32.76	Year 2005	**0.9146**	0.0041	222.98
Year 2006 * distance to Germany (km)	**0.00420**	0.0001	37.84	Year 2006	**0.9148**	0.0041	223.11
Year 2007 * distance to Germany (km)	**0.00464**	0.0001	41.96	Year 2007	**0.9258**	0.0041	226.72
Year 2008 * distance to Germany (km)	**0.00500**	0.0001	44.32	Year 2008	**0.9040**	0.0041	218.64
Year 2009 * distance to Germany (km)	**0.00476**	0.0001	40.14	Year 2009	**0.8569**	0.0043	201.12
Year 2010 * distance to Germany (km)	**0.00451**	0.0001	38.23	Year 2010	**0.8490**	0.0043	199.61
Year 2011 * distance to Germany (km)	**0.00455**	0.0001	38.05	Year 2011	**0.7995**	0.0043	185.69
Year 2012 * distance to Germany (km)	**0.00460**	0.0001	38.96	Year 2012	**0.7069**	0.0043	165.79
Year 2013 * distance to Germany (km)	**0.00472**	0.0001	31.77	Year 2013	**0.6343**	0.0051	125.32
Municipality id's (211 categories)	F(210, 853502) = 2057.843			All variables are significant at 1%			
Number of observations: 853807	Adj. R^2 = 0.8654			For dummies, remaining categories act as reference			
The dependent variable is the Natural logarithm of the transaction price corrected for inflation							

Figure A1: Population Density



Source: Eurostat, own illustration.

Table A2: Matched Pair Regression allowing for Time Variation

Difference in	1km	2 km	3km
2007	-0.14*	-0.11***	-0.14***
	(0.08)	(0.04)	(0.02)
2008	-0.13*	-0.17***	-0.18***
	(0.07)	(0.04)	(0.02)
2009	-0.21***	-0.21***	-0.17***
	(0.07)	(0.04)	(0.02)
2010	-0.21***	-0.16***	-0.14***
	(0.07)	(0.04)	(0.02)
2011	-0.11	-0.18***	-0.20***
	(0.70)	(0.03)	(0.02)
Living space	0.62***	0.37***	0.59***
	(0.12)	(0.06)	(0.04)
(Living space)^2	-0.34**	0.03	-0.02
	(0.15)	(0.07)	(0.05)
Lot size	0.26***	0.34***	0.34***
	(0.07)	(0.02)	(0.02)
(Lot size)^2	-0.06*	-0.05***	-0.07***
	(0.03)	(0.01)	(0.01)
Number of rooms	-0.0044	0.0098**	-0.0042
	(0.0082)	(0.0043)	(0.0031)
Year of construction	0.0082***	0.0071***	0.0072***
	(0.0013)	(0.0006)	(0.0004)
(Year of construction)^2	-0.000061***	-0.000036***	-0.000042***
	(0.000018)	(0.000008)	(0.000006)
Terraced, corner house	-0.17***	-0.10***	-0.18***
	(0.05)	(0.03)	(0.02)
Terraced, detached house	-0.40***	-0.27***	-0.30***
	(0.05)	(0.02)	(0.02)
Corner, detached house	-0.18***	-0.16***	-0.14***
	(0.05)	(0.02)	(0.02)
Distance to match	-0.12	-0.01	-0.03***
	(0.08)	(0.02)	(0.01)
Adj R-squared	0.68	0.67	0.67
Observations	391	1631	3842

Note: *, **, *** indicate significance at 10%, 5%, and 1% level. Standard errors in brackets underneath.