Capstone Project plan

of Antonio Ávila, ASDS student.

The effect of Traffic Management Strategies in London's economy: A synthetic control approach.

Abstract

Air pollution is a growing issue in health and policy initiatives and Traffic Management Strategies (TMS) have proven popular and useful to reduce it in European cities. While these policies are criticised for "hurting the economy", recent literature indicates how air pollution negatively affects inputs of production, making TMSs a contributor to economic growth. To solve this contradiction from a program evaluation perspective, I propose the use of a Synthetic Control method as introduced by Abadie and Gardeazabal (2003) to study London's TMS effects in the local economy. This research can provide a concrete answer to a pressing question for local authorities, academics and the broad public by providing specific estimates, accounting for the heterogeneity of implementation formulas, spill-over effects and transmission mechanisms.

Keywords — Synthetic Control, Difference in differences, Traffic Management Systems, London, Economic Geography

Literature review: Recent research estimates that 92% of the world's population lives in areas where levels of air pollution exceed the World Health Organization's air quality guidelines, with 3 million deaths a year being attributed to air pollution (Shaddick et al., 2018). In order to minimise these costs, substantial policy initiatives aimed at improving air quality have been implemented around the world. Cities and urban areas play a central role in this effort as virtually half of the world's total population - around 3 billion people - now live in urban settlements, a number that has greatly increased during the last 20 years (Gong et al., 2012; Pucher et al., 2005).

In European cities, TMS have proven popular when trying to improve air quality and comply with the increasingly strict EU regulations (Holman et al., 2015). According to classic economic theory, we would expect these policies to damage a city's economy as they involve taxes and prohibitions for certain vehicles, leading to claims of a "Jobs versus the Environment" trade-off as introduced by Morgenstern et al. (2002). Its impact on economic outputs such as economic growth, profits and employment has been a constant concern of citizens and local officials. And their concern is not unjustified. London, who has one of the most strict Low Emissions Zones (LEZ) in the world, houses more than 8 million people (ONS, a), generates one third of UK's GDP (ONS, b) and has a global economic and financial impact. **However, the effects of reducing congestion and pollution might offset other economic costs.** This hypothesis is based on recent research on the effect of TMS on increasing mobility (Kelly and Kelly, 2009) and decreasing health costs (Cesaroni et al., 2012) and air pollution (Gehrsitz, 2017; Wolff, 2014). Furthermore, recent studies suggest that air pollution reduces aggregate economic output (Dechezleprêtre, 2018; Hao et al., 2018). This can happen through various mechanisms such as increasing mortality (Xie et al., 2016), reducing productivity (Adhvaryu et al., 2014; Chang et al., 2016; Graff-Zivin and Neidell, 2012) and cognitive performance (Ebenstein et al., 2016; Roth, 2015; Zhang et al., 2018) or increasing absenteeism (Hanna and Oliva, 2015; Ransom and Pope, 1992).

Main question: :

- What was the effect of the application of TMS on London's local economic output and indicators?

Complementary questions: :

- Which industries, demographics and professions do they affect more?
- What is the relative effect of different TMZ in London, such as the LEZ, the ULEZ and the Congestion Charge Zone?
- How can spill-over effects be studied and estimated?

Research Design: I intend to look at the effects of TMS with a Synthetic Control approach such that the effects in each treated region can be quantified by constructing a synthetic control from all untreated regions[1]. Even if the Synthetic Control Method has not yet been applied to cities' LEZ, previous related research has used similar techniques. For example, Wolff (2014) and Gehrsitz (2017) applied differences-in-differences to estimate the causal effect of German LEZ in air quality. To the best of my knowledge, there is no published work on the causal effect of over 100 European LEZ, including London, on aggregate economic performance. Transport For London produces its own evaluation reports using a standard first-difference approach and thus unable to establish causal effects (TFL, 2006).

[1]This method was introduced in Abadie and Gardeazabal (2003) to study the effect of conflict in the Basque Country's macroeconomic performance and is extensively described in Abadie et al. (2010). Other methodologies that build on the Synthetic Control approach, and could be used in this research, are the Generalized Synthetic Control Method (Xu, 2017) and the Matrix Completion Method (Athey et al., 2018).

The data for this study will be a collection of regional statistics available for NUTS3 regions from Eurostat (between 1995 and 2017 and covering the whole EU)[2], public information on the implementation of TMS in European cities, as well as other sources for data on air pollution. An extensive summary of the potential variables and an illustration of the NUTS regions can be found in the appendix. The strength of this methodology is based on its ability to estimate city-specific effects on each economic output available, as long as there is a pool of untreated regions to construct a synthetic control[3]. A study of the relative impact of different TMS on economic output is also possible by comparing regions where the application differs. Furthermore, a study on the spill-over effects of TMS can also be thought by comparing areas that surround treated and non-treated urban areas. Some assumptions of the model are indeed questionable such as the non-interference between units (Rosenbaum, 2007) and that the differences in pre-treatment characteristics between cites with and without TMSs are not significant or independent of the policy application, resulting in biased results.

Potential impact and relevance of the study: This research can provide a concrete answer to an already pressing question for local authorities, academics and the broad public. The study results can be used to have a better understanding of the policy's effects by providing specific estimates for London's TMS effect in the economy accounting for the heterogeneity of implementation formulas, spill-over effects and transmission mechanisms. Furthermore, it could also promote further research looking at the potential effect of TMS in developing urban settlements in low and middle income countries, where the costs of pollution appear to be higher and policy advice is much needed.

Limitations and contingency plan: Limitations of the results are derived from assumptions of the model. In the best case scenario, I can claim the overall in GDP and other indicators. The mechanisms that drive this change would still be in question for lack of more detailed micro data regarding businesses. Furthermore, even though an intuition on the ranges of effect size can be extracted from London's example, the results can only be interpreted for this specific case study. Regarding contingency plans, if I can't get a convincing argument behind the assumptions of non-interference between units and omitted variable bias I should find other methodologies and data to estimate the policy effect.

Time Schedule:

Lent Term	**Questions, data and method:**
- Mid-February	Definition of questions and steps to take
- End of March	Gathering of data and preliminary results
Summer Term	**From first drafts to final editions:**
- May	Research proposal delivery (MY400)
- June	Delivery of drafts and modifications
- July	Final edits and review of literature

Supervisors: My 3 preferred supervisors are David Hendry, Patrick Sturgis, and Blake Miller, respectively. I have discussed the project and the methodology with Kenneth Benoit, Blake Miller, Patrick Sturgis and David Hendry.

[2]NUTS, or Nomenclature of Territorial Units for Statistics, is a geographical code to reference the subdivisions of countries. There is a vast amount of regional economic, demographic and environmental data at this geographical definition such as GDP, GVA per sector, unemployment, science and technology statistics (trademarks and patents), business outputs and demographics. Even if the available data are enough to achieve the research aim of this proposal, I am confident that further data can be found to get a deeper understanding of the transmission mechanisms at play.

[3]For major statistics such as regional GDP, data from non-European cities (US, Canada, or others) could be gathered to increase the pool of controls and test the argument of exogeneity of the treatment. Comparing treated areas with control areas that were treated in later periods as Neumark and Kolko (2010) is another alternative to the selection of controls.

References

Abadie, A., Diamond, A., and Hainmueller, J. (2010). Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. *Journal of the American Statistical Association*, 105(490):493–505.

Abadie, A. and Gardeazabal, J. (2003). The economic costs of conflict: A case study of the Basque Country. *American Economic Review*, 93(1):113–132.

Adhvaryu, A., Kala, N., and Nyshadham, A. (2014). Management and shocks to worker productivity: evidence from air pollution exposure in an Indian garment factory. *Unpublished Working Paper, University of Michigan*.

Athey, S., Bayati, M., Doudchenko, N., Imbens, G., and Khosravi, K. (2018). Matrix completion methods for causal panel data models. Working Paper 25132, National Bureau of Economic Research.

Cesaroni, G., Boogaard, H., Jonkers, S., Porta, D., Badaloni, C., Cattani, G., Forastiere, F., and Hoek, G. (2012). Health benefits of traffic-related air pollution reduction in different socioeconomic groups: the effect of low-emission zoning in Rome. *Occupational and Environmental Medicine*, 69(2):133–139.

Chang, T., Zivin, J. G., Gross, T., and Neidell, M. (2016). The effect of pollution on worker productivity: Evidence from call-center workers in China. Working Paper 22328, National Bureau of Economic Research.

Dechezleprêtre, A. (May 18, 2018). The economic cost of air pollution: Evidence from Europe. Conference on Environmental regulation and industrial performance, TSE.

Ebenstein, A., Lavy, V., and Roth, S. (2016). The long-run economic consequences of high-stakes examinations: Evidence from transitory variation in pollution. *American Economic Journal: Applied Economics*, 8(4):36–65.

Gehrsitz, M. (2017). The effect of low emission zones on air pollution and infant health. *Journal of Environmental Economics and Management*, 83:121 – 144.

Gong, P., Liang, S., Carlton, E. J., Jiang, Q., Wu, J., and Wang, L. (2012). Urbanisation and health in China. *The Lancet*, 379:843–852.

Graff-Zivin, J. and Neidell, M. (2012). The impact of pollution on worker productivity. *American Economic Review*, 102(7):3652–73.

Hanna, R. and Oliva, P. (2015). The effect of pollution on labor supply: Evidence from a natural experiment in Mexico city. *Journal of Public Economics*, 122:68 – 79.

Hao, Y., Peng, H., Temulun, T., Liu, L.-Q., Mao, J., Lu, Z.-N., and Chen, H. (2018). How harmful is air pollution to economic development? new evidence from pm2.5 concentrations of Chinese cities. *Journal of Cleaner Production*, 172:743 – 757.

Holman, C., Harrison, R., and Querol, X. (2015). Review of the efficacy of low emission zones to improve urban air quality in European cities. *Atmospheric Environment*, 111:161 – 169.

Kelly, F. J. and Kelly, J. (2009). London air quality: a real world experiment in progress. *Biomarkers*, 14(sup1):5–11.

Morgenstern, R. D., Pizer, W. A., and Shih, J.-S. (2002). Jobs versus the environment: An industry-level perspective. *Journal of Environmental Economics and Management*, 43(3):412 – 436.

Neumark, D. and Kolko, J. (2010). Do enterprise zones create jobs? evidence from California's enterprise zone program. *Journal of Urban Economics*, 68(1):1 – 19.

Pucher, J., Korattyswaropam, N., Mittal, N., and Ittyerah, N. (2005). Urban transport crisis in India. *Transport Policy*, 12:185–198.

Ransom, M. R. and Pope, C. A. (1992). Elementary school absences and pm10 pollution in Utah Valley. *Environmental Research*, 58(1):204 – 219.

Rosenbaum, P. R. (2007). Interference between units in randomized experiments. *Journal of the American Statistical Association*, 102(477):191–200.

Roth, S. (2015). The effect of indoor air pollution on cognitive performance: Evidence from the UK. Unpublished.

Shaddick, G., Thomas, M. L., Green, A., Brauer, M., van Donkelaar, A., Burnett, R., Chang, H. H., Cohen, A., Dingenen, R. V., Dora, C., Gumy, S., Liu, Y., Martin, R., Waller, L. A., West, J., Zidek, J. V., and Prüss-Ustün, A. (2018). Data integration model for air quality: a hierarchical approach to the global estimation of exposures to ambient air pollution. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, 67(1):231–253.

TFL (June, 2006). Central london congestion charging, impacts monitoring. fourth annual report.

van Donkelaar, A., Martin, R. V., Brauer, M., Hsu, N. C., Kahn, R. A., Levy, R. C., Lyapustin, A., Sayer, A. M., and Winker, D. M. (2016). Global estimates of fine particulate matter using a combined geophysical-statistical method with information from satellites, models, and monitors. *Environmental Science & Technology*, 50(7):3762–3772. PMID: 26953851.

Wolff, H. (2014). Keep Your Clunker in the Suburb: Low-Emission Zones and Adoption of Green Vehicles. *The Economic Journal*, 124(578):F481–F512.

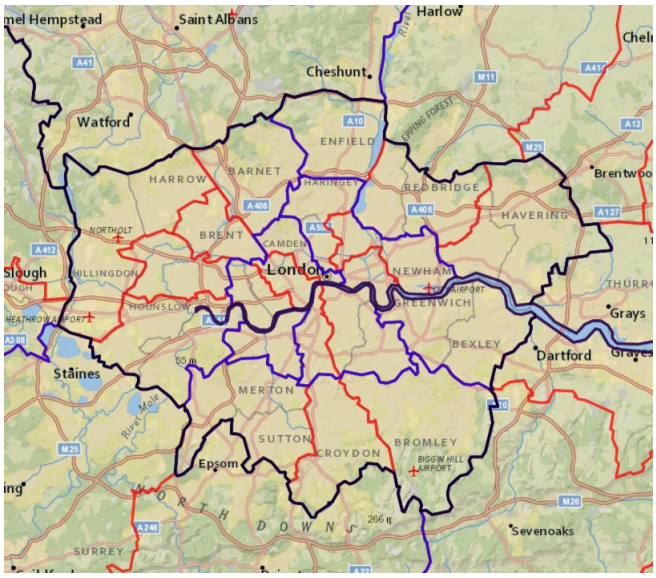
Xie, Y., Dai, H., Dong, H., Hanaoka, T., and Masui, T. (2016). Economic impacts from pm2.5 pollution-related health effects in China: A provincial-level analysis. *Environmental Science & Technology*, 50(9):4836–4843. PMID: 27063584.

Xu, Y. (2017). Generalized synthetic control method: Causal inference with interactive fixed effects models. *Political Analysis*, 25(1):57–76.

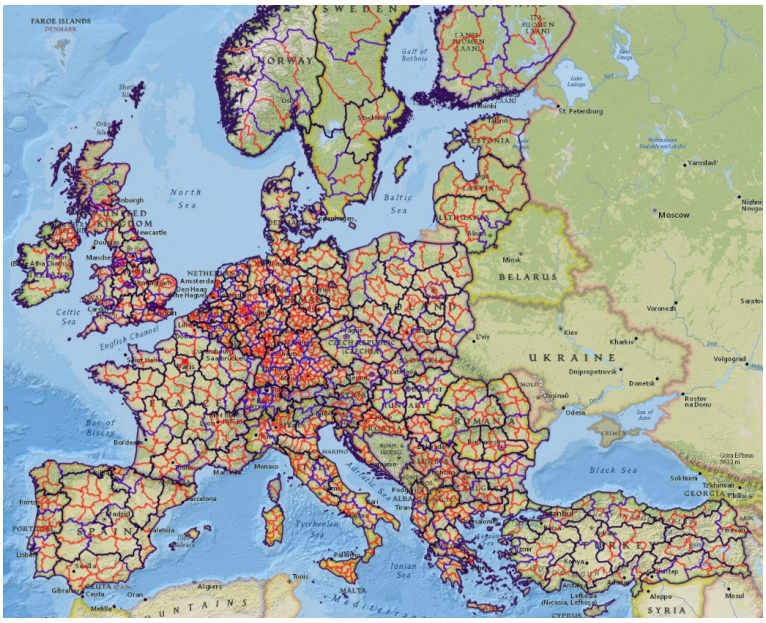
Zhang, X., Chen, X., and Zhang, X. (2018). The impact of exposure to air pollution on cognitive performance. *Proceedings of the National Academy of Sciences*, 115(37):9193–9197.

Appendices

(a) Madrid (1 NUTS1) (b) Paris (4 NUTS3) (c) Budapest (1 NUTS1)



(d) London (22 NUTS3, 1 NUTS1)



(e) Main coverage of NUTS 3 zones

Figure 1: Main coverage of NUTS zones across Europe, with examples of cities. Borders of NUTS 1, 2 and 3 regions are coloured in black, blue and red, respectively. *Source: Eurostat and own work.*

Table 1: Potential analysis variables with their source, geographic and time coverage.

Variable	Coverage	Geography	Start	End	Delta	Source
Outcomes (Y):						
Gross value added (GVA) by Industry	UK	NUTS 3	1998	2017	1 year	Office of National Statistics (ONS)
GVA at basic prices by NACE activites	EU	NUTS 3	1995	2017	1 year	Eurostat
GDP	UK	NUTS 3	1998	2017	1 year	ONS
GDP	EU	NUTS 3	2000	2017	1 year	Eurostat
Total GDP at current prices	EU	NUTS 4 (LAU 1)	2000	2017	1 year	Eurostat
Spatial variation (X):						
Boundaries of TMS zones	EU	georeferenced	Most recent			urbanaccessregulations.eu
Boundaries of TMS zones	EU	georeferenced	Most recent			"Green-Zones" App
Boundaries of TMS zones	Germany	georeferenced	Most recent			"Umweltzone" App
Boundaries of TMS zones and details on their implementation	EU	"Described"	All	All	All	Official and legal documents
Boundaries of TMS zones and details on their implementation	EU	georeferenced	Partial	Partial		openstreetmap.org
Details on TMS's implementation	Germany	"Described"	All	2017	1 month	Gehrsitz (2017) and Wolff (2014)
Transmission mechanisms (secondary Y):						
Productivity	UK	Cities	2004	2017	1 year	ONS
Employment ('000 persons) by NACE	EU	NUTS 3	1995	2017	1 year	Eurostat
Employer business demography by NACE Rev. 2	EU	NUTS 3	2008	2016	1 year	Eurostat
Employer business demography by size class	EU	NUTS 3	2008	2016	1 year	Eurostat
Business demography and high growth enterprise by NACE Rev. 2	EU	NUTS 3	2008	2016	1 year	Eurostat
Business demography by size class	EU	NUTS 3	2008	2016	1 year	Eurostat
Science and Tech statistics	EU	NUTS 3			1 year	Eurostat
Community design (CD) applications	EU	NUTS 3	2003	2016	1 year	Eurostat
Patent applications to the EPO by priority, IPC, sections and classes	EU	NUTS 3	1977	2012	1 year	Eurostat
High-tech patent applications to the EPO by priority year	EU	NUTS 3	1977	2012	1 year	Eurostat
Patent applications to the EPO by priority year	EU	NUTS 3	1977	2012	1 year	Eurostat
Business Demographics and Survival Rates	London	Borough	2002	2018	1 year	ONS
VAT enterprices by turover	London	Borough	2003	2019	1 year	ONS
Real labour productivity	UK	LEPs	2004	2017	1 year	ONS
PM2.5 mean concentration	EU	0.01^o x 0.01^o	2000	2017	1 year	van Donkelaar et al. (2016)
PM2.5 concentration	EU	$10km^2$	2008	2015	dialy	CAMS
Air pollutants concentration summary	EU	Weather Stations	2013	2018	1 year	EEA
Air pollutants concentration	EU	Weather Stations	2013	2018	dialy	EEA
Other variables (mostly control):						
Household income	UK	MSOA	2011	2016	2 years	ONS
Deaths (total)	EU	NUTS 3	1990	2017	1 year	Eurostat
Population change	EU	NUTS 3	2000	2018	1 year	Eurostat
Land use (degree of urbanization)	EU	NUTS 3	2015	2020	5 years	JRC
Electricity and Gas consumption	UK	LSOA	2016	2017	1 year	ONS
Live births	EU	NUTS 3	1990	2017	1 year	Eurostat
Area (m^3)	EU	NUTS 3	1990	2015	1 year	Eurostat
Population / age, sex	EU	NUTS 3	1990	2018	1 year	Eurostat
Live births / age mother	EU	NUTS 3	1990	2017	1 year	Eurostat
Fertility rate	EU	NUTS 3	1990	2017	1 year	Eurostat
Age dependency ratio by age class	EU	NUTS 3	2014	2018	1 year	Eurostat
Young age dependency ratio	EU	NUTS 6 (city)	2000	2018	1 year	Eurostat
Share of transport means to work (imperfect)	EU	NUTS 6 (city)	2001	2012	1 year	Eurostat
Cars/1000 persons (imperfect)	EU	NUTS 5 (LAU 2)	2002	2012	1 year	Eurostat
Shape files of NUTS and LAU regions:						
Shape Files	EU	NUTS and LAU	All	All	All	Eurostat