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# Urban traffic externalities

## *Quasi-experimental evidence from housing prices*

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**Urban traffic externalities: quasi-experimental evidence from housing prices**

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*Abstract*

This paper exploits a quasi-experiment to value the benefits of reducing urban traffic externalities. As a source of exogenous variation we use the opening of a new bypass in The Hague, the Netherlands, that reduced traffic on a number of local streets, leaving others unaffected. We calculate the effect of the change in traffic nuisance on housing prices and find that a reduction of 50% in traffic density induces a 1% increase in housing prices on average. Reductions in traffic nuisance are valued much more positively when the traffic density is already high. We do not find evidence of anticipation effects up to 3 years before the change. Furthermore, our results indicate that traffic nuisance effects are likely to be biased in cross-sectional studies.

*Key words: Traffic externalities; Quasi-experiment; Housing market; Hedonic approach.*
*JEL classification: Q53, R2, R4*

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## 1 Introduction[1]

Different cities have recently introduced or strengthened policies aimed at reducing the incoming automobile traffic. This is not without a reason. Data for the European Union indicate that passenger kilometres driven by car rose by a factor of two and a half between 1970 and 2000 and have increased by yet another ten percent since (European Commission, 2002, 2012). Although automobiles have become much cleaner and quieter in the recent decennia, they still are a leading source of greenhouse gases, local air pollution (Parry et al., 2007) and noise annoyance (CE, 2011).[2] In urban areas, the negative externalities caused by road traffic are especially harmful due to the high concentration of population. Before the introduction of the congestion charge in London in 2003, ninety percent of the city residents surveyed opined that there was too much traffic in London (Rocol, 2000).

This paper exploits a quasi-experiment to produce new and improved evidence on the benefits of reducing urban traffic externalities. As a source of exogenous variation we use the opening in 2003 of a new highway in the west of the Netherlands that provided bypass capacity for through traffic heading to the third largest Dutch city, The Hague. The bypass considerably reduced traffic on a number of local streets in the suburbs of The Hague, leaving others unaffected. We use a unique dataset including (i) micro data on local traffic densities on the streets in these suburbs, (ii) individual residential sales data on affected and unaffected streets before and after the opening of the bypass. A noteworthy feature of our dataset is the continuous and longitudinal data on traffic density. Affected streets not only differ in the level of traffic density in the before period, but also in the magnitude of the induced density change. This variation allows us to progress beyond a simple comparison of housing prices on affected and unaffected streets and estimate a functional relationship between traffic density and housing prices. Exact information on the location of the dwellings makes it furthermore possible to include fixed effects on a very low level of aggregation (street segment) and to identify the effect of traffic nuisance from the before-after variation in traffic nuisance and housing prices. Finally, our data covers a large enough time period before the opening of the bypass to be able to examine the anticipation effects.

With this paper we contribute to a growing literature on the effects of policies aimed at the reduction of urban traffic. The existing empirical papers

[1] This paper uses restricted access data of the Dutch Association of Real Estate Brokers (NVM).

[2] In 2008 fifteen percent of the EU-27 population (some eighty million people) was exposed to potentially harmful road noise levels above sixty decibels, compared to one and a half percent of the population exposed to railway and airplane noise above sixty decibels.

mainly focus on the effects of recently introduced congestion charges and report considerable reductions in traffic volume in London (Leape, 2006) and Stockholm (Eliasson, 2010, Kopp and Prud'homme, 2010). We contribute to this literature by examining how urban citizens value the decrease in traffic externalities. A number of theoretical papers analyse the effects and relative performance of a broader set of policy measures. De Borger and Proost (2013) consider tolls, bypass capacity to guide traffic around the city centre and capacity reduction measures such as speed limits and road bumps. Karamychev and Van Reeven (2011) investigate park-and-ride facilities that aim to intercept motorists from travelling into the city. We complement this literature by providing empirical evidence on the possible benefits of these policies; this evidence can be used to support the optimal choice of the policy instrument and its design in practice.

Our paper is the first to combine a quasi-experiment and a fixed effect hedonic price estimation to study the valuation of local traffic nuisance. By focusing on the effects of urban traffic nuisance our paper is related to the quasi-experimental research on the valuation of environmental goods (see Boes and Nüesch, 2011, and the references therein for airport noise; Palmquist, 1982, for highway noise; Chay and Greenstone, 2005, for air pollution; Davis, 2011, for the nuisance from power plants). Palmquist studies traffic externalities using variation in urban noise levels induced by the construction of a highway through a town. He does not, however, take into account the environmental effects of changes in the local traffic flows brought about by the realisation of the new highway. These latter effects constitute the focus of our paper.[3] Furthermore, in our study, the measured effect of traffic nuisance accounts not only for noise, but for the whole array of various local externalities induced by local urban traffic. As described in Parry et al. (2007), these mutually correlated externalities include among other things: congestion, noise, local pollution, accident risks. By focussing on the external effects of traffic, our paper is furthermore indirectly related to the small quasi-experimental literature on the accessibility effects of new transport infrastructure.[4]

Taking advantage of our detailed data on traffic density we detect a statistically significant positive effect of a decrease in traffic density on the

[3] Furthermore, two quasi-experimental studies make a difference-in-difference analysis of the effects of changes in highway nuisance without having at their disposal micro data about the corresponding nuisance levels. Julien and Lanoie (2007) measures the effect of a noise barrier on the prices of houses in the immediate neighbourhood and Klaiber and Smith (2010) measure the nuisance effect of a new highway on the house prices in the immediate neighbourhood. Both papers approximate the level of traffic nuisance by the distance to the highway.

[4] Klaiber and Smith (2010) study accessibility benefits of a new highway. Gibbons and Machin (2005) and Billings (2011) study these benefits for new train stations.

value of houses within 40 meters from the affected streets. The estimated elasticity of housing prices to traffic density is on average -0.02 for houses adjacent to the street; it is factor 2 to 4 smaller for houses located further away from the street. For houses located on very busy roads the effect of traffic density turns out to be much stronger: for streets with traffic flows above 15000 cars per day an elasticity coefficient of -0.1 is estimated. Furthermore, we show that the total benefits of traffic nuisance reduction amount to some 8% of the reference costs of the bypass construction.

Despite the benefits of reduced nuisance, there was a large local resistance to the construction of the bypass. To understand the reasons for this resistance we study whether people anticipated the reductions in traffic nuisance on local streets. Estimation results suggest no evidence of anticipation effects up to three years before the change in local nuisance. Existing literature presents no unambiguous conclusions about whether land values adjust in advance to the expected changes in the location characteristics. McDonald and Osuji (1995) and McMillen and McDonald (2004) find evidence that the future increase in rail accessibility was already partly capitalized in the land prices three years before the opening of the new Chicago transit line. Billings (2011) finds anticipation effects for the new light rail system in Charlotte, NC. Gibbons and Machin (2005) argue, however, that owner-occupiers discount the future benefits of transport improvements very heavily so that anticipation effects will, in most cases, be quite limited. In the light of the first literature, our results indicate that residents, although being able to form expectations about the direct effects of accessibility improvements, have trouble foreseeing the induced effects such as changes in local traffic flows. In the light of the second literature, our results may be seen as a support for the existence of a high discount rate for the expected changes in location characteristics.

Finally we investigate how much the use of the quasi-experimental methodology confers advantages in terms of pinning down the valuation of traffic nuisance in comparison with more conventional methods based on pooled cross-sectional regressions. The results of conventional studies are likely to suffer from the omitted variables bias, as unobserved neighbourhood characteristics tend to be correlated with both the housing prices and the environmental good (e.g. Greenstone and Gayer, 2009, Boes and Nuesch, 2011). A quasi-experimental study like ours has the advantage of avoiding this problem. We use our data to estimate pooled cross-sectional models and find considerably lower effects of traffic nuisance (about 5 times lower), suggesting a positive correlation between traffic density and unobserved neighbourhood amenities. This result may have implications for the valuation of road traffic externalities in transport policy appraisals in different countries. Currently, these valuations largely build on the outcomes of the conventional hedonic studies on the effects of traffic externalities (see Odgaard, 2005, Navrud, 2004).

The paper proceeds as follows. In the next section we describe the institutional framework of the events leading to the local traffic density changes and explain our identification strategy. Section 3 deals with the data used, and Section 4 presents the results of the estimations. Section 5 discusses the policy implications of the results for the valuation of traffic nuisance. Section 6 concludes.

## 2 Changes in local traffic and identification strategy

*Induced changes in local traffic density*

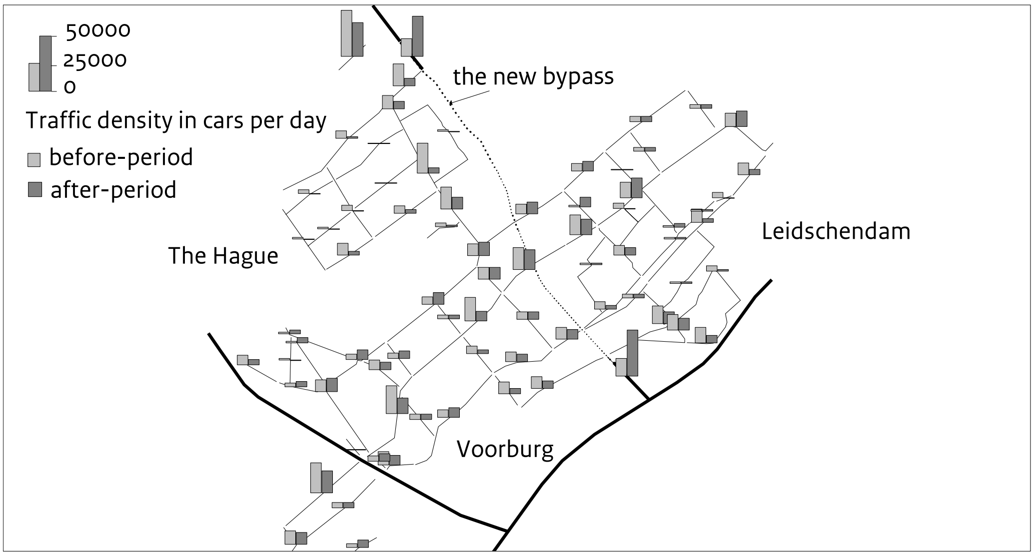
In November 2003 a new highway was opened in the Netherlands, providing bypass capacity for traffic heading to the northern part of the third largest Dutch city, The Hague. The lead time to the opening of the bypass was long. It first appeared in the plans of the Ministry of Transportation in 1930s. However, due to successful local opposition, construction was deterred several times. It was only at the end of 1998 that the construction decision was ratified by all involved city councils.

The bypass runs in a tunnel through the urbanized suburbs of The Hague (municipality Leischendam-Voorburg) and on the ground level along the Hague neighbourhood Mariahoeve (see Figure 1). Although relatively small in geographical scale, with its length of 5.2 kilometres, the bypass absorbed a large part of the through traffic that had previously used local streets in these suburbs. Traffic density on local through streets decreased on average by half (from 8.6 thousand to 4.5 thousand cars per day); some affected streets lost up to 90% of the before-traffic and up to 15 thousand cars per day. This traffic relief is major when compared with the general trend in the west of the Netherlands, where the traffic density remained more or less stable after 2003.[5]

We will use the described variation in the local traffic flows in the before and after period to estimate how the decrease in urban traffic nuisance is capitalized in housing prices. The next section describes the identification strategy in more detail. But first we address two general methodological concerns that might complicate the identification of the effects.

[5] The traffic density on larger streets in the West of the Netherlands increased with some 7% between 1999 and 2003 and remained more or less stable since (Statistics Netherlands).

**Figure 1 New bypass resulted in substantial decreases in local traffic density**
*The thick lines indicate the intercity road network; the thin lines are local through streets; the dotted line is the new bypass. The bars indicate traffic density before (in 1999) and after (in 2006) the opening of the bypass.*

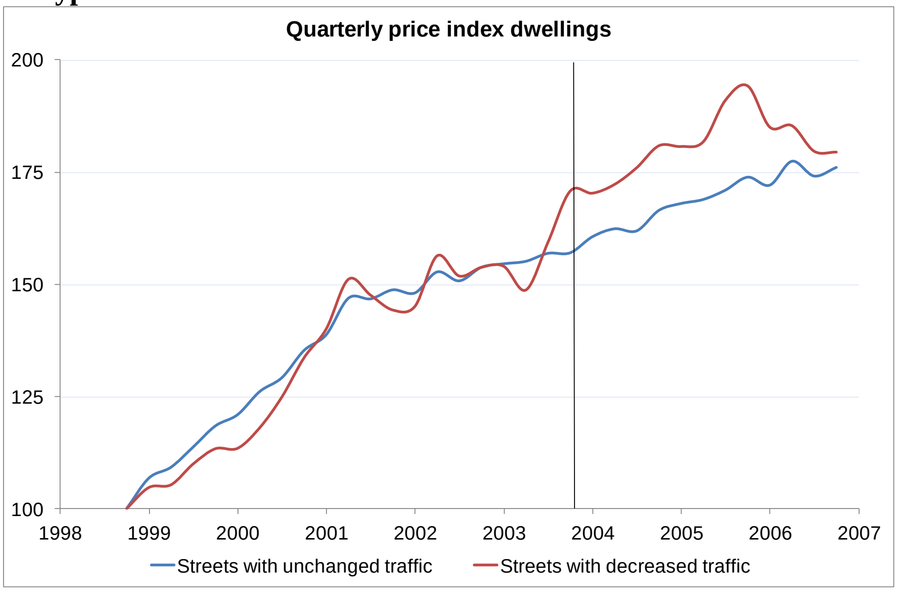



It is quite likely that the bypass influenced the housing prices in Leidschendam, Voorburg and Mariahoeve through mechanisms other than only changes in local traffic density, including: (i) improved accessibility (a faster connection to the intercity road network and The Hague), (ii) (negative) external effects of the bypass on the direct surroundings. If the variation in housing prices induced by either of these two mechanisms is highly correlated with the variation induced by traffic density changes, this would lead to biased estimates. However, the highly disaggregated data we have on traffic density changes allow us to easily control for the possibility of this bias. Variation in traffic density changes in our data is on the level of a street segment between two junctions (see Figure 1). Consultations with the transportation experts from local authorities revealed that travel time improvements due to the faster new connection to The Hague do not vary much within larger neighbourhoods[6] and can thus be accounted for by the inclusion of neighbourhood-specific time trends. The same argument holds for the negative external effects of the bypass. These nuisance effects were partly mitigated by tunnelling the bypass and partly by putting a noise wall around it. The possible remaining effects are restricted to the direct surroundings of the bypass; in the estimation we will include specific time trends for these areas as well.

[6] The extra time savings of the residents of streets with decreased traffic (e.g. due to easier and closer parking possibilities) we attribute to the effects of decreased local traffic density.

The construction of the bypass started in January 1999, and, in November 2003, the first cars made use of the new connection. If the residents of surrounding towns anticipated the effects of reduced local traffic densities before these became effective, the prices could have already partly adjusted to the new situation by 2003. To get more insight into this issue, we perform a simple difference-in-difference estimation comparing the price appreciation trends for houses that experienced a traffic decrease after the opening of the bypass with houses that remained unaffected (see Figure 2). The analysis suggests that, between 1998 and 2001, the first group of houses experienced slightly lower appreciation rates than the second group. In the period between 2001 and 2003, the two trends converged in value. In the last quarter of 2003, simultaneously with the opening of the bypass, housing prices on streets with decreased traffic experienced a permanent upward jump. This preliminary analysis suggests that if the anticipation effect existed, it took place in the three years before the opening of the bypass and was of limited size.[7] We will formally test for this in the next sections.

**Figure 2 Decreased traffic nuisance capitalized in housing prices after the opening of the bypass**




[7] Theoretically, reduced traffic nuisance could partly be capitalized in the housing prices as early as in the end of 1998, immediately after the announcement of the bypass construction. Our data on the years preceding the announcement are too limited to completely rule out this effect. If this capitalization took place, the effect of traffic nuisance reduction in our study will be underestimated. We have reasons, however, to expect the announcement effect, if any, to be small. Consultations with local transportation authorities revealed that residents had trouble realizing *ex ante* that the bypass would influence traffic flows on local streets. What is more, the construction of the bypass had been for many decades opposed by the local residents, who argued, among other things, that it would not reduce through traffic in the surroundings (Hobma, 2000). Finally, Billings (2011) finds no support for an immediate announcement effect from the decision about light rail construction in Charlotte, NC; he argues that land markets need several years to adjust to the new information.

*Identification strategy*

A starting point for our analysis is a location fixed effect equation (1) relating transaction prices of houses $P$ to the traffic density $D$ on the street where the house is located. To control for differences in other location characteristics of the houses sold, we include time-invariant fixed effects for the smallest administrative units in the Netherlands (postcode PC6 units) that include 10 to 15 dwellings located on the same segment of a street. This ensures that the traffic density discount $\beta$ is estimated from the variation within these units. We furthermore control for the variation in the structural characteristics of the houses sold by including covariates $X$ for these structural characteristics. Finally, the general time trend and neighbourhood specific time trends are accounted for.

$$\ln P_{ijt} = \alpha + \beta \ln D_{jt} + f_j + \gamma_1 X_{it} + \gamma_2 Y_t + \gamma_3 I_{neighb} Y_t + \varepsilon_{ijt} \qquad (1)$$

where $P_{ijt}$ is the price of dwelling $i$ located in postcode unit $j$ in year $t$; $D_{it}$ is the traffic density in postcode unit $j$; $f_j$ is the location fixed effect; $X_{it}$ is a vector of the structural housing attributes of dwelling $i$ in year $t$ (such as: size of the dwelling, number of rooms, presence of a garage, etc.); $Y_t$ are year dummies; $I_{neighb}Y_t$ are neighbourhood-specific time trends that account for possible differences between neighbourhoods in the accessibility effects and external effects of the bypass (see Section 2 above); $\beta$ and $\gamma$ are coefficients to be estimated and $\varepsilon_{ijt}$ is the residual term of an individual house.

After consultations with local transportation authorities we distinguished three larger neighbourhoods that can differ in accessibility effects[8] and two smaller neighbourhoods, adjacent to the bypass, that could have experienced negative external effects from the bypass. Vector $I_{neighb}$ thus contains five neighbourhood-specific dummies that take value one if the house is located in a specific neighbourhood and zero otherwise.

A double-log specification of the relationship between the housing price and the traffic density allows interpreting the coefficient by density as price elasticity. The choice to express density in logarithms is based on the following consideration: The level of noise, which is the major source of traffic nuisance, is commonly expressed by a logarithmic measure of the effective sound pressure relative to a reference value (measured in decibels).

Our estimates will be based on the price differences between the periods 1998-2003 and 2004-2006. Before 1998 the data on home sales in the area are

[8] These are: town of Voorburg, town of Leidschendam and The Hague neighbourhood Mariahoeve.

limited. After 2006 other important changes in the transport network in the area took place.

*Testing for anticipation effects*

We allow anticipation to take place up to three years before the opening of the bypass. We amend equation (1) with a term: $\beta_2 I_{2001-2003} D_{j,after} / D_{j,before}$, where $D_{j,after} / D_{j,before}$ is the relative change in traffic density between the before and after period, $\beta_2$ is the coefficient to be estimated and $I_{2001\text{-}2003}$ is an indicator variable taking the value one if the house was sold in the years 2001-2003 and the value zero otherwise.

Equation (1) becomes therefore:

$$\ln P_{ijt} = \alpha + \beta_1 \ln D_{jt} + \beta_2 I_{2001-2003} \frac{D_{j,after}}{D_{j,before}} + f_j + \gamma_1 X_{it} + \gamma_2 Y_t + \gamma_3 I_{neighb} Y_t + \varepsilon_{ijt} \qquad (2)$$

In equation (2), we allow the expected change in traffic nuisance in the after-period 2004-2006 to capitalize in the housing prices already in the years t=2001, 2002 and 2003. We expect the coefficient $\beta_2$ to be negative as expected decrease in traffic nuisance should capitalize in higher housing prices.

## 3 Data

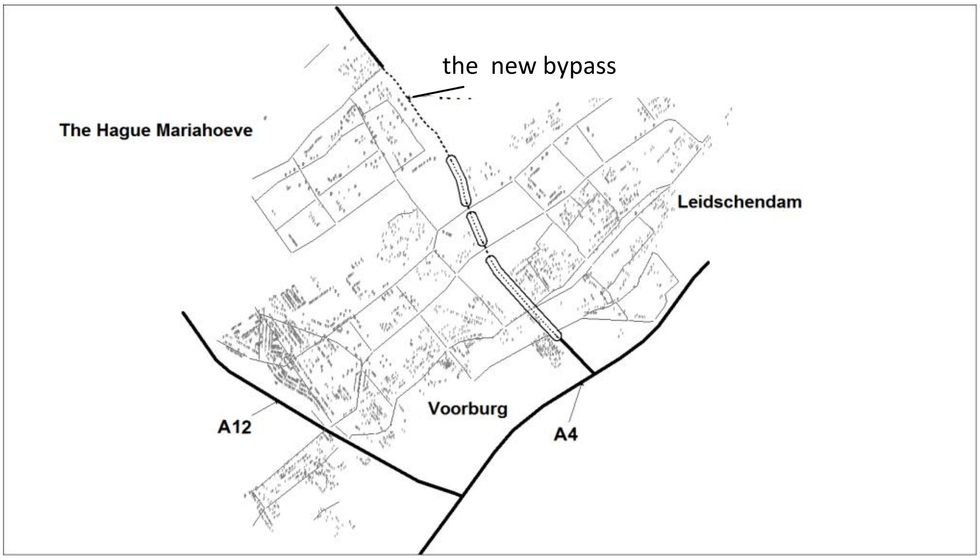
This research uses two main sources of data: (i) information on housing sales between 1998 and 2006 in the towns Voorburg, Leidschendam and the neighborhood Mariahoeve in The Hague, and (ii) data on traffic densities on the through streets in the same region. Micro data on the houses sold were provided by the Dutch Association of Real Estate Brokers (NVM).[9] These data include the transaction date, the transaction price and extended information on housing attributes, such as age, construction descriptors (e.g. type of heating, presence of a built-in garage, etc.) and various dimensional attributes (such as the size of the living area, the number of rooms, etc.) We know the exact location of each house.[10] Our identification strategy (see Section 2) is based on repeated sales on the level of a postcode PC6 unit. Consequently, we exclude the postcode units that are present in the before- or after-period only. This results in an unbalanced panel consisting of 9506 observations within 1120 different postcode units. Roughly 60% of the observations refer to the period before the bypass became operational (1998-2003), 40% of the observations refer to the after-period (2004-2006).

[9] Nationwide, around 75% of all residential property sales is performed through a real estate broker who is member of NVM. The sales data are similar to those used in Ommeren et al. (2011).

[10] For their help with geocoding the data, we thank the department Spatial Economics of the Vrije Universiteit Amsterdam.

Detailed data on traffic densities of approximately 80 through street segments in the research area in the before- and after-period were made available by the Municipality of Leidschendam-Voorburg. Based on the knowledge of the exact geographical location of every dwelling and every street segment, the two datasets could be linked. Figure 3 below shows the geographical reach of our research area and the location of the dwellings in our dataset in relation to the through streets and the bypass.

**Figure 3 Research area and location of dwellings sold**
*Dots refer to the houses sold. The bypass is indicated by a dotted line and three elongated circles (tunnels).*




Our dataset contains measurements of traffic density at two points in time: 1999 and 2006. To obtain figures for the years 1998 and 2000-2005 we use the data of Statistics Netherlands on the growth rate of traffic on larger streets in the western part of the Netherlands.

As described in Section 2, we control for the possible external effects of the bypass on its direct surroundings. Due to mitigation measures, if these effects were present, they were very local. As figure 3 shows, a large part of the bypass was built in tunnels on the top of which new residential housing and a park were realised. Nuisance from the ground part of the bypass was mitigated by a noise barrier. We allow dwellings within a distance of approximately 500 meters on both sides of the bypass to experience a (positive or negative) change in spatial quality; the precise borders of the proximity area are determined manually in GIS using, as guidelines, the location of larger streets. According to this definition, around 10% of the houses in our dataset lie in the area where external effects of the bypass might be present.

As a first step towards estimating the impact of the traffic density changes on housing prices, we compare prices and traffic densities for three groups of observations: (i) the observations on through streets that experienced a fall in traffic density after the opening of the bypass, (ii) the observations on through streets that experienced a rise in traffic density after the opening and (iii) the observations not lying on one of the affected streets.[11] For each group of observations, the before (1998-2003) and after (2004-2006) means are reported.

**Table 1 Housing price and traffic density in the before and after periods**

| | Dwellings with a fall in traffic density | | Dwellings with a rise in traffic density | | Non-affected dwellings | |
|---|---|---|---|---|---|---|
| Variable | Before | After | Before | After | Before | After |
| Housing price (x1000euro) | 170 | 212 | 208 | 255 | 182 | 222 |
| Traffic density (x1000 cars/day) | 8.6 | 4.5 | 5.4 | 6.2 | n/a | n/a |
| # observations | 835 | 448 | 369 | 205 | 4725 | 2924 |

Table 1 suggests that the opening of the bypass led to considerable decreases (on average 4000 cars a day) and only modest increases (1000 cars a day on average) in traffic density. The related percentage price changes between the before and the after period are in line with the expectations. The non-affected dwellings, and dwellings with a rise in traffic density, showed a price rise of 22% between the two periods. Dwellings that experienced a considerable fall in the traffic density, showed a larger price increase of 25%. Appendix A reports the full descriptive statistics of the data.

## 4 How does traffic density affect housing prices?

In this section we estimate model (1) and some extensions.[12] Column 1 of table 2 below presents the estimated elasticity of home prices to the traffic density on the street where these dwellings are located (model 1). This elasticity equals -0.02. This implies that a 1% decrease in the traffic density results in a 0.02% increase in the prices of houses affected by this traffic, and that decreasing traffic density by half induces a 1% increase in housing prices. The coefficient is highly significant.

[11] Non-affected dwellings are houses located within residential blocks, on non-through streets. For these streets no traffic density measurements were performed as this density is low and mainly influenced by local traffic flows. For the non-through streets we make two alternative assumptions: (i) traffic density did not change between the before- and after- period; (ii) traffic density grew with the average rate for the west of the Netherlands. Our results are robust to these assumptions.

[12] To account for possible correlation between the error terms within a postcode unit, we apply the clustered errors correction as suggested by Angrist and Pischke (2008).

It is quite possible that dwellings located further away from affected streets also profited from reduction in traffic nuisance. We test this hypothesis and find that the effect of the traffic density change reaches as far as 40 meters from the affected street. Column 2 of table 2 (baseline model) reports the elasticity of the prices of houses not adjacent to the street to be between -0.005 and -0.01. This is a factor 2 to 4 smaller than the effect for the houses directly adjacent to the affected streets.

In Appendix C we show that the estimated traffic nuisance effect is robust across space and for dwellings in different price segments. Below the baseline model is extended by allowing for (i) anticipation effects and (ii) different valuation of the traffic nuisance at medium and high traffic densities.

**Table 2 Estimations of the price elasticity to traffic density**#

Standard errors are in parentheses

| . | Adjacent houses only (model 1) | Adjacent and further away located houses (model 2, baseline) | Anticipation effect added (model 3) | High and medium density streets separate, (model 4) |
|---|---|---|---|---|
| Elasticity to density: | | | | |
| • houses adjacent to affected street, all densities | -0.019***<br>(0.005) | -0.020***<br>(0.005) | -0.025***<br>(0.007) | |
| • houses adjacent to affected street, medium densities | | | | -0.018***<br>(0.005) |
| • houses adjacent to affected street, high densities | | | | -0.101***<br>(0.029) |
| • houses not-adjacent to affected street, within 20 meter from it | | -0.010**<br>(0.005) | -0.010**<br>(0.005) | -0.010**<br>(0.005) |
| • houses not-adjacent to affected street, within 20 - 40 meter from it | | -0.005*<br>(0.003) | -0.005*<br>(0.003) | -0.005*<br>(0.003) |
| Anticipation effect (per 10% density change) | | | -0.002<br>(0.002) | |
| Neighbourhood-specific time trend | YES | YES | YES | YES |
| Location (PC6) fixed effects | YES | YES | YES | YES |
| Year dummies | YES | YES | YES | YES |
| Structural housing characteristics | YES | YES | YES | YES |
| $R^2$ within (adjusted) | 0.77 | 0.77 | 0.77 | 0.77 |
| # observations affected streets | 1857 | 1857 | 1857 | 1857 |
| # observations unaffected streets | 7649 | 7649 | 7649 | 7649 |

#Coefficient estimates for the structural housing characteristics are reported in the Appendix B.
* stands for 10% significance, ** for 5% significance and *** for 1% significance.

*Anticipation effects*

Column 3 in table 2 reports the results of estimating equation (2) with anticipation effects for dwellings that experienced a decrease in traffic density.

The point estimate of the anticipation coefficient $\beta_2$ has a correct negative sign, a low absolute value and is not significant. The point estimate of the price elasticity to density (-0.025) lies well within the confidence band of the baseline model 2. An alternative estimation, in which we remove years 2000-2003 altogether from the dataset, yields an elasticity of -0.023, which is also well within the confidence band of the baseline model. This supports the conclusion of no significant anticipation effects.

The result obtained is in line with expectations. We performed several interviews with municipal transportation experts from the towns surrounding the bypass. These interviews revealed that local population had great trouble realising *ex ante* that the bypass would relieve traffic flows on local streets and that this would influence the housing prices. The results are furthermore in line with Gibbons and Macchin (2005) who believe that owner-occupiers have a fairly short-run view of the benefits of a residential location: they value these benefits as a consumption good they can enjoy rather than as an asset.

*Traffic nuisance at high and low traffic densities*

Noise is an important source of traffic nuisance. Literature on the effects of traffic noise suggests that, starting with a noise level of around 45 decibels and higher, people experience noise as annoyance. Above a level of 60 decibels noise may lead not only to annoyance but also to health damages such as: sleep disturbance, heart disease etc. (World Health Organization, 2011). This insight suggests that the elasticity of the housing price to traffic density may be different for low/medium and high values of the density. To test this hypothesis we adjust equation (1) allowing for a piece-wise relationship between the logarithm home price and the logarithm traffic density. We allow for a kink at the density level of 15000 cars per day that corresponds to the noise level of approximately 60 decibel.[13]

Table 2, column 4 reports the results of this estimation. For the low and medium densities, the estimated value of price elasticity becomes slightly lower than in the baseline model (-0.018 instead of -0.020); it stays highly significant. For the high values of traffic density, a factor 5 larger elasticity value of -0.1 is found. The result for the high densities is highly significant and in line with the intuition. Nevertheless, the point estimate for the high densities should be treated with some caution. In our dataset the data coverage for the high traffic

[13] This calculation has been made using the SMRI method, which is applied in the Netherlands to calculate the noise levels corresponding to different values of traffic density. See www.stillerverkeer.nl. Note that equal traffic density values can lead to different noise levels depending on the local circumstances (e.g. the type of asphalt). In our calculation the average values suggested at the site were used.

densities is rather thin: less than 10% of the 1857 affected houses faced in the before period a traffic density above 15000 cars a day.

## 5 Implications for the transportation policy appraisals

Many transportation policies aim at reducing urban traffic nuisance. Think about the congestion charges in London and Stockholm; the park-and-ride facilities at the city borders in various countries; the high parking costs in downtowns; and so forth. To optimally shape these policies it is important to be able to estimate *ex ante* their benefits and costs. Below we show that the quasi-experimental approach we use confers important advantages in terms of pinning down the valuation of nuisance, in comparison with more conventional valuation approaches widely used to provide monetary values for transportation policy appraisals.

We estimate a conventional specification of equation (1) based on pooled cross-sectional regressions. We define the location fixed effects on the level of neighbourhoods (statistic entities that are aggregations of postcode PC6 units) and include additional variables to correct for differences in the geographical characteristics of the location. These additional variables comprise (see Appendix A for descriptives): land use within a 500 meter radius from the dwelling including shares of the land under transport infrastructure, shops and restaurants and open space; social-economic characteristics of the neighbourhood including percentage share of non-western immigrants, average income per household and population density.

The estimated traffic density effect is in the conventional approach 5 times (three standard deviations) lower than in the baseline estimation based on a quasi-experiment, see table 3. This outcome suggests the presence of positively valued characteristics of the living environment that are highly correlated with the home location on a busier street and introduce a bias in the conventional estimates. One may think of such factors as: a wider view out of the windows, larger distance to the neighbouring houses and houses on the opposite side, presence of trees, better transport accessibility, etc.

| Table 3 Comparison to conventional estimates | | |
|---|---|---|
| Elasticity to traffic density, standard errors in parentheses | Baseline estimation (model 2) | Conventional estimation (model 5) |
| adjacent to the street | -0.020*** | -0.004** |
| | (0.005) | (0.002) |
| distance (0,20] | -0.010** | -0.004** |
| | (0.005) | (0.002) |
| distance (20,40] | -0.005* | -0.003 |
| | (0.003) | (0.002) |

In various countries recommended valuation of traffic nuisance in transport project appraisals is based on conventional hedonic estimates (Navrud, 2004).[14] Our results suggest that caution is needed when using these results. Although modern studies based on pooled cross-sectional regressions (Day et al., 2007, Andersson et al., 2010) exploit very detailed information on a large range of housing and neighbourhood characteristics, it remains a hard task to exclude all sources of omitted variables.

## 6 Conclusions

Our study provides new and convincing evidence on the valuation of urban traffic nuisance. We implement a strong test based on a quasi-experimental change in traffic density on local streets as a result of the construction of a new bypass in the west of the Netherlands. We use a unique dataset that not only contains information on which dwellings were affected by the traffic density change, but also shows to what traffic density levels these dwellings were exposed in the before- and after-periods. We derive monetary valuation for the total of various negative urban traffic externalities that people perceive as nuisance, including congestion, noise, local pollution and accident risks.

We find that on medium density streets the elasticity of prices to traffic density amounts to -0.02. On streets with high density the valuation of traffic nuisance may be up to 5 times as high as on the medium density streets. The impact of the traffic nuisance is furthermore not only present for the houses adjacent to the main street, but also for those located further away, up to a distance of 40 meters from the street. We show that our estimates of the impact of traffic density changes are robust across space and across different house price segments.

As car drivers themselves do not internalize the costs they impose on others, local authorities in many urban agglomerations take various policy measures to

[14] See also Nelson (2008) for detailed overviews of the pooled cross-sectional literature on the effects of traffic noise on residential values.

reduce urban traffic flows. These include congestion charges, (high) parking costs as well as investment in tunnels and bypasses. Many such measures involve a substantial cost to car owners and taxpayers, so successful interventions require a careful appraisal of the costs and benefits of the resulting traffic reduction. Our paper offers a better insight into the benefits of these policies.

One can compute the benefits of traffic nuisance reduction brought about by the bypass studied in this paper. Following a conservative approach that only accounts for the effects on houses adjacent to the affected streets, and takes the medium density elasticity of -0.02, the total local benefits for the houses in our dataset amount to 1.4 million euros in Leidschendam-Voorburg and 2.6 million euros in The Hague Mariahoeve. Assuming that the houses in the dataset are a random sample from the housing stock, the total benefit of reduced nuisance equals some 18 million euros.[15] This is 3.5 million euros per kilometre bypass. To gain an insight into the relative importance of these benefits, we compare them with the reference construction costs of a two-lane bypass.[16] Vos (2004) reports that a simple two-lane highway on ground level costs some 10 million euros per kilometre. Where tunnels and bridges are involved, as was the case with the bypass near The Hague, the cost easily quadruples to more than 40 million euros per kilometre (V&W, 2003). This simple calculation suggests that, for a bypass to be cost-efficient it must generate other benefits in addition to the reduction of urban traffic nuisance. For the bypass in our study an important benefit was the improved accessibility of The Hague.

[15] The size of the housing stock as reported by Statistics Netherlands amounts to 34.2 thousand in Leidschendam-Voorburg and 8.4 thousand in The Hague Mariahoeve; the number of dwellings in our dataset for Leidschendam-Voorburg and The Hague Mariahoeve is 7.6 thousand and 1.8 thousand respectively.

[16] The bypass we studied was constructed by a private consortium, so its exact construction costs are unknown.

**References**


Andersson, H., Jonsson, L, and M. Ögren (2010), Property Prices and Exposure to Multiple Noise Sources: Hedonic Regression with Road and Railway Noise, *Environmental and Resource Economics* 45:73–89.

Angrist J.D., J. Pischke , 2008, *Mostly Harmless Economics: an Empiricist's Companion*, Princeton University Press.

Billings S. B. (2011), Estimating the Value of a New Transit Option, Regional Science and Urban Economics 41: 525-536.

Boes, S. and S. Nüesch, 2011, Quasi-Experimental Evidence on the Effect of Aircraft Noise on Apartment Rents, *Journal of Urban Economics* 69: 196–204.

Borger, B. de and S. Proost (2013), Traffic Externalities in Cities: The Economics of Speed Bumps, Low Emission Zones and City Bypasses, *Journal of Urban Economics* 76: 53-70.

CE, 2011, External Costs of Transport in Europe, CE Delft.

Chay, K.Y. and M. Greenstone, 2005, Does Air Quality Matter? Evidence from the Housing Market, *Journal of Political Economy* 113 (2): 376-424.

Day B., I. Bateman and I. Lake, 2007, Beyond Implicit Prices: Recovering Theoretically Consistent and Transferable Values for Noise Avoidance from a Hedonic Property Price Model, *Environmental and Resource Economics* 37(1), 211-232.

Davis, L.W. (2011), The Effect of Power Plants on Local Housing Values and Rents: Evidence from Restricted Census Microdata, *Review of Economics and Statistics* 93: 1391-1402.

Dijk, van and Romijn (2010), *Reforming the Dutch Housing Policy* (*Hervorming van het Nederlandse woonbeleid)*, CPB Bijzondere Publicatie 84, CPB Netherlands Bureau for Economic Policy Analysis.

Eliasson J. (2009), A Cost-benefit Analysis of the Stockholm Congestion Charging System, Transportation Research Part A 43(4): 468-480.

European Commission (2012), *Transport in figures: statistical pocketbook.*

European Commission (2002), *European Union energy & transport in figures.*

Gibbons, S. and S. Machin, 2005, Valuing Rail Access using Transport Innovations, J*ournal of Urban Economics*, 57(1): 148-169.

Greenstone M. and T. Gayer (2009), Quasi-experimental and Experimental Approaches to Environmental Economics, *Journal of Environmental Economics and Management* 57: 21-44.

Hobma, F.A.M. (2000), *Highways and Regional Planning (Rijkswegen en Ruimtelijke Ordening)*, Eburon, Delft.

Julien, B. and P. Lanoie (2007), The Effect of Noise Barriers on the Market Value of Adjacent Residential Properties, International Real Estate Review 10(2): 113-130..

Karamychev, V. and P. van Reeven (2011), Park-and-ride: Good for the city, good for the region?, *Regional Science and Urban Economics* 5: 455–464.

Klaiber H.A. and V.K. Smith, 2010 , Valuing Incremental Highway Capacity in a Network, *NBER Working Papers* 15989, National Bureau of Economic Research, Inc.

Kopp and Prud'homme (2010), The Economics of Urban Tolls: Lessons from the Stockholm Case, *International Journal of Transport Economics* 37:195-223.

Leape J. (2006), The London Congestion Charge, *Journal of Economic Perspectives* 20: 157-176.

McDonald, J.F. and C.I. Osuji (1995), The Effect of Anticipated Transportation Improvement on Residential Land Values, *Regional Science and Urban Economics* 25: 261-278.

D.P. McMillen, J. McDonald (2004), Reaction of House Prices to a New Rapid Transit Line: Chicago's Midway Line, 1983–1999, *Real Estate Economics* 32: 463–486.

Navrud, S. (2004), The State-of-the-Art on Economic Valuation of Noise, Final report to European Commission DG Environment, Agricultural University of Norway, Ås, Norway.

Nelson, J.P., 2008, Hedonic Property Value Studies of Transportation Noise: Aircraft and Road Traffic, in A. Baranzini, et al. (eds) Hedonic Methods in Housing Market Economics, Springer.

Odgaard, T., Kelly, C. and J. Laird, 2005, Current Practice in Project Appraisal in Europe: Analysis of Country Reports. Heatco workpackage 3, deliverable 1.

Ommeren, J.N. van, Wentink, D and J. Dekkers, 2011, The Real Price of Parking Policy, *Journal of Urban Economics* 70: 25-31.

Palmquist R.B. (1982), Measuring Environmental Effects on Property Values without Hedonic Regressions, *Journal of Urban Economics* 11: 333-347.

Parry I.W.H., M. Walls and W. Harrington, 2007, Automobile Externalities and Policies, *Journal of Economic Literature* 45: 373–399.

ROCOL [Review of Charging Options for London] Working Group, 2000, Road Charging Options for London: A Technical Assessment, London, HMSO.

Rosen, S., 1974, Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition, *The Journal of Political Economy* 82(1): 34-55.

Vos, A. de (2004). *How much does a Highway cost? (Wat kost een Weg?)* http://www.binnenlandsbestuur.nl/ruimte-en-milieu/achtergrond/achtergrond/wat-kost-een-weg.99178.lynkx.

V&W (2003), MIT-projecten: stand van zaken 2003.

World Health Organization (2011), Burden of Disease from Environmental Noise: Quantification of Healthy Life Years lost in Europe, WHO, http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf.

Working Group on Health and Socio-Economic Aspects (WGHSEA), 2003, The Valuation of Noise, position paper, Brussels.

# Appendix A. Descriptive statistics

**Table A.1 Descriptive statistics: means, standard deviations are in parentheses**

| | Affected dwellings, fall in traffic density | | | | Affected dwellings, rise in traffic density | | | | Not-affected dwellings | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Before | | After | | Before | | After | | Before | | After | |
| **Price** | | 170020 | | 212305 | | 208364 | | 254648 | | 182043 | | 221559 |
| | | (124558) | | (149116) | | (129453) | | (135411) | | (123461) | | (143185) |
| **Traffic density** | | | | | | | | | | | | |
| (x1000 cars per day) | 8.6 | (8.5) | 4.5 | (4.9) | 5.4 | (3.2) | 6.2 | (3.0) | | n/a | | n/a |
| **Structural attributes** | | | | | | | | | | | | |
| Living area in $m^2$ | 104 | (48) | 104 | (46) | 127 | (51) | 129 | (49) | 106 | (43) | 105 | (42) |
| Number of rooms | 4.2 | (1.5) | 4.1 | (1.6) | 4.9 | (1.6) | 4.9 | (1.7) | 4.3 | (1.4) | 4.1 | (1.4) |
| Dummy apartment | 0.75 | (.43) | 0.75 | (.43) | 0.69 | (.46) | 0.68 | (.47) | .70 | (.46) | 0.70 | (46) |
| Dummy detached house | 0.03 | (.16) | 0.02 | (.14) | 0.02 | (.15) | 0.02 | (.12) | 0.01 | (.10) | 0.01 | (.11) |
| Dummy semindetached house | 0.04 | (.19) | 0.03 | (.18) | 0.02 | (.14) | 0.02 | (.14) | 0.02 | (.15) | 0.03 | (.16) |
| Dummy corner house | 0.07 | (.25) | 0.07 | (.25) | 0.06 | (.24) | 0.05 | (.22) | 0.09 | (.28) | 0.08 | (.27) |
| Dummy row house | 0.12 | (.33) | 0.13 | (.33) | 0.20 | (.40) | 0.24 | (.43) | 0.18 | (.38) | 0.19 | (.39) |
| Dummy year of construction <1905 | 0.01 | (.11) | 0.01 | (.09) | 0.01 | (.07) | 0.01 | (.10) | 0.01 | (.10) | 0.01 | (.10) |
| Dummy year of construction 1906-1944 | 0.33 | (.47) | 0.34 | (.47) | 0.66 | (.47) | 0.65 | (.48) | 0.33 | (.47) | 0.31 | (.46) |
| Dummy year of construction 1945-1970 | 0.49 | (.50) | 0.58 | (.49) | 0.24 | (.43) | 0.26 | (.44) | 0.40 | (.49) | 0.46 | (.50) |
| Dummy year of construction 1971-1989 | 0.15 | (.35) | 0.05 | (.23) | 0.04 | (.20) | 0.02 | (.14) | 0.21 | (.40) | 0.18 | (.38) |
| Dummy built-in garage | 0.10 | (.30) | 0.10 | (.31) | 0.12 | (.33) | 0.08 | (.27) | 0.14 | (.34) | 0.10 | (.30) |
| Dummy hot water heating | 0.91 | (.29) | 0.91 | (.28) | 0.84 | (.36) | 0.92 | (.27) | 0.90 | (.31) | 0.92 | (.26) |
| Dummy ground lease | 0.36 | (.48) | 0.33 | (.47) | 0 | (0) | 0 | (0) | 0.12 | (.33) | 0.11 | (.31) |
| Dummy nice view (water, open space) | 0.37 | (.48) | 0.42 | (.49) | 0.3 | (.46) | 0.34 | (.47) | 0.40 | (.49) | 0.45 | (.50) |
| Dummy Located in Leidschendam | 0.22 | (.42) | 0.24 | (.43) | 0.11 | (.32) | 0.12 | (.32) | 0.22 | (.41) | 0.22 | (41) |
| Dummy Located in Voorburg | 0.43 | (.50) | 0.42 | (.49) | 0.89 | (.32) | 0.88 | (.32) | 0.60 | (.49) | 0.60 | (.49) |
| Dummy Located in The Hague Mariahoeve | 0.34 | (.48) | 0.34 | (.47) | 0 | (0) | 0 | (0) | 0.18 | (.39) | 0.18 | (.39) |
| Dummy direct proximity to bypass in tunnel | 0.07 | (.25) | 0.09 | (.28) | 0 | (0) | 0 | (0) | 0.04 | (.20) | 0.04 | (.19) |
| Dummy direct proximity to bypass on ground level | 0.04 | (.21) | 0.05 | (.22) | 0 | (0) | 0 | (0) | 0.02 | (.14) | 0.02 | (.15) |
| **Land use and socio-economic characteristics neighbourhood** | | | | | | | | | | | | |
| % land under transport infrastructure | 8.5 | (5.1) | 8.2 | (4.2) | 11 | (4.9) | 10 | (4.5) | 9.1 | (5.0) | 8.4 | (4.7) |
| % land under shops and restaurants | 2.3 | (3.8) | 2.2 | (3.7) | 3.5 | (3.5) | 3.6 | (3.6) | 3.2 | (3.9) | 3.0 | (3.8) |
| % land under open space | 6.4 | (4.9) | 7.4 | (5.2) | 6.7 | (5.1) | 6.9 | (4.6) | 8.0 | (5.4) | 9.3 | (5.5) |
| % not western immigrants | 13 | (6.5) | 16 | (7.0) | 11 | (4.2) | 12 | (4.3) | 12 | (6.9) | 14 | (8.6) |
| Average income per household (x1000) | 14 | (1.9) | 15 | (1.4) | 14 | (1.8) | 15 | (.84) | 14 | (2.0) | 15 | (1.9) |
| Population density | 7216 | (2314) | 7146 | (2230) | 8529 | (1644) | 8457 | (1584) | 7290 | (2297) | 7255 | (2252) |
| Number of observations | | 835 | | 448 | | 369 | | 205 | | 4725 | | 2924 |

# Appendix B. Coefficient estimates baseline model

**Table B.1 Baseline model**

| | coefficient | st. dev. |
|---|---|---|
| **Traffic density (ln)** | -0.019*** | 0.005 |
| | | |
| **Structural housing attributes** | | |
| Living area in $m^2$ (ln) | 0.557*** | 0.018 |
| Number of rooms (ln) | 0.101*** | 0.013 |
| Area in $m^2$ (ln) | 0.035*** | 0.006 |
| Dummy apartment | reference | |
| Dummy detached house | 0.357*** | 0.040 |
| Dummy semidetached house | 0.198*** | 0.035 |
| Dummy corner house | 0.143*** | 0.031 |
| Dummy row house | 0.099*** | 0.030 |
| Dummy year of construction <1905 | -0.081* | 0.043 |
| Dummy year of construction 1906-1944 | -0.080** | 0.031 |
| Dummy year of construction 1945-1970 | -0.101*** | 0.032 |
| Dummy year of construction 1971-1989 | -0.106*** | 0.032 |
| Dummy year of construction 1990-2006 | reference | |
| Dummy built-in garage | 0.065*** | 0.009 |
| Dummy hot water heating | 0.086*** | 0.006 |
| Dummy ground lease | -0.017 | 0.012 |
| Dummy nice view (water, open space) | 0.005 | 0.004 |
| | | |
| **Location attributes** | | |
| Dummy Located in Voorburg | reference | |
| Dummy Located in Leidschendam | -0.035*** | 0.006 |
| Dummy Located in The Hague Mariahoeve | -0.041*** | 0.011 |
| Dummy direct proximity to bypass in tunnel | 0.024* | 0.013 |
| Dummy direct proximity to bypass on ground level | -0.031** | 0.014 |

## Appendix C. Robustness checks baseline model

In this appendix we test whether the estimates of model (2) stay robust when we allow for different valuation of traffic nuisance in different housing market segments. We investigate regional and price segmentation. To control for possible income differences in nuisance valuation[17], we estimate separate regressions for houses in a higher and lower price segment.[18] To control for possible regional differences, we estimate separate regressions for each of the three towns in our dataset. The estimated traffic nuisance effect is robust across space and income.

**Table C.1 Robustness analysis for market segments**

| traffic density (ln) | (1) Voorburg | (2) Leidschendam | (3) The Hague Mariahoeve | (4) Low Income | (5) High Income |
|---|---|---|---|---|---|
| adjacent to street | -0.0261 | -0.0194 | -0.0187*** | -0.0184*** | -0.0178* |
| | (0.0196) | (0.0132) | (0.00649) | (0.00571) | (0.0104) |
| distance (0,20] | -0.0108** | -0.00591 | -0.0151 | -0.00854 | -0.0125* |
| | (0.00531) | (0.00941) | (0.0142) | (0.00644) | (0.00698) |
| distance (20,40] | -0.00589 | -0.0118 | -0.00308 | -0.00511 | -0.00828 |
| | (0.00380) | (0.00760) | (0.00486) | (0.00341) | (0.00612) |
| PC6 Fixed effects | YES | YES | YES | YES | YES |
| Year dummies | YES | YES | YES | YES | YES |
| Neighbourhood-specific time trend | YES | YES | YES | YES | YES |
| Housing attributes | YES | YES | YES | YES | YES |
| $R^2$ within (within) | 0.765 | 0.785 | 0.795 | 0.764 | 0.775 |

[17] Day et al. (2007) suggest that people with higher income have a higher valuation of the amenity of quiet.

[18] The higher price segment is defined as all the houses with prices above the average price, the lower price segment is defined in a similar way.

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