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Border Effects in House Prices

Martin Micheli,* Jan Rouwendal**,*** and Jasper Dekkers***

This article estimates the effect of the Dutch–German border on house prices. We argue that the difference between house prices at the border indicates the willingness to pay to stay in a country compared to living across the border. After a change in the tax rules in 2001, migration from the Netherlands to Germany increased substantially and the gradient of Dutch house price towards the German border steepened. Combining a German and Dutch real estate dataset and using different estimation strategies, we find that asking prices of comparable housing drop by about 16% when one crosses the Dutch–German border.

Introduction

House prices vary continuously over space due to arbitrage mechanisms like in the monocentric city model. However, prices may jump at boundaries, where these arbitrage mechanisms break down. One example for such boundaries are landscape features such as rivers or mountains, which hinder arbitrage via their effects on commuting costs. Other factors that are associated with language and culture, which have been shown to affect trade and migration flows (Guiso, Sapienza and Zingales 2006, Melitz 2008, Falck *et al.* 2012, Isphording and Otten 2013), might also result in a jump in house prices. It is well known that school quality affects housing prices (Black 1999, Fack and Grenet 2010), resulting in house price discontinuities at school district boundaries. Piazzesi, Schneider and Stroebel (2015) show that differences in search activity foster a segmentation of the housing market. Another source of price differences in the housing market are institutional features, which have been shown to result in discontinuities in land prices (Capozza and Helsley 1989).

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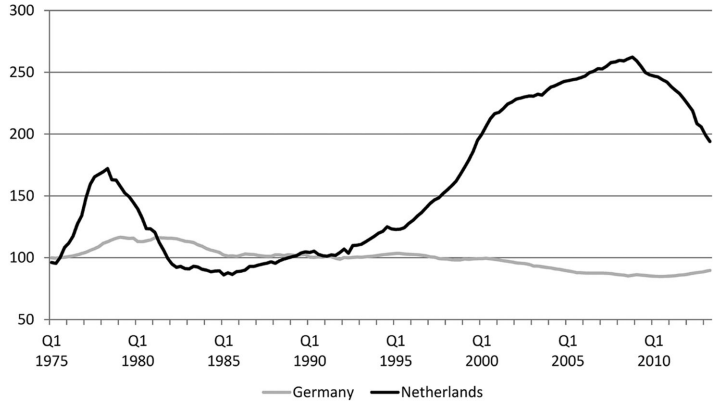
However, as far as we know, there is no research that investigates the possible presence of discontinuities in house prices across country boundaries. National borders typically are substantial barriers for arbitrage. The presence of a price discontinuity in tradable goods due to a national boundary has been well documented in the literature. Engel and Rogers (1996) find that the boundary between Canada and the United States, which may be qualified as "relatively innocuous" (McCallum 1995, p. 622), is equivalent to a distance of 1,780 miles between two cities in terms of price dispersion of similar goods (Engel and Rogers 1996, p. 1120).

A discontinuity in the house price function at a national border indicates reluctance to cross the border from the expensive to the cheap country to take advantage of lower house prices. The upper bound of this price difference between the two countries is determined by the willingness to accept the combination of higher house prices and staying in one's own country. This article contributes to the literature by analyzing this upper bound for two economically and culturally similar countries that allow free movement of workers: Germany and the Netherlands.

This article unfolds as follows: The following section discusses institutional and socioeconomic differences that might explain differences in house prices in the two countries. In Section "Interpretation of border effects in house prices," we develop a simple conceptual framework that suggests under which conditions a discontinuity in house prices at a border is informative about the willingness to pay for the difference in amenities on both sides of the border. We document the development of house prices in the Dutch border region in the past 25 years and show that house prices within the Netherlands were decreasing towards the German border. We also show that migration to Germany increased in the early 2000s, which coincidences with a change in Dutch tax rules. The substantial increase in migration flows since this time indicates that the house price difference might have reached this upper bound, such that price differences are informative about the willingness to pay to stay in a Dutch environment. Section "Data on house prices on both sides of the border 2007–2011" presents the combined geocoded Dutch and German asking price dataset covering the years from 2007 to 2011, which we use to analyze the border effect. Using information on the location of the different houses allows us to estimate the difference in the quality adjusted house price that occurs directly at the border. Section "Analysis" reports the results of several analyses of the price difference in the border region. We find an average border effect of about 16%, or approximately €38,000 at the mean. Section "Discussion of Results" discusses potential causes for a price difference. We show that differences in local charges partly explain this estimated price difference. However, about 10 percentage

Figure 1 ■ Real house prices in Germany and the Netherlands 1975–2013 (1975 = 100).



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

points of the house price difference remain unexplained. Section "Conclusion" concludes.

Institutional and Socioeconomic Differences

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 monetary and, more generally, macroeconomic policies. Nevertheless, the development of house prices in the two countries studied has been very different. Since 1975, the Netherlands faced two housing cycles while prices in Germany have been rather stable (Figure 1). Because the lines refer to indexes, they do not reveal price differences, but the substantial differences in price developments strongly suggest that at least during particular periods, there must have been huge differences in price levels as well, as was indeed the case.

The first things that come to mind when looking for explanations for differences between housing markets in the Netherlands and in Germany 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.

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. In contrast, 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-occupied housing in the two countries, which 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.[1] This is in stark contrast to Germany where mortgage interest payments for owner-occupied housing are not tax deductible.[2] In Germany, deductibility of interest paid is restricted to nonowner occupied real estate. Mortgage interest deductibility in itself does not necessarily lead to higher house prices unless there is some supply inelasticity. However, in combination with extremely price inelastic housing supply in the Netherlands this tax facility has probably contributed to a higher price level in the Netherlands.

To complete the picture, some other factors have to be considered. Both countries differ substantially 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.[3] For this insurance, households pay a one-time premium, but this premium is very low and because mortgage suppliers offer lower interest rates for insured loans, it typically is paid-back within a few years.[4]

[1]Since about the year 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. 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.

[2]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.

[3]For a detailed discussion of the National Mortgage Guarantee and the factors that determine whether households take advantage of this guarantee, see Cox and Zwinkels (2016).

[4]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

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 a permanent contract.[5]

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 five or six times their annual income for their houses while still qualifying for the mortgage insurance. Around 1980, there was a shift towards a much tighter monetary policy and initially interest rates increased considerably, implying much lower borrowing (and bidding) capacity of Dutch households. In the course of the 1980s and 1990s, interest rates gradually declined, while the increasing share of double earner households[6] and economic growth led to significant increases in household income. These developments contributed to the substantially higher borrowing capacity of Dutch households. Because 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 (Vermeulen and Rouwendal 2007). Note that in this analysis the possibility to realize high LTV ratios–which exists in the Netherlands, but not in Germany–is essential, because 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.

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pay it. This may raise doubts about the appropriateness of the level of the premium. However, 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.

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

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

In Germany, the government encourages saving for house purchases through fiscal measures.[7] A contractual savings system allows households to pin down interest rates on contracts for future borrowing for house purchases. Due to government subsidies, these contracts offer favorable conditions compared to other types of borrowing. On the other hand, such subsidized contracts are conditional on the commitment to save before obtaining the loan, which reduces the required size of the loan and decreases 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 further contributed to the different 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 consists predominantly of social rental housing, which is rent-controlled. In the Netherlands, there is severe excess demand for social rental housing, especially in larger cities, and because the rationing systems favor lower incomes, households with higher incomes are practically unable to rent. Unlike in Germany, renting is therefore not a genuine 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.

Interpretation of Border Effects in House Prices

The discussion in the previous section suggests that the housing markets in the Netherlands and in Germany differ substantially, which results in different developments of the house prices. If arbitrage would be impossible, this would imply that house prices on both sides of the Dutch-German border were independent of each other and substantial differences were possible. However, as Germany and the Netherlands are both members of the European Union and both have ratified the Schengen Treaty, the border dividing the two countries is in fact easy to cross. Arbitrage should thus be possible, at least in principle and it should be expected to impose a limit on the possible price difference. The size of this limit is determined by the value of the difference in amenities on both sides of the border. This includes possible differences in property taxation and other local charges that are directly related to housing, but also to "softer" aspects like the preference to live among people speaking the same language and the appreciation of differences in the landscape that are associated with the two land use planning systems. The total value of

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

all these differences determine the size of the limit, which may of course be different for Germans and Dutch citizens. In the time interval that we study–the early 21st century–house prices were clearly higher in the Netherlands and we should therefore expect an existing gap in the house prices at the border only to reveal the willingness to pay of Dutch households to stay in their own country.

The case for such an interpretation of a price difference that emerges at the border is especially convincing if arbitrage does indeed takes place, that is, if Dutch households regularly relocate across the border. It is therefore interesting to note that migration from the Netherlands to Germany responded substantially to a change in tax rules. Since 2001, Dutch citizens can opt for the Dutch income tax even if they live across the border in Germany as long as they have a job in the Netherlands.[8] This means that Dutch migrants can take the mortgage interest deductibility with them as long as their job remains in the Netherlands. This change in tax treatment should be expected to have facilitated arbitrage by moving across the border by significantly lowering the relevant limit for the price difference of housing prices.[9]

There is strong evidence that such arbitrage has been present since approximately 2000. First, *net* migration from the Netherlands to Germany increased substantially, 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 (see Figure A1 in the Appendix). After a temporary drop around 2008, which is probably due to the recession, net migration to Germany increased again until 2010.

Second, the number of Dutch citizens living in the German part of the border region started to increase in 2001 (Figure A2). 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. The arbitrage interpretation of these migration flows between the two countries is supported by the locations individuals

[8]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.

[9]In the example of the interest-only mortgage discussed in the previous section, a household can bid 2.5 times as much for a house when there is mortgage interest deductibility.

choose as residence. Dutch people who live in Germany are much more concentrated in the areas that are contiguous to the Netherlands (Figure 2).[10] For Germans living in the Netherlands, this pattern of a high concentration in the foreign border region does not exist.

A final piece of evidence that supports the presence of arbitrage since around 2000 is provided by a hedonic analysis of the development of house prices in the 50 km band along the Dutch border. We estimated a hedonic price function with municipality fixed effects, time fixed effects and distance to the German border with a year-specific coefficient as explanatory variables.[11]

Figure 3 shows the development of the implied price index for housing exactly at the border and 50 km inside the Netherlands. House prices at the border have increased considerably over time with a peak in 2008, when the financial-economic crisis started to affect the Dutch housing market.[12] Prices of properties 50 km within the Netherlands have always been higher than at the border. However, around 2000 the discrepancy between the two series is growing, probably reflecting the stronger impact of the proximity to the German border that is due to the improved possibilities for arbitrage. The development of the price gradient is shown in Figure A3 in the Appendix.

Data on House Prices on Both Sides of the Border 2007–2011

To evaluate the difference in house prices that can be attributed to the boundary we now 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.[13] 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). Because transaction values are not observed, we use the last price for which the house was offered on this website.

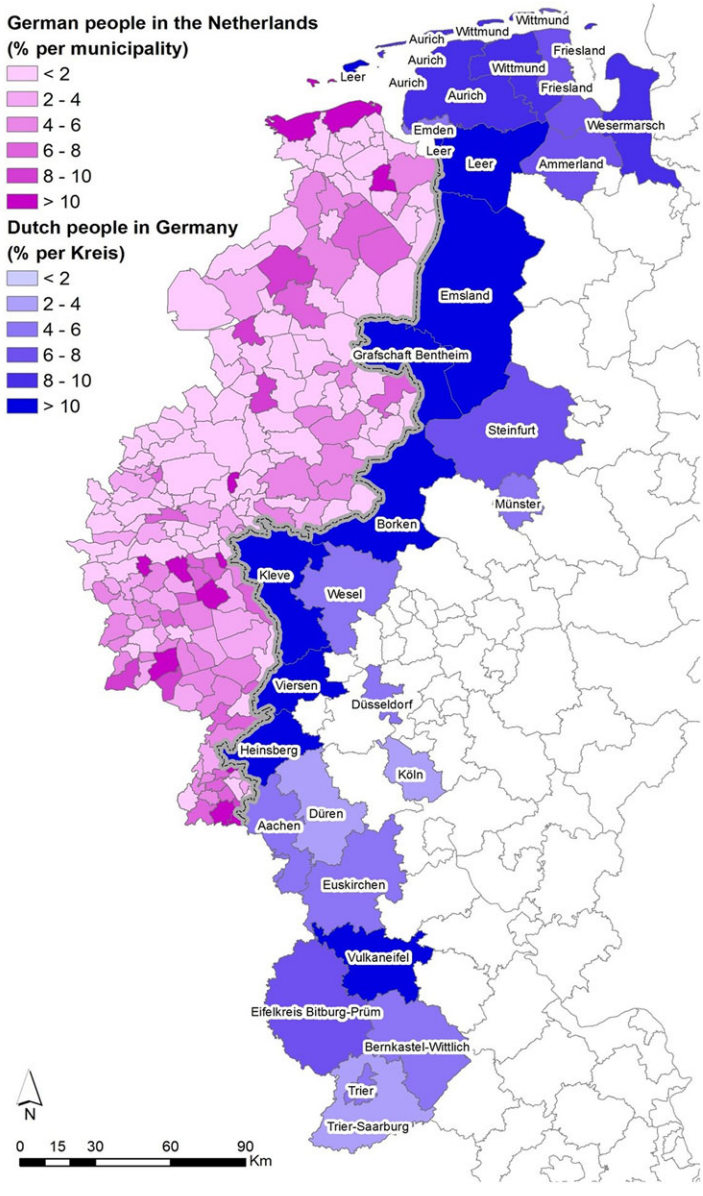
[10] Vulkaneifel, which also attracts a large number of Dutch people, is a popular holiday destination.

[11] Details are available on request.

[12] Another illustration of this finding is the development of the price gradient over time in Figure A3.

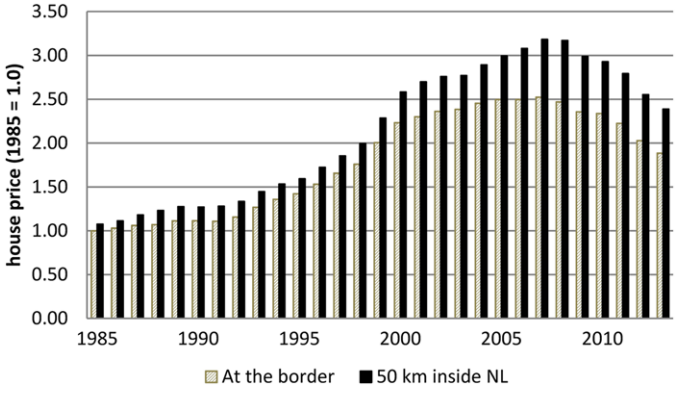
[13] For a description of the dataset see an de Meulen, Micheli and Schaffner (2014).

Figure 2 ■ Share of foreigners on both sides of the German–Dutch border. [Color figure can be viewed at wileyonlinelibrary.com]



Source: Data from CBS Statline (2013) and Statistisches Bundesamt (2014). Map: authors' illustration.

Figure 3 ■ Development of the Dutch housing price near the German border (1985–2013). [Color figure can be viewed at wileyonlinelibrary.com]



For 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.[14] 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 asking prices instead of observed transaction prices–unfortunately–adds an additional source of uncertainty. There is one study that investigates the difference between the last observed asking price of objects advertised at ImmobilienScout24 and the actual transaction price in Germany: For rural regions in Rhineland-Palatine, Dinkel and Kurzrock (2012) find a difference of about 15%. Kholodilin, Mense and Michelsen (2017) argue that for a sample in Berlin, the difference between online ads (including data from ImmobilienScout24) and transaction prices is rather small. Other studies (Faller *et al.* 2009, Henger and Voigtländer 2014) comparing asking prices from different sources with transaction prices find a slightly smaller price discrepancy

[14]Our sample of properties offered for sale–via ImmobilienScout24 for Germany and via FUNDA for the–Netherlands does not necessarily constitute a random sample the housing stock. However, the same is true for property transactions. To overcome this selection bias, in what follows we control for object quality employing hedonic methods.

than Dinkel and Kurzrock (2012). Therefore, given availability constraints for transaction prices in Germany, asking prices seem to be a useful substitute for transaction prices (Faller *et al.* 2009).

Using this combined dataset, we employ a method proposed by Black (1999) to measure the impact of the border on house prices. We restrict our analysis to a narrowly defined border region. We only include objects in our analysis that are located within a distance of 10 km of the German–Dutch border. This guarantees that objects far away from the border do not distort the analysis. The number of observations on the Dutch side of the border is substantially higher: the ratio 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 that of NVM in the Netherlands (70%).[15] Second, it might be due to differences in the average time until 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 10 years of the purchase. At the time, the Dutch housing market appeared somewhat overheated and the annual number of transactions dropped substantially when Dutch house prices decreased further after 2011. 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, 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 present population density in Figure A4 in the Appendix. 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 the exact location (x-y coordinates) and several other housing characteristics. Included in both datasets are living space, lot size (both in square meters), number of rooms, year of construction, house type, the last time an object has been advertised and the location. We report descriptive statistics for these variables in Table 1, subdivided for objects that are located within a 5 km distance to the German–Dutch border as well as objects further away (5–10 km) 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

[15]Note that the differences between the numbers of observations on both sides of the border are much larger than expected based on market coverage.

Table 1 ■ Descriptive statistics.

	Netherlands		Germany		Difference	
	0–5 km	5–10 km	0–5 km	5–10 km	0–5 km	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)	(24.1)	(34.7)
Living space (m^2)	140	143	145	145	−5.21***	−2.50***
	(0.14)	(0.22)	(0.38)	(0.48)	(−12.6)	(−4.7)
Number of rooms	5.4	5.3	5.2	5,2	0.19***	0.11***
	(0.0048)	(0.0070)	(0.0131)	(0.0151)	(13.5)	(6.5)
Lot size (m^2)	642	635	683	628	−41.15***	6.94
	(3.92)	(5.85)	(5.80)	(5.78)	(−5.9)	(0.8)
Year of construction (in percent)						
1500–1905	3.51	4.41	2.39	3.01	1.12***	1.40***
					(8.0)	(7.1)
1906–1930	9.65	10.52	6.44	5.61	3.21***	4.92***
					(14.1)	(18.2)
1931–1944	5.82	7.84	2.78	2.53	3.04***	5.31***
					(19.4)	(26.7)
1945–1959	12.11	9.74	11.46	9.47	0.65*	0.28
					(2.2)	(0.9)
1960–1970	16.44	16.91	13.88	13.43	2.56***	3.48***
					(8.1)	(9.0)
1971–1980	22.62	17.18	13.57	13.12	9.05***	4.07***
					(28.5)	(10.6)
1981–1990	11.84	11.81	9.97	9.25	1.86***	2.57***
					(6.8)	(7.8)

Table 1 ■ Continued.

	Netherlands		Germany		Difference	
	0–5 km	5–10 km	0–5 km	5–10 km	0–5 km	5–10 km
1991–2000	10.62	12.82	13.91	15.08	−3.28***	−2.26***
					(−10.6)	(−5.7)
2001–present	7.39	8.76	25.60	28.51	−18.21***	−19.75***
					(−47.8)	(−41.3)
Last observed in (in percent)						
2007	23.31	23.38	15.95	17.30	7.36***	6.08***
					(21.9)	(14.2)
2008	21.91	22.29	18.91	22.13	3.00***	0.15
					(8.4)	(0.3)
2009	18.19	19.07	21.54	18.70	−3.34***	0.37
					(−9.1)	(0.8)
2010	17.95	18.20	21.19	21.52	−3.25***	−3.33***
					(−8.8)	(−7.4)
2011	18.64	17.07	22.41	20.34	−3.77***	−3.27***
					(−10.1)	(−7.4)
House type (in percent)						
Terraced house	38.03	37.44	9.18	10.99	28.86***	26.45***
					(101.4)	(69.0)
Corner house	19.35	19.89	25.45	28.79	−6.10***	−8.91***
					(−15.6)	(−18.0)
Detached house	42.62	42.67	65.37	60.21	−22.75***	−17.54***
					(−52.7)	(−32.2)

Notes: *, **, *** indicate differences are significant at the 5%, 1% and 0.1% level. For averages: Standard errors in brackets. For differences: *t*-statistic 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.

prices of objects within a boundary of 5 km to the Dutch–German border are about 23,000 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, as 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 border documented in Tennekes and Harbers (2012).

Analysis

Up until now we have documented that first, house prices on the Dutch side of the Dutch-German border have been increasing less than within the country and that second, average house prices in a narrowly defined border region of within 10 km reach of the border are lower in Germany than in the Netherlands. This is suggestive of a price effect that can be attributed to the border, but it does not necessarily imply the presence of a discontinuity at the border. To investigate whether the house price function is discontinuous at the Dutch–German border, as we suggest in Section 2, we proceed with regression analysis. To check for the robustness of our results, we test for a discontinuity in the house price function in three different ways. First, in Section 5.1, we estimate a hedonic price function that takes the distance to the boundary into account. Second, in Section 5.2, we compare the house price difference of objects that are spatially close to each other such that these objects might be thought of as actual substitutes. Finally, in Section 5.3, we analyze regional variation in the price effect of the border.

Hedonic Price Analysis

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

$$P_i = \beta_Z\, Z_i + \beta_{dNed}\, Distance_i * dNed_i + \beta_{dGer}\, Distance_i * dGer_i + \beta_f\, dGer_i + \beta_b\, B_i + \varepsilon_i. \quad (1)$$

In Equation (1), P represents the logarithmic transformation of house i's asking price. We control for an object's individual characteristics via Z, individual characteristics are described in Section 4. As we observe an object's individual location, we can calculate the distance to the boundary given by the beeline, represented by $Distance$. The variables $dNed$ and $dGer$ are in order dummy variables indicating whether the house is located in the Netherlands

or in Germany. To allow for differences in the price level with respect to the location, we include fixed effects for the closest border segment B. The price effect of the respective border segment β_b is independent of whether the house is located in the Netherlands or in Germany.[16] This captures potential regional differences in house prices that are independent of the border, as house prices in employment centers such as Maastricht and Aachen might be higher than prices in the less densely populated regions in the North. In Table 2, we report the estimation results for the specification with polynomials up to the power four for distance to the boundary.

All estimation results are in line with the intuition. The estimated coefficient for the dummy variable β_f, 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.[17] Additionally to this direct effect, the border seems to affect 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 the distance to the Dutch–German border on house prices in Figure 4. 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.

These results are suggestive of the importance of the distance to the boundary for the respective object's price. However, the price of specific characteristics might also be a function of an object's distance to the boundary. To take this into account, we include the interaction of living space and lot size with distance to the boundary. Regression results are reported in Table A1. All interaction terms are highly significant, *e.g.*, the price for a one percent larger lot size for houses in Germany significantly decreases with increasing distance to the boundary. The coefficient of interest, however, the price discontinuity at the boundary β_f is hardly affected by allowing for the prices of characteristic to depend on the distance to the boundary. House prices in Germany are about 16% lower than in the Netherlands.

[16]We divide the border into segments of 1 km length. This results in a total of 490 border segments that are included in the estimation of Equation (2).

[17]This result is robust to excluding the border segments (B) as explanatory variable.

Table 2 ■ Hedonic regression.

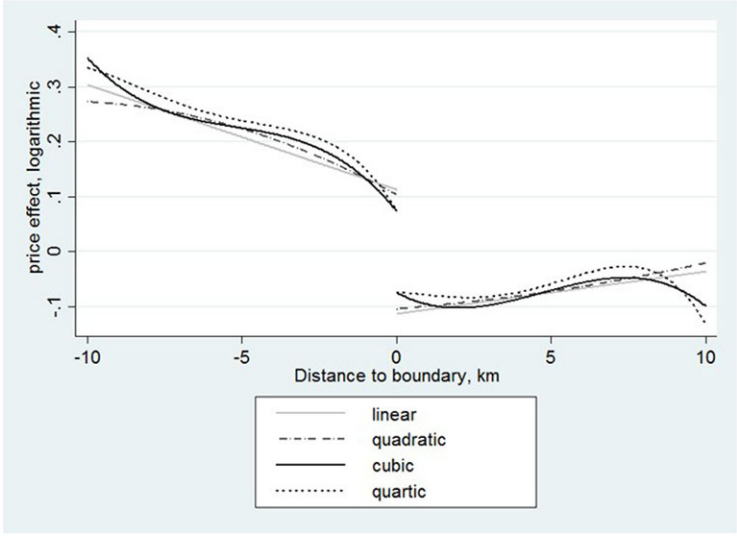
	Linear	Quadratic	Cubic	Quartic
Average border effect (β_f, in percent)	−22.79***	−21.02***	−15.00***	−15.10***
	−49.5	−34.1	−18.5	−14.9
Distance Germany (*100)	0.78***	0.47	−3.15***	−0.18
	9.8	1.73	−4.9	−0.14
Distance Netherlands (*100)	−1.92***	−3.09***	−6.97***	−9.62***
	−53.4	−26.2	−25.8	−18.1
(Distance Germany)^2 (*100)		0.04	1.01***	−0.40
		1.2	6.3	−0.7
(Distance Netherlands)^2 (*100)		−0.14***	−1.17***	−2.37***
		−10.4	−17.8	−10.9
(Distance Germany)^3 (*1000)			−0.72***	1.65
			−6.2	1.83
(Distance Netherlands)^3 (*1000)			−0.75***	−2.74***
			−16.0	−7.9
(Distance Germany)^4 (*10000)				−1.30**
				−2.7
(Distance Netherlands)^4 (*10000)				−1.07***
				−5.8
Living space	0.59***	0.59***	0.59***	0.59***
	275.9	276.0	276.1	276.1
Lot size	0.19***	0.19***	18.59***	18.58***
	210.9	211.0	211.1	210.8
Number of rooms (in percent)	0.85***	0.85***	0.86***	0.86***
	24.8	24.7	24.9	24.9
Terraced house (in percent)	−24.69***	−24.67***	−24.63***	−24.66***
	−148.6	−148.5	−148.4	−148.5
Corner house (in percent)	−20.01***	−20.00***	−19.96***	−19.98***
	−126.2	−126.2	−126.0	−126.1
Adj R-squared (in percent)	82.62	82.63	82.65	82.66
Observations	193920	193920	193920	193920

Note: *, **, *** indicate significance at the 5%, 1% and 0.1% level. t-Statistic underneath. Additional control variables are the year of construction (eight 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 1 km).

Spatial Matching

Even though we only include objects within a certain threshold distance to the boundary in the hedonic analysis, a concern one might have is that this analysis 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

Figure 4 ■ Price effect of distance to boundary.
[Color figure can be viewed at wileyonlinelibrary.com]



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

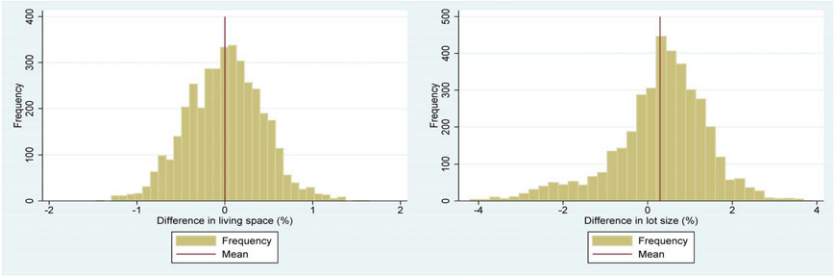
correctly. Therefore, we use matching techniques as an additional device to test for the presence of border effects, as this allows for a comparison of objects that are more or less directly adjacent. In a first step, we match all objects on the German side to its closest geographical neighbor on the Dutch side that was observed in the same year.[18] As there are more observations on the Dutch side of the border, some houses in the Netherlands have not been matched to a German counterpart and therefore are excluded from the following analysis.

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 indicate that, *e.g.*, floor size in the German houses is larger than in the Dutch ones.[19]

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

[19]For the variables in price, living space and lot size we build the log difference. For the three dummy variables 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

Figure 5 ■ Difference in lot size and living space.
[Color figure can be viewed at wileyonlinelibrary.com]



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

We test if these differences in quality persist even when looking at objects that are spatially close. Figure 5 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.

We estimate the hedonic price function

$$\Delta \ln p_i = \beta_f + \beta_Z \, \Delta Z_i + \varepsilon_i, \tag{2}$$

where $\Delta \ln p$ represents log price differences and ΔZ represents differences in the qualities of the characteristics and i identifies the matched pair. Negative values for the coefficient β_f indicate that prices in Germany are lower than in the Netherlands, ε is an error term. We report the estimation results in Table 3.

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. In addition, the estimated price effect of about 17% is perfectly in line with the result of the hedonic regression of 15% to 16%. The values of the other coefficients are also in line with intuition.

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 all of the three variables are assigned the value 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 3 ■ Matched pair regression.

Difference in	1 km	2 km	3 km
Average border effect (in percent)	−18.18**	−16.67***	−16.86***
	−2.99	−5.5	−8.3
Living space	0.62***	0.38***	0.60***
	5.1	6.9	15.6
(Living space)^2 (*100)	−34.04*	1.83	−2.85
	−2.4	0.26	−0.59
Lot size	0.24***	0.34***	33.73***
	3.64	13.9	20.3
(Lot size)^2 (*100)	−4.74	−5.62***	−6.71***
	−1.7	−5.9	−10.0
Number of rooms (in percent)	0.02	0.98*	−0.39
	0.02	2.3	−1.3
Year of construction (*100)	0.87***	0.71***	0.71***
	6.9	11.4	16.6
(Year of construction)^2 (*10000)	−0.63***	−0.36***	−0.42***
	−3.5	−4.4	−7.2
Terraced, corner house (in percent)	−18.10***	−8.90***	−18.10***
	−3.81	−3.5	−9.9
Terraced, detached house (in percent)	−41.69***	−25.90***	−29.52***
	9.4	−10.9	17.8
Corner, detached house (in percent)	−17.99***	−16.64***	−14.29***
	−3.4	−6.8	−9.6
Distance to match (*100)	−8.46	−1.20	−2.90**
	−1.1	−0.6	−3.3
Adj *R*-squared (in percent)	64.75	66.72	66.96
Observations	391	1631	3842

*, **, *** indicate significance at the 5%, 1% and 0.1% level. *t*-Statistic underneath.

Regional Differences

Finally, we looked at possible geographical differences in the border effect. To do so, we divide the border into three segments. If we follow the border starting in the north, the first segment consists of the first 200 km, the second one of the next 200 km and the third one of the remaining 156 km. We then assign each of the matched pairs as explained in Section 5.3 to a border segment, depending on the closest segment of the house located in Germany. The number of observations in the North is substantially lower than in the more urban environment in the South, as is also indicated by Figure A4.

The results of a matched pair regression referring to houses within 3 km on both sides of the border show that the price difference is substantially more pronounced in the northern part of the border (Table 4). One explanation for

Table 4 ■ Matched pair regression with regional differences.

Difference in	3 km	3 km
North (0 km to 200 km)	-0.34^{***}	-0.34^{***}
	(−11.7)	(−12.0)
Middle (200 km to 400 km)	-0.19^{***}	-0.21^{***}
	(−8.2)	(−9.1)
South (400 km to 556 km)	-0.14^{***}	-0.13^{***}
	(−7.0)	(−6.2)
Difference in population density		0.04^{***}
		(12.3)
Adj *R*-squared (in percent)	68.17	69.37
Observations	3,827	3,827

t-Statistics in brackets underneath. *, **, *** indicate significance at 5%, 1% and 0.1% level. Housing characteristics were included as control variables.

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 time consuming.

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.[20] 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 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%.

Discussion of Results

According to the capitalization hypothesis,[21] one source of house price differences between Germany and the Netherlands might be different ancillary

[20]We use population densities based on a 1 km 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.

[21]For a discussion of the theoretical and empirical literature, see Hilber (2017).

costs. To investigate how much of the price difference at the border can be explained by charges directly related to housing, we collected information about municipal taxes and other charges and discuss the case of full capitalization. According to Wassenaar, Allers and Verhagen (2014) the following charges are relevant for Dutch owner-occupiers: (1) a real estate tax of 0.11% of the value of the house on average, (2) sewage charges of 0.12% and (3) waste collection charges of 0.08%. The total of these taxes is on average 0.30% of the value of the house. The taxes differ per municipality, and the maximum for the whole country is 0.56% of the value of the house annually.

The situation in Germany is less clear. The property tax for West Germany is based on a theoretical house value and a multiplier that is set by the local government. In 2014, the average per capita tax revenue from property taxes (type B) was 178 Euro in North Rhine-Westphalia (Statistisches Bundesamt 2015), one of the federal states sharing a border with the Netherlands. Assuming an average household of two persons, this results in a tax burden of 356 Euro per household. Annual sewage charges are on average 700.69 Euro with a maximum of 1302.30 Euro. Waste collection charges are on average 262.80 Euro with a maximum of 528.00 Euro.[22] For the average household, German local charges thus appear to be twice as high as in the Netherlands. Assuming the same value of houses on both sides of the border (that is, without controlling for quality characteristics, and in agreement with our finding in the naïve regression discontinuity design, (see Section 5.2) this implies a total annual charge of 0.6% of the house value.[23]

Using an interest rate of 4.5%, which has been the average interest rate for new lending for house purchases with a duration of at least five years in the sample period from 2007 to 2011, this suggests a difference of 7 percentage points of the house value that can be attributed to differences in house-related charges. This still leaves about 10% of the house price difference unexplained. Even in the southern part of the Netherlands, where the total price gap is smallest, differences in local charges explain only about 50% of the total price gap.

Conclusion

This article has investigated the considerable difference between house prices in Germany and in the Netherlands while focusing on the difference at the

[22] Information on charges for sewage and waste collection are from the Tax Payers Union NRW.

[23] We used €218.000 as the reference value, which is close to the mean average housing price on the German side of the border (see Table 1). For the higher Dutch average, housing related charges expressed in percent of the house price would be somewhat lower.

border. Analyzing Dutch house prices in the period 1985–2013, we find that prices in the border region increased less in the Dutch–German border region than prices of objects 50 km away from the border. Additionally to that, the discrepancy of prices in the border region and in the heartland and migration flows from the Netherland to Germany increased in the early 2000s. This coincides with a change in the tax rules in 2001 that allowed Dutch workers to take advantage of mortgage interest deductibility even when moving across the border while keeping their job in the Netherlands. All this is suggestive of arbitrage made possible by the change in tax rules and lets us conclude that a potential prices difference between house prices in the two countries has a meaningful interpretation as the willingness of Dutch households to accept the combination of higher house prices and staying in one's own country.

Although arbitrage is relatively easy because Germany and the Netherlands are both Schengen-countries, we show that a sharp discontinuity in the quality-adjusted house prices at the border remained present in the period 2007–2011. This conclusion is based on the analysis of combined geocoded datasets on real estate prices in both countries. Using various techniques, we find a similar border effect on house prices. It is also in line with the empirical literature on housing in Europe. Cheshire and Magrini (2009) find that cities within the European Union still form national urban systems rather than a single European-wide system. Jacobs-Crisioni and Koomen (2014) show that national borders still affect the spatial urban pattern in northern Europe. Notwithstanding the fact that there is no "natural" border between the two countries, the progress made in the unification of the European Union and changes in the tax code facilitating house price arbitrage, there still is a gap in house prices in the Dutch–German border region.

On average, the difference in (last listed) asking prices seems to be about 16% of the price of a house, or approximately 38,000 Euro at the mean. Taking into account differences in ancillary costs, these explains about 7 percentage points of the house price gap and leave close to 10 percentage points of the house price difference unexplained. Even in the southern part of the border region, where the total price gap is smallest, differences in local charges explain only about 50% of the total price gap.

One interpretation of this remaining gap is that the Dutch are still reluctant to live among the Germans and appear to be willing to forego a substantial financial benefit. As differences in language and culture affect economic outcomes such differences might also be an explanation for remaining differences in housing prices.

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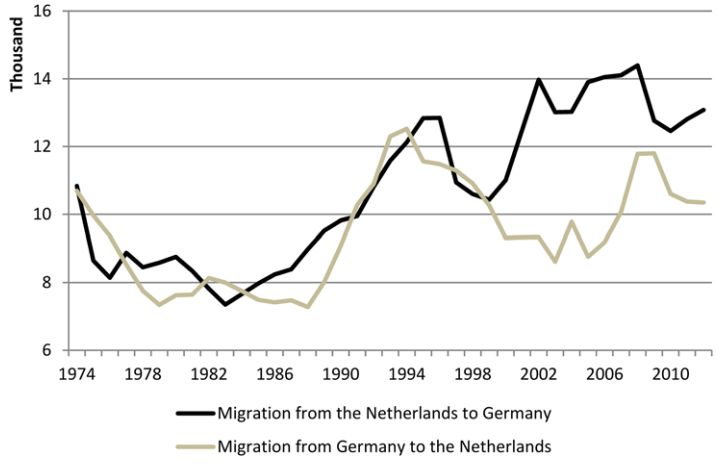
Appendix

Figure A1 ■ Bilateral migration, Netherlands and Germany, 1974–2012
[Color figure can be viewed at wileyonlinelibrary.com]



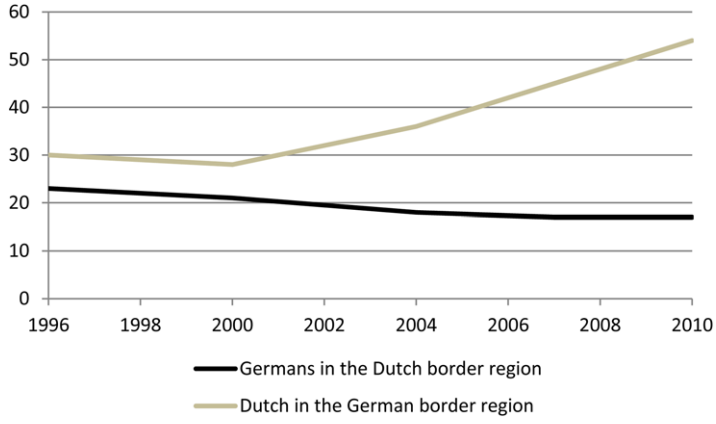
Source: Destatis.

Table A1 ■ Hedonic regression with distance to border interaction.

	linear	quadratic	cubic	quartic
Average border effect (β_f, in percent)	-23.65^{***}	-21.21^{***}	-16.23^{***}	-15.89^{***}
	-54.3	-34.4	-20.1	-15.8
Distance Germany (*100)	-0.74	-1.66^{*}	-4.04^{***}	-1.95
	-1.22	-2.5	-4.61	-1.4
Distance Netherlands (*100)	5.42^{***}	4.41^{***}	0.51	-2.18^{***}
	14.6	11.6	1.1	-3.4
(Distance Germany)^2 (*100)		0.08^{**}	0.77^{***}	-0.24
		2.7	4.9	0.44
(Distance Netherlands)^2 (*100)		-0.15^{***}	-1.12^{***}	-2.36^{***}
		-11.1	-17.2	-10.9
(Distance Germany)^3 (*1,000)			-0.51^{***}	1.20
			-4.4	1.33
(Distance Netherlands)^3 (*1,000)			-0.71^{***}	-2.75^{***}
			15.3	-8.0
(Distance Germany)^4 (*10,000)				-0.94
				-1.9
(Distance Netherlands)^4 (*10,000)				-1.10^{***}
				-6.0
Living space	0.50^{***}	0.50^{***}	0.50^{***}	0.50^{***}
	122.6	122.2	122.6	122.5
Lot size	0.21^{***}	0.21^{***}	0.21^{***}	0.21^{***}
	139.0	139.0	139.0	139.0
Living space* Distance Germany (x100)	2.96^{***}	3.00^{***}	2.95^{***}	2.95^{***}
	21.8	22.1	21.6	21.7
Lot size* Distance Germany (x100)	-2.09^{***}	-2.08^{***}	-2.07^{***}	-2.06^{***}
	-35.0	-35.0	-34.7	-34.6
Living space* Distance Netherlands (x100)	-2.04^{***}	-2.08^{***}	-2.04^{***}	-2.05^{***}
	-23.0	-23.5	-23.0	-23.2
Lot size* Distance Netherlands (x100)	0.45^{***}	0.45^{***}	0.45^{***}	0.46^{***}
	14.63	14.6	14.7	14.8
Number of rooms (in percent)	0.85^{***}	0.85^{***}	0.85^{***}	0.85^{***}
	24.6	24.6	24.8	24.8
Terraced house (in percent)	-24.79^{***}	-24.76^{***}	-24.73^{***}	-24.75^{***}
	-149.7	-149.6	-149.5	-149.6
Corner house (in percent)	-20.33^{***}	-20.33^{***}	-20.29^{***}	-20.30^{***}
	-128.5	-128.4	-128.3	-128.4
Adj R-squared (in percent)	82.76	82.77	82.79	82.79
Observations	193920	193920	193920	193920

Note: *, **, *** indicate significance at the 5%, 1% and 0.1% level. t-Statistic underneath. Additional control variables are the year of construction (eight 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 1 km).

Figure A2 ■ Foreigners on both sides of the German–Dutch border
[Color figure can be viewed at wileyonlinelibrary.com]



Source: PBL.

Figure A3 ■ Change in price gradient within 50 km of the Dutch–German border (1985–2013).

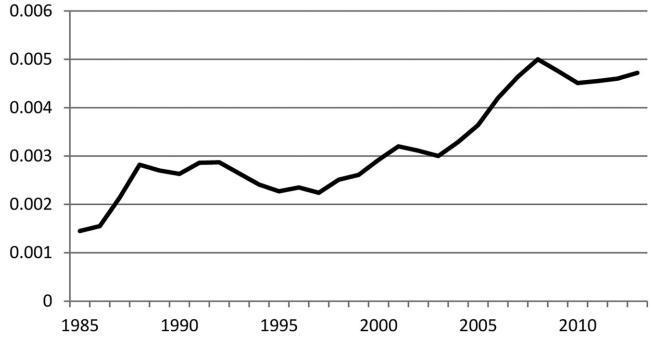
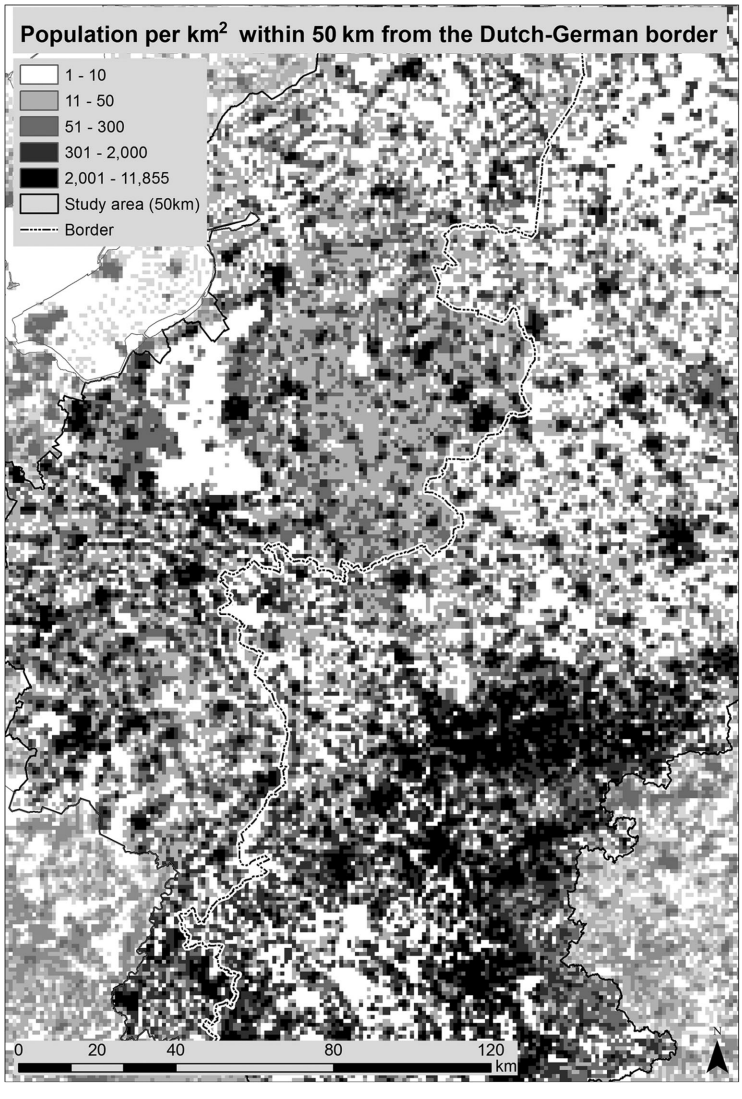


Figure A4 ■ Population density



Source: Eurostat.