Prostitution and House Prices: Evidence from Closing Brothels in the Netherlands*

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This Draft: *December 19, 2017*

Abstract

We measure the externalities of prostitution by quantifying the discount that households require to live next to a brothel. In our tests, we exploit a unique feature of Amsterdam's Red Light District (RLD), area inside a perimeter naturally delimited by canals where private homes are located next to prostitution windows. Using a novel two-dimensional difference-in-discontinuity (DiD) estimator, we find that households require a discount as high as 24% on homes inside the RLD. We also find that this discount disappears when prostitution windows are forcibly closed by local authorities. By incorporating the exact coordinates of brothel closings, our empirical design allows us to establish a direct link between these closings and changes in price discontinuities. To estimate the economic impact on households outside the RLD, we look at the closings of all brothels in Utrecht (the fourth largest city in the Netherlands) in 2013. Households are found to have paid up to 12% of the value of their home to be some distance from prostitution. In both cities, the contraction of the paid-sex industry is also associated with a drastic reduction in crime rates. Overall, our findings suggest that the nuisances prostitution creates do more harm than good to residents.

JEL Classification: C31, D12, D62, H43, K4, L83, R21, R53.

Keywords: Prostitution, Externality, House Prices, Willingness to Pay, Spatial Regression Discontinuity, Difference-in-Slope.

*The authors thank Christopher Timmins, Olivier Marie, Murillo Campello, J.J. Prescott, Thies Lindenthal, Frank Fagan, Jarek Kantorowicz, Jose Raimundo Carvalho, Mike Langen, seminar participants at the University of Amsterdam, Maastricht University and Syracuse University, and conference participants at the AREUEA International Conference, Annual Conference on Empirical Legal Studies (CELS), EALE Annual Conference, Singapore-Cambridge-Florida Real Estate Finance and Investment Symposium, Journées LAGV, and the America Latina Crime and Policy Network for helpful comments and suggestions. They also thank NVM for providing their housing transaction data, the municipalities of Amsterdam and Utrecht for their support, Arthur Croes and Joris van den Berg for research assistance, and Diloá Bailey-Athias, Martijn Dröes, Marc Francke, and Dorinth van Dijk for helping with housing data.

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1 Introduction

In the Epic of Gilgamesh, the sacred temple prostitute Shamhat uses her attractiveness to persuade Enkidu to leave the wild and join the civilized world in the city of Uruk, where Gilgamesh is king. The idea that prostitutes play a positive role is not uncommon in the epic world. Yet many societies have traditionally attached a negative connotation to paid sex, which is often related to many forms of violence, such as human trafficking, discrimination, and sexual abuse.[1] The public debate on prostitution gained new momentum in 2015 following a call by Amnesty International to protect the rights of sex workers, which several activist groups strongly opposed.[2] To weigh the pros and cons and make informed decisions on new policies, it is crucial to quantify how harmful the paid-sex industry is to society.

This paper attempts to value prostitution externalities by measuring individuals' willingness to accept (WTA) living next to a brothel, particularly in a context where it is legal but strictly regulated.[3] To do so, we exploit a unique feature of Amsterdam's Red Light District (RLD), an area inside a perimeter naturally delimited by canals where private homes are located right next to windows in which prostitutes display themselves. Empirically, identifying the causal effect of prostitution on house prices is difficult because it often emerges in declining areas, where rents are lower.[4] Using a novel two-dimensional difference-in-discontinuity (DiD) estimator, we find that homes next to prostitution windows are sold at a discount as high as 24%, compared to similar properties outside the RLD. This discount implies that households in Amsterdam require 4,100-7,100 euros per year to accept prostitutes working on their doorsteps.

To identify the causal effect of prostitution on housing values, we combine our discontinuity design with a city policy started in 2007 that aimed to reduce the number of sex windows. Since the Middle Ages, Dutch brothels have been tolerated, but confined in RLDs, sharing the city centers with family homes.[5] In the late 20th century, however, RLDs grew into free zones for sex-

[1] In an anecdotal case, the Dutch Central Bank (DNB) fired a supervisor in the Fall of 2014 for secretly being self-employed as a sex worker. She was officially dismissed for failing to inform her superiors of her second job and making herself vulnerable to blackmail (The Economist, Apr 17, 2015).

[2] The debate following Amnesty International's call to decriminalize prostitution has been extensively covered by the media. See The Guardian (Jul 28, 2015), The Huffington Post (Aug 4, 2015), New York Times (Aug 11, 2015), BBC (Aug 11, 2015), The Economist (Aug 19, 2015), and New York Times Magazine (May 25, 2016).

[3] The relationship between amenities and house prices has been broadly used to measure willingness to pay (WTP) and assess the monetary benefit of public policies. A non-exhaustive list includes studies on the value of education and school investments (Black, 1999; Cellini, Ferreira and Rothstein, 2010; Fack and Grenet, 2010; Gibbons, Machin and Silva, 2013), industrial pollution and health risk (Bui and Mayer, 2003; Davis, 2004; Hanna, 2007; Greenstone and Gallagher, 2008; Davis, 2011; Currie et al., 2015), air quality (Chay and Greenstone, 2005), airport noise (Mieszkowski and Saper, 1978; McMillen, 2004; Pope, 2008a) quality of neighbor properties (Rossi-Hansberg, Sarte and Owens, 2010), living in the homeland (Micheli, Rouwendal and Dekkers, 2014), and law enforcement (Thaler, 1978; Bishop and Murphy, 2011).

[4] See Kuminoff, Parmeter and Pope (2010) for the limitations of hedonic models in identifying WTA/WTP.

[5] Dutch society has a history of taking a tolerant approach to controversial issues, such as gay rights, abortion,

related businesses. With more than 400 "red" windows and a high concentration of sex shops and adult theaters, Amsterdam's RLDs became world famous. At the same time, the "legitimate" sex businesses increasingly turned into a cover for criminal activities involving hard drugs, protection rackets, human trafficking, and tax frauds (Huisman and Nelen, 2014).

In 2000, a new law legalized brothels and recognized prostitution as a legitimate profession. The goal was to give criminal courts jurisdiction to prosecute brothel owners in case of wrongdoing. In addition, the Public Administration Probity in Decision-Making Act of 2003 (*Bevordering Integriteitsbeoordelingen door het Openbaar Bestuur*, BIBOB) gave local governments the power to refuse licenses and permits to firms under investigation, including those in the sex industry. Empowered by the act, at the end of 2006 the city of Amsterdam started to close suspicious brothels. Furthermore, in 2007, the city council passed Project 1012, intended to reduce the number of brothels and coffeeshops (cannabis lounges) and upgrade shops and restaurants in the city center. By the end of 2014, the city had closed 27% of the red windows. According to our estimates, the result was an appreciation of 31 million euros in home values, somewhere between 16% and 26% of the initial deadweight loss.

As an alternative, we relax the assumption that the DiD in prices was all driven by the closure of brothels. Accordingly, we apply a conditional DiD design in which the DiD depends on both the changes in distance to a red window and unobserved events. In line with our main findings, our conditional results suggest that houses that are 100 meters closer to a brothel sell for 17-21% less. This marginal willingness to accept (MWTA) is very close to the one estimated using the unconditional DiD design. Furthermore, this analysis confirms that the average DiD is not driven by the gentrification promoted by Project 1012. Apart from the shrinkage of the RLDs, the gentrification has, if anything, appreciated properties on both sides of the border.

We perform several additional tests. First, we estimate the price discontinuity year by year, confirming that the discontinuity shift occurred in 2006-2008 (when Amsterdam started to close brothels). Second, we find that housing supply is continuous along the RLD borders and constant over time. Hence, changes in housing supply are unlikely to explain price discontinuities. Third, we find that the observable housing quality on both sides of the RLD bordering canals is similar. Fourth, our tests confirm that the distribution of non-prostitution businesses, such as bars, retailers, and coffeeshops, has not changed over time along the RLD borders. Finally, we find that all estimates are robust to several bandwidths around the MSE-optional value.

The setting that we exploit in Amsterdam identifies the minimum discount that households demand for accepting a brothel next to their house — i.e., the "environmental" cost of prostitution.

euthanasia, and drug legalization. Under its legal system, some transgressions, while not officially legalized, are tolerated (*gedogen*) (Buruma, 2007; Reinarman, 2016).

However, one may argue that the sex industry exerts positive effects on the local economy. By attracting tourists and clients, prostitution may affect jobs and income creation in related sectors.[6] If so, households everywhere else would be willing to pay more to live closer to the RLD. To identify their marginal willingness to pay (MWTP), we turn to the closing of all the RLDs in Utrecht, the fourth largest city in the Netherlands, which occurred in 2013 after allegations of human trafficking.[7] By applying a non-parametric difference-in-slope (DiS) estimator, we find that households paid up to 1.5% of their property value to be 100 meters further away from the RLDs. Their distaste for living close to a brothel makes them willing to overpay for houses as far as two kilometers away. This finding is robust to several bandwidths and specific to the chosen period — i.e., it does not appear before 2013 — and to the actual location of RLDs — i.e., random synthetic locations have a very small chance of replicating it.

To understand the type of nuisance related to prostitution, we also investigate the change in crime rates after the downsizing of RLDs in both cities. In Amsterdam, the crime rate in the RLD declined by 18% relative to other parts of the city. Even after accounting for the displacement to nearby areas, we observe a yearly reduction of at least 900 crimes (cases of violence, offenses against property, and illegal drug dealing). In Utrecht, the crime rate near the RLDs declined by 11%, which represents more than 300 crimes per year. Although felonies decreased more in the RLD near the center of the city, violent crimes significantly decreased in all the RLDs. Overall, the negative value attributed to prostitution is in part associated with households' perception of risk, which is justified by the actual occurrence of major felonies and misdemeanors.

Although much has been written about prostitution, the focus has been on the determinants of supply and demand in the sex industry (e.g., Edlund and Korn, 2002; Rao et al., 2003; Gertler, Shah and Bertozzi, 2005; Della Giusta, Di Tommaso and Strøm, 2009; Cunningham and Kendall, 2011; Arunachalam and Shah, 2012; Cunningham and Kendall, 2016; Li, Lang and Leong, 2017).[8] A few studies investigate the consequences of legalizing prostitution on people's acceptance (Kotsadam and Jakobsson, 2011), human trafficking (Cho, Dreher and Neumayer, 2013; Lee and Persson, 2015), and sexual violence (Cunningham and Shah, 2014; Bisschop, Kastoryano and van der Klaauw, 2017). Another related thread in the literature studies the influence of perceived risk, discrimination, and liberal policies on house prices (Gibbons, 2004; Pope, 2008b; Linden and Rockoff, 2008; Gautier, Siegmann and Vuuren, 2009; Funderburg and MacDonald, 2010; Ihlanfeldt

[6] The economic impact is not necessarily positive. For instance, Frondizi and Porcher (2016) provide evidence that the sex industry causes economic damage to other businesses.

[7] We note that neither setting is intended to identify the WTA/WTP of the whole population (Kuminoff, Smith and Timmins, 2013). Given the equilibrium sorting in the housing market, the WTP is estimated for those who are the least bothered by (or those who benefited the most from) the RLD. In the spirit of Harberger (1964) and Chetty (2009), under a few assumptions, our reduced-form estimates work as sufficient statistics for welfare effects. See also Banzhaf (2015).

[8] See also Cunningham and Shah (2016) for an overall view of this topic.

and Mayock, 2010; Adda, McConnell and Rasul, 2014). To the best of our knowledge, however, our study is the first to assess the monetary value of the externalities from prostitution.

The remainder of the paper is organized as follows. Section 2 provides a brief history of prostitution in the Netherlands. Section 3 outlines a model of rental prices to help understand our findings and identification assumptions. Section 4 describes the data. Sections 5 and 6 present the empirical strategy and the results for house prices in Amsterdam and Utrecht, in turn. Section 7 shows how safety has changed in the RLDs. Section 8 concludes the paper.

2 A Brief History of Prostitution in the Netherlands

Prostitution has been recorded in Amsterdam since the city was a fishing village in the 13th century. Two centuries later, when licensed brothels first appeared, one of its first by-laws had already recognized the importance of sex workers for a city of commerce. However, the city council legislated that only the city bailiff and his servants could operate a brothel within a restricted area close to the harbor, called *De Wallen* — Amsterdam's most famous RLD. Anyone pandering a sex worker outside this area would be subject to fines and imprisonment (Brants, 1998). Since the Middle Ages, local governments have tolerated prostitution in Dutch cities, as long as it was restricted to a designated area and did not become a public nuisance (Pol, 2011; Koski, 2007). Table 1 presents a timeline of events regarding prostitution policy in the Netherlands.

Table 1 About Here

There are only two periods in Dutch history in which either prostitution or brothels were criminalized. First, in the 16th century with the rise of Calvinism in the Netherlands. Rather than tolerated sinners, prostitutes were viewed as wretches who needed to be punished (Pol, 2011). Second, in the early 20th century, when religious parties obtained a parliamentary majority. Along with a growing abolitionist movement, this majority passed the Morality Laws in 1911, which criminalized prostitution-related activities, such as procuring and brothel keeping. Prostitution itself was not illegal, but profiteering from sex workers was (de Vries, 1997).

In practice, however, since the Dutch Golden Age in the 17th century, any effort to judicially suppress the operation of brothels was ineffective (Goodyear, 2009). Despite the ban on brothels of 1911, throughout the 20th century Dutch cities adopted unofficial tolerance policies, which confined prostitution to RLDs and *tippelzones* — nonresidential areas where street prostitution was allowed. These policies were in line with the Dutch pragmatic tolerance (*gedoogbeleid*) towards morally controversial issues. As long as public order was not threatened, authorities turned a blind eye to what was happening in the RLDs (Outshoorn, 2012).

The 1930s mark the beginning of the *raamprostitutie* (window prostitution), which gradually began attracting tourists to the Dutch RLDs (Goodyear, 2009). Until the end of the 1960s, in spite of the high concentration of sex workers, *De Wallen* was still one of the safest parts of Amsterdam, with many cafes and restaurants (Sabat, 2012). In the 1970s, the RLDs grew into free zones for sex-related businesses. Relaxation of the laws on pornography led to the proliferation of live porn theaters, sex shops, and adult cinemas (Brants, 1998).

Those who could afford it, including Dutch prostitutes catering for an elite clientele in sex clubs and through escort services, moved out of the RLDs. These sex workers were gradually replaced by immigrants from developing countries and former Dutch colonies (Brants, 1998). With a large turnover, prostitution became intrinsically connected to a complex criminal network involving drug trafficking, protection rackets, human trafficking, and tax frauds (Outshoorn, 2012; Huisman and Nelen, 2014) and RLDs, including *De Wallen*, became a no-go area for the police. With citizens complaining about drunkenness, rowdiness, and violence against sex workers, public opinion swung towards repealing the ban on brothels and regulating the sex industry (Koski, 2007). As brothels were prohibited by law, local efforts to regulate them were often rejected in court. The urge to empowering local authorities and clean up the sex industry entered the political agenda in the 1990s (Visser, Oomens and Boerman, 2000).

After an unsuccessful attempt from the Second Chamber in 1992, a bill decriminalizing voluntary exploitation was passed in 1999 and implemented in October 2000. This bill gave municipalities the authority to regulate prostitution branches, but also granted several rights to sex workers (including access to social security) along with the obligation to pay taxes (Outshoorn, 2012). The early 2000s were marked by an increase in red windows in Amsterdam, from around 200 to more than 400 (Amsterdam, 2008). There was also a large inflow of prostitutes from Eastern Europe, as well as from non-EU countries (Wijk et al., 2010).

To further empower local authorities in their fight against human trafficking and other crimes, the Public Administration Probity in Decision-Making (*Bevordering Integriteitsbeoordelingen door het Openbaar Bestuur*, BIBOB) Act went into effect on June 1, 2003. The municipality of Amsterdam first invoked the BIBOB law at the end of 2006. In that year, 108 sex businesses were investigated and 58 were closed (Amsterdam, 2010). At the same time, the city decided to buy 26 prostitution-related properties, where more than 10% of the red windows. This buyout is part of Project 1012, launched at the end of 2007 and intended to reduce crime and the presence number of businesses with little economic value in the central area.[9] By the end of 2014, 27% of the red

[9]Project 1012 has been executed along three lines: ten key projects intended to boost the district's economy; investments in public areas; and improvements to activities in a number of streets by closing or reallocating coffeeshops and brothels. Figure A1 of the Appendix shows the location of all interventions. According to Huisman and Nelen (2014), Project 1012 has not achieved its goals because it ran out of funds in 2011 due to the financial

windows were closed either by applying the BIBOB law or by buying out properties. Some of them have been converted into homes and others occupied by retailers.

Amsterdam is not the only city that has reduced the number of sex establishments. For instance, Alkmaar and Groningen have also used the BIBOB law to downsize their sex industry. In Utrecht, signs of human trafficking led the municipality to start an investigation in 2008, which culminated in the shutdown of all brothels in May-July 2013. The construction of a new RLD, far from the city center, was approved at the end of 2016, but the project has been delayed. In the whole Netherlands, the number of red windows declined from 2,096 in 1999 to 1,466 in 2009, while the number of sex clubs went from around 800 in 2000 to 370 in 2010 (Wagenaar, Altink and Amesberger, 2013).[10] With less work spaces available, sex workers are reported to be looking for other jobs or to be working from home using other forms of solicitation, such as online.

Despite the contraction of the paid-sex industry, Wijk et al. (2010) estimate that between 5,000 and 8,000 prostitutes were working in Amsterdam in 2009.[11] About 21-44% were working in red windows, 11-16% in sex clubs, 9-12% in licensed escort services, and 26-39% in private homes. No license is required for working as a prostitute at home; it is considered legal as long as the prostitute works alone and is self-employed. Finally, at least 12% of sex workers in Amsterdam are working illegally, mostly in unlicensed escorting and massage parlors.

3 Conceptual Framework

The two settings that we exploit — boundary discontinuity in Amsterdam and industry shutdown in Utrecht — have distinct interpretations. The former assesses only the environmental externality, related to the noise, crowdedness, and presence of sex workers in the RLD. The latter assesses the value of the RLD for those living out of the area. To illustrate the counterfactual differences, we outline a simple model of housing prices in the context of on-site prostitution. A detailed model is available in the online appendix.

We start by considering that on-site prostitution creates "noise." Some individuals may like it, but others may not. This noise depends on the distance to prostitution, h, and is measured by the function $r_t(h)$ at time t. Each location h also provides other amenities, such as bars, restaurants, schools, parks and theaters. Their level is measured by a continuous function, $g_t(h)$. Then for an individual living at h_i, their indirect utility function is given by:

$$V_{it} = v_i \left[r_t \left(h_i \right), g_t \left(h_i \right) \right] + w_{it} \left(h_i \right) - p_t \left(h_i \right),$$

crisis and imprecise financial planning.

[10] According to the blog Behind the Red Light District, there were 1,272 red windows in the country in 2016.

[11] These are annual numbers. Wagenaar, Altink and Amesberger (2013) estimate that in the four largest Dutch cities at least 2,200 sex workers are active on an average day, 35% of them in Amsterdam.

where $p_t(h_i)$ is the equilibrium price for location h_i at time t and $w_{it}(h_i)$ is the individual's disposable income. The disposable income depends on how often and close to prostitution the individual must go to earn and spend their salary.

The first order condition implies that the bid function for location h_i is equal to the marginal utility of h_i — or the marginal rate of substitution between h_i and a bundle of other private goods — plus the marginal income yielded by living at h_i:

$$\frac{dp_t}{dh_i} = \frac{\partial v_i}{\partial r_t}\frac{dr_t}{dh_i} + \frac{\partial v_i}{\partial g_t}\frac{dg_t}{dh_i} + \frac{dw_{it}}{dh_i}. \tag{1}$$

The first term represents the marginal willingness to accept (MWTA) the noise caused by prostitution, r, the second term is marginal willingness to pay (MWTP) for other amenities at h_i, and the third term is the marginal income at h_i. Given the confoundedness among those terms, neither can simply be recovered from a hedonic regression, also known as Rosen's (1974) first stage.

3.1 Setting 1 - Canal as a Border

3.1.1 Cross-sectional discontinuity

Suppose that brothels are located at $h = 0$ and a canal, or a wall, is placed at location $c > 0$, between part of the houses and the brothels. This area, denoted by $\overline{h} \in [0, c)$, is named RLD. Although the commuting cost to brothels is not affected, two environments are created: one where the noise is felt, and another that is isolated by the canal.

The bid price for a house in the RLD is the same as in (1). However, individual j living out of the RLD, $\underline{h}_j \in (c, 1]$, is not affected by r and the marginal bid function is simply:

$$\frac{dp_t}{d\underline{h}_j} = \frac{dw_{it}}{d\underline{h}_j} + \frac{\partial v_i}{\partial g_t}\frac{dg_t}{d\underline{h}_j}. \tag{2}$$

As $\overline{h}_i$ and $\underline{h}_j$ approach c, individuals i and j tend to be more similar in their taste for g and marginal income. Thus the price discontinuity at c is:

$$\begin{aligned}
\tau_t(c) &\equiv \lim_{\overline{h}_i \to c} p_t\left(\overline{h}_i\right) - \lim_{\underline{h}_j \to c} p_t\left(\underline{h}_j\right) \\
&= v_i\left[r_t(c), g_t(c)\right] - v_i\left[0, g_t(c)\right] \\
&\approx \frac{\partial v_i}{\partial r_t}(c) \cdot r_t(c),
\end{aligned} \tag{3}$$

which is equal to individual i's (discrete) willingness to accept (WTA) the noise at c.[12]

[12] The price discontinuity, $\tau_t(c)$, actually lies between the individual i's WTA and individual j's WTP for $r_t(c)$. By the continuity of individual types and inelasticity of the housing supply, their WTP and WTA must converge to the same value. That is to say, there is some individual out of the RLD, who is very similar to i and whose WTP will drive up the price inside. Yet the empirical evidence suggests that for the same individual, WTA is often greater than WTP (Brown and Gregory, 1999; Horowitz and McConnell, 2002).

By placing c at different locations, we can fully recover the hedonic function of externalities from $c = 0$, where r_t is the maximum, to $c \to \infty$, where r_t is the minimum. This is the reason why we adopt a two-dimensional regression discontinuity design, described in section 5.1. This hedonic function, however, is not equivalent to the average bid function because individuals are heterogeneous and sort themselves on the basis of their tastes. While the most receptive to prostitution will live close to brothels, the most averse will live as far away as possible. Then for $c \to 0$, the price discontinuity, $\tau_t(c)$, is the lower bound of the discount required by the average individual to live next door to a brothel. This lower bound is not sufficient to predict the welfare impact of expanding the RLD, but it is sufficient to predict the ex-ante impact of a contraction.

3.1.2 Difference in discontinuity

If either individuals i and j are different or houses are not homogeneous at the border, then the discontinuity $\tau_t(c)$ would also comprise these differences. To identify the WTA, suppose that the sex industry shrinks from time 0 to time 1, so that $r_0(\overline{h}) - r_1(\overline{h}) = \Delta r > 0$. Holding everything else constant, the bid function for r at c is identified by the difference in discontinuity:

$$\begin{aligned} \Delta\tau(c) &\equiv \tau_0(c) - \tau_1(c) \\ &\approx \frac{\partial v_i}{\partial r}(c) \cdot \Delta r. \end{aligned} \tag{4}$$

That is, the ratio between $\Delta\tau(c)$ and Δr identifies the MWTA at c.

A reduction in the sex industry would also provoke changes in the disposable income, w_{it}. Yet this change would equally affect individuals on both sides of the canal. Furthermore, a single-crossing condition is necessary for the identification in (4), so that individuals are ordered by the value that they give to the externality and the ordering is the same for an industry of any size.[13]

3.2 Setting 2 - Sex Industry Shutdown

In the second setting, we consider the case in which no one lives in the RLD and all brothels are closed from time 0 to time 1. At time 0, the hedonic function for location h looks like (2). At time 1, this hedonic function depends only on the MWTP for other amenities:

$$\frac{dp_1}{dh_i} = \frac{\partial v_i}{\partial g_1}\frac{dg_1}{dh_i}. \tag{5}$$

That is, with no prostitution, the disposable income becomes flat.

A necessary assumption for identification is that the relative distribution of other amenities does not change, so that $g_1'(h) = g_0'(h) = g'(h)$ for all h. Then the difference in hedonic prices at

[13] This condition implies that individuals can always be sorted across some attribute in the same order, even if the consumption of other attributes changes (Edlin and Shannon, 1998; Banzhaf, 2015).

h_i is only a function of the marginal income created by the sex industry:

$$\frac{dp_0}{dh_i} - \frac{dp_1}{dh_i} = \frac{dw_{i0}}{dh_i}. \tag{6}$$

As long as prostitution does not emerge somewhere else, this difference will not be driven by the relocation of households. It is worth stressing that the marginal income is not only related to the distance to the workplace, but also to the time spent in the RLD.

4 Data Sources

4.1 House prices

Our main data source is the NVM database. NVM is the Dutch Association of Real Estate Brokers and Experts, which has more than 4,000 members. Its members handle approximately 70% of all transactions of owner-occupied homes in the Netherlands. In cities such as Amsterdam and Utrecht, their market share is about 90%.[14] According to de Wit, Englund and Francke (2013), the NVM sample is unbiased and gives a reliable picture of the Dutch housing market.

NVM members are required to report all dwellings offered for sale. The information given includes geocoded location, transaction price and the date of sale, as well as initial asking price and first day on the market. The geographic coordinates refer to the centroid of six-digit postal codes, which represent a narrow range of about six house numbers on the same street. For dwellings located within one kilometer from an RLD, the exact coordinates were obtained using Google Maps API. For the purpose of this paper, we exclude houses that were either withdrawn from the market without being sold or remained unsold for more than six years, had either more than 500 square meters or less than 20 square meters, and had more than 15 rooms.

The NVM records also include an exhaustive list of characteristics and subjective assessments of the dwellings. Table 2 reports the descriptive statistics of some characteristics for two different samples. Statistics of the remaining characteristics are in Table A1 in the Appendix. The first sample is of sold houses within two kilometers from the RLDs in Amsterdam between 1991 and 2014. This sample, however, does not include houses in Amsterdam Noord, an area detached from the rest of the city by the IJ bay. The second sample is of sold dwellings within three kilometers from the RLDs in Utrecht in 1991-2014.

TABLE 2 ABOUT HERE

Overall, prices are higher in Amsterdam than in Utrecht and in the sample used. Because of our design, the sampled dwellings are close to the city centers, so they are smaller and more

[14] Market share is calculated by comparing sales numbers from NVM and Kadaster, available at statline.cbs.nl, from 2001 to 2014.

likely to be apartments than in the rest of the city. Buildings in the sample are also considerably older, most being built before 1931, and less likely to have a lift and parking space. However, in Amsterdam at least, they are a better maintained. In this sample, 23% of dwellings are considered of luxury standard and 10% are heritage listed.

4.2 Other data sources

The data on prostitution windows come from two different sources. The first is a website created in 2008 that contains information on RLDs in Europe, www.amsterdam-red-light-district-maps.com. This website provides maps of RLDs with the exact location of each red window, including the closed ones. The second is the city of Amsterdam, which provided the zoning plans of the municipality, the location of properties with brothels, and the dates when these properties were bought and when red windows were closed.

Registered crime data were obtained from the Department of Research and Statistics of the city of Amsterdam and from Utrecht's police department. In Amsterdam, these data are publicly available at neighborhood (*buurt*) level from 2003 to 2014. In Utrecht, data were provided at the sub-neighborhood (*subbuurt*) level from 2011 to 2015. For both cities, we observe the number of several kinds of reported felonies, such as burglary, motor vehicle theft, pick-pocketing, assaults, and drug trafficking. Moreover, the city of Amsterdam provides risk perception indices per neighborhood from 2003 to 2013. These indices derive from a survey collected by the Security Monitor (*Veiligheidsmonitor*) from the Ministry of Security and Justice. For Utrecht, data on risk perception are available for sub-districts (*subwijk*) from 2006 to 2015 on the municipality website.

Information on local businesses is obtained on Orbis from Bureau van Dijk. From this platform, we collected the street address, legal status, industry code and trade description for every establishment, including branches, that was active at any time between 2001 and 2015. The cities of Amsterdam and Utrecht also provided a list with all the businesses registered under their jurisdiction. By checking this list, we confirm that Orbis has the correct location of almost every establishment. These locations were then geocoded using Google Maps API. Another variable from Orbis is the number of employees, which is available only for 2007-2015.

The industry codes on Orbis do not distinguish cannabis sales from other retail trades and not every coffeeshop (cannabis lounge) includes cannabis in its trade description. As a result, we also consulted a list of coffeeshops from www.coffeeshopdirect.com, which has the most complete directory of coffeeshops in the Netherlands since 1998. From this list, we find almost 100% of the active coffeeshops and more than 90% of the inactive ones on Orbis, based on company name, trade description, address, and status.

5 Prostitution and House Prices in Amsterdam

Amsterdam currently has three RLDs: *De Wallen*, the biggest and most famous; *Singelgebied*, also located in the central area; and *Ruysdaelkade*, the smallest, which is located in the South District (*Amsterdam-Zuid*). Because of their size and location, we focus our analysis on the first two RLDs. *Ruysdaelkade* is hardly noticeable given its size and the absence of related businesses around (Weitzer, 2012). Moreover, there has been no significant change in the location of its windows.

De Wallen and *Singelgebied* have been well-defined, tolerance zones since the postwar period, with no red window operating out of their limits. Figure 1 shows the location of these two areas, which are about 300 meters apart, along with the heat maps of house prices in 1991-2006 (on the center) and 2007-2014 (on the right). These maps confirm that prices are lower in the RLDs, especially in *De Wallen*, than in nearby areas. Within 500 meters in the center of Amsterdam, the average house price can change by more than 1,500 euros/m^2.

FIGURE 1 ABOUT HERE

The spatial limits of these RLDs are partly defined by streets and alleys and part by canals. Although the "land" borders of the RLDs are debatable, the canals, or "natural" borders, clearly define a limit to what belongs to the area and what does not. These canals are named *Gelder-sekade*, on the east side of *De Wallen*, and *Herengracht* and *Blauwburgwal*, on the west side of *Singelgebied*. To estimate and test the effect of the RLDs on housing values, we use these natural borders as a spatial cutoff where prices are presumably discontinuous.[15] In the heat map at the center of Figure 1, we indeed observe that prices are very different across the border, at least until 2007. The price difference between two similar houses, arguably in the same area of the city but separated by a canal, could be more than 400 euros/m^2. After 2006, however, prices practically equalized along the bordering canals. This process can be explained by the fact that several red windows were closed and they are now concentrated towards the city center, where house prices remain low.

5.1 Empirical Strategy

The cross-sectional difference between house prices at the RLD borders is estimated using a sharp Regression Discontinuity (RD) design. This RD has two running variables: latitude and longitude. Unlike the conventional RD design, the cutoff point is not unique, but it is the set of coordinates that defines the natural border (the dark blue line in Figure 1). Given that prostitution is not

[15] We also estimate the price discontinuity at the land borders and findings are not significant.

evenly spread within the RLDs, this approach allows us to identify where the discontinuity is stronger and verify whether its strength is related to the location of red windows.

Because the number and location of red windows change over time, we expect that the RD estimates also change. As explained in section 3.1.2, a difference-in-discontinuity (DiD) design is applied to identify the MWTA of prostitution externality. All estimators and estimation procedures are described in detail in the Appendix.

5.1.1 Two-Dimensional Regression Discontinuity

Let y_{it} be the log price per square meter at which house i is sold at period t. Consider this variable a function of longitude, s_{1i}, and latitude, s_{2i}, as follows:

$$y_{it} = (1 - z_i)\,\mu_{0t}(s_{1i}, s_{2i}) + z_i\,\mu_{1t}(s_{1i}, s_{2i}) + x'_{it}\beta_t + \varepsilon_{it}, \tag{7}$$

where x_{it} is a vector of dwelling characteristics, z_i indicates whether property i is in the RLD, and μ_{1t} and μ_{0t} are functions mapping locations to prices in and out of the RLD, respectively. The estimated hedonic coefficients of β_t are reported in Table A2 of the Appendix.

Let $\mathbf{c} = \{(c_{11}, c_{21}), \ldots, (c_{1L}, c_{2L})\}$ be the set of coordinates that defines the RLD border and $d(.)$ be the distance function between two coordinates. Also let $\tilde{d}\left(\boldsymbol{c}_l, \boldsymbol{s}, z\left(\boldsymbol{s}\right)\right) = (1 - 2z) \cdot d\left(\boldsymbol{c}_l, \boldsymbol{s}\right)$, which is negative if coordinate $\boldsymbol{s} = (s_1, s_2)$ is in the RLD ($z = 1$) and positive otherwise ($z = 0$). At a specific location l on the border, the estimand of interest is:

$$\tau_{lt} \equiv \lim_{\tilde{d}(\boldsymbol{c}_l, \boldsymbol{s}) \uparrow 0} \mu_{1t}(s_1, s_2) - \lim_{\tilde{d}(\boldsymbol{c}_l, \boldsymbol{s}) \downarrow 0} \mu_{0t}(s_1, s_2)\,, \tag{8}$$

i.e., the difference between limits of a conditional expectation approaching the border from inside ($z = 1$) and from outside ($z = 0$). According to Hahn, Todd and Van der Klaauw (2001), τ_{lt} is identifiable as the average treatment effect at l under a few conventional smoothing assumptions.

As discussed in section 3.1.1, τ_{lt} tells us how much the household living at the edge of the RLD requires to accept the externality from prostitution — i.e., the price discontinuity derives from the non-marginal WTA. However, different points on the border line may sustain distinct levels of externality. That is, their distance to a red window, denoted by r_{lt}, is not constant. By letting τ_{lt} vary along the border, we can pin down the connection between house prices and red windows. Given that the number and location of red windows have changed over the years, the price discontinuity is estimated for two periods: 1991-2006 and 2007-2014. But we also estimate τ_{lt} for 1991-2000 and 2001-2006, as well as for every year from 1991 to 2014.

5.1.2 Difference in Discontinuity

Since the RD estimands are specific per location and period, this approach also enables us to calculate changes in the price discontinuity over time:

$$\Delta\tau_l \equiv \tau_{l0} - \tau_{l1}, \tag{9}$$

where $t = 0$ is the period when all red windows are operating and $t = 1$ is the period when some of them are closed. As discussed in section 3.1.2, the DiD controls for the unobserved differences at the border that remain unchanged. By spatially locating where the red windows were closed, we can verify the relationship between the closing of windows, Δr_l, and price changes, $\Delta\tau_l$.

Furthermore, assuming that other amenities remain constant, we can also identify the price effect in other parts of the RLD, far from the border. In this case, we compare the price change in any location in the RLD with the price change at the closest point of the border:

$$\Delta\tau\left(\boldsymbol{s}\right) = \mu_{10}(\boldsymbol{s}) - \mu_{11}(\boldsymbol{s}) - \left\{\mu_{00}(\boldsymbol{c}_l) - \mu_{01}(\boldsymbol{c}_l) \mid \boldsymbol{c}_l \in \mathbf{c} \text{ and } \boldsymbol{c}_l = \operatorname{argmin} d\left(\boldsymbol{c}_l, \boldsymbol{s}\right)\right\}. \tag{10}$$

Once again, we can visually compare $\Delta\tau\left(\boldsymbol{s}\right)$ with the location of the closed windows.

After estimating $\Delta\tau_l$ for different points on the border line, we calculate the MWTA of the externality by applying the following Wald estimator:

$$\hat{v}_r\left(r, g, \boldsymbol{x}\right) = \frac{\sum_l \hat{f}\left(\boldsymbol{c}_l\right)\Delta\hat{\tau}_l}{\sum_l \hat{f}\left(\boldsymbol{c}_l\right)\Delta\hat{r}_l}, \tag{11}$$

where $\hat{f}(.)$ is the estimated density of dwellings and $\Delta\hat{r}_l$ is the estimator for the difference in the distance to a red window at location l:

$$\Delta r_l = \lim_{d(\boldsymbol{c}_l,\boldsymbol{s}_i)\to 0} \mathbb{E}\left[r_{it}|\boldsymbol{x}, t=0\right] - \lim_{d(\boldsymbol{c}_l,\boldsymbol{s}_i)\to 0} \mathbb{E}\left[r_{it}|\boldsymbol{x}, t=1\right].$$

5.1.3 Conditional Difference in Discontinuity

Estimator (11) is unbiased as long as the expected DiD depends on no event other than the closing of red windows. Another approach to test the relationship between DiD and closed windows and estimate the MWTA is the conditional difference-in-discontinuity design.

Consider that the log price, y_{it}, is a function of the minimum distance to a red window, r_{it}:

$$y_{it} = \alpha_i \cdot r_{it} + x'_{it}\beta_t + \kappa_{it} + \varepsilon_{it}, \tag{12}$$

where α_i is the hedonic price that house i's occupant pays for r_{it}, κ_{it} is the effect of unobservables at time t, and ε_{it} is a zero-mean random term.

Unlike equation (7), location is not defined by latitude and longitude, but by minimum distance to the RLD border, s_i, and the initial distance to a red window, r_{i0}. If $s_i \leq 0$, then house i is in the RLD ($z_i = 1$). Otherwise, house i is out of the RLD ($z_i = 0$). Then we assume that α_i and κ_{it} depend on location (s_i, r_{i0}), as follows:

$$\alpha_i = z_i \cdot \alpha_1(s_i, r_{i0}) + (1 - z_i) \cdot \alpha_0(s_i, r_{i0}) \quad \text{and} \quad \kappa_{it} = z_i \cdot \kappa_{1t}(s_i, r_{i0}) + (1 - z_i) \cdot \kappa_{0t}(s_i, r_{i0}).$$

Both functions are continuous everywhere but at the border ($s = 0$), as explained in section 3.1.

From equation (12), the price discontinuity at the RLD border is:

$$\tau_{lt} = \lim_{s \uparrow 0} \left[\alpha_1(s, r_{l0}) \cdot r_{lt} + \kappa_{1t}(s, r_{l0})\right] - \lim_{s \downarrow 0} \left[\alpha_0(s, r_{l0}) \cdot r_{lt} + \kappa_{0t}(s, r_{l0})\right]; \tag{13}$$

and the DiD is approximately given by:

$$\Delta\tau_l \approx \delta^0 \Delta r_l + \delta^1 (r_{l0} \cdot \Delta r_l) + \delta^2 + \delta^3 r_{l0}, \tag{14}$$

where

$$\begin{aligned}
\delta^0 &\equiv \lim_{s \uparrow 0} \left[\partial\alpha_1(s,0)/\partial r\right] - \lim_{s \downarrow 0} \left[\partial\alpha_0(s,0)/\partial r\right], \\
\delta^1 &\equiv \lim_{s \uparrow 0} \left[\partial^2\alpha_1(s,0)/\partial r_0 \partial r\right] - \lim_{s \downarrow 0} \left[\partial^2\alpha_0(s,0)/\partial r_0 \partial r\right], \\
\delta^2 &\equiv \lim_{s \uparrow 0} \Delta\kappa_1(s,0) - \lim_{s \downarrow 0} \Delta\kappa_0(s,0), \text{ and} \\
\delta^3 &\equiv \lim_{s \uparrow 0} \left[\Delta\partial\kappa_1(s,0)/\partial r_0\right] - \lim_{s \downarrow 0} \left[\Delta\partial\kappa_0(s,0)/\partial r_0\right].
\end{aligned}$$

From equation (4) in section 3.1.2, δ^0 represents the MWTA of the externality at the house right next to a red window ($r = 0$), whereas δ^1 is its derivative with respect to r. Moreover, for $\Delta r = 0$, if $\delta^2 = \delta^3 = 0$, then the average price discontinuity does not depend on other events. The estimation of equation (14), as well as equations (7)-(11), is described in the Appendix.

5.2 Estimation Results

5.2.1 Price Discontinuity at the Canals

As predicted by the monocentric city model, house prices should decrease with distance to the city center (Brueckner, 1987). In Amsterdam we indeed observe decreasing values, but only after a few hundred meters from the center. The inverse U-shaped relationship between prices and distance to the center may be due to the location of RLDs, which in theory lowers property values.

In Figure 2, we compare properties in and out of the RLD that are separated by the natural border. These properties are essentially at the same location in the city, but on opposite sides of the bordering canal. By applying an one-dimensional RD design, which takes only the minimum

distance to the border as a running variable, we find that households until 2007 were paying 16.8% less to live on the RLD side of the canal. This price difference confirms that the most expensive square meter in Amsterdam is on the banks of the canals that demarcate the RLDs.

FIGURE 2 ABOUT HERE

In 2007-2014, the period when the municipality closed some red windows and re-designed the RLDs, the gap between house prices at those canals disappeared. To confirm that the discontinuity decreased after 2006, we also estimate RDs for three-year periods using transaction prices and for one-year periods using asking prices. Despite the bias, the sample of asking prices is 60% higher than the sample of transaction prices, so it provides narrower confidence intervals per year. The RD estimates in Figure 3 show that the difference is negative at least up to 2006. Prices in the RLD side of the border increased in 2006-2008 and the difference remained close to zero afterwards. Not even the legalization of brothels in 2000 has an effect as clear as the use of the BIBOB Act and the buyout policy, which started at the end of 2006.

FIGURE 3 ABOUT HERE

To verify whether the price equalization at the border coincides with the closing of red windows, we present RD estimates that vary along the canals. Presumably, the closer the red windows are to the border, the higher the estimated discontinuity. Figure 4 present the two-dimensional RD estimates, along with the location of the operating and closed windows. In panel (a), for 1991-2006, the RD estimates range from nearly zero, in parts that are far from the operating windows, to -24%, in parts that are close to them. That is to say, not all properties in the RLD are subject to a discount; this depends on how close they are to the prostitution windows.

FIGURE 4 ABOUT HERE

In 2007-2014, in panel (b), the number of operating windows is much lower than before. It is worth noting that most of the closed windows, identified with an 'x', are near the bordering canals. As a result, the price discount on the border practically disappears. In fact, house prices are even higher in some parts of the RLD than outside. As noted before, this positive difference may be caused by unobserved characteristics, which implies that the discount in 1991-2006 is underestimated.

5.2.2 Difference in Price Discontinuity

To control for unobserved characteristics, we estimate the difference in price discontinuities in different parts of the RLD, as shown in Figure 5. These estimates confirm that from 1991-2006

to 2007-2014, house prices increased more in the RLD than outside. The DiD is particularly significant along the natural borders (dark blue lines), where most of the closures of red windows took place. Prices anywhere else changed as much as prices outside the RLDs. The flexible way of estimating price differences reveals that the discount is between 21% and 30% if the house is directly beside a red window.

FIGURE 5 ABOUT HERE

To compare the location of the closed windows in Figure 5 with other developments, Figure A1 of the Appendix shows the map of interventions from Project 1012. This map confirms that these developments are spread over several places. However, they do not coincide with the closing of red windows at the border, particularly on *Geldersekade* (east border) and between *Singel* and *Herengracht* (west border). Therefore, these developments either have no immediate effect on house prices in the RLD or affect values equally on both sides of the border.

Table 3 presents the average DiD at the border, along with changes in the distance to a red window and estimates for the MWTA, as in equation (11). Under several bandwidths, the estimated average DiD ranges between 11.4% and 25.2%. Even if we change the initial period to 2001-2006, the estimates remain similar. Our findings also show that there was no significant change in price discontinuity from 1991-2000 to 2001-2006, after brothels were legalized. Judging from the distance to a red window, changes after 2000 were not as great as changes after 2006. In the latter period, the average distance of a house at the border to a red window increased by almost 100 meters. This first-stage effect is strong enough to identify a significant MWTA, which lies between 17.6% and 25% per 100 meters.

TABLE 3 ABOUT HERE

Another approach to estimating the MWTA and testing whether other events explain the average DiD is the conditional DiD design, as shown in equation (14). Table 4 presents these estimates, which confirm that the MWTA is between 17% and 21% per 100 meter. Therefore, the conditional DiD estimates do not deviate from the ones in Table 3. Table 4 also shows, however, that the MWTA declines with distance. That is, the coefficient of the interaction between change in distance and initial distance is significantly negative. Its value implies that the MWTA drops by half for each 100 meters.

TABLE 4 ABOUT HERE

Moreover, neither the intercept nor the coefficient of initial distance is found to be significant. Because both parameters are close to zero, it is unlikely that an event other than the closure of windows affected the estimated discount in house prices. Thus we confirm that other components of Project 1012 do not drive our DiD estimates. Finally, the results are robust if we use 2001-2006

as the initial period and no significant change is found after the legalization of brothels, between 1991-2000 and 2001-2006.

5.2.3 Willingness to Accept Prostitution and Welfare Loss in Amsterdam

In summary, our findings indicate that households require around 21-30% of their home's value to live next to a prostitution window. However, this discount declines with distance and tends to disappear after 200 meters. To calculate the external cost of prostitution in terms of annual outflow, we consider that in 2014 the median property within 100 meters from the RLD border was worth 370,000 euros. With a mortgage interest rate between 3.5% and 5% per annum for a 30-year loan, we estimate that brothels cost 4,100-7,100 euros per year to any household next door. This cost represents 16-28% of the median household income in Amsterdam.

Furthermore, considering that all homes in the RLD are worth 920 million euros, we calculate that up until 2007 about 121-192 million euros used to be lost in property values.[16] This figure means that to live in the RLD all households together required 7-12 million euros a year, which is close to the annual budget of Project 1012.

Based on the estimates in Figure 5, we calculate that all houses in the RLDs have appreciated, since 27% of the red windows were closed, by at least 31 million euros, which lies between 16% and 26% of the initial loss. Although the number is not publicly available, a local source claims that Project 1012 had spent almost 25 million euros in property buyouts up to 2015.[17] If we take only the social nuisance into account, but not the economic impact, we conclude that the buyouts have had a surplus of at least six million euros.

5.2.4 Housing Supply at the Canals

Since some of the red windows have been converted into homes, the above results could also be affected by a shock in the housing supply. In addition, the price difference on the canal borders might be driven by housing developments on either side. A simple way of testing these shocks is verifying whether the number of houses for sale is continuous at the border.[18]

Figure 6 presents McCrary's (2008) density test, where θ is the log difference between the limits of the density function approaching the border from both sides. This test reveals that the

[16] These numbers take into account several linear and non-linear specification derived from Tables 3 and 4. The aggregation is made through a sample of houses on the market in the last 30 years, whose price is deflated using annual hedonic regressions. The aggregate amount is also divided by 46%, which is the percentage of the dwelling stock in the center of Amsterdam that has been offered for sale through a NVM member.

[17] Source: De Telegraaf (Mar 19, 2015).

[18] Another hypothesis is that mortgage lenders deny loans to properties in the RLD, making sales less frequent. Accordingly, we also test for discontinuity in sales and find no significant evidence.

density of houses on the market is fairly continuous in both periods. Since the density test can be sensitive to the choice of bin width, we also present test results under several bin widths in Table A3 of the Appendix. In any case, the continuity hypothesis is never rejected.

FIGURE 6 ABOUT HERE

Although housing supply is constrained, landlords may respond to externalities by improving and maintaining their dwellings. In fact, Table 5 presents some significant differences in housing features at the RLD border.[19] In 1991-2006, for instance, the interior and exterior maintenance condition was slightly worse on the RLD side. However, by combining those estimates with hedonic coefficients, we find that they account for a price difference of less than 1%. More characteristics are found to be significantly different in 2007-2014. In particular, the dwellings sold on the RLD side were on average smaller. This difference may have been a response to the increase in the value of the square meter, but the price effect remains small, around 2%.

TABLE 5 ABOUT HERE

5.2.5 Distribution of Other Businesses

One may argue that the RLDs in Amsterdam also concentrate other types of business that create externalities, such as bars, coffeeshops (cannabis lounges and dispensaries) and nightclubs. To verify the distribution of other businesses, we divide them into four categories:

1. *coffeeshops* – Establishments that sell cannabis for consumption either inside or outside.
2. *cafes* – Establishments that serve mostly alcoholic beverages, such as bars and nightclubs.
3. *restaurants* – Establishments classified as either 'restaurant' or 'hotel-restaurant,' excluding diners and lunchrooms.
4. *stores* – Specialized retailers, excluding grocery stores, gift shops, and sex shops.

The maps in Figure 7 show the location of the first three types in 2001, 2007, and 2014. First, they confirm that coffeeshops are neither restricted to the RLD nor to the central "island" in Amsterdam. Second, along with coffeeshops, cafes and restaurants are indeed more concentrated in the RLD. However, these establishments also appear on the other side of the RLD border. McCrary's test, shown in Table A5 of the Appendix, confirms that the density of coffeeshops, cafes, and restaurants is higher on the RLD side of the border in any year. But this difference has not significantly changed over time.

FIGURE 7 ABOUT HERE

[19] The remaining estimated differences are in Table A4 of the Appendix.

For each house sold on the market, we also calculate the shortest distance to these establishments on their side of the RLD border. Then we estimate the average difference in distance at the border using the RD design. Our findings in Table 6 reveal that in 2001-2006 a house on the RLD side was 87 meters closer to a coffeeshop, but 50 meters farther from a cafe, than a house on the other side. The distance to a retail store was also significantly shorter in the RLD. After 2006, however, the distance to a coffeeshop, as well as the distance to a retailer, has not significantly changed.

TABLE 6 ABOUT HERE

Our cross-sectional estimates for house discontinuity may be driven by the difference in the initial distance to other businesses. Accordingly, we deal with this confoundedness by applying the DiD design, which is consistent as long as the other amenities remain constant. Since the discontinuity in the distance to coffeeshops, restaurants, and retailers has not changed, their location is unlikely to drive the DiD in house prices. The only businesses that could explain our results are the cafes. Table 6 shows that the average distance to a cafe on the RLD side has decreased. However, by plotting the spatial distribution of DiDs, we find that the DiD in house prices does not coincide with the DiD in distance to a cafe, or to any other business. The only pattern that matches the DiD in house prices in both RLDs is that of changes in distance to red windows. See Figure A2 of the Appendix.

6 Prostitution and House Prices in Utrecht

Utrecht used to have two RLDs: *Hardebollenstraat*, a two-block street in the center of Utrecht; and *Zandpad*, also known as *Rode Brug* (Red Bridge), where window prostitutes worked in houseboats. Although these areas are much smaller than Amsterdam's RLDs, they have witnessed many disputes between residents and sex workers in the last decade. On 25 July 2013 all the red windows on *Hardebollenstraat* and sex boats on *Zandpad* were closed on suspicion of human trafficking and other criminal activities. Although both areas remain closed, there is still a chance that the latter will re-open. The project for a new RLD in *Zandpad* was approved at the end of 2016, but has so far been delayed. On *Hardebollenstraat*, the plan, announced in 2017, is to replace the former brothels with cafes and restaurants.

FIGURE 8 ABOUT HERE

The location of the two RLDs in Utrecht is shown in Figure 8, along with heat maps of sales density and price. *Hardebollenstraat* is located in a dense and expensive area, with prices per square meter above 2,800 euros. In contrast, *Zandpad* is in a sparse and low-priced area, where the value of the square meter is below 2,200 euros. The difference in sales density can make

the prices in *Hardebollenstraat* more sensitive. In fact, after the closing of the RLDs, the red area in Figure 8, where the most expensive properties in Utrecht are located, expanded towards *Hardebollenstraat*, while in *Zandpad* prices remain low.

6.1 Empirical Strategy

To test for changes in house prices after the RLDs were closed, we use a non-parametric difference-in-slope (DiS) approach. In this approach, the distance to the RLDs is viewed as a continuous treatment and the systematic difference across locations is captured by the distance function before the shutdown. After closing the RLDs, if prices increase or decrease everywhere, then this function should shift up or down. But this movement is not necessarily driven by the shutdown. But if prices are affected by the RLDs, then the shutdown should change the shape of the distance function, measured by its first derivative. Moreover, since households tend to sort themselves by taste, we allow the DiS be spatially heterogeneous by applying a two-dimensional non-parametric estimator. Details of the estimator are in the Appendix.

6.1.1 Two-Dimensional Difference-in-Slopes

Let y_{it} be the log price per square meter at which house i is sold at period t and $\boldsymbol{s}_i = (s_{1i}, s_{2i})$ be the coordinates of its location. The RLD is located at $\mathbf{c} = (c_1, c_2)$, so $d(\mathbf{c}, \boldsymbol{s}_i)$ is the distance between house i and the RLD. To simplify our notation, let $h_i = d(\mathbf{c}, \boldsymbol{s}_i)$. In this setting, h_i determines how much house prices are potentially affected by prostitution, so the treatment is denoted by a continuous variable. As with a difference-in-differences approach, the treatment effect is measured by the change in the relationship between y_{it} and h_i after the intervention. Thus, the estimating equation is:

$$y_{it} = \mu_t(\boldsymbol{s}_i) + \gamma_t(\boldsymbol{s}_i)\, h_i(\boldsymbol{s}_i) + x_i'\beta + \varepsilon_{it} \tag{15}$$

where x_i is a vector of dwelling characteristics and ε_{it} is the error term. This equation is estimated for two periods: from January 2011 to December 2012 (before) and from August 2013 to December 2014 (after). We also use other periods to verify the robustness of our results.

Consider that the RLD is open at time 0 and is closed at time 1. While $\Delta\mu = (\mu_0 - \mu_1)$ controls for other changes in the spatial distribution of prices (time effect), $\Delta\gamma = (\gamma_0 - \gamma_1)$, named DiS, captures the treatment effect. If households want to stay away from the RLD, then $\gamma_0(\boldsymbol{s}) > 0$ as long as there is no confounding amenity in the area. When the RLD is closed, the distance function should become flat: $\gamma_1(\boldsymbol{s}) = 0$. Thus $\Delta\gamma(\boldsymbol{s})$ captures the marginal effect of the distance to the RLD on house prices.

Under the presence of confounding factors, as shown in equation (5) in section 3.2, the distance function is not necessarily flat in the absence of the RLD. However, the difference between time 0 and time 1 should eliminate these factors. As shown in equation (6), $\Delta\gamma(\boldsymbol{s})$ depends on the MWTA of externalities and the marginal income (MI) created by the sex industry. Therefore, the DiS should be interpreted as follows:

$$\Delta\gamma(\boldsymbol{s}) \quad \begin{cases} > 0 & \text{if prostitution has a negative net value,} \\ < 0 & \text{if prostitution has a positive net value,} \\ = 0 & \text{if either MWTA and MI are zero or they offset each other.} \end{cases} \tag{16}$$

To test the effect of the RLD, it is enough to verify whether $\Delta\gamma(\boldsymbol{s})$ is different from zero. But to calculate the non-marginal effect, we assume counterfactuals derived from a linear approximation. That is, the price effect at location $\boldsymbol{s}$ is given by a second-order approximation:

$$\tau(\boldsymbol{s}) \approx \Delta\gamma(\boldsymbol{s}) \cdot h(\boldsymbol{s}) + \frac{1}{2}\Delta\gamma'(\boldsymbol{s}) \cdot h(\boldsymbol{s})^2 . \tag{17}$$

where γ' is the derivative of γ with respect to h — i.e., the second derivative of the log price with respect to distance. For this approximation, we consider only the marginal estimates that are significant at 10%.

6.2 Estimation Results

6.2.1 Marginal Effect of the RLDs

We start our analysis by defining location as a one-dimensional variable — i.e., by the distance to the RLD. The graphs on the left of Figure 9 show that the relationship between price and distance to RLD is negative for *Hardebollenstraat* (upper graph), but positive for *Zandpad* (lower graph). These curves confirm that houses are more expensive in the former area than the average house in the city and cheaper in the latter. After the closing of the RLDs, the first curve becomes considerably steeper, while the second curve becomes slightly flatter.

Both changes suggest that the relationship between prices and distance to RLDs is positive — see the DiS on the right in Figure 9. This means that house prices increase with the distance to on-site prostitution. Given the low housing density in *Zandpad*, confidence intervals are wider and the DiS is not significant. On *Hardebollenstraat*, however, we find that prices tend to increase by almost 1.5% for 100 meters distance from brothels. This marginal effect declines with distance and disappears after one kilometer.

FIGURE 9 ABOUT HERE

Since households are sorted by their taste, the marginal effect of brothels can be spatially heterogeneous. In this case, the one-dimensional approach is limited because it does not show

where the slope has changed. Figure 10 shows that the distance function has mostly changed in the area between the two RLDs. The positive and significant DiS suggests that households pay a premium to move away from brothels, which can be as high as 1.6% per 100 meters. If brothels were still operating in the RLD, the houses in the green area would be more expensive than similar houses anywhere else.

FIGURE 10 ABOUT HERE

There are two possible reasons why we do not observe significant changes in the city center: 1) houses are already expensive due to other amenities and there is no room for a premium; and 2) it concentrates households that are less concerned by the RLD. These two reasons are not mutually exclusive; in fact they may explain one another. Furthermore, we do not observe any area where households are willing to live closer to an RLD.

To have a better idea of the share of affected households, Figure 11 shows the distribution of marginal effects among dwellings per length of radius around the RLDs. Up to 500 meters from a RLD, practically all households are willing to pay at least a slight premium to move farther away. For most of the households within this radius, the premium is at least 0.9% per 100 meters. Considering the actual value of properties, we find that the premium can be as high as 8,000 euros — i.e, 431-515 euros a year.[20] Most of the households within 500 meters are willing to pay at least 1,500 euros — or 81-97 euros a year — to move 100 meters farther away.

FIGURE 11 ABOUT HERE

To verify the robustness of our findings, we estimate the marginal effects using different bandwidths. Results are reported in Table A6 of the Appendix. Overall, the estimated distribution of DiS is very similar for a range of bandwidths around the optimal one. Furthermore, we estimate the DiS for 1,000 random locations within the city limits. Figure A3 confirms that the distribution of DiS for the actual RLDs has a very small chance of being replicated by a random pair of points.

Figure A4 of the Appendix shows the distribution of estimated DiS for other periods. These estimates confirm that our findings do not result from historic trends in house prices. In fact, we find that before 2013 the trend in prices was in the opposite direction. This previous trend may have been due to an inflow of sex workers to Utrecht after Amsterdam and Rotterdam downsized their soliciting areas.

6.2.2 Welfare Effect of Prostitution in Utrecht

The previous part indicates that some households pay more for their homes so as to live far from prostitution. In Figure 12, we present the distribution of premiums that households pay, based

[20] With a mortgage interest rate between 3.5% and 5% per annum for a 30-year loan.

on a linear approximation — see equation (17). Up to one kilometer, 25% of the households pay at least 4% more for their homes. With a mortgage rate of 3.5% per annum for 30 years, this premium represents around 500 euros a year. Overall, the premium can be as high as 12%, or 1,600 euros a year.

FIGURE 12 ABOUT HERE

By using information about the houses on the market in the last 30 years and deflating their prices using annual hedonic models, we calculate the total value of the dwelling stock per postal code in Utrecht.[21] Then we integrate the price effects, as in Figure 12, over this stock to obtain the deadweight loss caused by prostitution in the RLDs. For this integration, presented in Figure 13, we consider only the DiS estimates that are significant at 10%. Depending on the radius for the integration — a wider radius may lead to noisy estimates — and the chosen bandwidth in the DiS estimates, the aggregate loss caused by RLDs ranges between 125 and 225 million euros. In other words, taxpayers were spending 6.75-14.5 million euros per year to stay away from prostitution.

FIGURE 13 ABOUT HERE

6.2.3 Changes in Employment in Utrecht

One way in which prostitution can affect house prices is by changing the distribution of employment in the city. On one hand, prostitution may bring a considerable number of clients and tourists to the RLD and then encourage the growth of other businesses. On the other hand, prostitution may cast a shadow over these businesses if their clients prefer to stay away from the RLD. To verify how employment has changed after the RLDs were closed, Figure 14 presents the density of jobs per distance to these areas. In *Zandpad*, the density is very low in all periods, so we do not observe a clear change. In *Hardebollenstraat*, however, there seems to be a reduction in the employment level within 500 meters.

FIGURE 14 ABOUT HERE

The reduction in the employment level around *Hardebollenstraat* could be either statistically insignificant or caused by drastic changes in other areas. To test for the effect of the RLDs, we first rasterize the number of jobs and then estimate the DiS, $\Delta\gamma$, from the following equation:

$$\Delta \ln(jobs_i) = \Delta\mu(\boldsymbol{s}_i) + \Delta\gamma(\boldsymbol{s}_i)\, h_i(\boldsymbol{s}_i) + \Delta\varepsilon_i,$$

where $\Delta \ln(jobs_i) = \ln(jobs_{i0}) - \ln(jobs_{i1})$ and $jobs_{it}$ is the total number of employees at cell i and time t. As in equation (15), $\boldsymbol{s}_i$ is the vector of longitude and latitude and h_i is the minimum

[21] We also divide the amount by the percentage of the stock that has been offered for sale through a NVM member, which ranges between 1% and 73%.

distance to an RLD. Figure 15 presents these estimates under three raster resolutions. With smaller cells, we verify that the relationship between employment level and distance to RLD is either insignificant or negative, particularly around *Hardebollenstraat*.

FIGURE 15 ABOUT HERE

This finding suggests that the RLD, if located in a dense area, raises the employment level nearby. Then, with the end of the RLD, labor demand is lower and, according to Glaeser and Gyourko (2005), this shock should, if anything, reduce house prices. Our results, however, do not fit this story. After the brothels were closed, house prices increased and employment declined more on *Hardebollenstraat* than in areas further from the RLD. Thus an economic disruption does not seem to be the reason why households pay to stay away from prostitution.

7 Crime Rates Near RLDs

The external cost of prostitution can in part be explained by the criminal activities behind the sex industry, such as drug trafficking, human exploitation, and misbehaving clients. Both issues may collaborate for the development of an unhealthy environment for residents. By using data on criminal activities and subjective evaluations, we verify whether safety in the RLDs has indeed improved more than in other areas of Amsterdam and Utrecht.

Figure 16 shows how crime rates and perception of risk have changed over time across neighborhoods in Amsterdam. The first panel on the left confirms that the RLDs (in purple) are located in areas with a much higher incidence of crime. The situation, however, has improved over the years, particularly since 2007, when the number of red windows started to decrease. Given that these crime rates comprise several types of felony, each one with unknown impact on the overall sense of safety, we also verify changes in the perception of risk declared by residents — on the right-hand side of Figure 16.[22] Indeed, the spatial changes in the perception of risk mirror the changes in crime rates. That is, in 2003 the RLDs were located in the least safe neighborhoods, but their situation has considerably improved. In 2006, we already observe an increase in safety, but this is still not exclusive to the RLDs. In 2007 and 2013, the improvements are in fact more expressive in the RLDs and their surrounding neighborhoods.

FIGURE 16 ABOUT HERE

After the RLDs in Utrecht are closed, we observe a very similar pattern. Figure 17 presents the spatial distribution of crime rates, on the left, and perception of risk, on the right, in this

[22] The risk perception index is calculated by the city of Amsterdam, with a base value of 100 in 2003.

city.[23] One of the RLD, *Zandpad* (small purple dot), is located in a less dense area, as shown in Figure 8, so the surrounding crime rates are low. Even so, 40-55% of residents in 2009 did not feel safe in those neighborhoods. In 2011-2015, this percentage was still between 35% and 45%. In *Hardbollenstraat* (large purple dot), however, the crime rates in 2011-2012 were among the highest, but they dropped considerably after the RLD was closed. It is worth noting that other unsafe areas (in red) have not changed as much. Moreover, the percentage of residents who felt unsafe also decreased by about five points from 2011 to 2015.

FIGURE 17 ABOUT HERE

Since the crime data are aggregated by neighborhood, we cannot apply the same identification strategies as we do for house prices. Therefore, the following analysis is simpler. Although not as trustworthy, it helps us to understand the particular changes that took place in the RLDs. Table 7 presents difference-in-difference estimates that compare neighborhoods where the RLDs are located with those up to 200m distant, up to 500m, and up to 2km. In Amsterdam, the first sample period is between 2003 and 2006 (before) and the second is from 2007 to 2014 (after); we find that the overall crime rate has declined 18% more in the RLDs than in more distant areas. We also observe an increase of 9-10% in close areas (up to 500m), which suggests that crime has been displaced. However, while the direct effect represents a reduction of 1,250 crimes per year in the RLDs, the displacement counts for only 320 more crimes per year in these areas. Furthermore, the subjective safety has improved by 18% in the RLDs and has not significantly declined nearby.

By looking at the type of felony, we note a reduction not only in violence and other reported nuisances, such as vandalism and complaints about neighbors, but also in major property crimes, such as burglary and motor vehicle theft. These property crimes are arguably unrelated to prostitution, but this finding suggests that the reduction in other felonies may free up the police to prevent those cases (Adda, McConnell and Rasul, 2014). Cases of violence, minor thefts, and reported nuisances have all decreased in the RLDs, but they have also been displaced to areas nearby. In any case, however, the absolute reduction in the RLD is about four times greater than the displacement.

TABLE 7 ABOUT HERE

Since the RLDs in Utrecht are much smaller than the ones in Amsterdam, the absolute effects are not as pronounced. Yet we still observe a significant decline of 11% in the RLDs and of 10% in areas up to 200m. These changes represent 210 fewer crimes per year in the RLDs and 110 fewer per year in their vicinity. As in Amsterdam, major property crimes have also declined, but

[23] Data on the perception of risk are not available for the same years and levels as crime rates, so the maps in Figure 17 do not have the same dimensions.

more so in the surrounding areas. Again, this finding supports the hypothesis that a reduction in the occurrence of other felonies enables the police to focus more on these major crimes. From 2011-2012 to 2014-2015, violence, reported nuisances, minor thefts, and illegal drug dealing in the RLDs declined by 25%, 14%, 43%, and 51%, respectively. As a result, the percentage of resident who feel unsafe has since 2013 declined by almost three percentage points in the RLDs and by six percentage points nearby. Table A7 of the Appendix shows that the crime rate has declined most on *Hardbollenstraat*. Although *Zandpad* is a less dense area, with many fewer individuals exposed to risk, cases of violence have also declined by 36% since its RLD was closed.

Overall, these findings indicate that a reduction of on-site prostitution is associated with the dispersion and reduction of violence, vandalism and other nuisances. Furthermore, with the lower incidence of these cases, other crimes, such as burglary, motor vehicle theft and drug trafficking, also become easier to prevent. In both cities, the closing of brothels is associated with an increase in individuals' perception of safety.

8 Conclusion

The acceptance of prostitution as a regular activity depends on the externalities that it creates. In this paper, we make use of the fact that the by-laws on prostitution have become stricter in the last two decades in the Netherlands. To identify the externality created by the sex industry, we present two novel empirical strategies that disentangle this effect from other spatial determinants.

Our results suggest that households have a strong distaste for living close to brothels. In Amsterdam, we calculate that they require at least 4,100 euros a year to accept sex workers performing on their doorstep. Furthermore, the impact of prostitution spreads over the limits of the RLDs, making households pay extra for properties that are nowhere near. In Utrecht, a household living 1.5km from the RLD may pay up to 1,600 euros more per year than if it were next to a brothel. Even though the concentration of sex workers in the RLDs seems to raise the labor demand from businesses close by, this positive externality does not offset the resulting cost of violence and other nuisances.

We should not ignore the fact that prostitution is valuable to some tourists and clients and that sex workers must have a place in our society. However, from the residents' point of view, prostitution still carries the stigma of a subversive activity, with a tight connection to many forms of violence. This conclusion does not imply that the sex industry should be abolished, but keeping it to a regulated size and less concentrated in dense areas may reduce the social burden.

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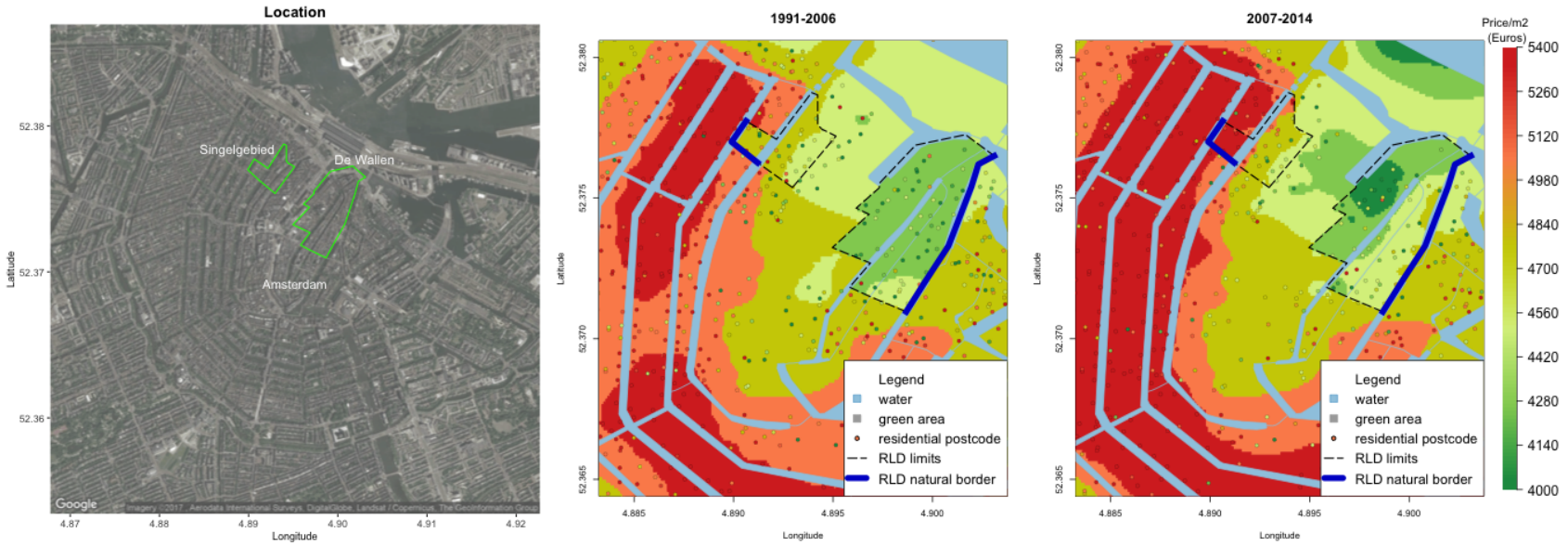
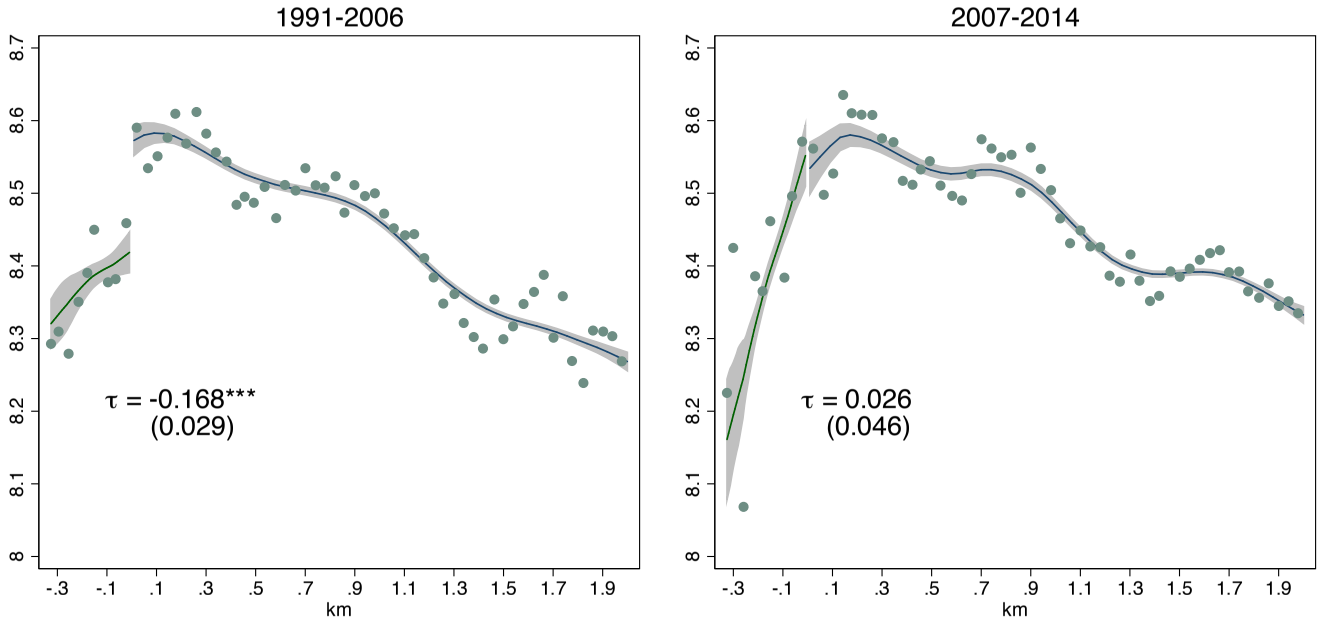
Figure 1: Location of RLDs and House Prices in Amsterdam



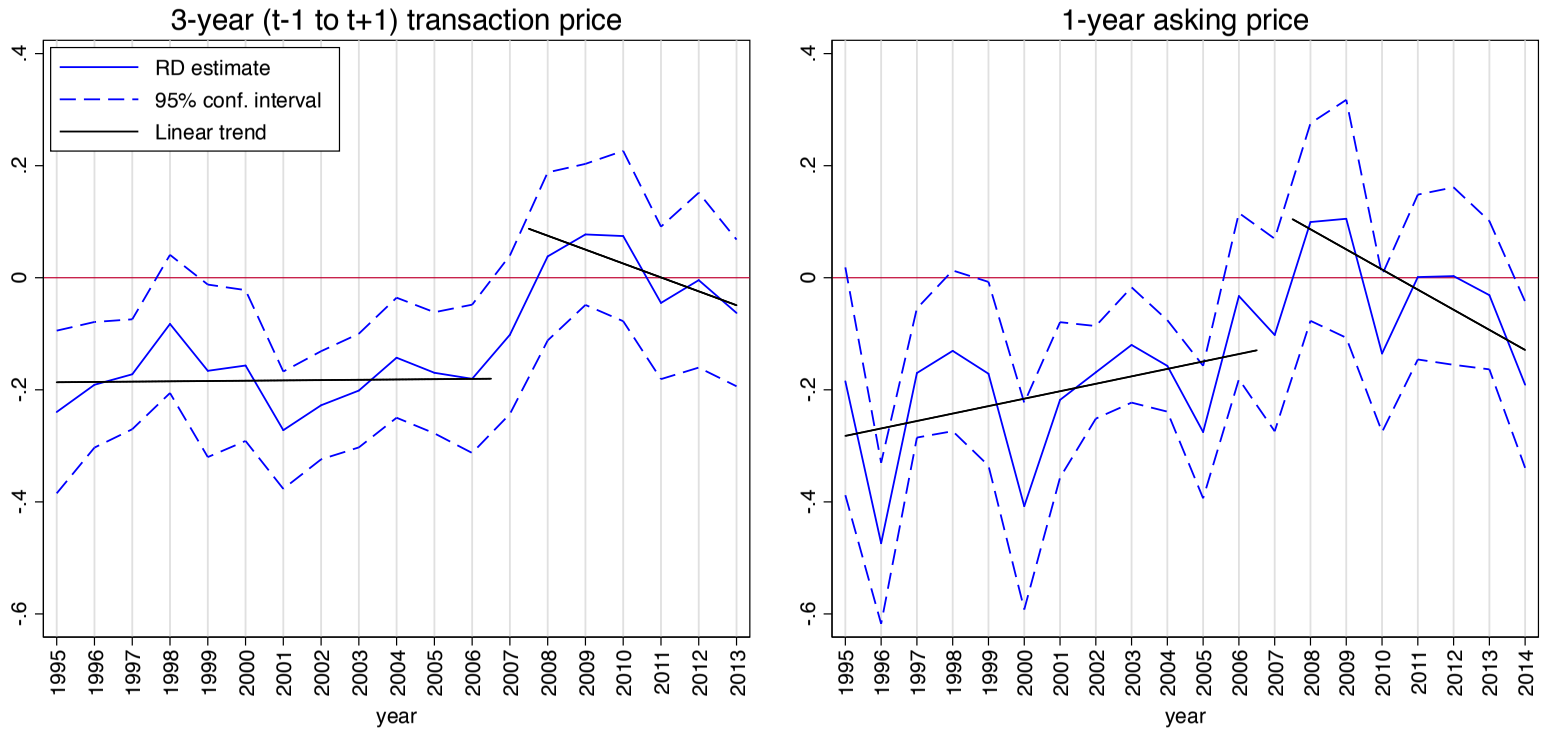
This figure shows the location of the two main Red Light Districts (RLDs) in Amsterdam (on the left), and the average price per square meter of dwellings per postal code in 1991-2006 (in the center) and 2007-2014 (on the right). Dwelling characteristics are controlled for using a hedonic model, equation (7), and prices are deflated to values of 2014. The heat map shows the predicted values estimated using a two-variable kernel-weighted regression, holding all characteristics constant. The bandwidth is selected using a procedure adapted from Calonico, Cattaneo and Titiunik (2014).

Figure 2: House Prices per Distance to RLD Border in Amsterdam and Regression Discontinuity Estimates



This figure shows the log price per square meter as a function of the minimum distance in km to the closest natural border of a Red Light District (RLD) in Amsterdam. The sample includes properties located up to 2km from the closest border and it excludes properties outside an RLD that are not separated by a natural border. Dwelling characteristics are controlled for as shown in equation (7). Distance functions are estimated using triangular kernel with the bandwidth selection procedure proposed by Calonico, Cattaneo and Titiunik (2014). τ is the regression discontinuity estimate, with robust standard errors in parentheses. ***, **, * represent statistical significance at the 1%, 5% and 10% levels, respectively.

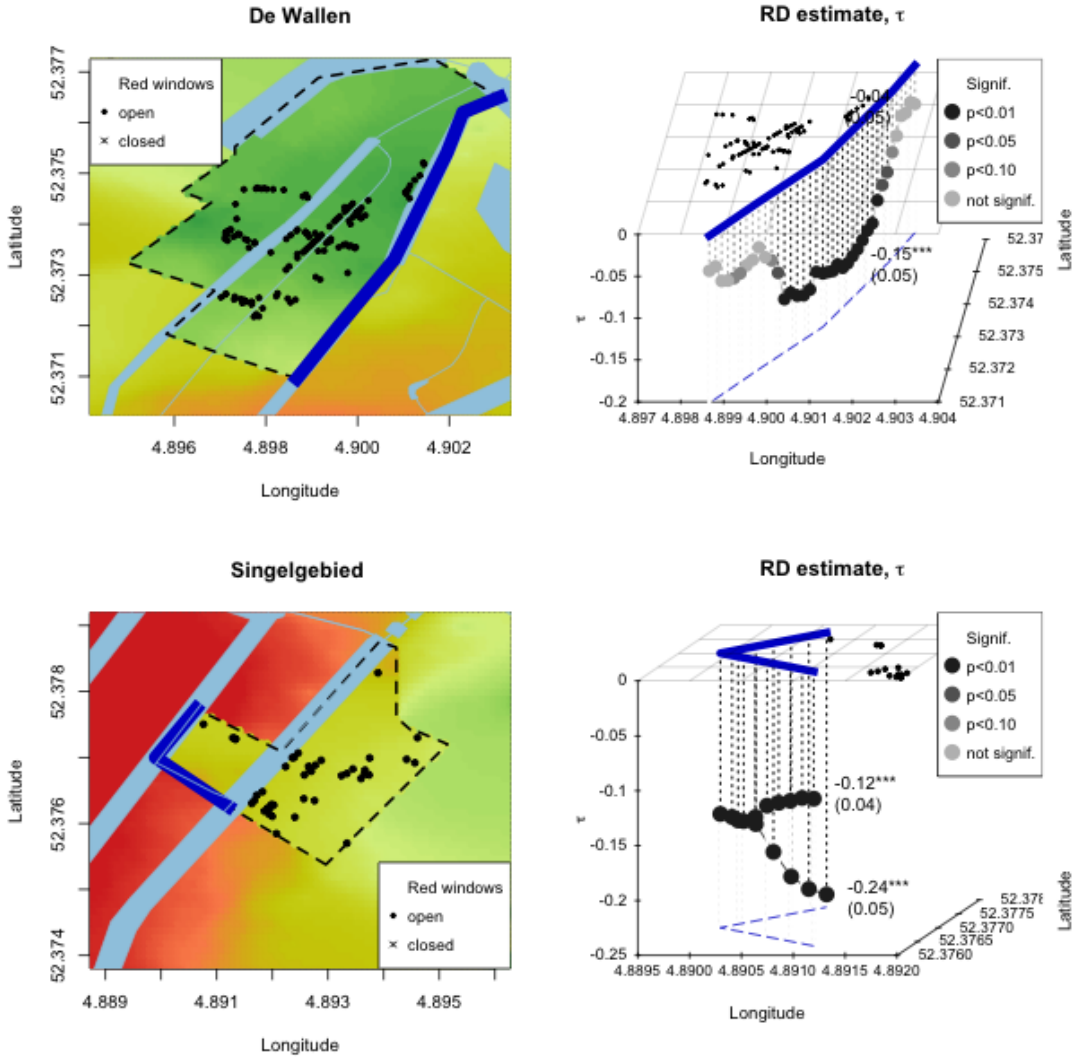
Figure 3: Regression Discontinuity Estimates per Year in Amsterdam



This figure shows one-dimensional regression discontinuity estimates at the natural border of Amsterdam's Red Light Districts (RLDs). The graph on the left uses a moving sample of transaction prices for three years, centered at the middle one. The graph on the right uses annual samples of asking prices. Both samples include properties located up to 2km from the closest border and it excludes properties outside an RLD that are not separated by a natural border. Dwelling characteristics are controlled for as shown in equation (7). Distance functions are estimated using triangular kernel with the bandwidth selection procedure proposed by Calonico, Cattaneo and Titiunik (2014). The dashed lines represent the 95% robust confidence interval.

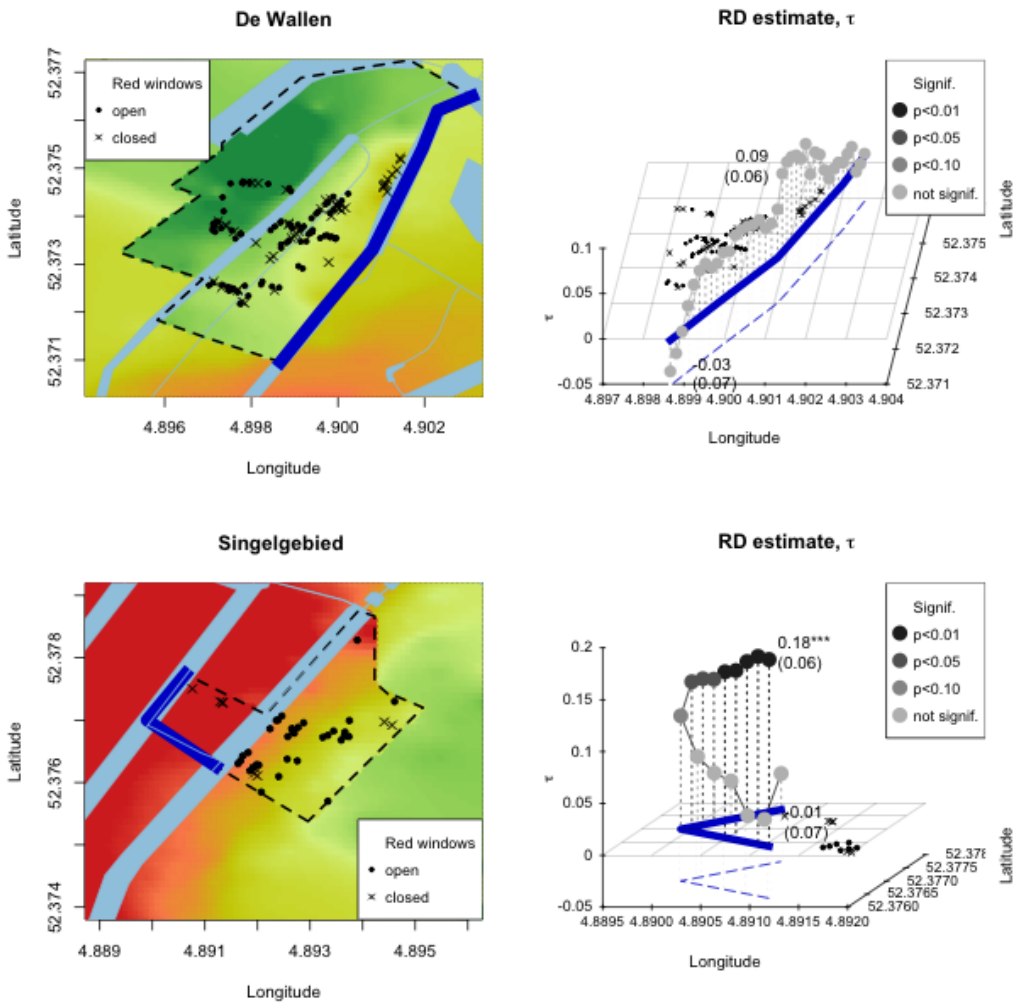
Figure 4: Two-Dimensional Regression Discontinuity Estimates in Amsterdam's RLDs

(a) 1991-2006



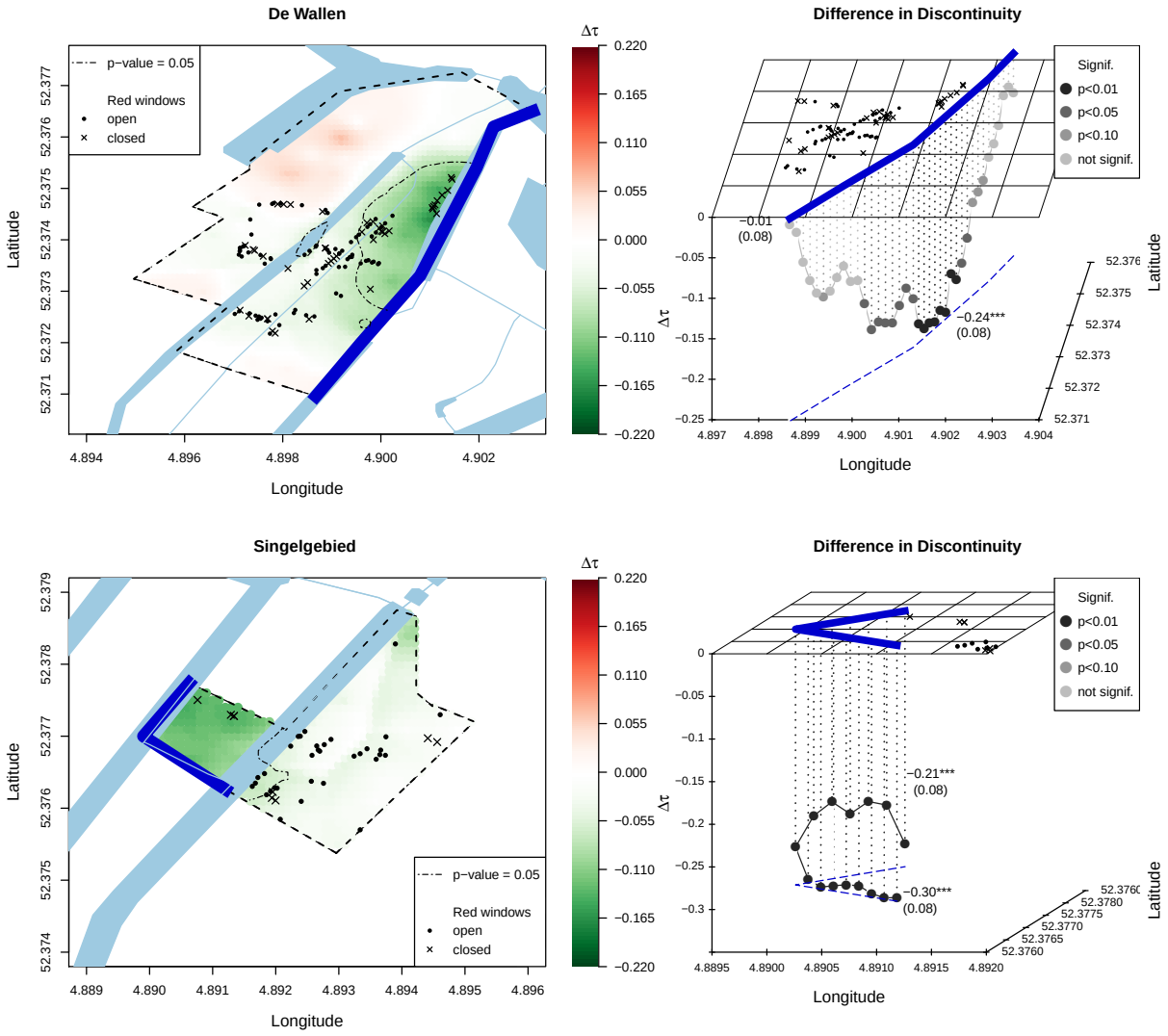
(continuing)

(b) 2007-2014



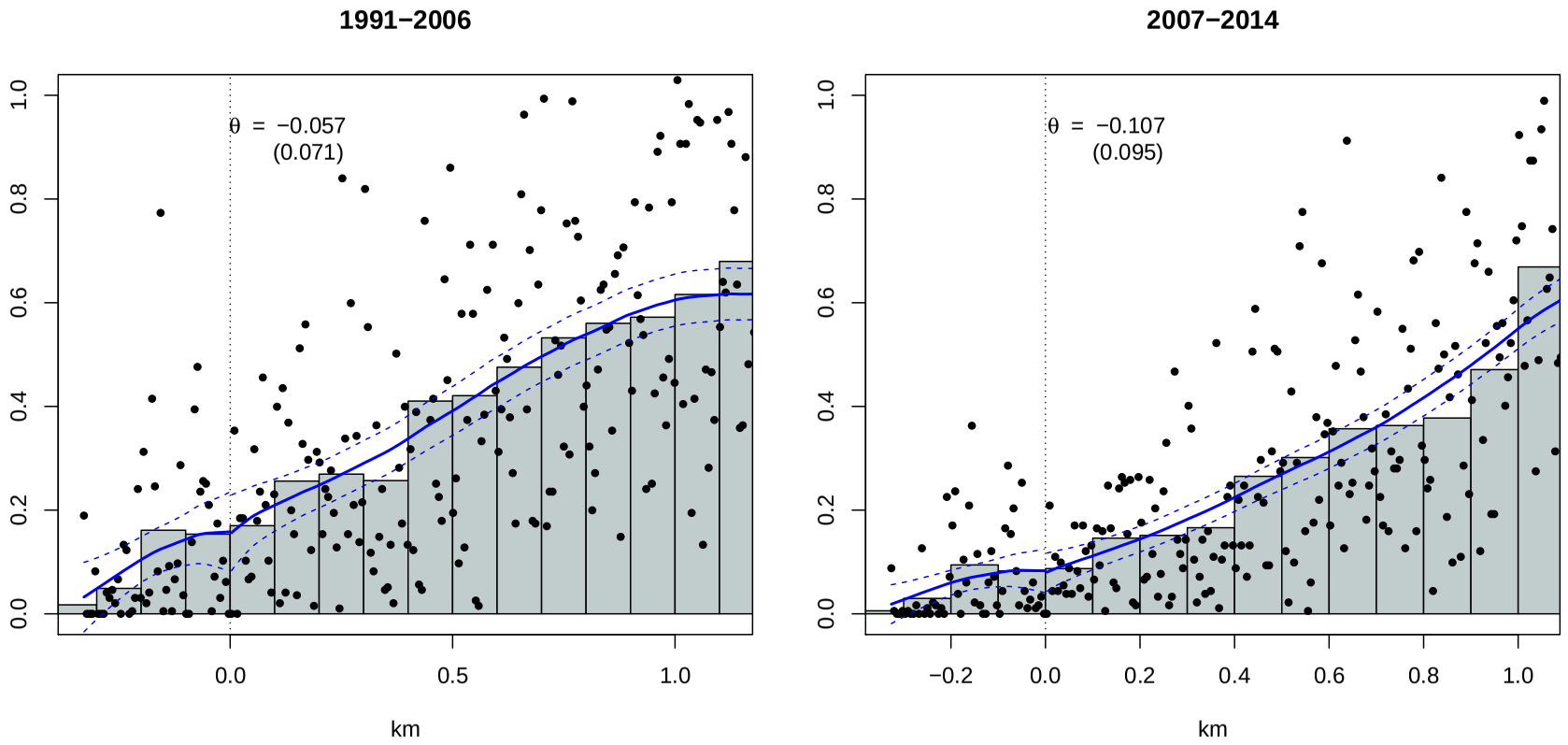
This figure shows on the left the heat maps of house prices in the Red Light Districts (RLDs) of Amsterdam. The graphs on the right show the regression discontinuity (RD) estimates along the RLD natural borders, as shown in equation (8). Minimum and maximum values are highlighted with robust standard errors in parentheses. ***, **, * represent statistical significance at the 1%, 5% and 10% levels, respectively. The sample includes properties located up to 2km from the closest border. Dwelling characteristics are controlled for as shown in equation (7). Log prices are estimated using triangular kernel with the bandwidth selection procedure proposed by Calonico, Cattaneo and Titiunik (2014). The figure also shows the location of operating and closed red windows.

Figure 5: Difference in Price Discontinuity in Amsterdam's RLDs, 1991/2006 – 2007/2014



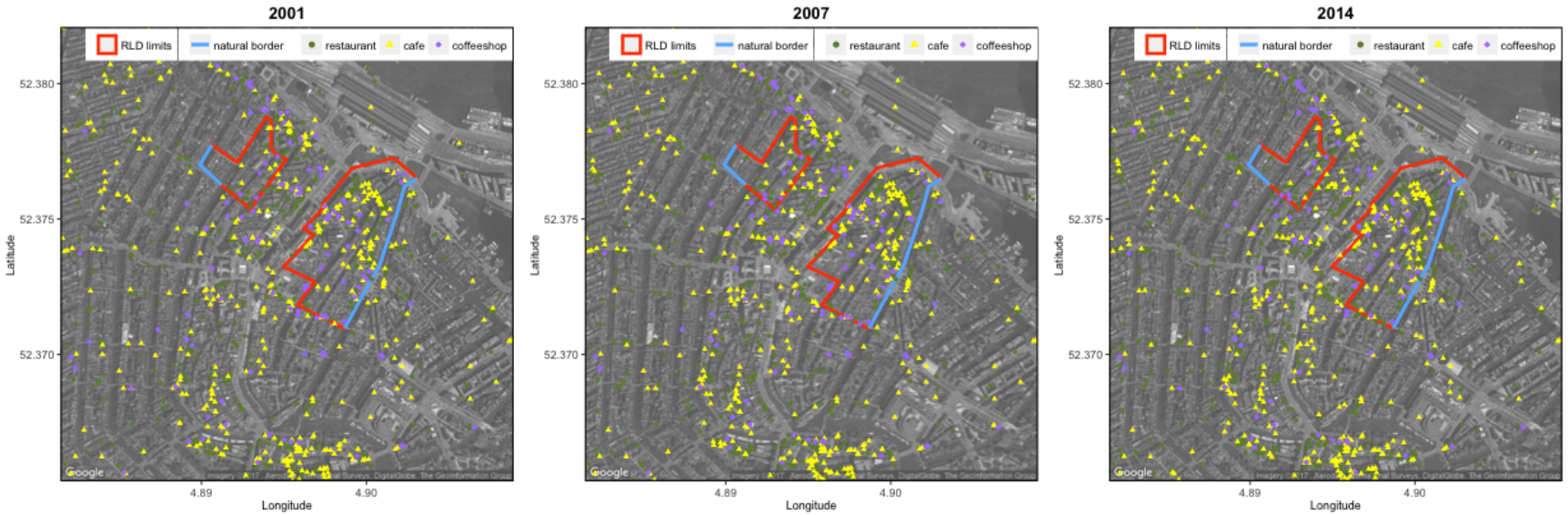
This figure presents difference-in-discontinuity (DiD) estimates as shown in equations (9), on the right, and (10), on the left. The sample includes properties located up to 2km from the closest Red Light District (RLD). Dwelling characteristics are controlled for as shown in equation (7). Log prices are estimated using triangular kernel with the bandwidth selection procedure proposed by Calonico, Cattaneo and Titiunik (2014). On the left, the contour line delimits the areas where the DiD is significant at 5%. On the right, minimum and maximum values are highlighted, with robust standard errors in parentheses. ***, **, * represent statistical significance at the 1%, 5% and 10% levels, respectively. The figure also shows the location of operating and closed red windows.

Figure 6: Density of Houses for Sale per Distance to RLD's Border in Amsterdam and Discontinity Test



This figure shows the density of dwellings for sale as a function of the distance in km to the closest Red Light District (RLD) natural border in Amsterdam. The sample includes properties located up to 2km from the closest border and it excludes properties outside an RLD that are not separated by a natural border. θ is the McCrary's (2008) estimator for log density discontinuity, with standard error in parentheses. ***, **, * represent statistical significance at the 1%, 5% and 10% levels, respectively. Black dots are bins with size around 0.006km.

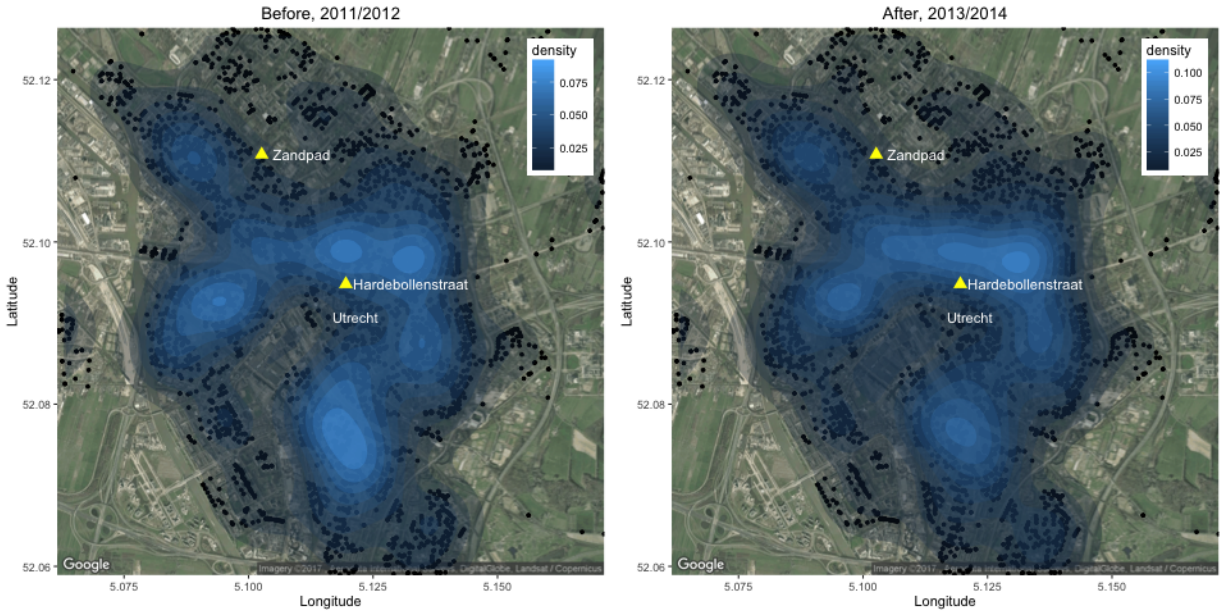
Figure 7: Location of Other Businesses in the Center of Amsterdam



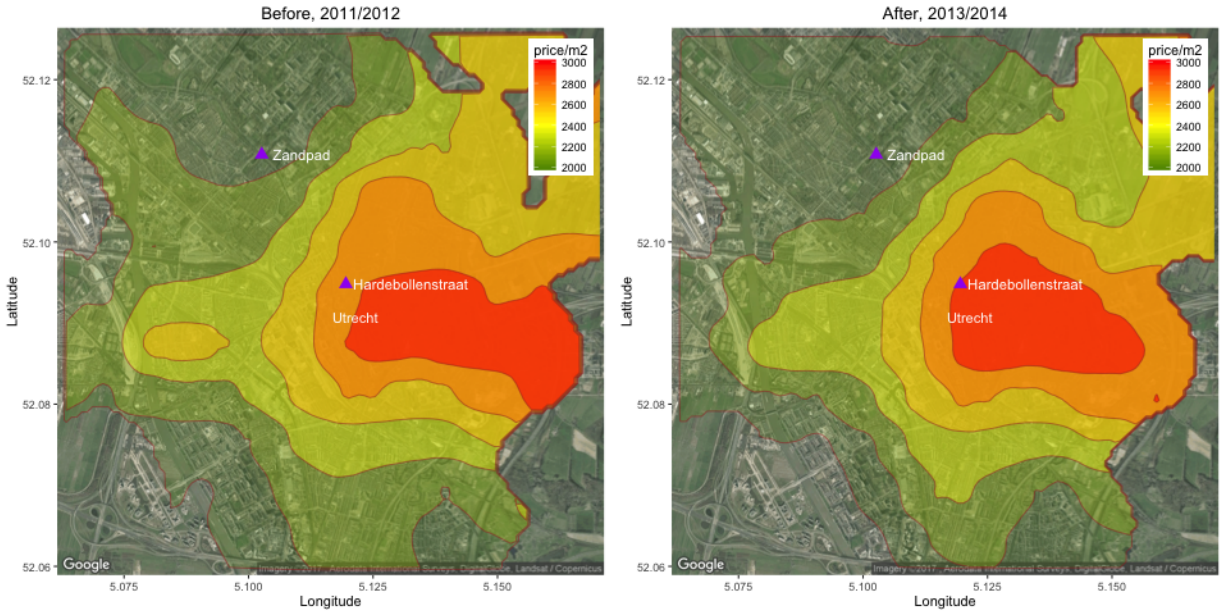
This figure shows the maps locating the Red Light Districts (RLDs) in the center of Amsterdam, their natural borders, and three types of establishments: restaurants, cafes, and coffeeshops. 'Restaurants' are establishments serving food, which also include hotel-restaurants, but exclude diners and lunchrooms. 'Cafes' are establishments whose main activity is to serve alcoholic beverages. 'Coffeeshops' are establishments that sell cannabis.

Figure 8: Map of Sales Density and House Prices in Utrecht, Before and After Closing RLDs

(a) Sales Density

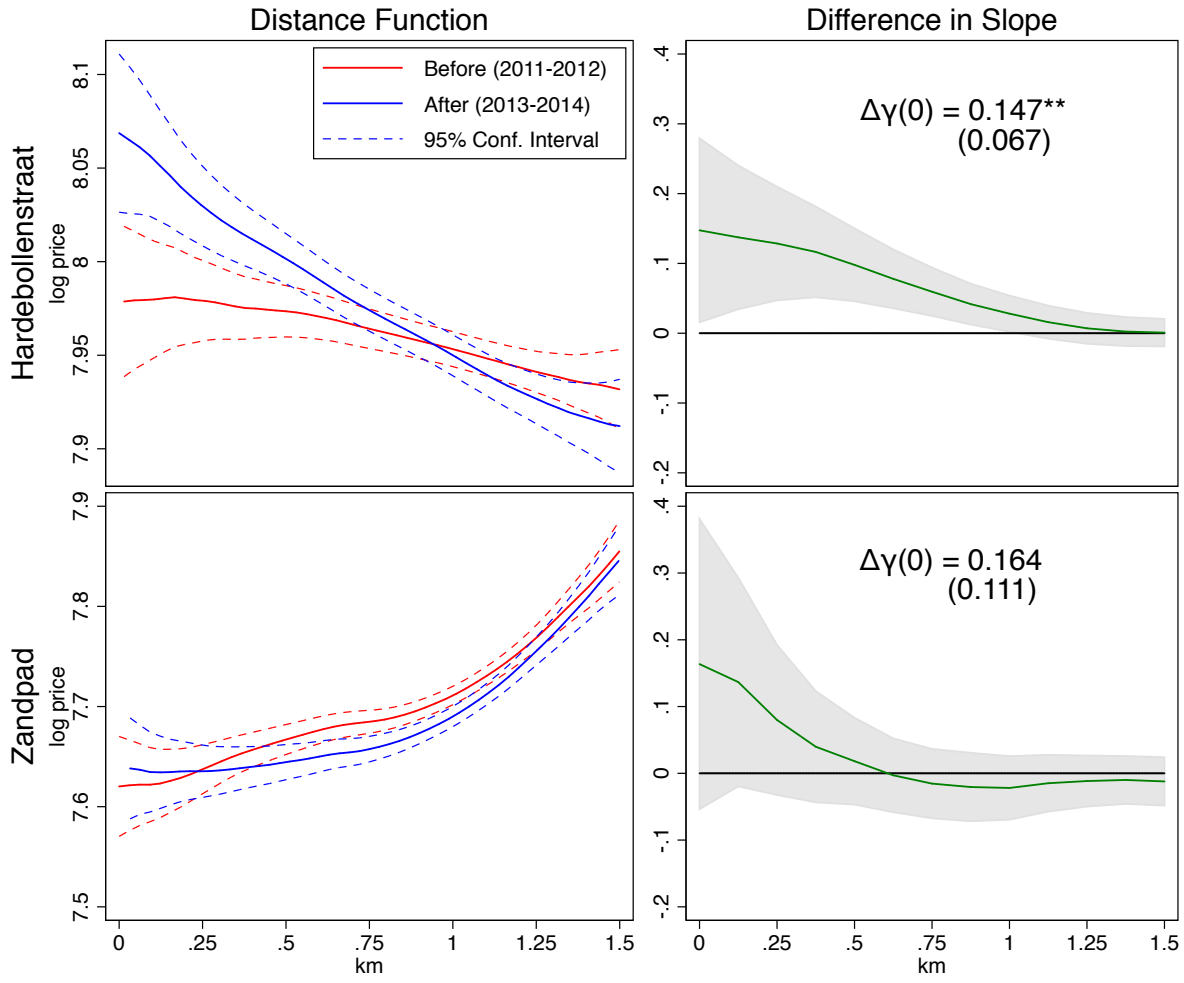


(b) House Prices



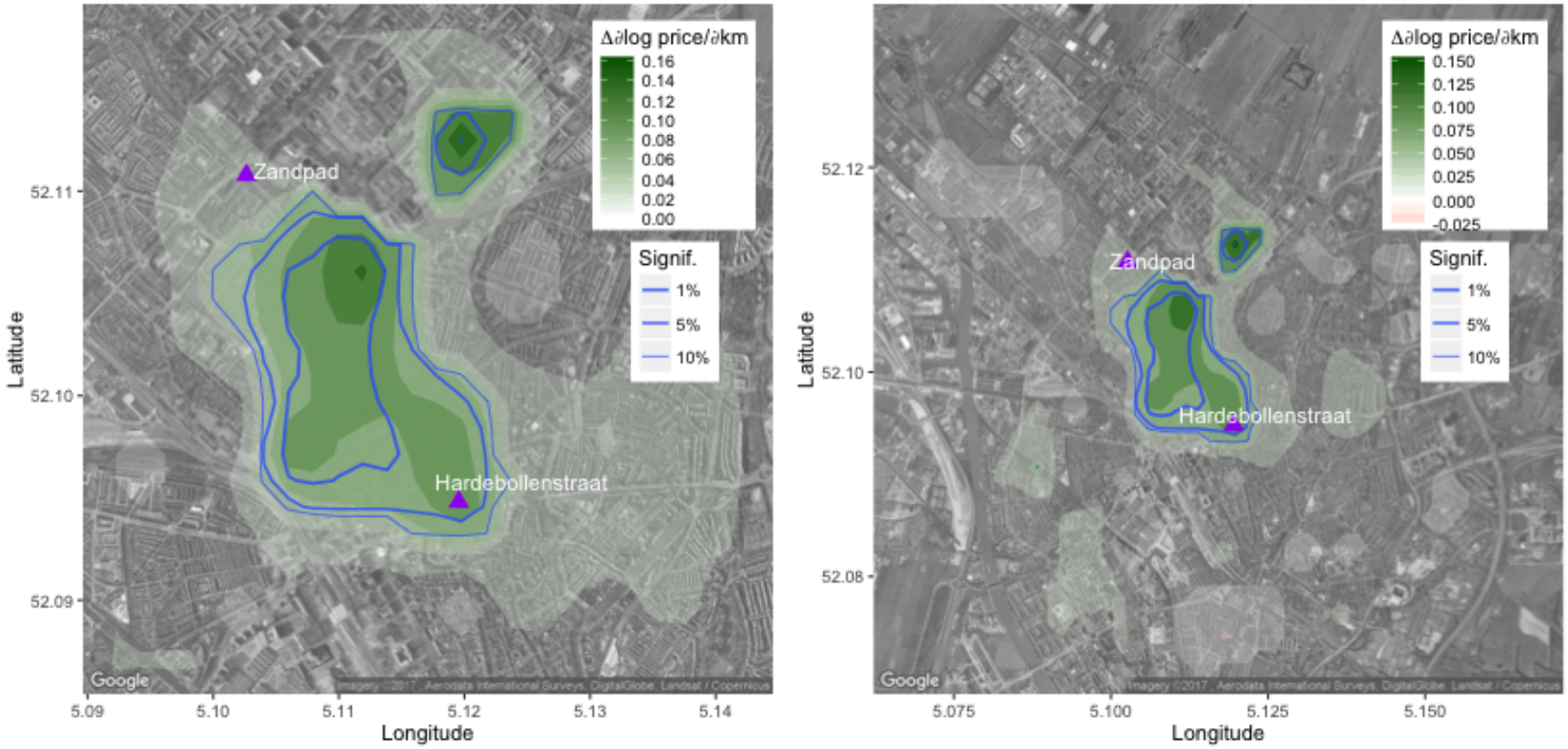
This figure presents heat maps of house prices and sales density in Utrecht in 2011-2012, 'before' the Red Light Districts (RLDs) were closed, and between August 2013 and December 2014, 'after' they were closed. The two upper maps show the density of house sales, estimated using a bivariate normal kernel, with bandwidth selected using Silverman's (1986) procedure. The two lower maps show the price per square meter predicted by a two-variable kernel-weighted regression. The bandwidth is the same in these maps and is selected using the procedure adapted from Calonico, Cattaneo and Titiunik (2014). See Table A6 in the Appendix (scale 1). Dwelling characteristics are controlled for using a hedonic model, equation (15), and prices are deflated to values of 2014.

Figure 9: House Prices per Distance to RLDs and Difference-in-Slope in Utrecht



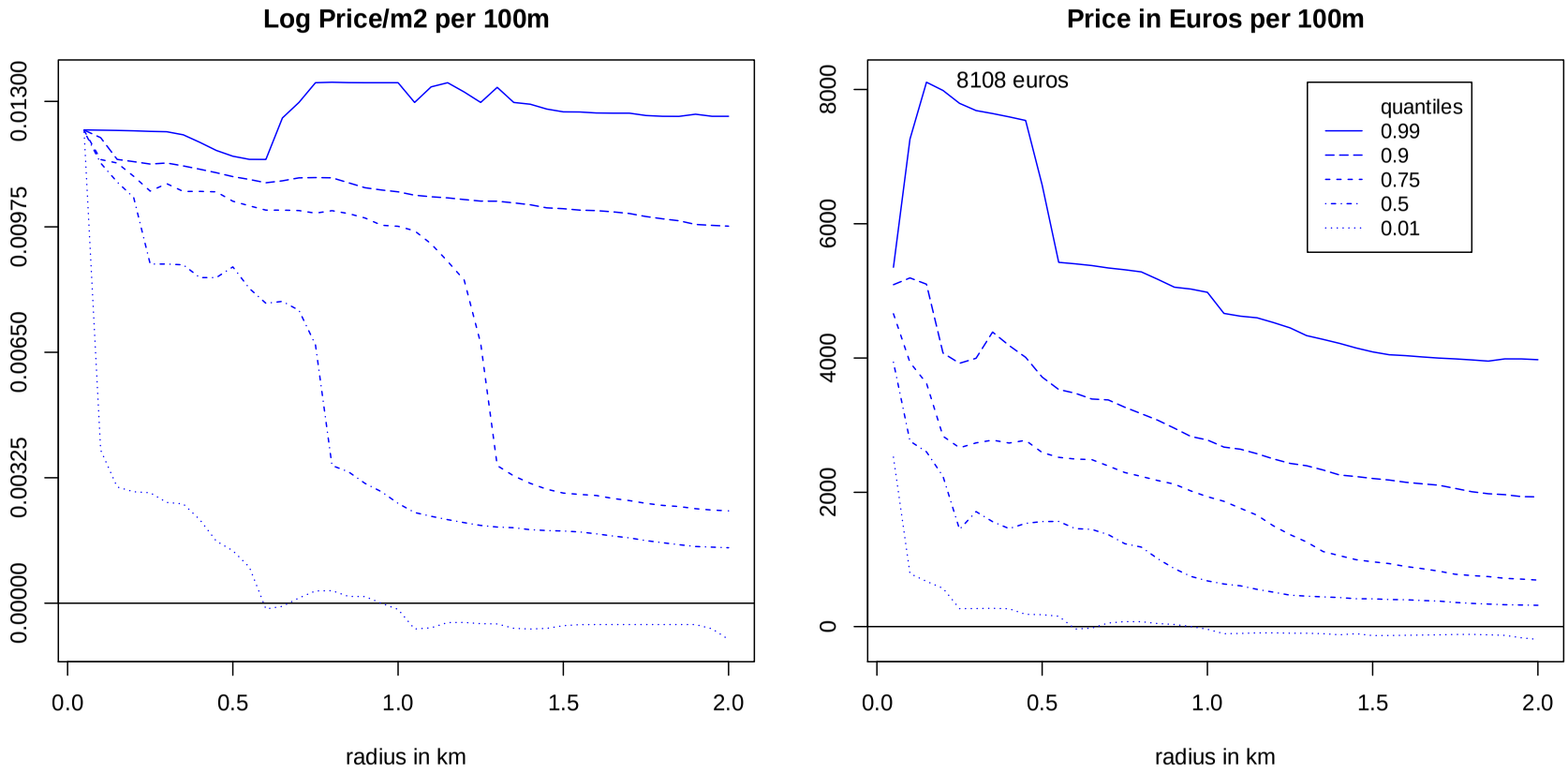
The first graphs on the left show the relationship between log price per square meter and distance to the Red Light District (RLD) on *Hardebollenstraat* (top) and *Zandpad* (bottom), Utrecht, in January 2011-December 2012 (before) and August 2013-December 2014 (after). The graphs on the right show the first derivative of the distance functions before minus the first derivative after the RLDs are closed (DiS). The bandwidth is selected using the procedure adapted from Calonico, Cattaneo and Titiunik (2014). Dwelling characteristics are controlled for using a hedonic model, equation (15), and prices are deflated to values of 2014. The sample includes properties located up to 3km from the RLDs. For DiS estimates at distance zero, $\Delta\gamma(0)$, robust standard errors are in parentheses. ***, **, * represent statistical significance at the 1%, 5% and 10% levels, respectively.

Figure 10: Spatial Marginal Effect of RLDs on House Prices in Utrecht



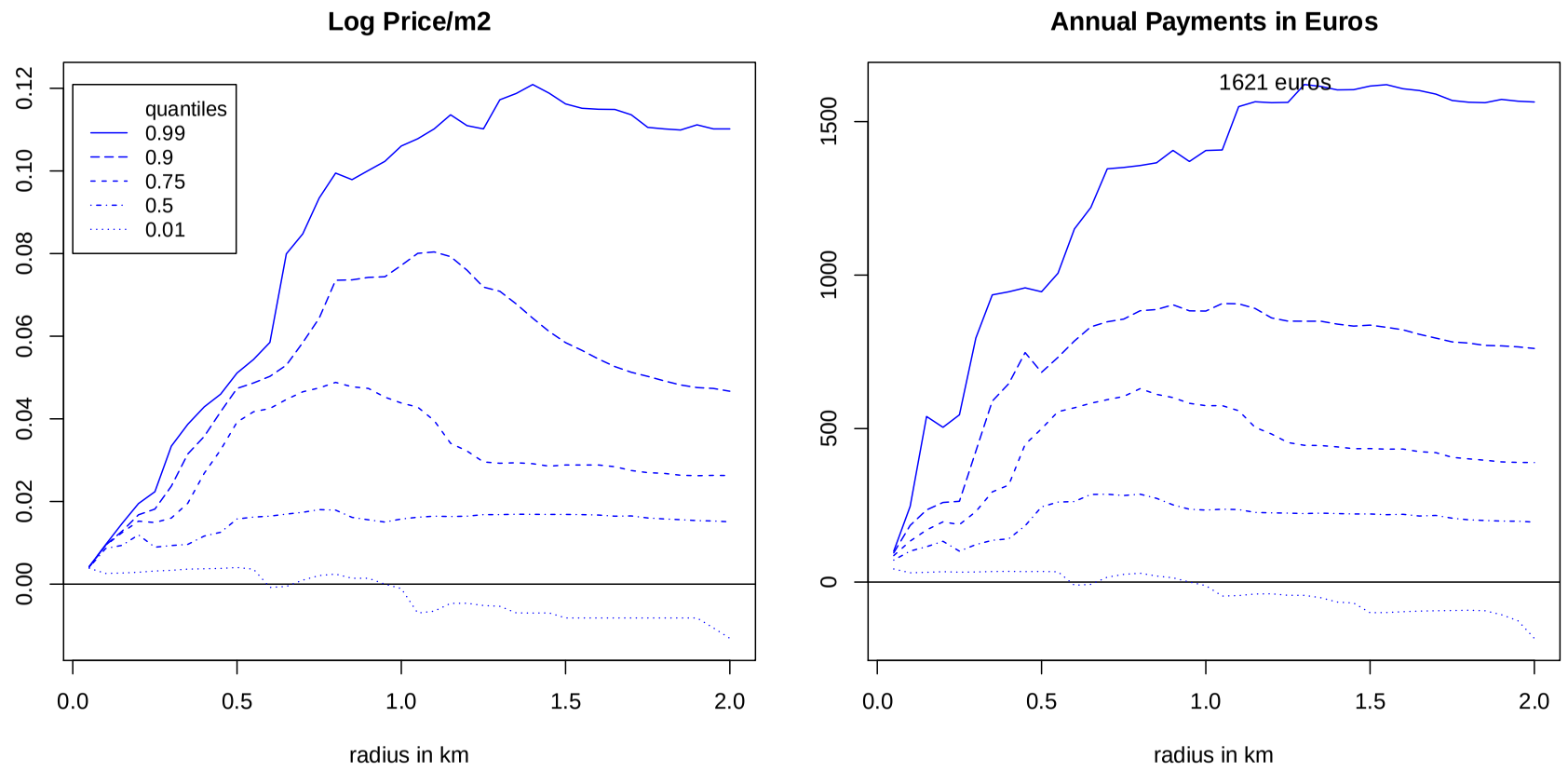
This figure shows the location of changes in the relationship between log price per square meter and distance to a Red Light District (RLD) in Utrecht. See equation (15). The 'marginal effect', or Difference-in-Slope (DiS), is the difference in the first derivative of the distance functions in January 2011-December 2012 and August 2013-December 2014. For better illustration, we apply an empirical Bayes shrinkage to estimates that are not significant at 10%. The bandwidth is selected using the procedure adapted from Calonico, Cattaneo and Titiunik (2014). See Table A6 in the Appendix (scale 1). Dwelling characteristics are controlled for using a hedonic model, equation (15), and prices are deflated to values of 2014. The sample includes properties located up to 3km from the RLDs.

Figure 11: Quantiles of Marginal Effects of RLDs on House Prices in Utrecht



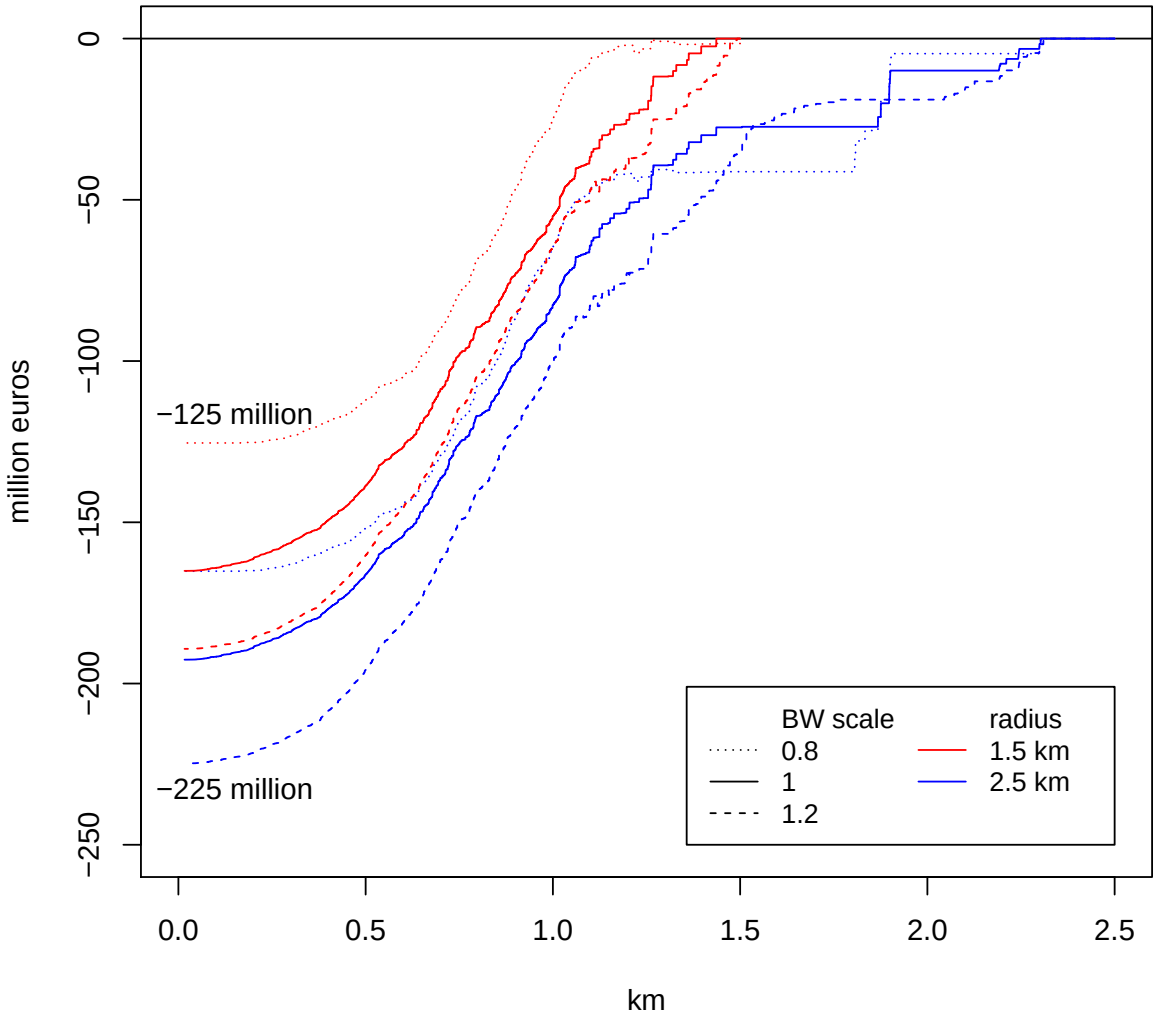
This figure shows the distribution (quantiles) of marginal effects in log price (on the left) and in euros (on the right) as a function of the radius to the center of the Red Light Districts (RLDs) in Utrecht. The 'marginal effect', or Difference-in-Slope (DiS), is the difference in the first derivative of the distance functions in January 2011-December 2012 and August 2013-December 2014. The distribution of DiS is weighted by the density of houses for sale in 2011-2012. For better illustration, we apply an empirical Bayes shrinkage to estimates that are not significant at 10%. The bandwidth is selected using the procedure adapted from Calonico, Cattaneo and Titiunik (2014). See Table A6 in the Appendix (scale 1). Dwelling characteristics are controlled for using a hedonic model, equation (15), and prices are deflated to values of 2014. The sample includes properties located up to 3km from the RLDs.

Figure 12: Quantiles of Price Effects of RLDs in Utrecht



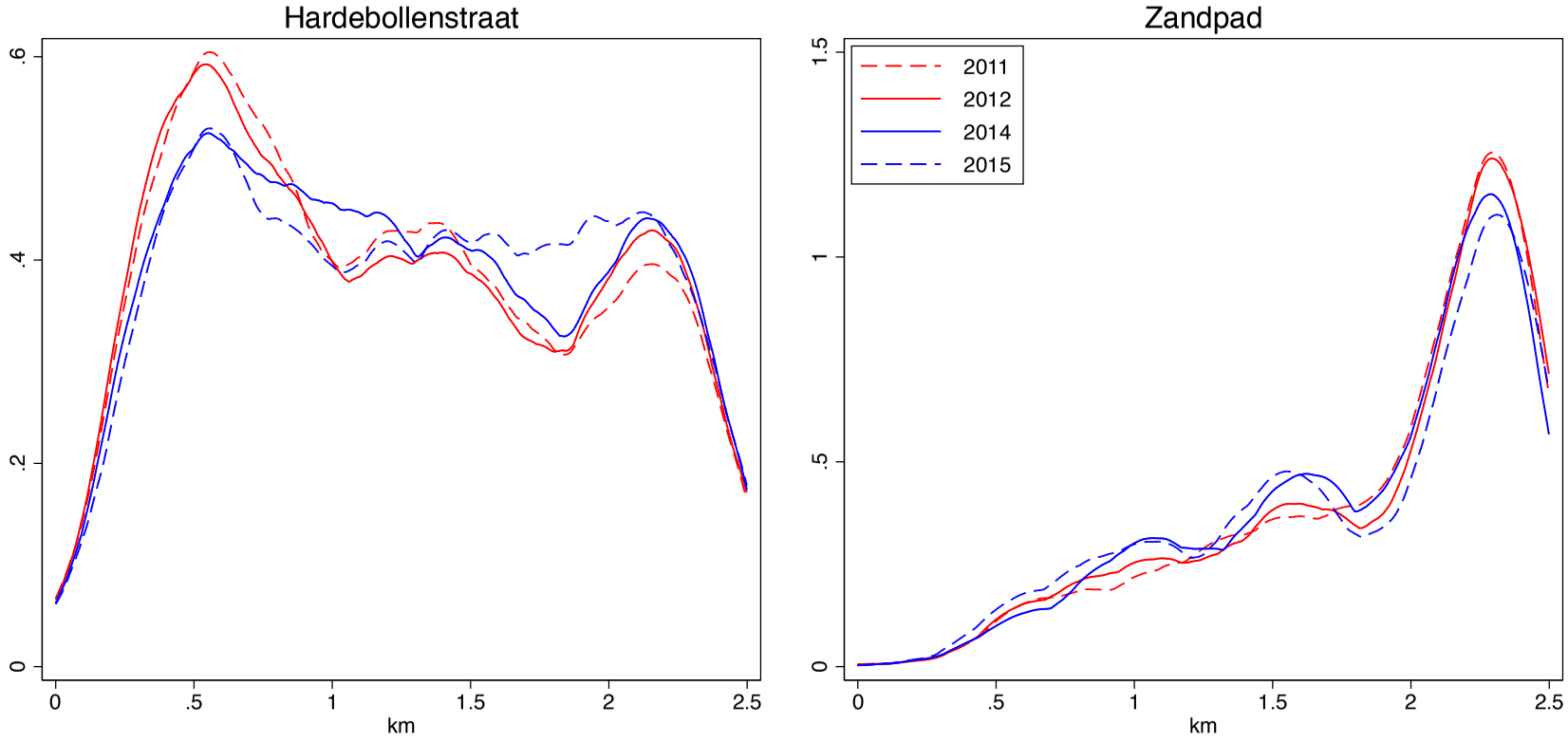
This figure shows the distribution (quantiles) of non-marginal effects in log price (on the left) and annual payments in euros (on the right) as a function of the radius to the center of the Red Light Districts (RLDs) in Utrecht. The effects are calculated through a second-order approximation, equation (17), using the estimated Difference-in-Slope (DiS) presented in Figure 11. Annual payments are calculated considering the total value of properties and a mortgage interest rate of 3.5% per annum for a 30-year loan. The DiS is the difference in the first derivative of the distance functions in January 2011-December 2012 and August 2013-December 2014. The distribution of effects is weighted by the density of houses for sale in 2011-2012. For better illustration, we apply an empirical Bayes shrinkage to estimates that are not significant at 10%. The bandwidth is selected using the procedure adapted from Calonico, Cattaneo and Titiunik (2014). See Table A6 in the Appendix (scale 1). Dwelling characteristics are controlled for using a hedonic model, equation (15), and prices are deflated to values of 2014. The sample includes properties located up to 3km from the RLDs.

Figure 13: Aggregate Effect of RLDs on House Prices in Utrecht



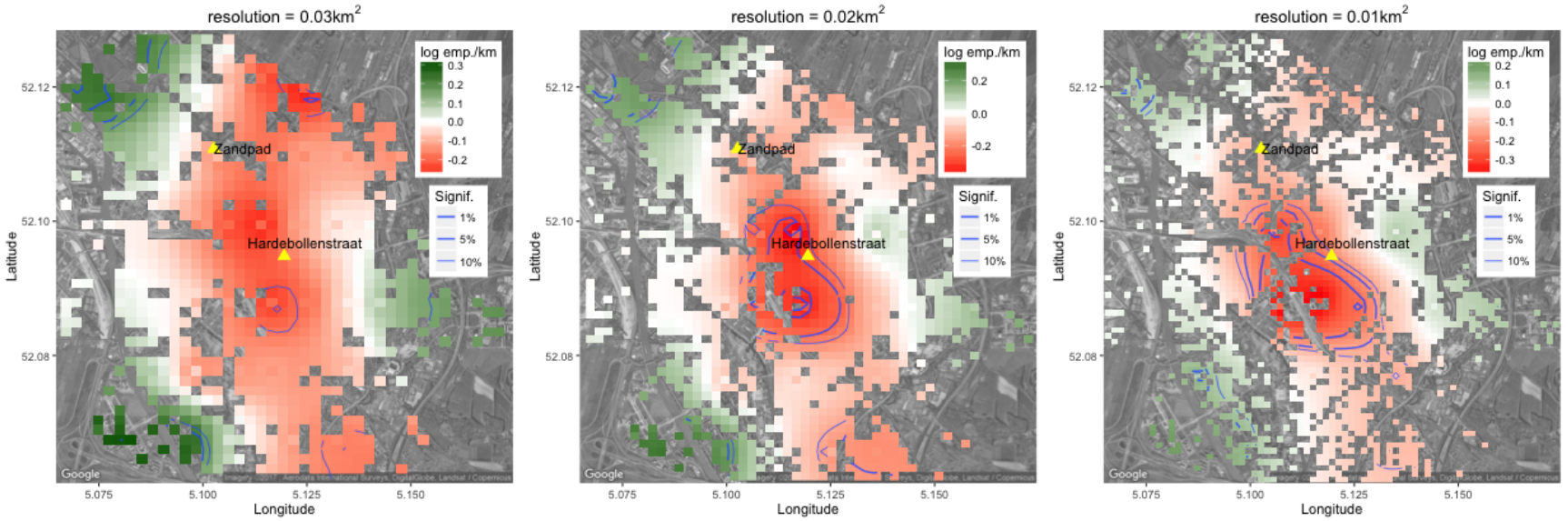
This figure shows the cumulative effect of the Red Light Districts (RLDs) on house prices. The effects are integrated over the distance to the RLDs within two radii: 1.5km (in red) and 2.5km (in blue). The effects are calculated through a second-order approximation, equation (17), using the estimated Difference-in-Slope (DiS) from Table A6 in the Appendix. We consider only estimates that are significant at 10%. The value of dwellings per postal code is obtained by deflating, based on their characteristics, the prices of all houses in the market since 1984. This value is also divided by the share of houses for sale per postal code.

Figure 14: Density of Employment per Distance to RLDs in Utrecht



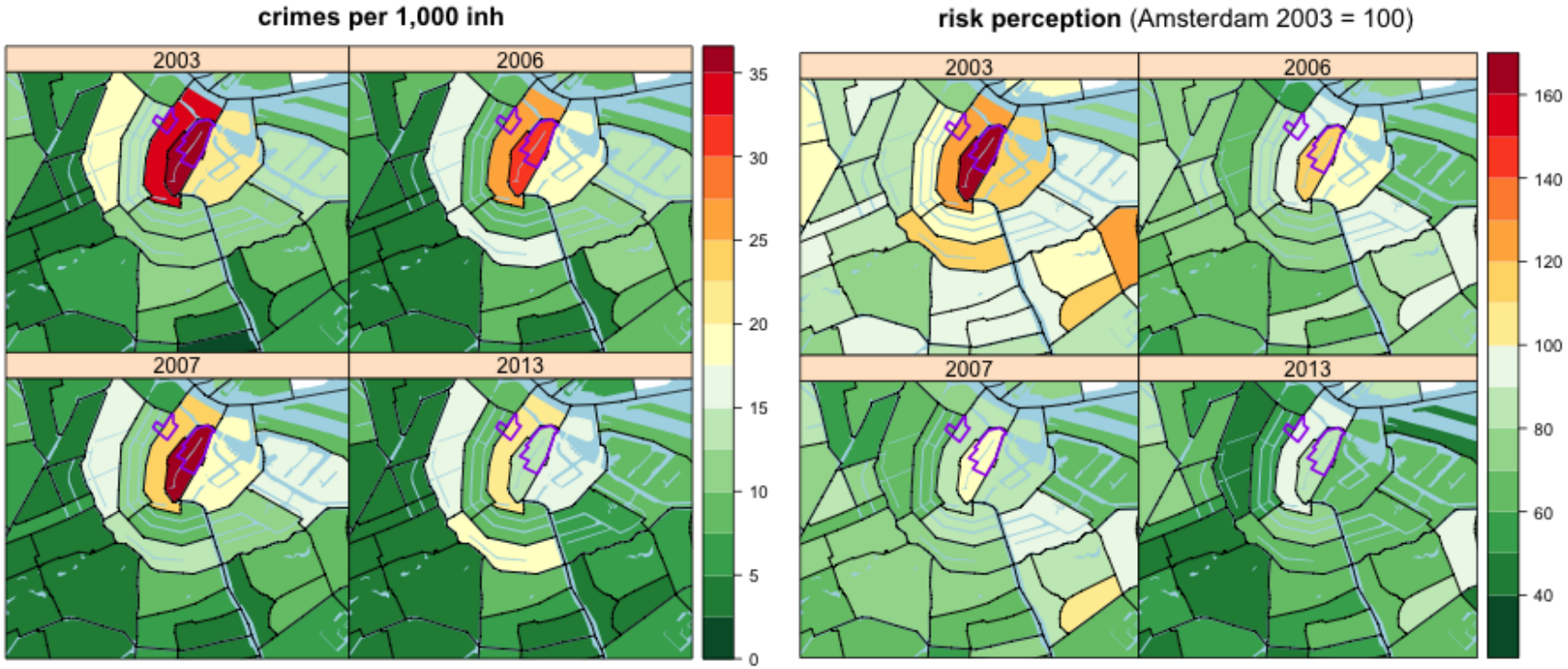
This figure shows the density of employment as a function of the distance in km to the Red Light Districts (RLD) in Utrecht. Employment level is measured by the total number of employees per six-digit postal code.

Figure 15: Spatial Marginal Effect of RLDs on Employment in Utrecht, 2012-2014



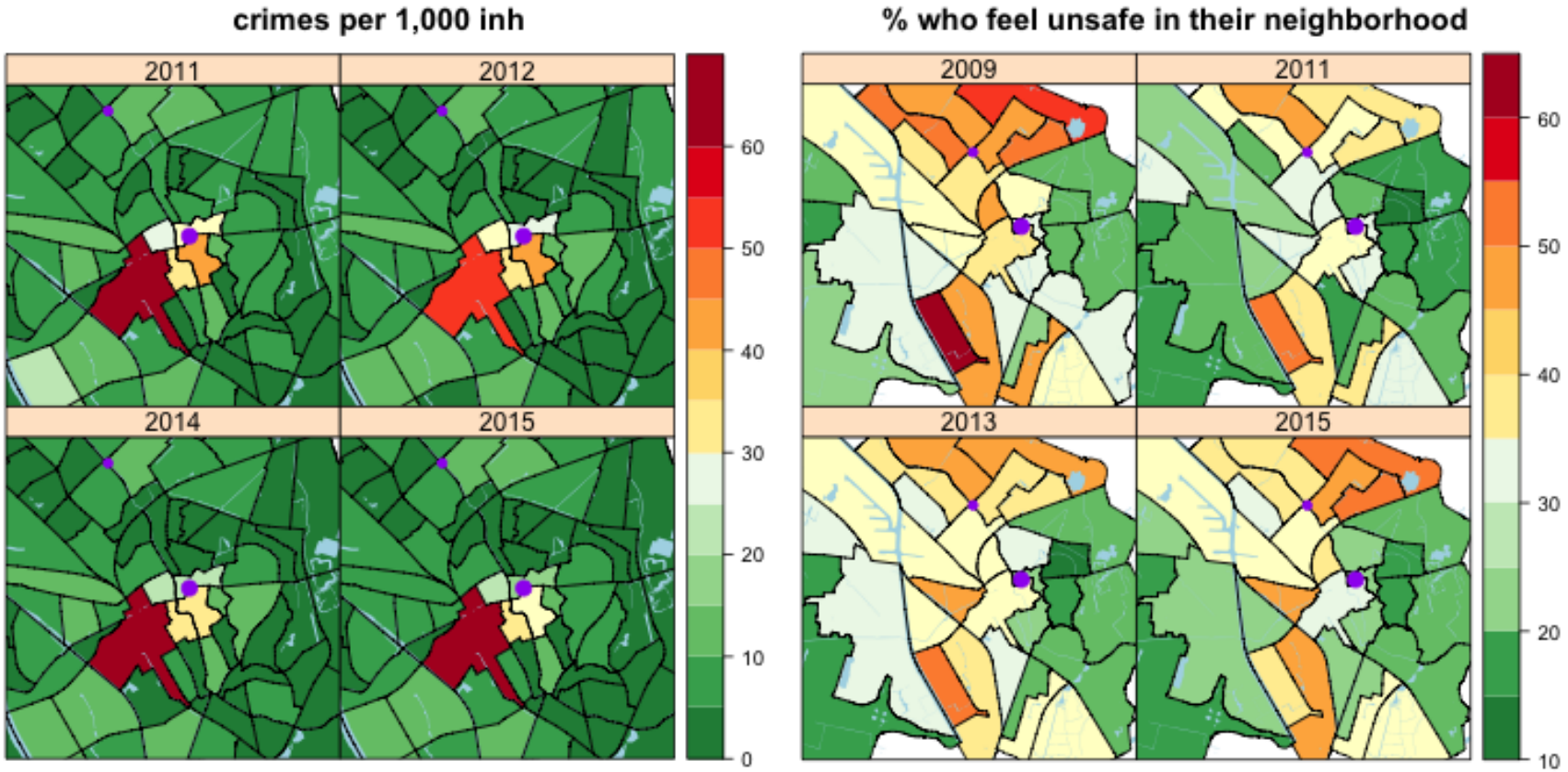
This figure shows the location of changes in the relationship between the log of total number of employees and distance to a Red Light District (RLD) in Utrecht. See equation (16). The 'marginal effect', or Difference-in-Slope (DiS), is the difference in the first derivative of the distance functions in 2012 and 2014. The total number of employees is calculated per pixel in three raster resolutions: 0.03km^2 on the left, 0.02km^2 in the center, and 0.01km^2 on the right. The bandwidth is selected using the procedure adapted from Calonico, Cattaneo and Titiunik (2014).

Figure 16: Crime Rates and Risk Perception in Neighborhoods of Amsterdam



This figure shows four maps on the right with the number of reported crimes per 1,000 inhabitants and four maps on the left with the risk perception index calculated by the Department of Research and Statistics of the city of Amsterdam. The Red Light Districts (RLDs) are identified by the purple contour lines. The number of inhabitants is calculated by district (*wijk*) to obviate the inflation of crime rates by small denominators. Reported crimes do not include minor felonies such as shoplifting, pickpocketing, and bike theft. The risk perception index has base 100 for the average safety level in Amsterdam in 2003. The safer the neighborhood, the lower the index.

Figure 17: Crime Rates and Risk Perception in Neighborhoods of Utrecht



This figure shows four maps on the right with the number of reported crimes per 1,000 inhabitants and four maps on the left with the percentage of residents who feel unsafe in their own neighborhood in Utrecht. *Hardebollenstraat* is identified by the large purple dot and *Zandpad* is identified by the small purple dot. The number of inhabitants is calculated by district (*wijk*) to obviate the inflation of crime rates by small denominators. Reported crimes do not include minor felonies such as shoplifting, pickpocketing, and bike theft. Data on risk perception are available at the sub-district (*subwijk*), so the maps on the right are for aggregated neighborhoods (*buurten*). Moreover, these data are not available for 2012 and 2014.

Table 1: History of the Dutch Policy on Prostitution

Date	Event
1275	Amsterdam was founded and the first RLD, named *De Wallen*, expanded around the harbor.
15th century	City governments shifted from keeping prostitution outside the city walls to designating soliciting zones in the city.
1413	A by-law of Amsterdam officially claimed that prostitution was necessary for the city, but allowed only in *De Wallen*.
16th century	Rise of Calvinism. Prostitution was viewed as a sin by the church and therefore prohibited.
1578	Calvinists took over the city government in Amsterdam and closed all brothels.
17th century	In the Golden Age, brothels appeared inevitable, but they had to remain unnoticeable.
1810-1813	French occupation. Prostitution was decriminalized and regulated. Prostitutes were required to register and undergo medical examinations.
1851	Local Government Act was passed to permit the sanitary control of prostitution.
Late 19th century	The abolitionist movement. Public opinion became strongly hostile to the practice of trafficking in and enslaving women. City governments started to abolish regulated prostitution, ending mandatory health checks and criminalizing brothel-keeping.
1911	The Morality Laws criminalized brothel keeping, but prostitution itself was not prohibited.
20th century	Dutch cities adopted tolerance policies and prostitution was allowed but only in designated areas (RLDs).
1930s	*Raamprostitutie* (window prostitution) was introduced in the RLDs.
1950s and 1960s	Post-war recovery. *De Wallen* reestablished itself as the main RLD in Amsterdam.
1970s	Relaxation of pornography laws led to the growth of live porn theaters, sex shops and adult cinemas in the RLDs. Procurers started trafficking in women from Southeast Asia.
1980s	Prostitutes started to migrate from Latin America and Africa. The Hague and Utrecht created official soliciting zones (*tippelzones*).
1990s	Fall of the Berlin Wall. Prostitutes started to migrate from Eastern Europe.
1996	Amsterdam created a *tippelzone*, moving street prostitution out of the city, along with a strict zoning plan that limited the expansion of RLDs.
October 1st, 2000	Brothels became licensed and fully legal. Prostitutes could work either as regular employees or as independent contractors. Labor unions started to accept prostitutes as members.
December 2003	Amsterdam closed its *tippelzone* following evidence of criminal activities.
June 1st, 2003	BIBOB Act came into effect, allowing city governments to refuse and withdraw permits from suspicious business owners.
2007	With the BIBOB Act, Amsterdam closed 58 sex businesses out of 108 that were investigated.
September 2007	The city of Amsterdam announced the intention to purchase several buildings in the RLD.
December 2007	Project 1012, which restricts window brothels to a few streets, was approved by the municipal council.
End of 2008	The mayor of Amsterdam announced plans to close half of the red windows, but no property was bought until 2011.
2009	The 'Law Regulating Prostitution' (WRP, *Wet Regulering Prostitutie*) was introduced in parliament. Sex workers would be required to register and receive a registration pass. The minimum age to work would rise from 18 to 21 years. A vote on the law has been deferred so far.
2011-2014	The city of Amsterdam purchased more properties in 2011 and 2014.
May-July 2013	Evidence of human trafficking in Utrecht led to the shutdown of all red windows in the city.

Sources: de Vries (1997), Bossenbroek and Kompagnie (1998), Brants (1998), Pol (2011), Koski (2007), Goodyear (2009), Wijk et al. (2010), Outshoorn (2012), Aalbers and Deinema (2012), McCoy (2013), Huisman and Nelen (2014), and Bisschop, Kastoryano and van der Klaauw (2017).

Table 2: Descriptive Statistics of House Characteristics

	Amsterdam				Utrecht area			
	in sample		out of sample		in sample		out of sample	
	mean	std.dev.	mean	std.dev.	mean	std.dev.	mean	std.dev.
Price/m^2 (euros)	4,030	1,095	3,119	1,048	2,660	713	2,626	824
In the RLD	0.024	0.152	0.000	0.000	0.000	0.000	0.000	0.000
Distance to RLD border	1.159	0.561	4.053	1.957	1.494	0.682	5.530	1.504
Distance to red window	1.239	0.567	4.139	1.955	1.494	0.682	5.530	1.504
Size (m^2)	87.3	47.7	89.6	40.3	98.1	38.5	121.1	41.7
Number of rooms	2.959	1.458	3.389	1.348	3.874	1.453	4.481	1.349
Top-level apartment	0.588	0.492	0.449	0.497	0.134	0.341	0.022	0.148
Ground-level apartment	0.144	0.351	0.129	0.335	0.127	0.333	0.019	0.137
Staircase-access flat	0.091	0.288	0.103	0.304	0.158	0.365	0.093	0.291
Maisonnette	0.034	0.181	0.037	0.188	0.034	0.182	0.035	0.183
Gallery	0.074	0.261	0.119	0.324	0.076	0.265	0.085	0.279
Townhome	0.031	0.174	0.084	0.278	0.334	0.472	0.337	0.473
Semi-detached house	0.004	0.060	0.036	0.186	0.064	0.244	0.267	0.443
Detached house	0.003	0.059	0.010	0.099	0.005	0.069	0.055	0.229
Attached mansion	0.028	0.166	0.022	0.148	0.052	0.221	0.030	0.169
Detached mansion	0.003	0.051	0.011	0.102	0.016	0.125	0.056	0.230
Built before 1906	0.442	0.497	0.073	0.259	0.170	0.375	0.014	0.117
Built 1906-1930	0.225	0.417	0.320	0.466	0.320	0.467	0.083	0.276
Built 1931-1944	0.060	0.238	0.098	0.297	0.143	0.350	0.094	0.291
Built 1945-1970	0.022	0.145	0.197	0.398	0.197	0.398	0.268	0.443
Built 1971-1990	0.105	0.306	0.151	0.358	0.056	0.230	0.277	0.447
Built after 1990	0.147	0.354	0.162	0.369	0.114	0.318	0.265	0.441
Heritage listed	0.102	0.303	0.008	0.091	0.014	0.119	0.003	0.050
Interior maintenance*	2.647	1.298	2.870	1.229	3.052	1.141	2.884	1.170
Exterior maintenance*	2.595	1.067	2.757	0.887	2.986	0.981	2.824	1.012
Luxury	0.234	0.424	0.120	0.325	0.058	0.234	0.033	0.180
Lift	0.149	0.356	0.203	0.402	0.092	0.289	0.106	0.308
Parking available	0.054	0.227	0.116	0.320	0.078	0.269	0.360	0.480
Number of observations	35,724		87,303		54,148		27,466	

'In sample' comprises dwellings within 2km from the Red Light Districts (RLDs) in the center of Amsterdam and within 3km from RLDs in Utrecht. In Amsterdam, 'in sample' excludes Amsterdam Noord. The Utrecht area includes dwellings from Utrecht, De Bilt, Bunnik and Zeist. Prices are deflated to values of 2014. *Interior and exterior maintenance conditions are assessed on a scale from 1 (excellent) to 9 (bad). The descriptive characteristics of the remaining variables are shown in Table A1 of the Appendix.

Table 3: Average Difference-in-Discontinuity and MWTA of Prostitution Externality in Amsterdam

	Bandwidth selection procedure									
	CCT					IK				
scale	1.0	0.8	0.9	1.1	1.2	1.0	0.8	0.9	1.1	1.2
Reduced-form - DiD										
1991/2006-2007/2014	-0.213 (-3.97)	-0.158 (-2.54)	-0.185 (-3.11)	-0.233 (-4.74)	-0.252 (-5.53)	-0.163 (-2.71)	-0.209 (-3.15)	-0.213 (-3.42)	-0.145 (-2.64)	-0.114 (-2.50)
2001/2006-2007/2014	-0.153 (-2.54)	-0.096 (-1.36)	-0.124 (-1.82)	-0.173 (-2.97)	-0.188 (-3.36)	-0.192 (-3.60)	-0.149 (-2.32)	-0.183 (-3.03)	-0.197 (-3.83)	-0.202 (-4.32)
1991/2000-2001/2006	-0.038 (-0.67)	-0.079 (-1.17)	-0.050 (-0.80)	-0.039 (-0.71)	-0.039 (-0.73)	0.062 (0.71)	0.021 (0.23)	0.049 (0.50)	0.026 (0.37)	0.026 (0.50)
1st Stage - Difference in distance (in 100m) to a red window										
1991/2006-2007/2014	-0.999 (-12.4)	-0.895 (-9.93)	-0.920 (-10.8)	-1.089 (-14.0)	-1.081 (-13.8)	-0.803 (-7.95)	-1.081 (-9.41)	-0.927 (-8.51)	-0.649 (-6.74)	-0.456 (-4.80)
2001/2006-2007/2014	-0.931 (-9.31)	-0.813 (-7.43)	-0.861 (-8.07)	-0.983 (-10.1)	-0.974 (-10.1)	-0.893 (-8.49)	-1.202 (-9.90)	-1.047 (-9.13)	-0.734 (-6.94)	-0.561 (-5.36)
1991/2000-2001/2006	-0.375 (-4.05)	-0.359 (-3.75)	-0.370 (-3.92)	-0.430 (-4.78)	-0.468 (-5.11)	-0.426 (-3.58)	-0.667 (-4.90)	-0.533 (-4.08)	-0.292 (-2.51)	-0.047 (-0.40)
2nd stage - MWTP per 100m										
1991/2006-2007/2014	0.213 (3.97)	0.176 (2.58)	0.201 (3.18)	0.214 (4.66)	0.233 (5.29)	0.202 (2.76)	0.193 (3.27)	0.229 (3.50)	0.224 (2.56)	0.250 (2.27)
2001/2006-2007/2014	0.165 (2.50)	0.119 (1.37)	0.144 (1.83)	0.176 (2.87)	0.193 (3.19)	0.215 (3.18)	0.124 (2.23)	0.175 (2.79)	0.269 (3.18)	0.360 (3.18)
1991/2000-2001/2006	0.100 (0.69)	0.220 (1.17)	0.134 (0.83)	0.090 (0.73)	0.082 (0.75)	-0.146 (-0.64)	-0.032 (-0.22)	-0.091 (-0.47)	-0.088 (-0.36)	-0.551 (-0.29)
Bandwidth in km	main pilot	main pilot	main pilot	main pilot	main pilot	main pilot	main pilot	main pilot	main pilot	main pilot
1991-2006	0.282 0.434	0.225 0.347	0.253 0.391	0.310 0.478	0.338 0.521	0.652 0.517	0.522 0.413	0.587 0.465	0.717 0.568	0.782 0.620
1991-2000	0.289 0.481	0.231 0.385	0.260 0.433	0.318 0.529	0.347 0.577	0.711 0.630	0.569 0.504	0.640 0.567	0.783 0.693	0.854 0.755
2001-2006	0.249 0.378	0.199 0.302	0.224 0.340	0.273 0.416	0.298 0.454	0.705 0.606	0.564 0.485	0.634 0.546	0.775 0.667	0.846 0.728
2007-2014	0.243 0.381	0.194 0.305	0.219 0.343	0.267 0.419	0.292 0.457	0.390 0.620	0.312 0.496	0.351 0.558	0.429 0.682	0.468 0.744

This table presents the average difference-in-discontinuity (DiD) estimates of house prices on the top, followed by the average difference in distance from the Red Light District (RLD) border to a red window (1st stage), and the estimated marginal willingness to accept (MWTA) the externality (2nd stage), as in equation (11). The sample includes properties located up to 2km from the closest RLD. Robust z-statistics are in parentheses. Bandwidths, shown at the bottom, are selected using the procedures proposed by Calonico, Cattaneo and Titiunik (2014), CCT, and by Imbens and Kalyanaraman (2012), IK. We also multiply the optimal bandwidths by several scales, from 0.8 to 1.2.

Table 4: Conditional Difference in Price Discontinuity in Amsterdam's RLDs

		Bandwidth selection procedure									
		CCT					IK				
scale		1.0	0.8	0.9	1.1	1.2	1.0	0.8	0.9	1.1	1.2
1991/2006-2007/2014											
Difference in distance to window	δ^0	0.194 (3.30)	0.177 (2.90)	0.185 (3.09)	0.204 (3.52)	0.212 (3.68)	0.193 (3.28)	0.176 (2.88)	0.184 (3.07)	0.204 (3.50)	0.211 (3.67)
Difference × initial distance	δ^1	-0.094 (-2.04)	-0.082 (-1.71)	-0.087 (-1.86)	-0.101 (-2.20)	-0.106 (-2.33)	-0.094 (-2.02)	-0.082 (-1.70)	-0.087 (-1.85)	-0.100 (-2.19)	-0.106 (-2.32)
Intercept	δ^2	0.024 (0.57)	0.038 (0.86)	0.030 (0.71)	0.017 (0.40)	0.012 (0.30)	0.016 (0.32)	0.008 (0.13)	0.005 (0.09)	0.018 (0.38)	0.018 (0.39)
Initial distance to window	δ^3	-0.009 (-0.46)	-0.018 (-0.81)	-0.014 (-0.64)	-0.005 (-0.26)	-0.002 (-0.12)	-0.010 (-0.48)	-0.018 (-0.83)	-0.014 (-0.65)	-0.006 (-0.28)	-0.003 (-0.13)
Bandwidth in km (main/pilot)		0.445 0.667	0.356 0.533	0.400 0.600	0.489 0.733	0.534 0.800	0.441 0.335	0.353 0.268	0.397 0.302	0.485 0.369	0.529 0.402
2001/2006-2007/2014											
Difference in distance to window	δ^0	0.167 (2.47)	0.142 (2.04)	0.154 (2.25)	0.175 (2.63)	0.177 (2.67)	0.177 (2.67)	0.162 (2.39)	0.174 (2.61)	0.177 (2.70)	0.175 (2.69)
Difference × initial distance	δ^1	-0.090 (-1.77)	-0.076 (-1.45)	-0.083 (-1.61)	-0.095 (-1.88)	-0.096 (-1.91)	-0.096 (-1.91)	-0.087 (-1.71)	-0.094 (-1.86)	-0.097 (-1.93)	-0.096 (-1.92)
Intercept	δ^2	0.058 (1.19)	0.075 (1.46)	0.067 (1.36)	0.053 (1.10)	0.052 (1.11)	0.056 (0.81)	0.097 (1.21)	0.072 (0.99)	0.032 (0.50)	0.025 (0.39)
Initial distance to window	δ^3	-0.002 (-0.10)	-0.014 (-0.60)	-0.009 (-0.39)	0.002 (0.08)	0.003 (0.13)	0.003 (0.13)	-0.004 (-0.20)	0.001 (0.06)	0.004 (0.20)	0.005 (0.27)
Bandwidth in km (main/pilot)		0.490 0.687	0.392 0.550	0.441 0.619	0.539 0.756	0.588 0.825	0.590 0.345	0.472 0.276	0.531 0.310	0.649 0.379	0.708 0.414
1991/2000-2001/2006											
Difference in distance to window	δ^0	0.064 (1.03)	0.068 (1.06)	0.066 (1.04)	0.064 (1.03)	0.065 (1.06)	0.071 (1.08)	0.060 (0.87)	0.065 (0.96)	0.070 (1.08)	0.068 (1.06)
Difference × initial distance	δ^1	-0.034 (-0.66)	-0.031 (-0.58)	-0.032 (-0.62)	-0.036 (-0.70)	-0.039 (-0.75)	-0.031 (-0.57)	-0.022 (-0.38)	-0.026 (-0.47)	-0.031 (-0.58)	-0.031 (-0.59)
Intercept	δ^2	-0.060 (-1.25)	-0.063 (-1.26)	-0.062 (-1.27)	-0.060 (-1.27)	-0.059 (-1.27)	-0.105 (-1.83)	-0.139 (-2.14)	-0.127 (-2.09)	-0.079 (-1.44)	-0.063 (-1.19)
Initial distance to window	δ^3	-0.020 (-0.85)	-0.016 (-0.62)	-0.018 (-0.73)	-0.021 (-0.90)	-0.023 (-0.98)	-0.018 (-0.65)	-0.027 (-0.91)	-0.023 (-0.80)	-0.016 (-0.61)	-0.016 (-0.63)
Bandwidth in km (main/pilot)		0.518 0.741	0.414 0.593	0.466 0.667	0.569 0.815	0.621 0.889	0.359 0.337	0.287 0.269	0.323 0.303	0.395 0.370	0.431 0.404

This table presents the difference-in-discontinuity (DiD) estimates of house prices conditional on the difference in the distance to a red window, initial difference to a red window, and the interaction of these two covariates, as shown in equation (14). All covariates are measured in 100m. The 'intercept' represents the average DiD if both difference in distance and initial distance are equal to zero. The three panels present the conditional DiDs for different periods. The sample includes properties located up to 2km from the closest Red Light District (RLD). Robust z-statistics are in parentheses. Main and pilot bandwidths, in the bottom row of each panel, are selected using the procedures proposed by Calonico, Cattaneo and Titiunik (2014), CCT, and by Imbens and Kalyanaraman (2012), IK. We also multiply the optimal bandwidths by several scales, from 0.8 to 1.2.

Table 5: Average Discontinuity in Dwelling Characteristics at the RLD Border in Amsterdam

	1991-2006				2007-2014			
	discontinuity		mean	price eff.	discontinuity		mean	price eff.
Log size	0.068	(0.74)	4.398	0.003	-0.495	(-4.41)	4.300	-0.018
Number of rooms	0.635	(1.88)	2.912	-0.004	-1.764	(-4.01)	3.011	0.011
Has 2+ floors	0.243	(2.93)	0.394	0.001	-0.067	(-0.55)	0.285	0.000
Has 3+ floors	0.108	(1.45)	0.124	0.000	-0.162	(-1.58)	0.079	0.000
Top-level apartment	-0.103	(-1.26)	0.491	-0.002	0.278	(2.36)	0.705	-0.010
Ground-level apartment	0.022	(0.54)	0.135	0.000	-0.106	(-1.13)	0.158	0.001
Staircase-access flat	-0.012	(-0.22)	0.126	0.000	-0.102	(-1.54)	0.050	0.001
Maisonnette	-0.024	(-0.77)	0.039	0.000	-0.071	(-2.42)	0.027	0.000
Gallery	-0.031	(-0.70)	0.126	0.000	0.000	(0.00)	0.011	0.000
Townhome	0.040	(0.64)	0.040	0.000	-0.188	(-2.46)	0.019	-0.005
Semi-detached house	0.011	(1.15)	0.004	0.000	-0.053	(-1.12)	0.003	-0.001
Detached house	-0.030	(-0.86)	0.004	-0.002	0.153	(1.84)	0.003	0.005
Attached mansion	0.036	(0.83)	0.033	-0.001	-0.070	(-2.10)	0.021	0.001
Detached mansion	0.071	(0.99)	0.003	-0.003	-0.004	(-0.28)	0.002	0.000
Built after 1906	-0.110	(-1.54)	0.546	0.003	0.473	(4.24)	0.581	-0.008
Built after 1931	-0.037	(-0.61)	0.337	-0.001	-0.132	(-0.73)	0.330	-0.001
Built after 1945	-0.056	(-0.95)	0.278	-0.001	-0.157	(-0.88)	0.266	-0.001
Built after 1971	-0.065	(-1.26)	0.250	0.003	-0.376	(-7.72)	0.251	0.014
Built after 1990	-0.096	(-1.43)	0.144	-0.001	-0.197	(-5.42)	0.149	-0.004
Heritage listed	-0.042	(-0.51)	0.118	-0.001	-0.161	(-1.41)	0.071	-0.005
Interior maintenance	0.474	(1.99)	2.655	0.000	0.051	(0.20)	2.637	0.000
Exterior maintenance	0.563	(2.72)	2.564	-0.002	0.069	(0.30)	2.629	0.000
Luxury	-0.150	(-2.14)	0.244	-0.001	-0.219	(-2.36)	0.225	-0.001
Lift	-0.089	(-0.55)	0.164	-0.001	-0.322	(-2.18)	0.130	-0.004
Balcony	-0.068	(-1.33)	0.345	0.001	-0.274	(-2.97)	0.455	0.003
Terrace	-0.009	(-0.15)	0.107	0.000	-0.391	(-3.70)	0.156	-0.001
Central heating	-0.115	(-1.89)	0.780	-0.001	0.094	(0.85)	0.890	0.001
Some isolation	-0.299	(-3.74)	0.469	0.004	-0.036	(-0.29)	0.728	0.001
Full isolation	-0.004	(-0.34)	0.100	0.000	-0.210	(-4.23)	0.191	0.000
Total effect on log price				-0.009				-0.021

This table presents the average regression discontinuity (RD) estimates for some dwelling characteristics, their mean value in the sample, and their effect on log price. The RD estimates for the remaining characteristics are in Table A4 of the Appendix. The sample includes properties located up to 2km from the closest Red Light District (RLD). Robust z-statistics are in parentheses. Bandwidths are the same as those applied in Table 3. Effect on log price is calculated by plugging the estimated discontinuities in Tables 5 and A4 into a hedonic regression, controlling for year and location.

Table 6: Discontinuity in Distance to Other Businesses at the RLD Border in Amsterdam

	discontinuity in distance (100m)		mean distance (100m)
2001/2006			
coffeshop	-0.874	(-5.87)	1.745
cafe	0.495	(7.21)	0.906
restaurant	-0.122	(-1.57)	0.885
store	-0.145	(-3.01)	0.392
2007/2014			
coffeshop	-0.975	(-7.26)	1.835
cafe	0.278	(4.51)	0.926
restaurant	-0.008	(-0.13)	0.845
store	-0.118	(-2.77)	0.388
2014/2007-2006/2001			
coffeshop	-0.102	(-0.51)	0.090
cafe	-0.217	(-2.35)	0.020
restaurant	0.114	(1.13)	-0.040
store	0.027	(0.43)	-0.004

This table presents the average regression discontinuity (RD) estimates for the distance from sold houses to business establishments on the same side of the border. The sample includes properties located up to 2km from the closest Red Light District (RLD). Robust z-statistics are in parentheses. Bandwidths are the same as those applied in Table 3. Types of business are described as: 'coffeeshop,' which sells cannabis; 'cafe,' whose main activity is to serve alcoholic beverages; 'restaurant,' which serves food and includes hotel-restaurants, but excludes diners and lunchrooms; and 'store,' which denotes a specialized retailer, except for grocery stores, gift shops, and sex shops.

Table 7: Difference-in-Differences in Crime Rates and Risk Perception

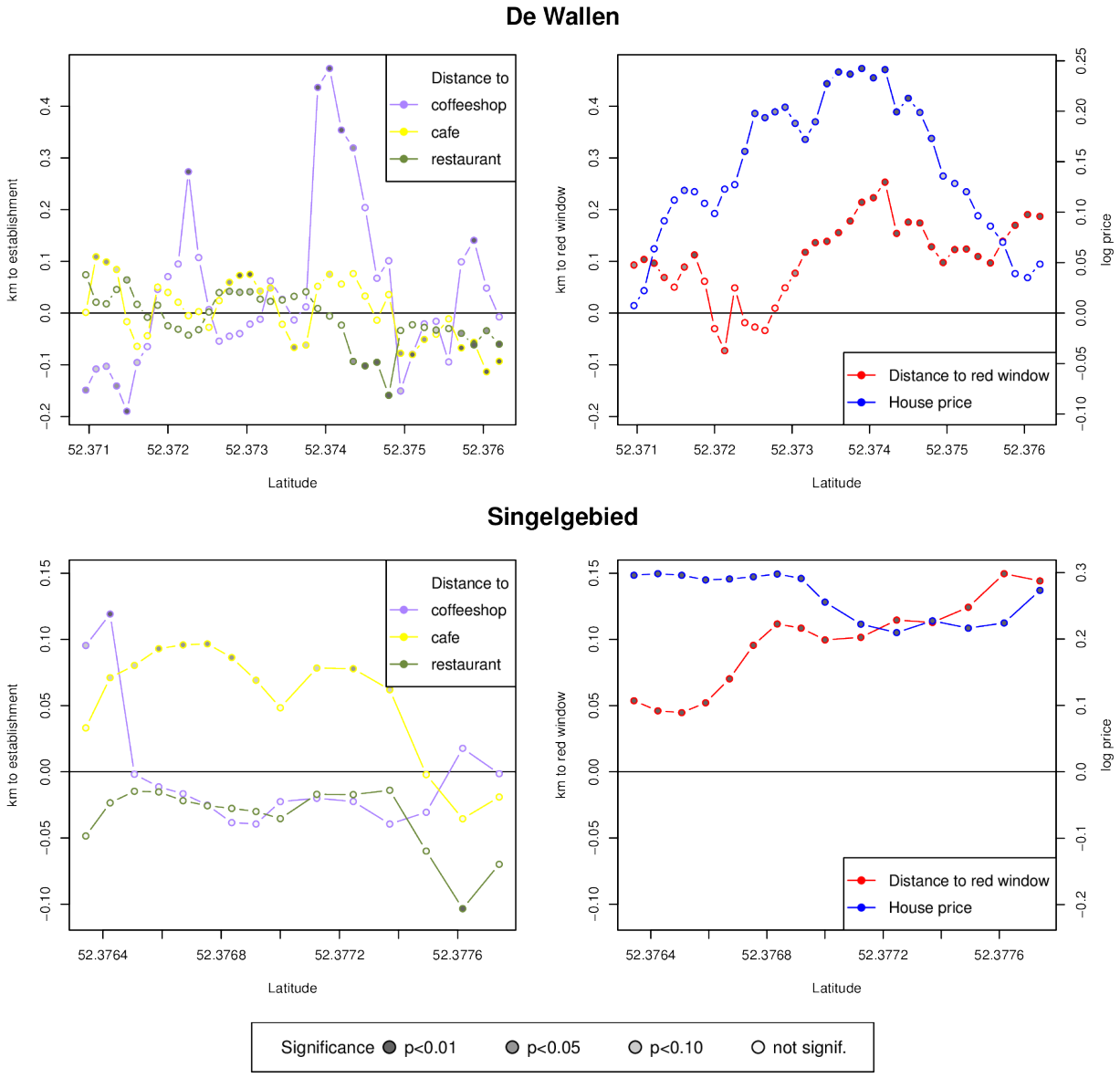
Amsterdam							
	Crime rate						log risk index
	total	violence	nuisances	major property	minor thefts	illegal drug dealing	
(year $\geq$ 2007) $\cdot$ (distance $\leq$ 50m)	-0.182	-0.129	-0.108	-0.138	-0.222	-0.674	-0.18
	(-4.65)	(-2.69)	(-2.24)	(-2.63)	(-5.16)	(-4.96)	(-3.31)
(year $\geq$ 2007) $\cdot$ (50m $<$ distance $\leq$ 200m)	0.096	0.124	0.112	0.085	0.200	0.009	0.03
	(1.83)	(1.80)	(1.69)	(1.21)	(3.49)	(0.05)	(0.90)
(year $\geq$ 2007) $\cdot$ (200m $<$ distance $\leq$ 500m)	0.116	-0.022	0.124	0.117	-0.064	-0.258	-0.15
	(1.64)	(-0.24)	(1.42)	(1.22)	(-0.80)	(-1.01)	(-5.73)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	372	372	372	372	372	372	341
Number of neighborhoods	31	31	31	31	31	31	31
Utrecht							
	Crime rate						% who feel unsafe in the neighborhood
	total	violence	nuisances	major property	minor thefts	illegal drug dealing	
(year $\geq$ 2013) $\cdot$ (distance $\leq$ 50m)	-0.114	-0.251	-0.141	0.055	-0.430	-0.507	-2.71
	(-1.86)	(-2.56)	(-1.82)	(0.60)	(-3.21)	(-1.73)	(-1.25)
(year $\geq$ 2013) $\cdot$ (50m $<$ distance $\leq$ 200m)	-0.103	-0.061	0.047	-0.264	-0.101	0.190	-6.04
	(-1.59)	(-0.53)	(0.54)	(-2.73)	(-0.76)	(0.74)	(-3.66)
(year $\geq$ 2013) $\cdot$ (200m $<$ distance $\leq$ 500m)	-0.004	0.085	0.067	-0.098	-0.008	0.327	-1.88
	(-0.09)	(1.03)	(1.10)	(-1.41)	(-0.09)	(1.21)	(-1.14)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	268	268	268	268	268	260	66
Number of neighborhoods	67	67	67	67	67	65	22

This table presents Difference-in-Difference estimates for crime rates, estimated using a negative binomial regression, and risk perception, estimated using a linear regression. The level of observation is the neighborhood (*buurt*), except for the '% who feel unsafe' in Utrecht, where it is the sub-district (*subwijk*). 'Distance' means the shortest distance between the area and a red window in a Red Light District (RLD) and the sample includes only areas within 2km. The sample period in Amsterdam is between 2003 and 2014 and in Utrecht between 2011 and 2015, excluding 2013. The 'total' crime rate do not include minor felonies, such as shoplifting, pickpocketing, and bike theft, and reported nuisances, such as complaints about neighbors and alcohol abuse. Cases of 'violence' include declarations of abuses, threats, sexual offenses, fights, assaults, and street robbery, but they exclude cases of domestic violence. 'Nuisances' include complaints against neighbors, vandalism, and cases of drug and alcohol abuse registered by the police. 'Major property' crimes include burglaries and motor vehicle thefts. 'Minor thefts' include bike thefts, shoplifting, pickpocketing and other property crimes. Standard errors are clustered by neighborhood and the t-statistics are in parentheses.

Figure A1: Map of Interventions from Project 1012 in Amsterdam

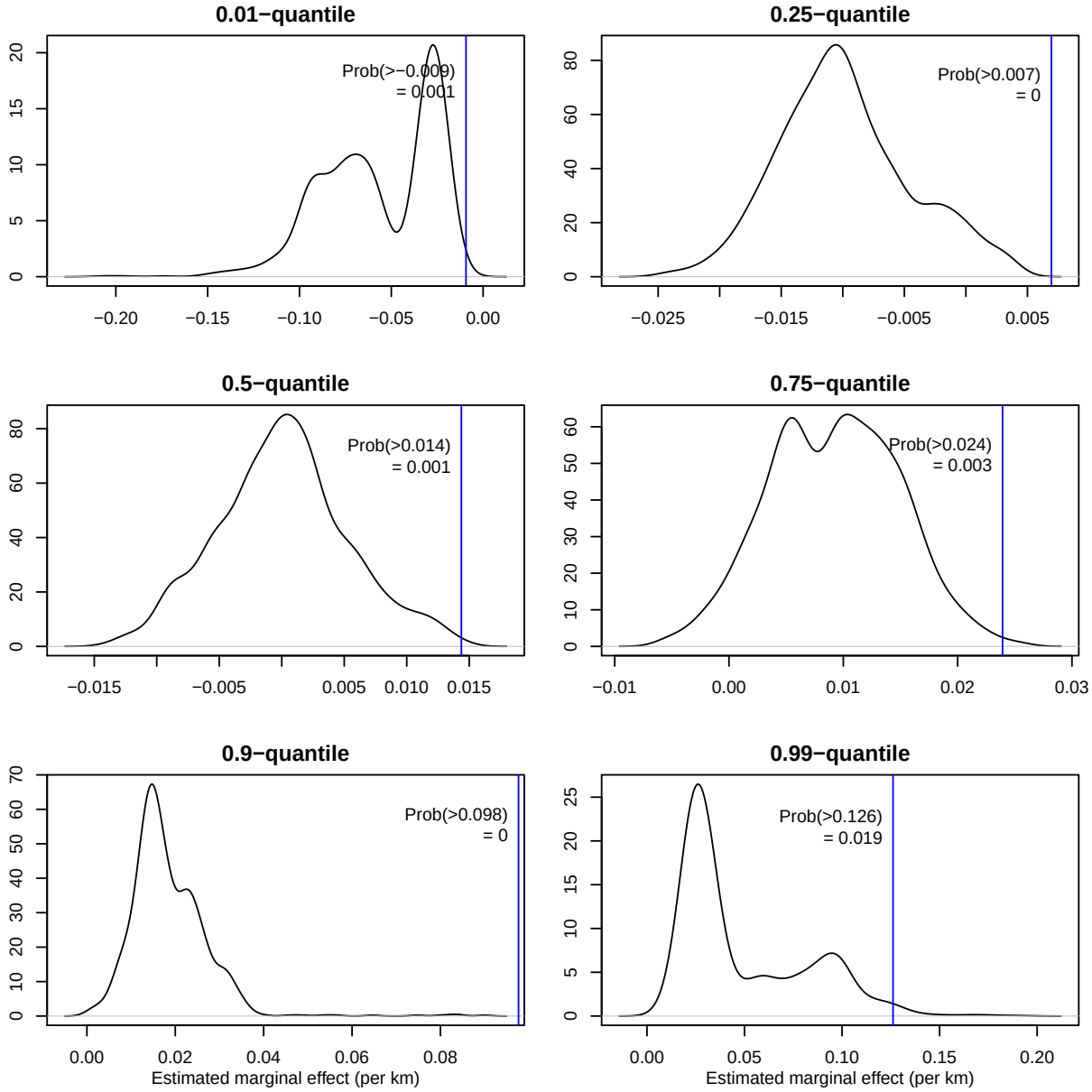
This map, copied from the Municipality of Amsterdam website, shows the location of all interventions from Project 1012 since 2007, excluding those related exclusively to prostitution windows. Source: www.amsterdam.nl/projecten/project-1012.

Figure A2: Difference-in-Discontinuity for Distance to Other Businesses in Amsterdam, 2007/2014 – 2001/2006



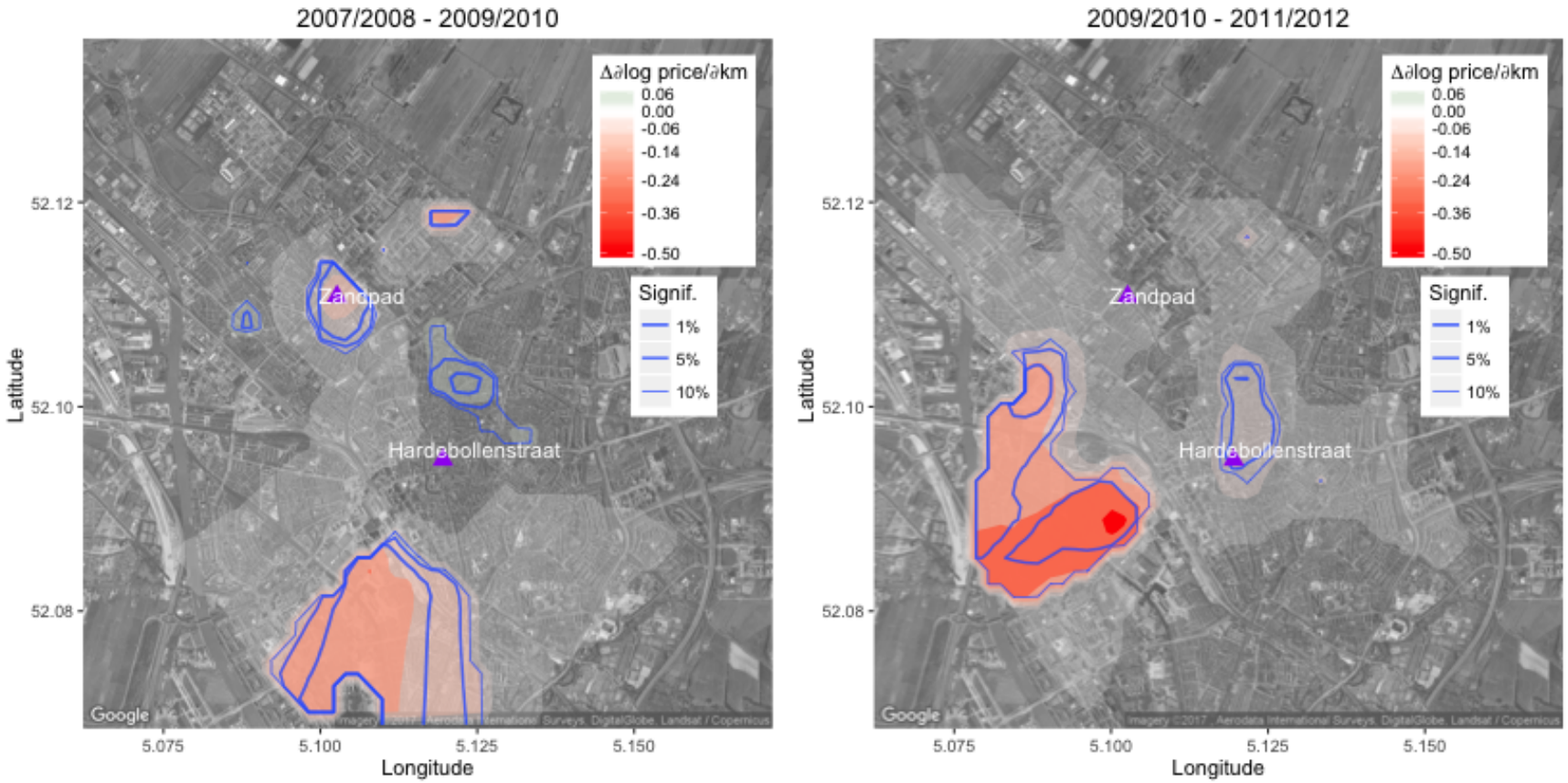
This figure presents difference-in-discontinuity (DiD) estimates, as shown in equation (9), for distance from sold houses to a business establishment (on the left) and for distance to a red window and log prices (on the right). 'Coffeeshop' is an establishment that sells cannabis. 'Cafe' is an establishment whose main activity is to serve alcoholic beverages. 'Restaurant' is an establishment serving food, which also includes hotel-restaurants, but excludes diners and lunchrooms. The sample includes properties located up to 2km from the closest Red Light District (RLD). Dwelling characteristics are controlled for as shown in equation (7). Outcomes are estimated using triangular kernel and the bandwidths are the same as those applied in Table 3.

Figure A3: Quantiles of Marginal Effects of Random Locations on House Prices in Utrecht



This figure shows the distribution of estimated Difference-in-Slope (DiS) quantiles for random locations in Utrecht. The DiS is the difference in the first derivative of log price with respect to distance in January 2011-December 2012 and August 2013-December 2014. The distance is calculated 1,000 times from different pairs of random locations within the city limits. The blue vertical line represents the quantile DiS for the actual Red Light Districts (RLD). The bandwidth is selected using the procedure adapted from Calonico, Cattaneo and Titiunik (2014). See Table A6 (scale 1). Dwelling characteristics are controlled for using a hedonic model, equation (15), and prices are deflated to values of 2014. The sample includes properties located up to 3km from the RLDs and quantiles are calculated for properties up to 2km from the RLDs.

Figure A4: Marginal Changes in House Prices Before Closing of RLDs in Utrecht



This figure shows the location of changes in the relationship between log price per square meter and distance to a Red Light District (RLD) in Utrecht. See equation (15). The Difference-in-Slope (DiS) is the difference in the first derivative of the distance functions in 2007-2008 and 2009-2010 (on the left) and in 2009-2010 and 2011-2012 (on the right). For better illustration, we apply an empirical Bayes shrinkage to estimates that are not significant at 10%. The bandwidth is selected using the procedure adapted from Calonico, Cattaneo and Titiunik (2014). Dwelling characteristics are controlled for using a hedonic model, equation (15), and prices are deflated to values of 2014. The sample includes properties located up to 3km from the RLDs.

Table A1: Descriptive Statistics of Other House Characteristics

	Amsterdam				Utrecht area			
	in sample		out of sample		in sample		out of sample	
	mean	std.dev.	mean	std.dev.	mean	std.dev.	mean	std.dev.
Apartment with open porch	1.450	0.677	1.502	0.715	2.066	0.846	2.407	0.800
Number of floors	0.814	0.500	0.810	0.484	0.811	0.525	0.891	0.546
Number of kitchens	0.959	0.604	1.015	0.594	1.094	0.625	1.357	0.671
Number of WCs	0.914	0.453	0.927	0.379	0.904	0.387	0.977	0.347
Number of bathrooms	0.019	0.136	0.021	0.142	0.012	0.110	0.011	0.103
L-shaped living room	0.058	0.234	0.075	0.264	0.148	0.356	0.151	0.358
Sun-through living room	0.041	0.198	0.080	0.271	0.083	0.276	0.029	0.167
Room and suite	0.016	0.126	0.022	0.147	0.151	0.358	0.232	0.422
Dormer window	0.390	0.488	0.562	0.496	0.385	0.487	0.329	0.470
Balcony	0.834	0.372	0.868	0.339	0.787	0.410	0.937	0.244
Central heating	0.070	0.255	0.084	0.277	0.103	0.305	0.140	0.347
No isolation	0.414	0.493	0.336	0.472	0.340	0.474	0.188	0.391
Some isolation	0.445	0.497	0.502	0.500	0.581	0.493	0.577	0.494
Full isolation	0.141	0.348	0.162	0.369	0.079	0.269	0.235	0.424
Attic	0.042	0.201	0.057	0.232	0.184	0.388	0.278	0.448
Terrace	0.131	0.337	0.091	0.288	0.111	0.314	0.064	0.245
Carport	0.028	0.164	0.043	0.202	0.022	0.147	0.080	0.272
Garage	0.021	0.143	0.046	0.208	0.045	0.208	0.240	0.427
Garden	0.194	0.395	0.277	0.447	0.555	0.497	0.689	0.463
South-facing garden	0.106	0.308	0.147	0.354	0.260	0.439	0.357	0.479
Sold in 1991-2000	0.241	0.428	0.218	0.413	0.293	0.455	0.292	0.455
Sold in 2001-2004	0.170	0.376	0.179	0.383	0.223	0.417	0.204	0.403
Sold in 2005-2008	0.250	0.433	0.262	0.440	0.234	0.423	0.242	0.429
Sold in 2009-2012	0.217	0.412	0.212	0.409	0.162	0.369	0.167	0.373
Sold in 2013-2014	0.122	0.328	0.130	0.336	0.088	0.283	0.095	0.294
Number of observations	35,724		87,303		54,148		27,466	

This table presents the descriptive statistics of the remaining variables, not included in Table 2. The category 'in sample' comprises dwellings within 2km from the Red Light Districts (RLDs) in the center of Amsterdam and within 3km from the RLDs in Utrecht. In Amsterdam, the 'in sample' excludes Amsterdam Noord. The Utrecht area includes dwellings from Utrecht, De Bilt, Bunnik and Zeist.

Table A2: Hedonic Coefficients of Dwelling Characteristics

	Amsterdam				Utrecht			
	1991-2006		2007-2014		1991-2010		2011-2014	
Log size	-0.269***	(0.005)	-0.222***	(0.005)	-0.520***	(0.006)	-0.362***	(0.005)
Ground-level apartment	0.002	(0.004)	0.022***	(0.004)	0.039***	(0.006)	0.043***	(0.004)
Staircase-access flat	-0.019***	(0.005)	-0.002	(0.006)	0.026***	(0.008)	0.021***	(0.005)
Maisonette	-0.002	(0.007)	-0.033***	(0.008)	0.049***	(0.010)	0.043***	(0.007)
Gallery	-0.002	(0.006)	-0.004	(0.011)	0.028***	(0.008)	0.009	(0.006)
Townhouse	0.042***	(0.007)	0.086***	(0.010)	0.060***	(0.005)	0.066***	(0.004)
Semi-detached house	0.118***	(0.018)	0.120***	(0.020)	0.089***	(0.007)	0.102***	(0.005)
Detached house	-0.046**	(0.020)	0.090***	(0.021)	0.415***	(0.023)	0.440***	(0.020)
Attached mansion	-0.015*	(0.008)	-0.015	(0.010)	0.176***	(0.007)	0.187***	(0.006)
Detached mansion	0.012	(0.023)	0.069***	(0.025)	0.199***	(0.011)	0.194***	(0.009)
Built 1906-1930	-2.448***	(0.775)	-0.518	(0.744)	-2.159***	(0.575)	0.063	(0.407)
Built 1931-1944	1.388	(4.260)	1.195	(4.583)	5.284*	(2.852)	13.841***	(2.473)
Built 1945-1970	3.410	(2.856)	0.939	(3.726)	11.278***	(1.500)	13.384***	(1.005)
Built 1971-1990	0.400	(1.777)	-2.654	(1.822)	-22.910***	(2.112)	-21.009***	(1.508)
Built after 1990	4.902**	(1.985)	-4.280***	(1.306)	-0.471	(3.705)	-2.788***	(1.020)
Year built	0.000***	(0.000)	0.000***	(0.000)	0.000**	(0.000)	0.000***	(0.000)
Built 1906-1930 × year built	0.001***	(0.000)	0.000	(0.000)	0.001***	(0.000)	0.000	(0.000)
Built 1931-1944 × year built	-0.001	(0.002)	-0.001	(0.002)	-0.003*	(0.001)	-0.007***	(0.001)
Built 1945-1970 × year built	-0.002	(0.001)	0.000	(0.002)	-0.006***	(0.001)	-0.007***	(0.001)
Built 1971-1990 × year built	0.000	(0.001)	0.001	(0.001)	0.012***	(0.001)	0.011***	(0.001)
Built after 1990 × year built	-0.002**	(0.001)	0.002***	(0.001)	0.000	(0.002)	0.001***	(0.001)
Heritage listed	0.038***	(0.005)	0.043***	(0.005)	0.105***	(0.011)	0.049***	(0.007)
Interior maintenance	-0.026***	(0.002)	-0.019***	(0.002)	-0.014***	(0.002)	-0.033***	(0.002)
Exterior maintenance	-0.014***	(0.002)	-0.004*	(0.002)	-0.011***	(0.002)	0.000	(0.002)
Int. maint. × ext. maint.	-0.003***	(0.001)	-0.004***	(0.001)	-0.005***	(0.000)	-0.002***	(0.000)
Luxury	0.029***	(0.004)	0.037***	(0.004)	0.067***	(0.007)	0.044***	(0.004)
Number of rooms	0.022***	(0.001)	0.020***	(0.002)	0.035***	(0.001)	0.017***	(0.001)
Apartment with open porch	0.007	(0.011)	0.001	(0.008)	0.017	(0.012)	-0.002	(0.009)
Has 2 floors	0.006*	(0.003)	0.019***	(0.004)	0.007	(0.005)	-0.011***	(0.004)
Has 3+ floors	-0.012**	(0.006)	-0.001	(0.007)	0.022***	(0.006)	-0.013***	(0.004)

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Table A2 – continued from the previous page

	Amsterdam				Utrecht			
	1991-2006		2007-2014		1991-2010		2011-2014	
Has 1 kitchen	-0.004	(0.004)	-0.002	(0.003)	-0.016*	(0.009)	-0.010***	(0.002)
Has 2+ kitchens	-0.019***	(0.007)	-0.036***	(0.007)	-0.018*	(0.010)	-0.051***	(0.005)
Has 1 WC	-0.008**	(0.004)	-0.024***	(0.006)	-0.003	(0.004)	-0.022***	(0.004)
Has 2+ WCs	0.024***	(0.005)	0.014**	(0.007)	0.027***	(0.005)	0.026***	(0.005)
Has 1 bathroom	0.030***	(0.004)	0.004	(0.006)	0.027***	(0.003)	-0.001	(0.004)
Has 2+ bathrooms	0.059***	(0.007)	0.022***	(0.008)	0.066***	(0.008)	0.049***	(0.006)
Central heating	0.066***	(0.004)	0.039***	(0.004)	0.043***	(0.003)	0.036***	(0.003)
L-shape living room	-0.002	(0.005)	-0.009	(0.006)	0.004	(0.004)	-0.015***	(0.004)
Sun-through living room	0.003	(0.006)	-0.007	(0.005)	0.008**	(0.003)	-0.002	(0.004)
Room and suite	0.030***	(0.007)	0.010	(0.007)	0.057***	(0.004)	0.041***	(0.004)
Dormer window	-0.004	(0.011)	-0.026***	(0.008)	0.014***	(0.004)	0.011***	(0.003)
Balcony	0.015***	(0.003)	0.024***	(0.003)	0.026***	(0.003)	0.023***	(0.003)
Some isolation	0.011***	(0.003)	0.003	(0.003)	0.020***	(0.003)	0.003	(0.002)
Full isolation	0.006	(0.005)	0.007	(0.004)	0.009	(0.009)	0.015***	(0.004)
Attic	-0.011*	(0.006)	-0.014*	(0.007)	-0.012***	(0.003)	-0.015***	(0.003)
Terrace	0.034***	(0.004)	0.060***	(0.004)	0.019***	(0.005)	0.014***	(0.003)
Lift	0.052***	(0.004)	0.064***	(0.005)	0.027***	(0.007)	0.016***	(0.004)
Parking available	0.094***	(0.011)	0.102***	(0.010)	0.085***	(0.011)	0.061***	(0.006)
Carport	-0.011	(0.012)	-0.001	(0.011)	0.032**	(0.013)	0.036***	(0.007)
Garage	0.025**	(0.012)	0.024**	(0.011)	-0.018	(0.012)	0.007	(0.008)
Garden	0.030***	(0.005)	0.041***	(0.005)	0.038***	(0.004)	0.039***	(0.003)
South-facing garden	0.019***	(0.005)	0.013**	(0.006)	0.010***	(0.003)	0.007***	(0.002)
Year dummies	Yes		Yes		Yes		Yes	
Number of observations	19,118		16,606		45,394		8,754	

This table presents the value (coefficients) of dwelling characteristics in the hedonic models, described by equation (7) for Amsterdam and equation (15) for Utrecht. The samples include properties within 2km from the Red Light Districts (RLDs) in the center of Amsterdam and within 3km from the RLDs in Utrecht. The nonparametric term in these models are estimated using triangular kernel with the bandwidth selection procedure proposed by Calonico, Cattaneo and Titiunik (2014). Robust standard errors are in parentheses. ***, **, * represent statistical significance at the 1%, 5% and 10% levels, respectively.

Table A3: Density Discontinuity Test under Multiple Bin Widths for Housing Supply in Amsterdam

	Bin width (in km)											
	0.001		0.003		0.006		0.009		0.012		0.020	
	θ	p-value	θ	p-value	θ	p-value	θ	p-value	θ	p-value	θ	p-value
1991-2006	-0.065	0.370	-0.062	0.391	-0.055	0.435	-0.056	0.432	-0.028	0.676	-0.055	0.437
	(0.073)		(0.073)		(0.071)		(0.071)		(0.067)		(0.070)	
2007-2014	-0.103	0.274	-0.100	0.286	-0.097	0.305	-0.102	0.279	-0.087	0.385	-0.090	0.349
	(0.094)		(0.094)		(0.095)		(0.094)		(0.100)		(0.096)	

This table shows the density discontinuity test for dwellings for sale at the natural borders of the Red Light Districts (RLDs) in Amsterdam. The sample includes properties located up to 2km from the closest RLD and it excludes properties outside the RLDs that are not separated by a natural border. θ is the McCrary's (2008) estimator for log density discontinuity, with standard errors in parentheses.

Table A4: Average Discontinuity in Other Characteristics at the RLD Border in Amsterdam

	1991-2006				2007-2014			
	discontinuity		mean	price eff.	discontinuity		mean	price eff.
Apartment with open porch	-0.002	(-0.98)	0.013	0.000	-0.020	(-0.74)	0.027	0.000
Has a kitchen	0.010	(0.18)	0.841	0.000	-0.117	(-0.88)	0.675	0.000
Has 2+ kitchens	0.010	(0.26)	0.060	0.000	-0.098	(-1.53)	0.037	0.000
Has a WC	-0.048	(-0.67)	0.710	0.000	0.140	(1.32)	0.898	0.001
Has 2+ WCs	-0.075	(-1.11)	0.140	0.000	-0.127	(-1.27)	0.190	0.000
Has a bathroom	-0.080	(-1.29)	0.812	-0.001	0.126	(1.26)	0.895	0.000
Has 2+ bathrooms	0.019	(0.42)	0.058	0.000	-0.088	(-1.13)	0.068	0.000
L-shape living room	-0.065	(-1.84)	0.091	0.000	-0.019	(-0.65)	0.046	0.000
Sun-through living room	0.067	(0.42)	0.056	-0.001	-0.058	(-1.05)	0.062	0.001
Room and suite	-0.015	(-0.49)	0.046	0.000	-0.012	(-0.43)	0.036	0.000
Dormer window	-0.001	(-0.17)	0.013	0.000	-0.008	(-0.06)	0.020	0.000
Attic	0.017	(0.42)	0.052	0.000	0.006	(0.25)	0.030	0.000
Parking available	-0.017	(-0.46)	0.052	0.000	0.084	(1.25)	0.056	0.000
Carport	-0.022	(-0.61)	0.023	0.000	0.073	(1.11)	0.032	0.000
Garage	-0.008	(-0.21)	0.021	0.000	0.074	(1.11)	0.020	0.000
Garden	-0.030	(-0.44)	0.222	0.000	-0.009	(-0.17)	0.167	0.000
South-facing garden	0.055	(1.03)	0.124	0.000	-0.141	(-1.72)	0.088	0.000
Total effect on log price				-0.009				-0.021

This table presents the average regression discontinuity (RD) estimates for other dwelling characteristics, not shown in Table 5, their mean value in the sample, and their effect on log price. The sample includes properties located up to 2km from the closest Red Light District (RLD). Robust z-statistics are in parentheses. Bandwidths are the same as those applied in Table 3. Effect on log price is calculated by plugging the estimated discontinuities in Tables 5 and A2 into a hedonic regression, controlling for year and location.

Table A5: Density Discontinuity Test for Other Businesses at the RLD Border in Amsterdam

	Bin width (in km)									
	0.02		0.03		0.04		0.05		0.06	
	θ	p-value	θ	p-value	θ	p-value	θ	p-value	θ	p-value
Coffeeshops										
2001	1.300	0.028	1.361	0.013	1.296	0.030	1.317	0.020	1.559	0.000
	(0.592)		(0.548)		(0.597)		(0.565)		(0.446)	
2007	0.941	0.076	1.066	0.025	0.902	0.072	0.978	0.049	1.156	0.001
	(0.531)		(0.475)		(0.502)		(0.497)		(0.357)	
2014	0.744	0.141	1.066	0.013	0.754	0.161	1.020	0.015	1.006	0.014
	(0.505)		(0.427)		(0.538)		(0.421)		(0.411)	
2007-2001	-0.359	0.652	-0.294	0.685	-0.394	0.614	-0.339	0.652	-0.403	0.481
	(0.796)		(0.725)		(0.780)		(0.752)		(0.571)	
2014-2007	-0.198	0.787	0.000	1.000	-0.149	0.840	0.042	0.949	-0.150	0.783
	(0.733)		(0.639)		(0.736)		(0.651)		(0.544)	
2014-2001	-0.556	0.475	-0.295	0.672	-0.542	0.500	-0.298	0.672	-0.553	0.362
	(0.778)		(0.695)		(0.803)		(0.704)		(0.606)	
Cafes										
2001	1.028	0.002	1.021	0.001	0.969	0.003	1.068	0.001	0.946	0.003
	(0.326)		(0.321)		(0.331)		(0.315)		(0.316)	
2007	1.020	0.002	1.028	0.002	0.853	0.013	1.075	0.001	0.933	0.004
	(0.331)		(0.327)		(0.343)		(0.315)		(0.323)	
2014	1.229	0.001	1.234	0.001	1.086	0.005	1.313	0.000	1.129	0.001
	(0.371)		(0.367)		(0.383)		(0.350)		(0.352)	
2007-2001	-0.008	0.987	0.007	0.987	-0.116	0.807	0.007	0.988	-0.013	0.977
	(0.464)		(0.458)		(0.477)		(0.445)		(0.452)	
2014-2007	0.209	0.673	0.206	0.675	0.233	0.651	0.238	0.613	0.196	0.682
	(0.497)		(0.492)		(0.514)		(0.471)		(0.478)	
2014-2001	0.202	0.683	0.214	0.661	0.117	0.818	0.245	0.602	0.183	0.699
	(0.494)		(0.488)		(0.507)		(0.470)		(0.473)	

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Table A5 – continued from previous page

	Bin width (in km)									
	0.02		0.03		0.04		0.05		0.06	
	θ	p-value	θ	p-value	θ	p-value	θ	p-value	θ	p-value
Restaurants										
2001	0.681	0.014	0.691	0.013	0.909	0.000	1.093	0.000	1.177	0.000
	(0.277)		(0.279)		(0.260)		(0.265)		(0.267)	
2007	1.017	0.000	1.009	0.000	1.242	0.000	1.421	0.000	1.398	0.000
	(0.269)		(0.271)		(0.254)		(0.259)		(0.261)	
2014	0.935	0.000	0.919	0.000	0.971	0.000	0.932	0.000	1.257	0.000
	(0.230)		(0.231)		(0.221)		(0.219)		(0.232)	
2007-2001	0.336	0.385	0.318	0.413	0.333	0.358	0.328	0.376	0.221	0.554
	(0.386)		(0.389)		(0.363)		(0.371)		(0.373)	
2014-2007	-0.082	0.818	-0.090	0.801	-0.271	0.421	-0.489	0.150	-0.141	0.687
	(0.354)		(0.356)		(0.337)		(0.340)		(0.349)	
2014-2001	0.254	0.480	0.228	0.528	0.062	0.855	-0.161	0.640	0.080	0.821
	(0.360)		(0.362)		(0.341)		(0.344)		(0.354)	
Stores										
2001	-0.120	0.580	-0.059	0.816	-0.113	0.593	-0.097	0.697	-0.120	0.619
	(0.217)		(0.252)		(0.211)		(0.250)		(0.242)	
2007	0.132	0.520	0.187	0.401	0.086	0.665	0.220	0.356	0.193	0.399
	(0.206)		(0.223)		(0.198)		(0.238)		(0.229)	
2014	0.100	0.611	0.098	0.658	0.061	0.743	0.090	0.691	0.086	0.691
	(0.197)		(0.221)		(0.187)		(0.226)		(0.217)	
2007-2001	0.252	0.399	0.246	0.465	0.198	0.492	0.317	0.358	0.314	0.347
	(0.299)		(0.336)		(0.289)		(0.345)		(0.333)	
2014-2007	-0.032	0.910	-0.090	0.776	-0.024	0.929	-0.130	0.691	-0.107	0.734
	(0.285)		(0.314)		(0.272)		(0.328)		(0.316)	
2014-2001	0.220	0.452	0.157	0.640	0.174	0.537	0.187	0.579	0.207	0.525
	(0.293)		(0.335)		(0.282)		(0.336)		(0.325)	

This table shows the density discontinuity test for business establishments at the natural border of the Red Light Districts (RLDs) in Amsterdam in 2001, 2007, and 2014. The sample includes establishments located up to 2km from the closest RLD and it excludes the ones outside the RLDs that are not separated by a natural border. θ is the McCrary's (2008) estimator for log density discontinuity, with standard errors in parentheses. It also presents estimated differences in θ for 2007-2001, 2014-2007, and 2014-2001. 'Coffeeshops' are establishments that sell cannabis. 'Cafes' are establishments whose main activity is to serve alcoholic beverages. 'Restaurants' are establishments serving food, which also include hotel-restaurants, but exclude diners and lunchrooms. 'Stores' denotes specialized retailers, excluding grocery stores, gift shops, and sex shops.

Table A6: Marginal Effects of RLDs on House Prices in Utrecht

	Log price per 100m					Euros per 100m				
Bandwidth scale	0.80	0.90	1.00	1.10	1.20	0.80	0.90	1.00	1.10	1.20
radius	0.99 quantile					0.99 quantile				
0.2 km	0.005	0.012	0.012	0.012	0.010	3,307	8,439	8,284	8,058	7,532
	(1.05)	(1.90)	(2.22)	(2.49)	(2.53)	(0.95)	(1.91)	(2.20)	(2.53)	(2.71)
0.5 km	0.013	0.012	0.012	0.011	0.011	5,878	7,617	7,517	7,155	6,354
	(2.19)	(2.36)	(2.58)	(2.94)	(3.24)	(1.65)	(1.88)	(2.17)	(2.45)	(2.51)
1.0 km	0.018	0.014	0.014	0.012	0.011	5,173	5,127	4,977	5,000	4,913
	(3.32)	(2.69)	(2.96)	(2.78)	(3.19)	(2.03)	(2.08)	(2.44)	(2.76)	(3.07)
1.5 km	0.016	0.014	0.013	0.012	0.011	4,617	4,494	4,098	4,179	4,189
	(2.88)	(2.58)	(2.07)	(2.94)	(1.93)	(1.82)	(2.11)	(2.51)	(2.87)	(2.60)
radius	0.75 quantile					0.75 quantile				
0.2 km	0.004	0.011	0.011	0.011	0.010	1,181	2,844	2,778	2,673	2,456
	(0.88)	(1.94)	(2.27)	(2.59)	(2.56)	(0.87)	(1.94)	(2.22)	(2.52)	(2.66)
0.5 km	0.011	0.011	0.010	0.010	0.010	2,092	2,700	2,598	2,636	2,570
	(1.74)	(2.09)	(2.43)	(2.76)	(2.97)	(1.70)	(2.04)	(1.66)	(2.36)	(3.18)
1.0 km	0.005	0.010	0.010	0.009	0.009	1,766	1,971	1,935	1,878	1,865
	(1.14)	(2.00)	(2.12)	(2.42)	(2.58)	(1.79)	(1.97)	(2.86)	(1.74)	(2.60)
1.5 km	0.003	0.003	0.003	0.003	0.005	933	1,012	965	1,029	1,024
	(0.75)	(0.91)	(0.92)	(1.14)	(1.79)	(0.79)	(0.72)	(0.51)	(1.68)	(0.85)
radius	median					median				
0.2 km	0.004	0.011	0.011	0.010	0.009	841	1,775	2,235	2,131	1,942
	(0.83)	(1.81)	(2.13)	(2.31)	(2.41)	(0.77)	(1.77)	(1.76)	(1.99)	(2.09)
0.5 km	0.004	0.009	0.009	0.008	0.008	1,028	1,346	1,566	1,698	1,585
	(0.85)	(1.72)	(2.00)	(2.12)	(2.68)	(1.85)	(1.83)	(2.12)	(2.84)	(3.38)
1.0 km	0.003	0.003	0.003	0.003	0.002	549	628	681	765	696
	(0.58)	(0.78)	(0.91)	(1.04)	(1.04)	(0.66)	(0.58)	(1.09)	(0.87)	(0.59)
1.5 km	0.002	0.002	0.002	0.002	0.001	392	435	414	407	321
	(0.38)	(0.54)	(0.56)	(0.57)	(0.67)	(0.75)	(0.41)	(0.63)	(0.42)	(1.10)
radius	0.01 quantile					0.01 quantile				
0.2 km	0.002	0.003	0.003	0.002	0.002	346	602	568	449	298
	(0.36)	(0.63)	(0.82)	(0.78)	(0.66)	(0.36)	(0.63)	(0.82)	(0.78)	(0.66)
0.5 km	0.001	0.001	0.001	0.001	0.001	128	208	176	135	110
	(0.19)	(0.39)	(0.43)	(0.40)	(0.39)	(0.20)	(0.38)	(0.39)	(0.35)	(0.36)
1.0 km	-0.002	-0.001	0.000	0.000	0.000	(327)	(107)	(40)	(12)	21
	(-0.32)	(-0.18)	(-0.06)	(-0.03)	(0.04)	(-0.31)	(-0.18)	(-0.05)	(-0.03)	(0.04)
1.5 km	-0.002	-0.002	-0.001	0.000	0.000	(624)	(373)	(134)	(41)	(29)
	(-0.45)	(-0.49)	(-0.17)	(-0.07)	(-0.07)	(-0.36)	(-0.23)	(-0.16)	(-0.08)	(-0.04)
main bandwidth	0.661	0.744	0.826	0.909	0.992	0.661	0.744	0.826	0.909	0.992
pilot bandwidth	1.161	1.306	1.451	1.596	1.741	1.161	1.306	1.451	1.596	1.741

This table presents the quantiles of marginal effects in log price (on the left) and in euros (on the right) as a function of the radius to the center of the Red Light Districts (RLDs) in Utrecht. The 'marginal effect', or Difference-in-Slope (DiS), is the difference in the first derivative of the distance functions in January 2011-December 2012 and August 2013-December 2014. Estimates are obtained using several different bandwidths around the optimal, given by Calonico, Cattaneo and Titiunik's (2014) procedure. Robust z-statistics are in parentheses. The distribution of DiS is weighted by the density of houses for sale in 2011-2012. For better illustration, we apply an empirical Bayes shrinkage to estimates that are not significant at 10%. Dwelling characteristics are controlled for using a hedonic model, equation (15), and prices are deflated to values of 2014. The sample includes properties located up to 3km from the RLDs.

Table A7: Difference-in-Differences in Crime Rates and Risk Perception in each RLD of Utrecht

	Crime rate						% who feel
	total	violence	nuisances	major property	minor thefts	illegal drug dealing	unsafe in the neighborhood
Hardbollenstraat							
(year $\geq$ 2013) $\cdot$ (distance $\leq$ 50m)	-0.271	-0.210	-0.281	-0.120	-0.678	-0.582	-4.58
	(-3.32)	(-1.74)	(-2.86)	(-0.91)	(-3.71)	(-1.56)	(-2.45)
(year $\geq$ 2013) $\cdot$ (50m $<$ distance $\leq$ 200m)	-0.226	-0.029	-0.085	-0.463	-0.333	0.289	-6.33
	(-2.60)	(-0.18)	(-0.72)	(-3.43)	(-1.90)	(0.89)	(-4.82)
Zandpad							
(year $\geq$ 2013) $\cdot$ (distance $\leq$ 50m)	0.068	-0.357	0.022	0.247	-0.111	-0.510	-0.08
	(0.85)	(-2.33)	(0.20)	(2.14)	(-0.63)	(-1.06)	(-0.05)
(year $\geq$ 2013) $\cdot$ (50m $<$ distance $\leq$ 200m)	0.029	-0.122	0.153	-0.005	0.256	-0.088	-5.33
	(0.35)	(-0.77)	(1.33)	(-0.04)	(1.34)	(-0.21)	(-3.90)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	268	268	268	268	268	260	66
Number of neighborhoods	67	67	67	67	67	65	22

This table presents Difference-in-Difference estimates for crime rates, estimated using a negative binomial regression, and risk perception, estimated using a linear regression. The level of observation is the neighborhood (*buurt*), except for the '% who feel unsafe', where it is the sub-district (*subwijk*). 'Distance' means the shortest distance between the area and a Red Light District (RLD) and the sample includes only areas within 2km. The sample period is between 2010 and 2015, excluding 2013. The 'total' crime rate does not include minor felonies, such as shoplifting, pickpocketing, and bike theft, and reported nuisances, such as complaints about neighbors and alcohol abuse. Cases of 'violence' include declarations of abuses, threats, sexual offenses, fights, assaults, and street robbery, but they exclude cases of domestic violence. 'Nuisances' include complaints against neighbors, vandalism, and cases of drug and alcohol abuse registered by the police. 'Major property' crimes include burglaries and motor vehicle thefts. 'Minor thefts' include bike thefts, shoplifting, pickpocketing and other property crimes. Standard errors are clustered by neighborhood and the t-statistics are in parentheses.