

The effect of Low Emission Zones in Economic outputs: A Synthetic Control approach to German cities

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Introduction

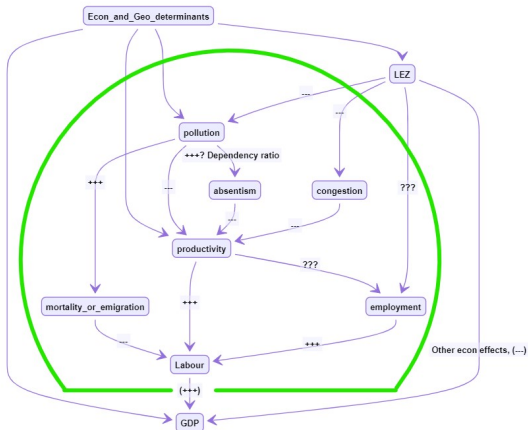
- ▶ 92% of the world's population lives in areas where levels of air pollution exceed the WHO guidelines
- ▶ 3 million deaths a year being attributed to air pollution. (Shaddick et al., 2018)
- ▶ Hundreds of LEZ have been applied in Europe
- ▶ Most German cities over 10.000 inhabitants having applied one from 2008 to 2013 (Gehrsitz, 2017)

Theoretical background

- ▶ We would expect these policies to damage a city's economy as they involve taxes and prohibitions for certain vehicles.
- ▶ Reducing congestion and pollution might offset other economic costs.

This hypothesis is based on...

New evidence of pollution:



Research Questions:

Main question:

- ▶ What was the effect of the application of Low Emission Zones (LEZ) on German cities economies and their labour market indicators?

Complementary questions: *(subject to the adequacy of methods and time constraints)*

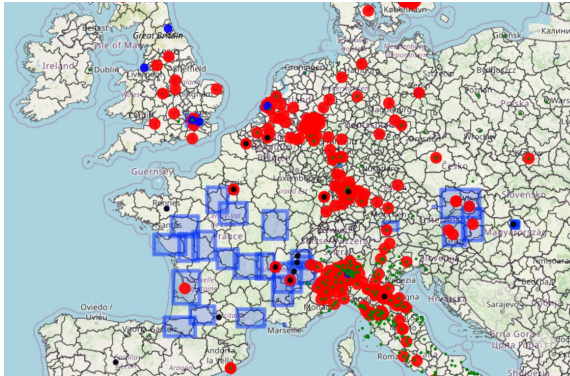
- ▶ Is the reduction of pollution a mediator of this effect and how much it influences the final economic output?
- ▶ Which sectors are more affected by the policy?
- ▶ What are the relative effects of the different stages of LEZ in Germany?

Data collection

- ▶ Economic and demographic variables → *Eurostat, NUTS regions*
- ▶ Application of LEZ zones and similar policies:
 - ▶ Germany → Past research and *Umweltbundesamt*
 - ▶ Rest of Europe → *UAR* and "*Green Zones*" App.
- ▶ Local pollution:
 - ▶ Satellite estimates → van Donkelaar et al. (2016)
 - ▶ Local air stations → AirBase of European air quality e-reporting (EEA)

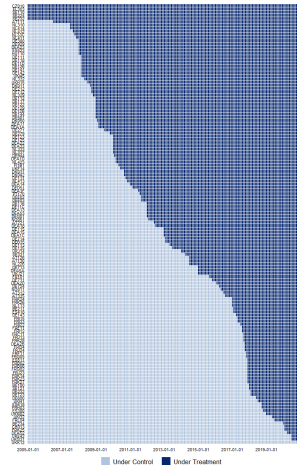
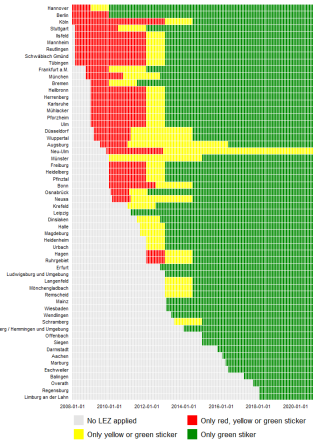
Current Situation

In Europe



Current Situation

Experiment



Units of study - NUTS regions

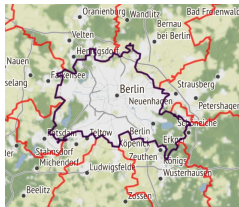


Figure 1: Main coverage of NUTS zones across Europe and Germany

Units of study - Cities from NUTS regions



(a) Hamburg



(b) Berlin



(c) Munich

Figure 2: Cities and their NUTS regions

What are we going to **do**?

Estimate the effect of the LEZ in each city for

1. Overall GDP (main effect)
2. Industry-specific GVA
3. Decompose its effect on the labour market
 - ▶ Productivity
 - ▶ Absenteeism / Temporality
 - ▶ Employment
 - ▶ Change in population (Mortality / migration)
4. Look how pollution levels mediate each one of the past effects

Quite a lot... a bit worried about that

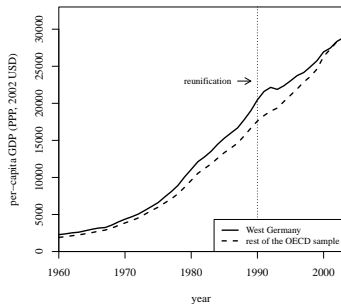
Crash-course on the Synthetic Control Method (SCM) (1)

The SCM works very similar to Difference-in-Differences (DID), both

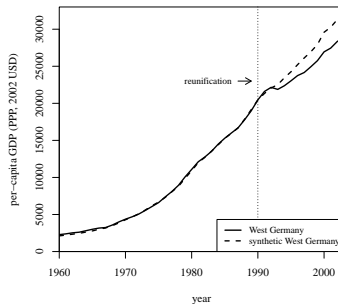
- ▶ lay their main identification requirement on having similar trends before treatment and
- ▶ avoid the need of assuming an exogenous treatment assignment

The difference is how the counterfactual unit is chosen, while DID is mostly theory-based the SCM can be thought as a data-based procedure to find the best DID counterfactual possible from a weighted average of control regions and then perform DID.

Crash-course on the SCM (2)



(a) West Germany and the mean of the control pool



(b) West Germany and its synthetic control

Figure 3: We can see how the Synthetic control closely follows the pre-intervention path of West Germany and deviates from it after the intervention.

Source: Abadie et al. (2015).

Crash-course on the SCM (3)

Countries	Weights
Australia	-
Austria	0.42
Belgium	-
Denmark	-
France	-
Greece	-
Italy	-
Japan	0.16
Netherlands	0.09
New Zealand	-
Norway	-
Portugal	-
Spain	-
Switzerland	0.11
UK	-
USA	0.22

Table 1: Weights of different countries in the control pool that construct the synthetic Germany in Abadie et al. (2015).

Crash-course on the SCM (3)

	West Germany	Synthetic West Germany	Rest of OECD Sample
GDP per-capita	15808.9	15802.2	8021.1
Trade openness	56.8	56.9	31.9
Inflation rate	2.6	3.5	7.4
Industry share	34.5	34.4	34.2
Schooling	55.5	55.2	44.1
Investment rate	27.0	27.0	25.9

Table 2: Here we can see the resemblance in characteristics of West Germany and its synthetic control compared to the mean of the rest of OECD sample.

Source: Abadie et al. (2015).

Crash-course on the SCM (4)

So what do we need?

- ▶ **Sizeable effect:** Its not clear this is the case but gives an idea of the statistical power of the method.
- ▶ **Non interference between units/cities:** Mostly already researched, there continues to be some fear of business displacement to non-LEZ cities.
- ▶ **Valid comparison group:** Large European pool of controls.
- ▶ **No anticipation:** I need to look at dates of announcement too.

Decomposition on the labour market

Given $GDP \equiv \frac{GDP}{\text{Hours worked}} * \frac{\text{Hours worked}}{\text{Employed pop.}} * \frac{\text{Employed pop.}}{\text{Working age pop.}} * \frac{\text{Working age pop.}}{\text{Population}} * \text{Population}$, then the main causal effect to estimate, its decomposition on labour market outputs and their respective interpretation are:

$$\begin{aligned}
 \underbrace{\frac{\partial \ln(GDP)}{\partial \text{LEZ}}}_{\text{Main effect}} &= \underbrace{\frac{\partial \ln(GDP/\text{Hours worked})}{\partial \text{LEZ}}}_{\text{Effect on productivity}} + \underbrace{\frac{\partial \ln(\text{Hours worked}/\text{Employed pop.})}{\partial \text{LEZ}}}_{\text{Effect on absenteeism or temporality}} + \\
 &\quad \underbrace{\frac{\partial \ln(\text{Employed pop.}/\text{Working age pop.})}{\partial \text{LEZ}}}_{\text{Effect on employment}} + \\
 &\quad \underbrace{\frac{\partial \ln(\text{Working age pop.}/\text{Population})}{\partial \text{LEZ}}}_{\text{Effect on the proportion of working age population}} + \underbrace{\frac{\partial \ln(\text{Population})}{\partial \text{LEZ}}}_{\text{Effect on population}}.
 \end{aligned}$$

Mediation analysis!

To answer how pollution mediates the final effect of the policy I plan to use the Mediation Analysis Synthetic Control (MASC) introduced in Mellace and Pasquini (2019)

A (very short) summary is:

Mediation Analysis

LEZ' effect on outcome and mediator

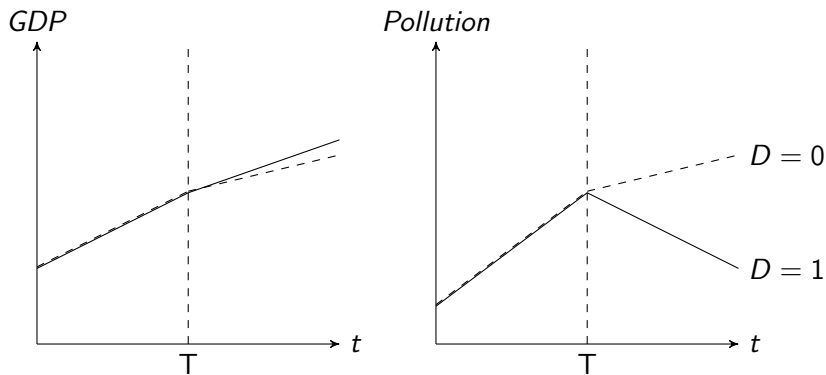
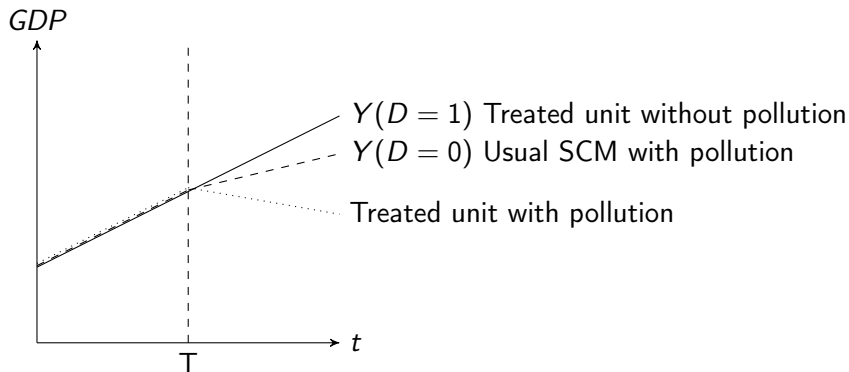


Figure 4: Effect of a LEZ in GDP and Pollution

Mediation Analysis

Calculation of mediator effect



My assumptions I want to discuss

- ▶ Pre-intervention time and where to find date of announcement
- ▶ Other German-specific context characteristics
- ▶ The level of craziness of "Synthetic Treated" idea

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