The External Cost of Prostitution: Evidence from Closing Brothels in the Netherlands

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Motivation

- Prostitution has always been a controversial activity
- One may see prostitution as a human right and inevitable
- Others may attach a negative connotation to it
  - Paid sex is often associated with many forms of violence (Outshoorn, 2005; Limoncelli, 2009)
- A 2015 vote by Amnesty International gave the debate a new momentum and revealed a split among activists.
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- **Is the sex industry harmful to society?**
  - In principle, we could survey individuals’ willingness to accept prostitution.
  - But preferences may diverge from opinions
    - A liberal endorser might pay the cost to never get involved.
  - For example, sex workers can be discriminated even in a liberal society, where paid sex is legalized.
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The Economist

**Sex and finance in Amsterdam**

**Full disclosure**

*The Dutch central bank fires an inspector who failed to report her part-time job*

<table>
<thead>
<tr>
<th>Europe</th>
<th>Apr 17th 2015</th>
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<td>Amsterdam's Red Light District, an area dominated by other trades long considered disreputable but which the city's liberal government has tried to bring above-board. But <strong>even in Amsterdam, sex work has not shed its stigma</strong>, as a former supervisor at the Dutch Central Bank (DNB) discovered last year.*</td>
<td><strong>The Dutch magazine Quote</strong></td>
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Objective

- We attempt to value prostitution externalities.
  - By estimating households’ willingness to accept (WTA) living next to a brothel.
- If brothels are harmful to households nearby, they will require a discount on their rents.
  - If brothels benefit them, they will pay a premium.
- As for many non-market goods, the prostitution externality can be valued through housing demand.
  - Revealed preferences for amenities
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  - Revealed preferences for amenities
Identification Strategies

- Identifying WTA is difficult because prostitution often emerges in inexpensive areas (reverse causality).
- Using house price data (NVM), we exploit unique settings in Red Light Districts (RLD) of two Dutch cities.
- In Amsterdam, RLDs are naturally delimited by canals
  - With no “red” window operating outside.
  - Boundary discontinuity of house price at the canals.
  - And difference in discontinuity (DiD) after sex windows are forcibly closed.
- Utrecht has closed all RLDs since July 2013.
  - We compare houses as a function of distance to RLDs before and after.
  - Non-parametric difference-in-slope (DiS) estimator.
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Related Literature on Housing and Amenities

- **Housing demand** have been broadly used to assess the value of amenities, externalities and public goods.

- These estimates help to determine the **monetary benefit of public policies** (cost-benefit analysis).

For example:

- Education and school investment (Black, 1999; Cellini, Ferreira, Rothstein, 2010; Gibbons, Machin and Silva, 2013).
- Toxic waste and health risk (Bui and Mayer, 2003; Davis, 2004; Greenstone and Gallagher, 2008; Currie et al., 2015).
- Quality of neighborhood (Rossi-Hansberg, Sarte, Owens III, 2010).
- Crime risk and law enforcement (Thaler, 1978; Gibbons, 2004; Linden and Rockhoff, 2008).
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Related Literature on the Economics of Prostitution

Most studies on prostitution are focused on the determinants of supply and demand.

- See Cunningham and Shah (2016) for a review.

Just a few investigate the effects of prostitution policy:

- 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, van der Klaauw, 2017).

To our knowledge, ours is the first to assess the monetary value of externalities from the sex industry.
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(Very) Brief History of Prostitution Policy

- Since the Middle Ages, brothels have been allowed in Dutch cities, but **confined into RLDs**.
  - It is how local authorities have kept them under control.
  - A system of regulation through toleration (*gedogen*).
- Although **illegal** (and **unregulated**), brothels were **tolerated**.
- They became vehicles to cover criminal activities, including tax fraud and human trafficking.
- To combat them:
  - Brothels and prostitution were legalized in 2000
  - Local authorities gained more power to close brothels under investigation in 2003 (BIBOB law).
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Recent Developments

- Amsterdam has used the BIBOB law since the end of 2006.
  - 108 sex businesses were investigated and 58 were closed.
- The city also decided to buy properties and reduce the size of the RLDs.
  - Part of Project 1012, launched in 2007.
  - The goal was to reduce the number of windows by half.
  - But only 27% were closed so far (out of 477).
- The city of Utrecht started to investigate sex businesses in 2008 and shut down all brothels and windows in May-July 2013.
  - A new RLD was approved in 2016, but it has been delayed.
- In the Netherlands, the number of red windows decreased from 2,096 in 1999 to 1,272 in 2016.
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Theoretical Framework

The settings for Amsterdam and Utrecht have distinct interpretation:

1. **Boundary discontinuity** in Amsterdam assesses the environmental externality
   - Such as noise, crowdedness, liveliness, and presence of sex workers itself.
   - On the most receptive (lower bound).

2. **Distance function** in Utrecht assesses the economic impact away from the RLD.
   - If the RLD creates jobs and/or attract customers, some households will pay to live as close as possible.
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Amsterdam
RLDs in Amsterdam

- Amsterdam has two RLDs:
  - *De Wallen*, the biggest and most famous
  - *Singelgebied*

- Well-defined, tolerance zones since the postwar, with almost no red window operating out of their limits.
  - There is also a small RLD (*Ruysdaelkade*) located in the South district.
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Houses and Red Windows in Amsterdam

Operating window
Houses and Red Windows in Amsterdam

Operating window

Closed window at the canal
Houses and Red Windows in Amsterdam

Operating window

Closed window at the canal

House on the other side
Houses and Red Windows in Amsterdam
House Prices in Amsterdam

- Prices are different across the canals and a house can cost 400 euros/m² less in the RLD.
- Since 2007, prices at the canals have practically equalized.
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Average Discontinuity

- First, we use only the **minimum distance** to the border
- Prices decline with distance to center.
- But prices were 17% lower in the RLD in 1991-2006
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![Graphs showing average discontinuity](image-url)

\[ \tau = -0.168^{***} \ (0.029) \]

\[ \tau = 0.026 \ (0.046) \]
Discontinuity per Year

- Is 2007 the year of change?
- We use 3-year intervals and 1-year asking prices (bigger sample)
- Prices on the RLD side start growing in 2006-2008
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Empirical Strategy, Difference-in-Discontinuity

- Red windows are not equally spread within RLDs.
- To account for that, the **cut-off point** is not unique.
- The **log price per square meter** is a function of **longitude**, $s_{1i}$, and **latitude**, $s_{2i}$.
- The price discontinuity at point $l$ and time $t$:
  \[
  \tau_{lt} \equiv \lim_{d(c_l, s) \uparrow 0} \mu_{1t}(s_1, s_2) - \lim_{d(c_l, s) \downarrow 0} \mu_{0t}(s_1, s_2)
  \]
- Difference in discontinuity (DiD) for each point of the border:
  \[
  \Delta \tau_l \equiv \tau_{l0} - \tau_{l1}
  \]
- And everywhere else in the RLD:
  \[
  \Delta \tau(s) = \mu_{10}(s) - \mu_{11}(s) - \{\mu_{00}(c_l) - \mu_{01}(c_l) \mid c_l \in c \text{ and } c_l = \arg\min d(c_l, s)\}.
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Main Findings, Difference-in-Discontinuity

Do differences in discontinuity coincide with closing of windows?
Main Findings, Difference-in-Discontinuity

- Prices increased particularly by the border, where they were closed.
- Discount is 21-30% if the house is right next to a red window.
- Or 4,100-7,100 euros/year.

- In total, properties have appreciated by 31 million euros.
  - The buyouts have costed 25 million euros.
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Cross-section
Project 1012
So far we assume that expected change (DiD) is only driven by closing windows.

House location is now defined by minimum distance to the border, $s_i$, and initial distance to a red window, $r_{i0}$.

The DiD is approximately given by:

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

where

$\delta^0 = \text{MWTA},$

$\delta^1 = \text{derivative of MWTA w.r.t. } r,$

$\delta^2 = \text{average effect of other events (at } r_0 = 0),$  

$\delta^3 = \text{derivative of other effects w.r.t. } r.$

If $\delta^2 = \delta^3 = 0$, then DiD does not depend on other events.
Empirical Strategy, Conditional DiD

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Estimated MWTA (Conditional DiD)

- We find that the MWTA is 16.6-19.3% per 100 meters.
- It means 3,200-4,500 euros a year
- Other events have no significant effect on the average DiD.

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MWTA from Unconditional DiD

Giambona & Ribas

Prostitution Externality
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Deadweight Loss

- About **125-200 million euros** was lost in property value until 2007.
  - Out of 920 million euros.
- All households together, required **7-13 million euros a year** to live in the RLD
  - Considering a 30-year mortgage rate of 3.5%-5% p.a.
  - Close to the annual budget of Project 1012.

- **Other findings:**
  - No significant effect on housing supply
  - No significant change in other businesses
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Utrecht
Red Light Districts in Utrecht

- *Hardebollenstraat*, a two-block street in the central area.
- *Zandpad*, 3km away, where prostitutes worked in houseboats.
Red Light Districts in Utrecht

Hardebollenstraat
Red Light Districts in Utrecht

Zandpad

[Image of Zandpad in Utrecht]

http://www.amsterdam-red-light-district-maps.com
House Prices in Utrecht

- On July 25, 2013, the last red windows and sex boats were close.
  - On suspicion of human trafficking.
- Prices on *Hardebollienstraat* became as high as in the center.
Empirical Strategy

- To test for changes in house prices, we use a nonparametric difference-in-slope (DiS) approach.
- The distance to the RLD is a continuous “treatment”
- Systematic differences across locations is captured by the distance function after the shutdown.

Identification works as follows:
- If prices change in all locations, the distance function just moves upward or downward.
- But if prices are affected by the RLD, then the slope should change too.
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Empirical Strategy

- Let \( s_i = (s_{1i}, s_{2i}) \) be coordinates of house \( i \) and \( h_i \) be the distance to the RLD. Then:

\[
y_{it} = \mu_t(s_i) + \gamma_t(s_i)h_i + x'_i\beta + \varepsilon_{it}
\]

where \( \mu_t \) and \( \gamma_t \) are estimated using triangular kernel functions.
- \( \Delta \mu = (\mu_0 - \mu_1) \) controls for spatial changes unrelated to the RLD.
- \( \Delta \gamma = (\gamma_0 - \gamma_1) \) captures the marginal treatment effect (DiS):

\[
\Delta \gamma(s) \begin{cases} 
> 0 & \text{if prostitution has a negative net value}, \\
< 0 & \text{if prostitution has a positive net value}
\end{cases}
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\end{cases}$$
Main Findings, One Dimension

- Prices in the RLDs are higher in the absence of brothels.
- Before, prices increase with distance to prostitution (positive slope).

![Graph showing distance function and difference in slope between Hardebollenstraat and Zandpad with 95% confidence intervals and log price on the y-axis and distance on the x-axis.](image-url)
Main Findings, Two Dimensions

- Two-dimensional approach identifies where prices changed.
  - Households are spatially sorted based on their tastes.
- No effect towards the city center, where prices were high.
  - No room for a premium to stay away from the RLD
Main Findings, Two Dimensions

- Effect concentrates between the two RLD.
  - The least tolerant households raise rents in between.
  - By moving closer to either RLD, they apply a discount.

- The discount goes up to 1.5% per 100m in some areas.
  - And up to 500 euros per year for a household.
Quantiles of Price Effects

- Based on their location, we calculate the change in households’ disposable income

![Graph showing quantiles of price effects with log price per m² and annual payments in euros against radius in km.](image)
Deadweight Loss

- Price effect is integrated over distance.
  - Only DiS significant at 10%.
- Most of the impact is within 1.5km.
- Total loss is 125-225 million euros.
  - Or 7-14.5 million euros/year

Other findings:
- Positive effect on employment
Deadweight Loss

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  - Only DiS significant at 10%.
- Most of the impact is within 1.5km.
- Total loss is 125-225 million euros.
  - Or 7-14.5 million euros/year
- Other findings:
  - Positive effect on employment
Safety in the Red Light Districts
Crime Rates Near RLDs

- The externality can be explained by the criminal activities attached to the sex industry.
  - Such as drug trafficking, sexual assaults, and misbehaving clients.
- We use data on crime rates, nuisances complaints, and subjective safety at neighborhood level.
  - To verify whether safety has improved in RLDs more than in other areas of Amsterdam and Utrecht.
Crime Rates Near RLDs

• The externality can be explained by the criminal activities attached to the sex industry.
  • Such as drug trafficking, sexual assaults, and misbehaving clients.

• We use data on crime rates, nuisances complaints, and subjective safety at neighborhood level.
  • To verify whether safety has improved in RLDs more than in other areas of Amsterdam and Utrecht.
Crime and Distance to RLD in Amsterdam

- In Amsterdam, crime rates decline 18% more in the RLDs.
  - Or 1,250 crimes/year (930 crimes/year with displacement)
- Some displacement in violence, minor thefts, and other nuisances.
- Safety perception has also improved.

<table>
<thead>
<tr>
<th></th>
<th>Crime rate</th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th>log unsafety index</th>
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<tr>
<td></td>
<td>total</td>
<td>violence</td>
<td>nuisances</td>
<td>major thefts</td>
<td>minor thefts</td>
<td>drug dealing</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>($t \geq 2007) \cdot (\text{dist} \leq 50\text{m})$</td>
<td>-0.182</td>
<td>-0.129</td>
<td>-0.108</td>
<td>-0.138</td>
<td>-0.222</td>
<td>-0.674</td>
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<tr>
<td></td>
<td>(-4.65)</td>
<td>(-2.69)</td>
<td>(-2.24)</td>
<td>(-2.63)</td>
<td>(-5.16)</td>
<td>(-4.96)</td>
<td></td>
<td>(-3.31)</td>
</tr>
<tr>
<td>($t \geq 2007) \cdot (50\text{m} &lt; \text{dist} \leq 200\text{m})$</td>
<td>0.096</td>
<td>0.124</td>
<td>0.112</td>
<td>0.085</td>
<td>0.200</td>
<td>0.009</td>
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<tr>
<td></td>
<td>(1.83)</td>
<td>(1.80)</td>
<td>(1.69)</td>
<td>(1.21)</td>
<td>(3.49)</td>
<td>(0.05)</td>
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<td>(0.90)</td>
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<tr>
<td>($t \geq 2007) \cdot (200\text{m} &lt; \text{dist} \leq 500\text{m})$</td>
<td>0.116</td>
<td>-0.022</td>
<td>0.124</td>
<td>0.117</td>
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<td>(1.64)</td>
<td>(-0.24)</td>
<td>(1.42)</td>
<td>(1.22)</td>
<td>(-0.80)</td>
<td>(-1.01)</td>
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<td>(-5.73)</td>
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</table>
Crime and Distance to RLD in Utrecht

- In Utrecht, crime rates decline 11% more in the RLDs.
  - Or 210 crimes/year.
- Particularly violence, minor thefts, and drug dealing.
- Safety perception has also improved nearby.

<table>
<thead>
<tr>
<th>Crime rate</th>
<th>% who feel unsafe</th>
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</thead>
<tbody>
<tr>
<td>total</td>
<td>violence</td>
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<tr>
<td>$(t \geq 2013) \cdot (\text{dist} \leq 50\text{m})$</td>
<td>-0.114</td>
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<tr>
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<td>(-1.86)</td>
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<tr>
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<td>(-1.59)</td>
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<tr>
<td>$(t \geq 2013) \cdot (200\text{m} &lt; \text{dist} \leq 500\text{m})$</td>
<td>-0.004</td>
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<tr>
<td></td>
<td>(-0.09)</td>
</tr>
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</table>
Despite being a human right and the individual benefits that it provides to clients and workers, on-site prostitution is found to be costly to residents.

- Households have a strong distaste for living in next to a brothel.
  - Even the most tolerant requires 4,000 euros a year to accept sex workers on their doorstep.
- Because some households pay to live far away, the economic impact spreads to other areas.
- Economic benefits don’t seem to offset social nuisances.
  - Or the negative effect on safety.
Conclusion

- Despite being a human right and the individual benefits that it provides to clients and workers, on-site prostitution is found to be costly to residents.

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Conclusion

- Despite being a human right and the individual benefits that it provides to clients and workers, **on-site prostitution** is found to be **costly to residents**.

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  - Or the negative effect on safety.
Thank you!

Multidimensional Difference in Discontinuity package available for Stata:
net de mdrd, from(https://sites.google.com/site/r4ribas/codes/packages)
Theoretical Assumptions

- There is a continuum of individual types.
- Exogenous wealth is unrelated to individual tastes.
- Housing supply is continuous and inelastic
- Competitive housing market
  - Improvements have zero profit
- Single-crossing restriction
  - Households are ordered by their MWTA and the ordering is the same at any level of externality.
  - If violated, capitalization effect is a lower bound of the deadweight loss (Banzhaf, 2015).
Multidimensional DiD Estimator

- Let $Z_i = 1$ if inside the RLD and $Z_i = 0$ otherwise; and $d_{li} = d(c_l, s_i)$ be the distance of house $i$ to border point $l$.

- For $z = \{0, 1\}$:

$$
\hat{\mu}_{zlt}(h, b) = \arg \min_a \sum_{i=1}^n 1(Z_i = z) \left( Y_{it} - a - X_{it} \hat{\beta} \right) K\left( \frac{d_{li}}{h} \right) - h^2 \hat{B}_{zlt}(h, b)
$$

where $\hat{B}_{zlt}(.)$ is the bias correction proposed by Calonico, Cattaneo, and Titiunik (2014, CCT), $K(.)$ is a triangular kernel function, $h$ and $b$ are MSE-optimal main and pilot bandwidths (CCT and IK), and $\hat{\beta}$ is a 2-stage FWL estimator.

- Then, $\hat{\tau}_{lt} = (\hat{\mu}_{1lt} - \hat{\mu}_{0lt})$ and $\Delta \hat{\tau}_l = (\hat{\tau}_{l0} - \hat{\tau}_{l1})$
2D Regression Discontinuity, 1991-2006 (Before)
2D Regression Discontinuity, 2007-2014 (After)
Interventions from Project 1012
Conditional DiD Estimator

- Let $Z_i = 1$ if inside the RLD and $Z_i = 0$ otherwise; and $d_i = \min_l d(c_l, s_i)$ be the shortest distance to the border.

- For $z = \{0, 1\}$:

$$\hat{\alpha}_{zt} = \arg \min \sum_{i=1}^{n} 1(Z_i = z) \left( Y_{it} - a^0 \Delta r_i - a^1 (r_{i0} \Delta r_i) - a^2 - a^3 r_{i0} - X_{it} \hat{\beta} \right) K\left(\frac{d_i}{h}\right) - h^2 \hat{B}_{zt}(h, b)$$

where $\hat{B}_{zt}(.)$ is the bias correction proposed by Calonico, Cattaneo, and Titiunik (2014, CCT), $K(.)$ is a triangular kernel function, $h$ and $b$ are MSE-optimal main and pilot bandwidths (CCT and IK), and $\hat{\beta}$ is a 2-stage FWL estimator.

- Then, $\hat{\delta}^k = \hat{\alpha}^k_{10} - \hat{\alpha}^k_{00} - (\hat{\alpha}^k_{11} - \hat{\alpha}^k_{01})$. 
Empirical Strategy, Marginal Willingness to Accept (IV)

- Assume that the expected DiD is only driven by the closing of red windows.
- Then a Wald/IV estimator is applied:

\[
\hat{\nu}_r (r, g, \mathbf{x}) = \frac{\sum_l \hat{f} (c_l) \Delta \hat{r}_l}{\sum_l \hat{f} (c_l) \Delta \hat{r}_l},
\]

where \( \hat{f}(.) \) is the estimated density of dwellings and \( \Delta \hat{r}_l \) is the change in distance to a window:

\[
\Delta r_l = \lim_{d(c_l,s_i) \to 0} E [r_{it} | \mathbf{x}, t = 0] - \lim_{d(c_l,s_i) \to 0} E [r_{it} | \mathbf{x}, t = 1].
\]
Estimated MWTA (Unconditional DiD)

- We find that the MWTA is 16.5-21.5% per 100 meters.
- It means 3,200-5,000 euros a year

<table>
<thead>
<tr>
<th>Bandwidth selection procedure</th>
<th>CCT</th>
<th>IK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced-form - DiD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991/2006-2007/2014</td>
<td>-0.213 (-3.97)</td>
<td>-0.163 (-2.71)</td>
</tr>
<tr>
<td>2001/2006-2007/2014</td>
<td>-0.153 (-2.54)</td>
<td>-0.192 (-3.60)</td>
</tr>
<tr>
<td>1991/2000-2001/2006</td>
<td>-0.038 (-0.67)</td>
<td>0.062 (0.71)</td>
</tr>
<tr>
<td>1st Stage - Difference in distance to red window</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991/2006-2007/2014</td>
<td>-0.999 (-12.41)</td>
<td>-0.803 (-7.95)</td>
</tr>
<tr>
<td>2001/2006-2007/2014</td>
<td>-0.931 (-9.31)</td>
<td>-0.893 (-8.49)</td>
</tr>
<tr>
<td>1991/2000-2001/2006</td>
<td>-0.375 (-4.05)</td>
<td>-0.426 (-3.58)</td>
</tr>
<tr>
<td>2nd stage - MWTP per 100 meters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991/2006-2007/2014</td>
<td>0.213 (3.88)</td>
<td>0.202 (2.78)</td>
</tr>
<tr>
<td>2001/2006-2007/2014</td>
<td>0.165 (2.48)</td>
<td>0.215 (3.28)</td>
</tr>
<tr>
<td>1991/2000-2001/2006</td>
<td>0.100 (0.67)</td>
<td>-0.146 (-0.64)</td>
</tr>
</tbody>
</table>
Density of Offers in Amsterdam

- Supply looks **continuous** around the border and don’t change over time.
- McCrory’s test don’t reject it, even under several bin widths.

\[ \theta = -0.057 \quad (0.071) \]

\[ \theta = -0.107 \quad (0.095) \]
Other Businesses in Amsterdam

- Data from Orbis/BvD for 2001-2014
Coffeshops in Amsterdam

- McCrory’s test for density of coffeeshops

<table>
<thead>
<tr>
<th>Bin width (in km)</th>
<th>0.02</th>
<th>0.03</th>
<th>0.04</th>
<th>0.05</th>
<th>0.06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>θ</td>
<td>p-value</td>
<td>θ</td>
<td>p-value</td>
<td>θ</td>
</tr>
<tr>
<td>2001</td>
<td>1.300</td>
<td>0.028</td>
<td>1.361</td>
<td>0.013</td>
<td>1.296</td>
</tr>
<tr>
<td></td>
<td>(0.592)</td>
<td>(0.548)</td>
<td>(0.597)</td>
<td>(0.565)</td>
<td>(0.446)</td>
</tr>
<tr>
<td>2007</td>
<td>0.941</td>
<td>0.076</td>
<td>1.066</td>
<td>0.025</td>
<td>0.902</td>
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<tr>
<td></td>
<td>(0.531)</td>
<td>(0.475)</td>
<td>(0.502)</td>
<td>(0.497)</td>
<td>(0.357)</td>
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<tr>
<td>2014</td>
<td>0.744</td>
<td>0.141</td>
<td>1.066</td>
<td>0.013</td>
<td>0.754</td>
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<tr>
<td></td>
<td>(0.505)</td>
<td>(0.427)</td>
<td>(0.538)</td>
<td>(0.421)</td>
<td>(0.411)</td>
</tr>
<tr>
<td>2007-2001</td>
<td>-0.359</td>
<td>0.652</td>
<td>-0.294</td>
<td>0.685</td>
<td>-0.394</td>
</tr>
<tr>
<td></td>
<td>(0.796)</td>
<td>(0.725)</td>
<td>(0.780)</td>
<td>(0.752)</td>
<td>(0.571)</td>
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<tr>
<td>2014-2007</td>
<td>-0.198</td>
<td>0.787</td>
<td>0.000</td>
<td>1.000</td>
<td>-0.149</td>
</tr>
<tr>
<td></td>
<td>(0.733)</td>
<td>(0.639)</td>
<td>(0.736)</td>
<td>(0.651)</td>
<td>(0.544)</td>
</tr>
<tr>
<td>2014-2001</td>
<td>-0.556</td>
<td>0.475</td>
<td>-0.295</td>
<td>0.672</td>
<td>-0.542</td>
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<tr>
<td></td>
<td>(0.778)</td>
<td>(0.695)</td>
<td>(0.803)</td>
<td>(0.704)</td>
<td>(0.606)</td>
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</table>
Cafes in Amsterdam

- McCrory’s test for density of cafes (bars and nightclubs)

<table>
<thead>
<tr>
<th>Bin width (in km)</th>
<th>0.02</th>
<th>0.03</th>
<th>0.04</th>
<th>0.05</th>
<th>0.06</th>
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<tr>
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<td>θ</td>
<td>p-value</td>
<td>θ</td>
<td>p-value</td>
<td>θ</td>
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<tr>
<td>2001</td>
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<td>0.002</td>
<td>1.021</td>
<td>0.001</td>
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<tr>
<td></td>
<td>(0.326)</td>
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<td>(0.321)</td>
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<td>(0.331)</td>
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<tr>
<td>2007</td>
<td>1.020</td>
<td>0.002</td>
<td>1.028</td>
<td>0.002</td>
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<td>(0.327)</td>
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<td>(0.343)</td>
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<td>2014</td>
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<td>1.234</td>
<td>0.001</td>
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<td>(0.367)</td>
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<td>2007-2001</td>
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<td>0.987</td>
<td>0.007</td>
<td>0.987</td>
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<tr>
<td></td>
<td>(0.464)</td>
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<td>(0.458)</td>
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<td>(0.477)</td>
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<tr>
<td>2014-2007</td>
<td>0.209</td>
<td>0.673</td>
<td>0.206</td>
<td>0.675</td>
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<td>2014-2001</td>
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<td>(0.507)</td>
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</table>
## Restaurants in Amsterdam

- **McCrary’s test for density of restaurants**

<table>
<thead>
<tr>
<th></th>
<th>Bin width (in km)</th>
<th></th>
<th>Bin width (in km)</th>
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<th>Bin width (in km)</th>
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<tr>
<td></td>
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<td></td>
<td>θ</td>
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<td>θ</td>
<td>p-value</td>
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<td>p-value</td>
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</tr>
<tr>
<td>2001</td>
<td>0.681</td>
<td>0.014</td>
<td>0.691</td>
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<td>0.909</td>
<td>0.000</td>
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<td>(0.265)</td>
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<tr>
<td>2007</td>
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<tr>
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<td>(0.269)</td>
<td>(0.271)</td>
<td>(0.254)</td>
<td>(0.259)</td>
<td>(0.261)</td>
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<tr>
<td>2014</td>
<td>0.935</td>
<td>0.000</td>
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<td>(0.231)</td>
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<tr>
<td>2007-2001</td>
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<td>0.385</td>
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<td>0.413</td>
<td>0.333</td>
<td>0.358</td>
<td>0.328</td>
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<td>(0.389)</td>
<td>(0.363)</td>
<td>(0.371)</td>
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<td>2014-2007</td>
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<td>0.818</td>
<td>-0.090</td>
<td>0.801</td>
<td>-0.271</td>
<td>0.421</td>
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<td>(0.356)</td>
<td>(0.337)</td>
<td>(0.340)</td>
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<td>2014-2001</td>
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<td>0.480</td>
<td>0.228</td>
<td>0.528</td>
<td>0.062</td>
<td>0.855</td>
<td>-0.161</td>
<td>0.640</td>
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<td></td>
<td>(0.360)</td>
<td>(0.362)</td>
<td>(0.341)</td>
<td>(0.344)</td>
<td>(0.354)</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Retailers in Amsterdam

- McCrary’s test for density of *specialized retail stores*

<table>
<thead>
<tr>
<th>Year</th>
<th>Bin width (in km)</th>
<th>θ</th>
<th>p-value</th>
<th>θ</th>
<th>p-value</th>
<th>θ</th>
<th>p-value</th>
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Difference-in-Slope Estimator

- Let $d_{li} = d(c_l, s_i)$ be the distance between house $i$ and location $l$.
- For $t = \{0, 1\}$:

$$(\hat{\mu}_{lt}, \hat{\gamma}_{lt})' = \arg \min_{a, b} \sum_{i=1}^{n} 1(T_i = t) \left( Y_{it} - a - bh_i - X_{it}\hat{\beta} \right) K\left( \frac{d_{li}}{h} \right) - h^2 \hat{B}_{lt}(h, b)$$

where $\hat{B}_{lt}(.)$ is the bias correction adapted from Calonico, Cattaneo, and Titiunik (2014, CCT), $K(.)$ is a triangular kernel function, $h$ and $b$ are MSE-optimal main and pilot bandwidths (CCT), and $\hat{\beta}$ is a 2-stage FWL estimator.

- Then, $\Delta\hat{\gamma}_l = \hat{\gamma}_{l0} - \hat{\gamma}_{l1}$. 
Quantiles of Difference-in-Slope

- Up to 500m, all households are willing to pay something.
- The majority pays at least 0.9% per 100 meter.
Quantiles of DiS in Random Locations

0.01-quantile

0.25-quantile

0.5-quantile

0.75-quantile

0.9-quantile

0.99-quantile

Estimated marginal effect (per km)

Prob(>0.098) = 0

Prob(>0.126) = 0.019

Prob(>0.007) = 0

Prob(>0.024) = 0.003

Prob(>0.014) = 0.001

Prob(>−0.009) = 0.001

Prob(>0.007) = 0

Prob(>0.014) = 0.001

Prob(>0.024) = 0.003
DiS Before Closing of RLDs, 2009/2010 - 2011/2012

- Price were in an opposite trend before 2013.
- Growth of RLDs in Utrecht after Amsterdam and Rotterdam downsized their soliciting zones.

![Google Maps images of Amsterdam, Utrecht, and Rotterdam with data points indicating changes in prices and growth rates.](image-url)
Employment in Utrecht

- We use data from Orbis/BvD for 2011-2015 and estimate the density per distance to RLDs.
Marginal Effect of RLDs on Employment

- DiS is negative, so employment decreases with distance to prostitution.
Crime and Distance to RLDs in Utrecht

- Crimes declined mostly in *Hardbollenstraat*, in the center of the city.
- But violence is a common factor.

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<td>violence</td>
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<th>Crime rate</th>
<th>%</th>
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