Long-run effects of floods at municipality level in Spain

Guillermo Peña[a,*], Marcos Sanso-Navarro[a]

[a] *Departmento de Análisis Económico e IEDIS, Universidad de Zaragoza, Gran Vía 5, Zaragoza (Spain)*

Abstract

This paper deals with the persistence of the effects of natural disasters on population, concretely at the municipal level. With this aim, we analyze information about the population of all Spanish municipalities and flood events from 1877 to 2011. Using recent developments in differences-in-differences estimation methods, we find a negative and significant impact of floods on population in the short term when there are casualties involved. Therefore, and in line with the results of other types of shocks, we provide evidence that shocks related to natural disasters have a demographic transitory effect.

Keywords: Natural Disasters, Floods, Shocks, Differences-in-Differences, Panel Data

JEL: Q54, C23, Q56

[*] Corresponding author

Email addresses: gpena@unizar.es (Guillermo Peña), marcossn@unizar.es (Marcos Sanso-Navarro)

1. INTRODUCTION

The climate change and other environmental issues as pollution or CO2 emissions concern everybody in the society, and addressing this topic is essential for the development and well-being of the humanity. Other gas emissions may also be responsible of the global warming, as the methane, from which some countries in the 2022 COP-27 have agreed to reduce its emissions, in addition to others already included in the 2021 Treatment of Glasgow. The Earth will probably be at least 3º C warmer in the next century than currently even if human beings immediately react (Tollefson, 2020). Therefore, "climate change" may be considered as a challenge of our times (Peri and Robert-Nicoud, 2021). This is a relevant topic for keeping save the Earth from the hands of people that may hurt the planet. Recently, it has started to be observed the fact that these issues, overall the climate change, can be responsible of an increase of hazardous and extreme events, which are more frequent since some years ago, as some reports alert (IPCC, 2022). This field is even more relevant nowadays when, currently, natural disasters are in the covers of many newspapers, the TV and social media. Nonetheless, the affections of these events on economic, social and demographic variables are still unclear, and it is important to know their consequences.

Tol (2018) review the main economic effects present on the literature, highlighting that climate change initially improves economic welfare but these original effects are sunk since the impacts are predominantly negative later, overall for developing countries. Nonetheless, there are additionally indirect effects such as negative impacts on economic development, biodiversity loss, violent conflict, the long-term effects. These effects are also associated with urbanization. According to a recent study of Castells-Quintana (2021) using census population data and light density at night they observe global non-linear effect of climate conditions on cities. Concretely, they obtain that there is a positive correlation between deteriorating climatic conditions and urbanization. Cavallo et al. (2013) observe that the average causal effect of catastrophic natural disasters on economic growth, with a negative impact in the short and long-run.

This paper deals with the target of studying the effects of natural disasters on the growth rate population dynamics of cities in a country. Among these extreme events maybe provoked by the global warming it is worth highlighting the extreme temperatures, forest fires, storm raining and floods. Concretely, this paper focuses on floods, "which displaced more than 650 million people worldwide in the last 35 years" (Kocornik-Mina et al., 2020, p.1).

The floods may hurt agricultural fields and natural ecosystems, but they also hold as a relevant trouble for many urban areas. These specific natural hazards provoke many economic losses in cities, even with a trade-off between environment and income that several authors discuss (Grossman and Krueger, 1995, Zhang et al., 2023) and, in some cases, events as floods may also lead to human being fatalities. This paper takes advantage of the recent developments on the estimation methods of differences-in-differences for analyzing the transitory or permanent way of the shocks derived from these floods by using log-term information about Spanish municipalities. For achieving this objective, the paper is based on flood events data from Desinventar and population data from the Spanish National Institute of Statistics (INE) for the total municipalities of Spain in the period 1877-2011. The most recent and advanced econometric techniques are used, mainly the Callaway and Sant'Anna's (2021) differences-in-differences methodologies, concretely, considering multiple time periods and including the variation in treatment timing. For a review of recent differences-in-differences methods in treatment of timing and heterogeneous effects; see the reviews by Chaisemartin and D'Haultfoeuille (2022) and Roth et al. (2022). The goal of this paper is to test the impact of the occurrence of floods The main result is the statistical significance of the negative impact of the flood events on city size populations only when there are casualties.

Internationally, a good homogenous driver for analyzing sustainable development is given by using satellite imagery as Burke et al (2021) and Tellman et al. (2021) suggest. Regarding the presence of persistent long-run effects on population of natural disasters, Testa (2021) finds relevant negative effects of earthquakes on the city population growth of 1860 world cities for the period 1973-2018. These effects are driven by being located outside from stable democracies. It is worth to highlight that, according to Cirone and Pepinsky (2021), historical persistence is referred to the causal effects that fulfill two conditions. First, the effects operate over a decade or more time, and second, when the effects explain spatial changes in social, political or economic outcomes. Allen and Donaldson (2020) propose a model of theoretical persistence in which temporary historical shocks are path dependent, that is, have huge persistence effects or even permanent consequences. They simulate the model using data of spatial changes across U.S. counties for the 1800-2000 period, observing that conditions have significant effects for both the spatial distribution and the efficiency of the economic activity, both currently and in the long-run. Another example is shown by Ambrus et al. (2020), who find the negative impact of the cholera epidemic on housing prices a decade after the epidemic in a neighborhood of London during the nineteenth century. In fact, authors as Bosker (2022) highlight that the availability of better and more fine-grained data on the historical and geographical features of cities enriches this debate with further empirical evidence.

The main contribution of this paper is to be the first on applying the above-mentioned novel techniques for floods in the case of Spain in that period for all the municipalities. For achieving so, temporal and geographical techniques are used. The paper is divided as follows. Next section deals with a brief literature review, Section 3 presents the data and methodology used in the paper, Section 4 analyzes the floods data, Section 5 shows the results, discussing them, and, finally, Section 6 concludes.

2. LITERATURE REVIEW

Glaeser (2022) selectively reviews the literature of the long-term impact of natural disasters on cities. Among the first authors in studying the effect of exogenous shocks in cities, it is worth to highlight Davis and Weinstein (2002), who observe that, by analyzing Allied bombing of Japanese cities during the World Wide II (WWII), these large temporary shocks to urban areas lead to no long-run relevant effect on city size. They use a model with instrumental variables for analyzing the persistence/transitorily of the shocks, similar to the techniques later used by authors as Brakman et al (2004) or Sanso-Navarro et al. (2015). They apply rank correlations and show that the population growth rates of the villages with casualties during the WWII was inversely correlated with the values of the same period of years immediate after the war. They apply the study to the villages with casualties as this paper will perform with the flood event. According to Brakman et al. (2019), the previous authors theoretically distinguish between three different approaches: fundamental geography, increasing returns and random growth. For the first case, exogenous and fixed characteristics and endowments influence on economic growth. The second approach considers a permanent shock if it is large enough. Finally, the random growth approach considers the size evolution of cities follows a random path and temporary shocks as the WWII one would have permanent effects on cities.

Brakman et al. (2004) apply the same procedure and study whether bombs in German urban areas during the WWII affected to the city growth of those areas, checking its permanent or transitory effects. They find a negative and significant impact of the shocks in city growth after the war in Germany as a whole and in West Germany, while there is no significance in East Germany. Some papers study the effects of the WWII bombs neighborhoods and its people in London (Redding and Sturm, 2016) or French cities (Gaubert, 2018), using the notion of spatial equilibrium with an approach combined with agglomeration economies and sorting. The empirical evidence is provided by a Simulated Method of Moments (SMM).

In line with the previous authors, Sanso-Navarro et al. (2015) find that the effects of the battles of the American Civil War were transitory. Some authors have also studied the impact of terrorism attacks as an exogenous shock. Concretely, Sanso-Navarro et al. (2018) also obtain transitory effects of the ETA terrorism in the Basque country and Navarre, with a negative effect more pronounced when the attacks provoked deaths. So, casualties may play an important role in the empirical exercise of this paper, as we will confirm later. So, this literature has been based on applying estimation methods for instrumental variables and dynamic differences-in-differences to conflicts and violence. More recently, Ciccione (2021) finds that the negative effect of the World War I (WWI) persists in German municipalities to 1933, and for not agricultural cities, beyond. The data includes the historical German state of Württemberg for the 1875-1970 period and he uses instrumental variables.

Currently, and given the rising environmental awareness, the impact of natural hazards on cities has been analyzed. Therefore, the consequences of natural disasters are studied by considering the last phenomenon as an exogenous shock on cities, there is a vast literature. According to Masiero and Santarossa (2019), the response of local governments to the social and economic damages provoked by natural disasters may vary in terms of stimulatory power, which leads to asymmetric and heterogeneous effects. The authors use municipality data of all the earthquakes of Italy in the period 2000-2015, finding a raise in the public expenditure for around 11 to 12 years after the exogenous shock, coming back to the pre-disaster levels since then.

Raker (2020) leverages the change from 1980 to 2010 of the exposure of the United States to an exogenous natural hazard, concretely, tornadoes, by using two different econometric techniques: matching and difference-in-difference. He observes that severe tornadoes are not associated with a net variation in local population size but they are with socio-economical compositional changes: neighborhoods become more advantaged. Other studies have documented that natural disasters lead to a net population gain or an acceleration in total population growth, as in Schultz and Elliott (2013). They use US population census from 1990 and 2000 and obtain an association between the growth on larger and more unequal populations and the presence of environmentally hazardous places.

There is also an effect of natural disasters on net emigration as Boustan et al. (2020) observe. They analyze 100 natural disasters of US counties from 1920 to 2010, finding an effect of increase on out-migration rates and lower housing prices/rents by applying a spatial econometric models. Logan et al. (2016) analyze the variation on population from 1970 to 2005, annually, in the U.S. Gulf Coast region associated to 32 hurricanes. They find that these natural hazards are associated with a decrease in the growth rate of population by spatial time-series methods. In contrast, Deryugina (2017) finds no significant change of population at all, consistent with Strobl's (2011) analysis of the US coastal county's population after a hurricane. Deryugina (2017) takes into account both direct costs and indirect costs by using data from the years 1969–2012. He estimates variations in government non-disaster transfers perceived by individuals in US counties in the decade next to a hurricane strike from 1979–2002. The econometrical technique is the differences-in-differences framework through the comparison of counties experiencing a hurricane with those without it. The author's findings show that taking into account disaster aid alone significantly understates the fiscal costs of natural hazards.

Many studies also have remarked a considerable impact heterogeneity (Fussell et al. 2017; Logan et al. 2016). The first authors analyze the variations of population in all US counties experiencing hurricanes and tropical storms from 1980 to 2012 by using random-effects of generalized least squares regression estimation model. They obtain that these weather events affect future population growth, but only in counties with rising, high-density populations.

Several studies have additionally found effects on emigration of less advantaged groups, such as ethnic minorities and low-income people (Boustan et al. 2020; Elliott 2015), but other studies find the opposite (Logan et al. 2016). As Pécastaing and Chávez (2020) show, natural disasters can lead to huge damages with high economic costs. These authors study the Coastal El Niño in Peru in the 2008–2016 period by applying a triple difference (DDD) method. They find that living close to dry forests areas reduce the likelihood of being poor that otherwise. Boustan et al. (2020) find that severe natural disasters increase the emigration rate in the counties of the USA, where they are very common.

In the specific field of floods, the impact of natural disasters on the development of land is still unclear (Magontier and Martinez-Mazza, 2021). These authors analyze Spanish data and find that new land development is not influenced by floods, and residential buildings still locate close to risky and dangerous areas. Fatica et al. (2021) use European manufacturing firms' data for the period 2007-2018 and find that the regular occurrence of water hazards as repeated floods leads to significant and likely disruptive economic and social effects for regions that are hit repeatedly by them. Gallagher (2014) studies the effects of US floods on insurance risk-taking during the period 1958-2007 and observes that insurance take-up prickles the year after a flood, but after that, it steadily declines to baseline. Gandhi et al. (2022) use a wide sample of 9,468 cities from 175 countries for 2012-2018 and obtains that the growth of the population is lower in cities affected by a higher frequency of floods, while richer cities suffer from a fewer number of casualties from flood events. For data availability, Lindersson et al. (2020) collect a good review of open-access global datasets for the analysis of the effects of floods. Castells-Quintana et al. (2021), using worldwide data, discover that exposure to floods can be associated with a higher urban social disorder appeared by the displacement of the population into large cities.

The closest paper to the present one is the work by Magoniter and Martinez-Mazza (2022), where they use the National Catalogue of Historical Floods, where this paper uses its international version, benefiting from the same original source. They combine these data with the digitalized floodplain maps of risk of flood provided by the national authorities in the Spanish National Institute of Geography (IGN) and analyze Spanish municipalities between 1978 and 2010 [1], which provides a shorter term view than this paper, where floods data from 1842 to 2010 are used, with a more remarkable long-run view in decadal data instead of yearly as them. The dependent variable is also different, they analyze the effect on building construction, while this paper is only focused on population. Finally, there is

[1] For Spain, Barredo et al. (2012) assess the trends in insured losses from floods in Spain for the period 1971-2008. Their results show no significant trend over that period and suggest that societal factors are mainly driving economic and insured losses from natural hazards. These authors consider that flood disasters have raised over recent decades, but in most cases due to increasing exposure and vulnerability to floods. In fact, Olcina et al. (2015) state that exposure to floods has recently increased, mainly after the sharp growth of urbanization in lands with risk of flood during the 1990s and early 2000s

also a novelty in the methodology: this paper applies recent dynamic difference-in-difference techniques with multiple periods. They observe that a food event does not necessarily affect development in most cases. The residential buildings are built following the same growth rate on average as before the flood, being a natural hazard without impact on unemployment, migration or housing prices. Nonetheless, they do not check the results in the case of events with casualties, as this paper proposes.

3. DATA AND METHODOLOGY

The data used for this article is taken from the INE, and includes the "de jure population" (1877-2011), which is the population in the city at a specified time[2]. Additionally, there is information about households for the full period (1842-2011). The widest available period considering population and floods at the same time is the one used in this paper, from 1830 to 2010. The population measured by the three previous variables is the outcome of the estimations, and the lags of the previous variables in levels or in growth rates are also used as independent variables in most of the conditional estimations. The other conditional estimation, in which lags are not used, is the one with geographical variables, such as the latitude, altitude, longitude, perimeter of the municipality, taken from the Spanish National Institute of Geography (IGN). The data for the floods is taken from the Desinventar Sendai United Nations database[3], with a value of 1 whether in any period there was a flood in that municipality. From this database it is also available the data regarding whether there have been deaths or not related with the flood. So, we have collected the data regarding the casualties for empirical purposes for distinguishing the most dangerous events.

Next Table 1 shows the time of the empirical analysis, jointly with the year employed for obtaining the population and the flood events. In 2011, there were 8,116 municipalities with an average population of 3022.258 I the full period considered. For the use of growth rates, the population of the last year of the period has been weighted respect to the correlative periods of flood events considered.

Table 1: Time data

t	Periods of flood events	Events of flood	Causalities by flood	t	Periods of flood events	Events of flood	Causalities by flood
1	1830-1842	337	126	9	1931-1940	314	22
2	1843-1860	453	194	10	1941-1950	322	99
3	1861-1877	378	187	11	1951-1960	394	235
4	1878-1887	271	914	12	1961-1970	848	101
5	1888-1900	526	948	13	1971-1981	879	139
6	1901-1910	266	84	14	1982-1991	2723	168
7	1911-1920	369	33	15	1992-2001	5781	186
8	1921-1930	371	68	16	2002-2010	2976	43

The data of all the floods of the period have been included for the correspondent population time.

[2] https://stats.oecd.org/glossary/detail.asp?ID=580

[3] https://www.desinventar.net/

The specification of this article considers the proposal of Callaway and Sant'Anna (2021), where semi-parametric DiD estimators are developed for multiple time periods and variation in treatment timing. A panel data context is considered by considering a random sample $\{(Y_{i1}, Y_{i2}, ..., Y_{i\tau}, D_{i1}, D_{i2}, ..., D_{i\tau}, X_i)\}_n^{i=1}$ where Y_{it} is the outcome in unit i at time t, D_{it} is a set of variables with value one if municipality i has been treated in period t and zero otherwise and X_i is a regressor's vector for unit i. With a staggered treatment scheme, $D_{it} = 1$ implies that $D_{it+1} = 1 \forall t = 1, 2, ..., \tau$. In addition, the initial time treatment uses cohort dummies G_{ig} with a value equal to 1 if unit i is first treated at time g and zero otherwise. By considering no treatment anticipation, the most relevant parameter of interest is the Average Treatment Effect (ATE) for the first treated data at period g and calendar time t:

$$ATE\,(g,t) = E\,[Y_t\,(g) - Y_t\,(0)\,|G_g = 1]\,, \forall t \geq g\,(0)\,(1)$$

4. EXPLORATORY ANALYSIS

This section provides a synthetic overview on the main characteristics of the floods according to the main databases of floods in Spain, the one that provides the areas with flood risks, based on the National Catalogue of Historical Floods (NCHF), and on the desinventar database with national data provided by the Spanish Minister in the international source with data of the year and municipality of each flood event.

Figure 1 shows the municipal map of Spain with the areas with significant potential risk of flood of first cycle (2011), according to the NCHF, below. It is relevant to highlight that most of the risky-flood areas are mainly located around rivers or the coast. Above two maps appear, in the left, with the municipalities with casualties provoked by floods, in the right, with municipalities with an event of flood. Finalizing with the use of the full sample of flood events (1830-2010), there have been a total of more than 20 thousand of flood events and more than 3500 casualties.

The Table 3 shows the municipalities with the highest number of casualties, with all of them, except nine, before 1900, and in most cases in big cities or capitals of the province.

Continuing with the data of the full sample, next Figure 4 shows in Map A the flood events per provinces. It is worth remarking that the province of Murcia is the one with all the cities with at least one event of flood in the sample. In the peninsula, there are high levels in almost all the South, Center-South-West, North and East. In the Map B, it is easy to see that the provinces with the higher proportion of cities with floods are mostly in the coast or in the south of the peninsula. The Map C geographically represents the total population per province in 2021, showing a higher populated coast, Madrid, and the Ebro valley. Finally, Map D shows the number of flood events per capita for each province. The provinces of the North of the peninsula that are neighbors of coast provinces also suffer from a slightly high level of floods. So, with the exception of Madrid, we can conclude that the

Table 2: The 20 municipalities with the highest casualties in the full sample

Year	Municipality	Province	Causalties
1891	Consuegra	Toledo	900
1879	Murcia	Murcia	761
1958	Galende	Zamora	145
1843	Girona	Girona	120
1871	Tudela	Navarra	100
1880	Logroño	Rioja, La	90
1996	Biescas	Huesca	87
1973	Puerto Lumbreras	Murcia	79
1965	Torrejón el Rubio	Cáceres	70
1953	Zestoa	Gipuzkoa	48
1945	Zestoa	Gipuzkoa	40
1834	Mula	Murcia	39
1863	Vic	Barcelona	33
1874	Espluga de Francolí, L´	Tarragona	30
1907	Xerta	Tarragona	29
1834	Murcia	Murcia	27
1834	Santa Cruz de Mudela	Ciudad Real	25
1906	Santomera	Murcia	24
1879	Cuevas del Almanzora	Almería	23
1979	Valdepeñas	Ciudad Real	21

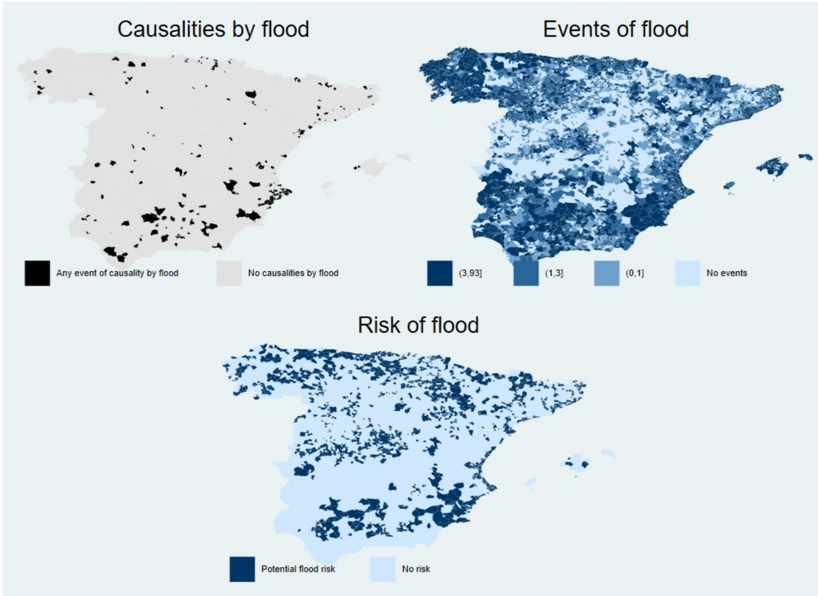

Figure 1: Spanish areas with significant potential risk of flood on 2011, casualties and flood events

provinces may benefit from a lower level of flood events once that we approach to the center of the country. The graphical representation of Map d is similar to that of Map a, but in different scale.

The Figure 3 shows the provinces with the highest (left) and lowest (right) share of municipalities with an event, both floods and any causality provoked by flood. It is remarkable that the provinces with the highest share of flood events are usually on the coast, jointly with the highest share of municipalities with causalities caused by those floods, while in the opposite case they appear overall interior provinces. It is also worth to highlight that eight provinces did not suffer from any causality caused by floods in the full period considered.

5. RESULTS

The Figures 4-8 collects four graphs for the dynamic average treatment effects on de jure population, for unconditional effects (a), conditional to population (b), to geography (c) and to population and geography (d). The first four results (models 1) are those for the impact of the floods with no treatment, models 2 are those results of the impact of the event of floods with casualties, models 3 reflect the same impact but treating only with the sample with floods, models 4 reflect the impact of events of flood, with or without casualties, for the sample with risk of flood and models 5 only treat with the areas with risk of flood when there is a causality. The reason for considering deaths in the estimations is the relevance of the presence of death people as a consequence of the exogenous shock in order to reflect an effect in the population (Brackman et al., 2004, Davis and Weinstein, 2002 and Sanso-Navarro et

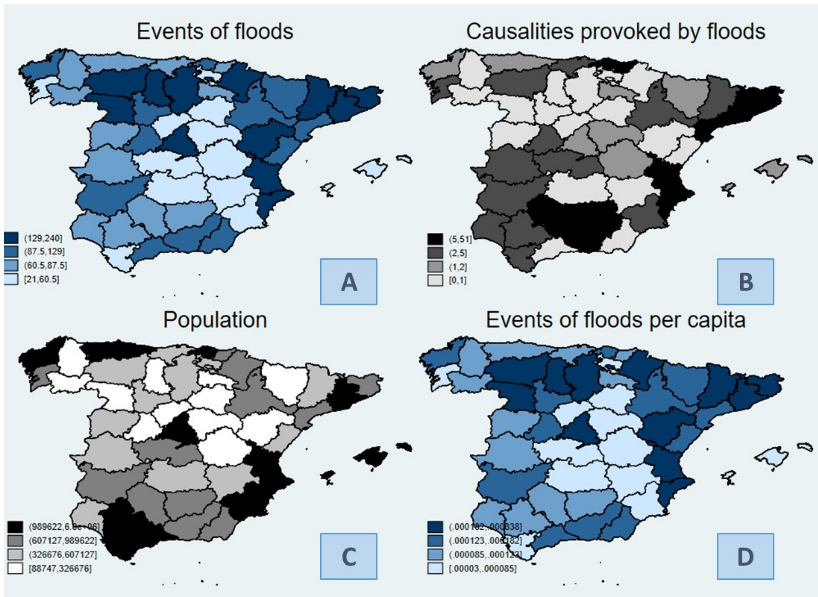

Figure 2: Flood events (A), events of causalities provoked by floods (B), population (C) and floods per capita (D) in Spain

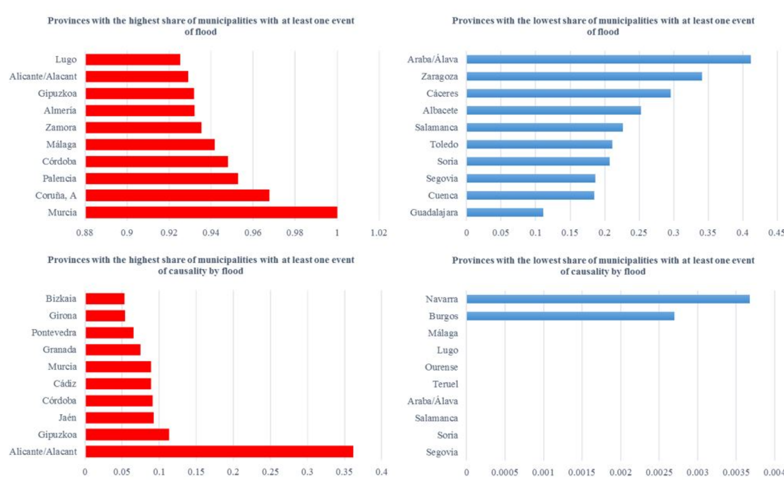

Figure 3: Provinces with the highest (left) and the lowest (right) share of events

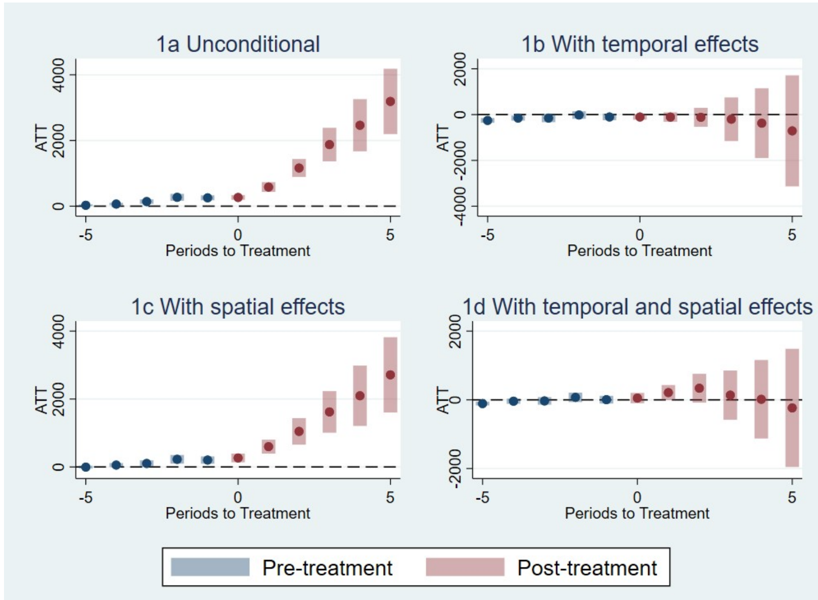

Figure 4: Dynamic average treatment effects by treating floods in the full sample

al., 2018).

There is a robustness check in the three last figures (Fig. 9-11). They show the robustness of the results for the geographical and lags independent variables estimating with the three first estimation techniques for households. All the figures show the sign of the effect for each period before (left, in blue) and after (right, in red) the period of treatment (of the occurrence of the exogenous shock, which is in this case the first flood in the sample), independently from the calendar time in which it happened. The boundaries show the 5% interval of confidence for each period respect to the zero, which denotes insignificant impact. These results show that the ATEs pre-average are non-significant, and significant with negative sign in the post-average, in the lags and lags and geo estimations for de jure population with models 1 (1b-1d), models 3 (3b-3d) and models 5 (5b-5d), and these cases are robust to the dependent variable employed (households, 6c and 6d). Nonetheless, there is no always significance of the post-average ATEs in the rest of cases.

There is a robustness check with households instead of population in Figure 6. They show the robustness of the results for the conditional by geography and population estimating with the four estimation strategies for households. All the figures show the sign of the effect for each period before (left, in blue) and after (right, in red) the period of treatment (of the occurrence of the exogenous shock, which is in this case the first flood in the sample), independently from the calendar time in which it happened. The boundaries show the 5% interval of confidence for each period respect to the zero, which denotes insignificant impact. Finally, calendar and group effects for four types of models

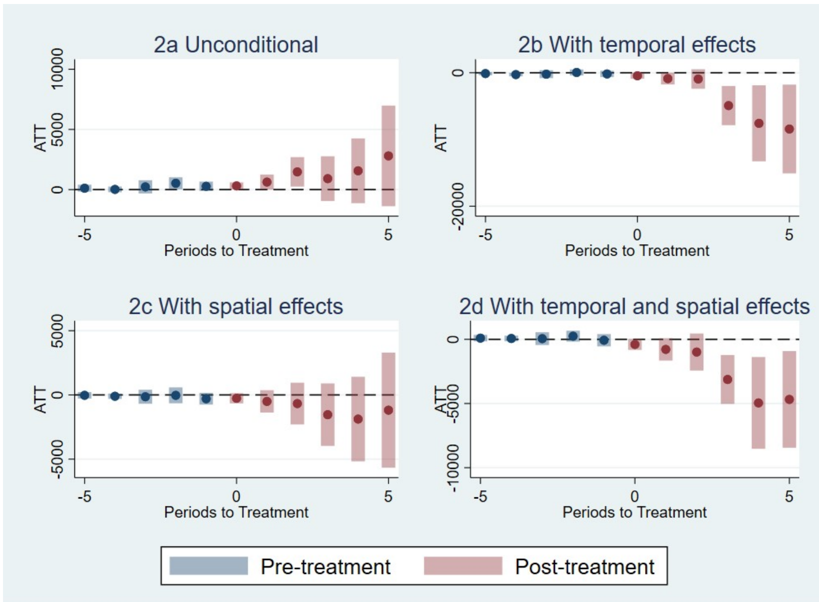

Figure 5: Dynamic average treatment effects by treating causalities by floods in the full sample

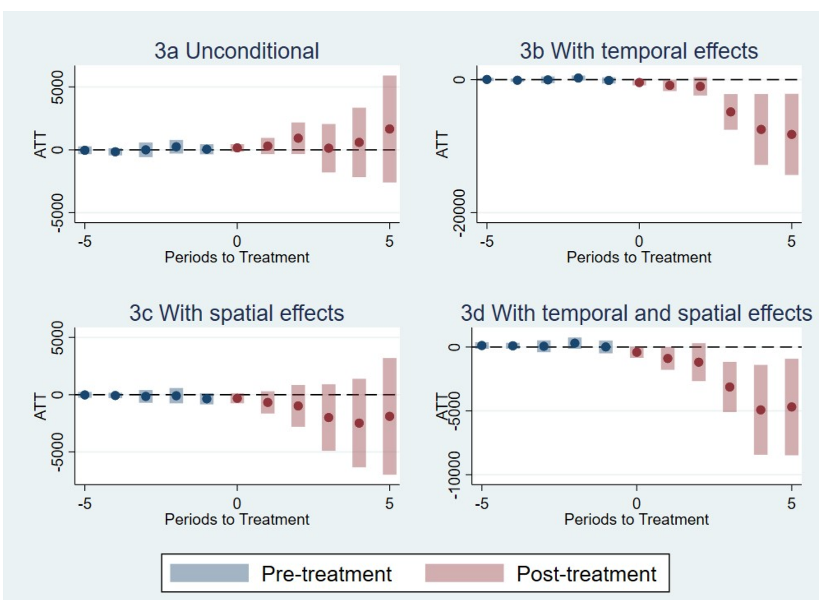

Figure 6: Dynamic average treatment effects by treating causalities by floods in the flood sample

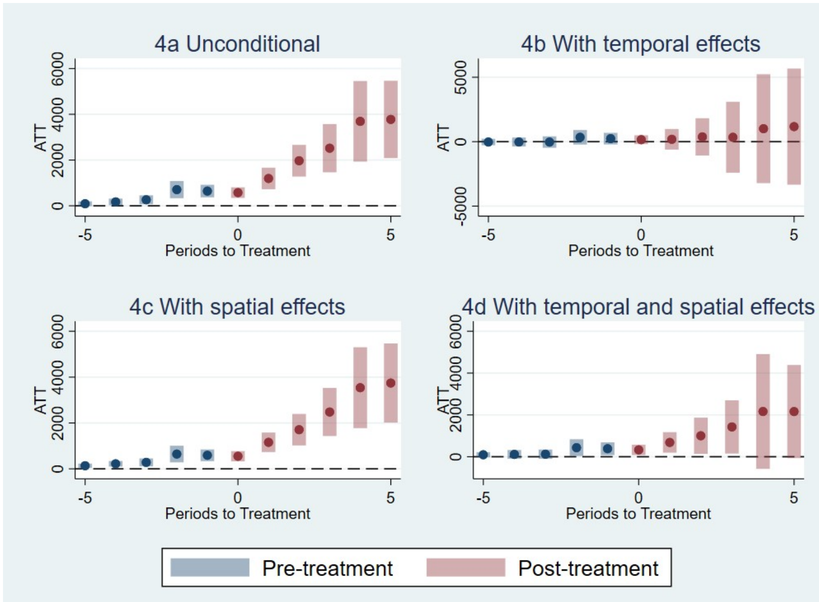

Figure 7: Dynamic average treatment effects by treating floods in the risk of flood sample

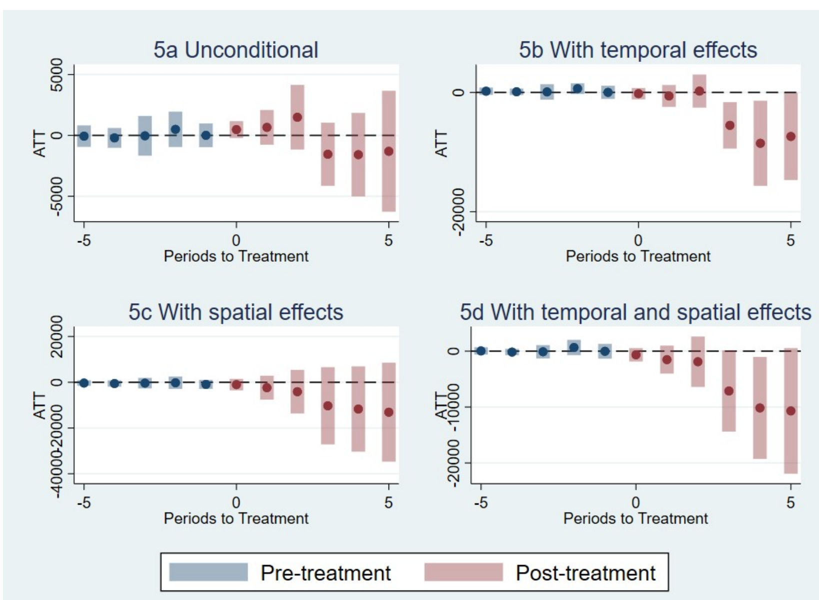

Figure 8: Dynamic average treatment effects by treating causalities by floods in the risk of flood sample

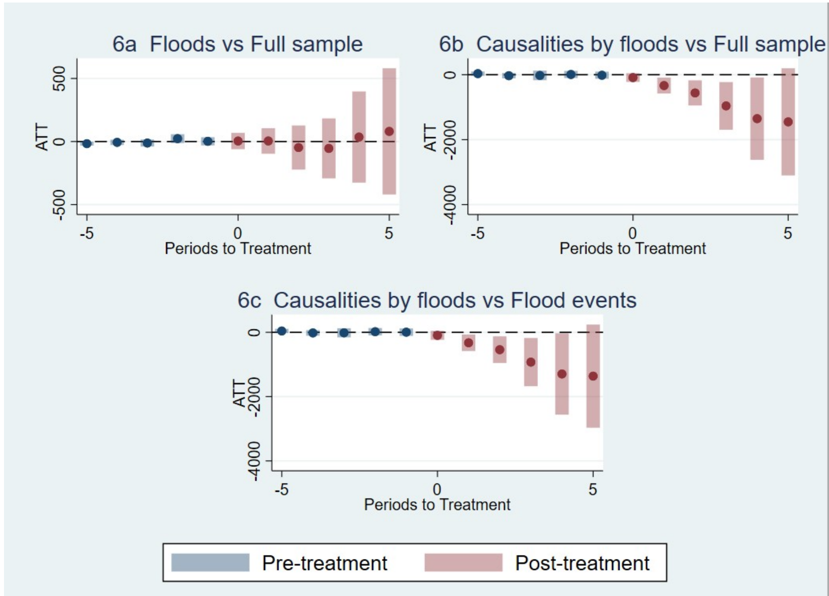

Figure 9: Robustness check: Dynamic average treatment effects on households with temporal and spatial effects

(1,2,4,5) appear, respectively, in Figures 10 and 11.

The conclusion from these results is that it seems that a flood only has significant and persistent effects on population when the flood has provoked causalities, which are negative effects probably due to migration to other places. The reason could be an instinctive panic that lead people to leave places where natural disasters have causes deaths, in order to safe their own life. In this case, the psychological effect of raising low-probability happenings, something very well-known in behavioral economics (Kahneman and Tversky, 1979) and precautionary saving (Hubbard et al., 1995), which constitutes an essential rule for the survival of businesses as the insurance firms, may play an important role in these migrations.

A policy measure derived from this paper is opening the question of which are the limits of natural disasters as floods, whether the human beings may do anything for alerting or diminishing their force, or, at least, reduce the effects. With other natural disasters, as pollution, there is a recent discovery that join human acts as the Kyoto's protocol (2005) can be effective for reallocating CO2 emissions around the world (Peña et al., 2022).

The results also show that the presence of a flood event with casualties leads to a statistical significant reduction of the population of the municipality of the event some decades after when spatial-dynamic variables are taken into account, while the impact of flood events on population has no significant effect when geographical and lag variables are considered.

Furthermore, an exercise for obtaining additional results is estimating the impact on population of the events with causalities respect to the full sample when the population, income or income inequality

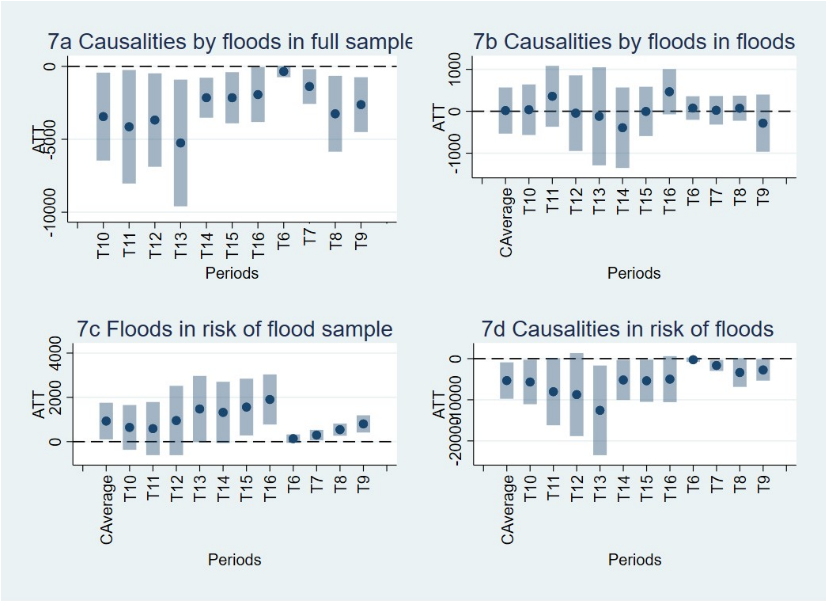

Figure 10: Calendar effects

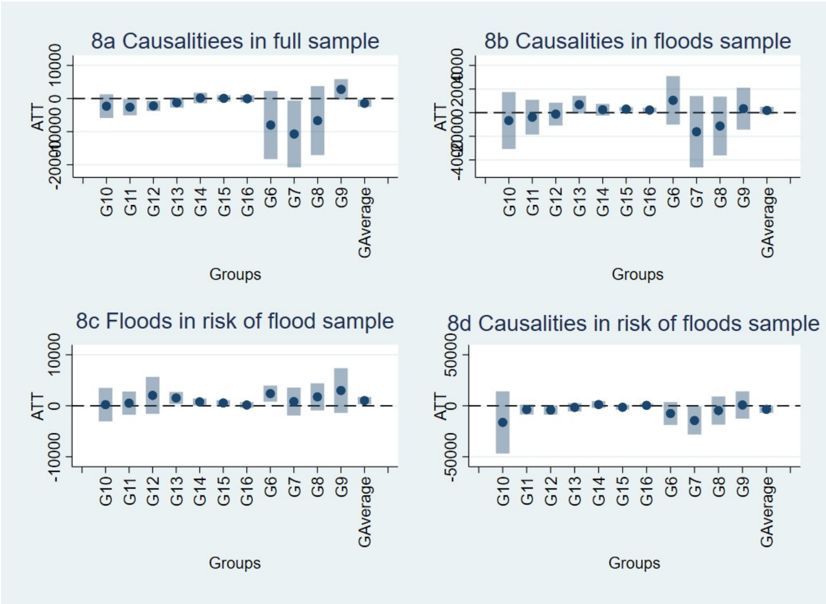

Figure 11: Group effects

measured by the Gini index is higher/lower than the average. This aspect could be included for further research.

6. CONCLUSIONS

This paper handles with a wide dataset of all the Spanish municipalities for the period 1842-2011, with this last year being the latest period with homogenous data of floods. The estimations follow the methodology provided by Callaway and Sant'Anna (2021) for Difference-in-Difference with multiple periods and uses their proposed package of Stata. The results are that of the impact of floods on population provides a non-significant effect, whilst this effects turn into negative and significant when only floods with causalities are considered, even controlling by the rest of floods. This result is in line with other papers that show that this exogenous shocks have a real impact on population movements when there are deaths provoked by the shock, something more visible when there are conflicts as wars and terrorist attacks.

Acknowledgments

The authors acknowledge the funding by Ministerio de Ciencia e Innovación/Agencia Estatal de Investigación (Grant PID2020-112773GB-I00).

Declaration of Competing Interest

Declarations of interest: none

Data Availability

The routines used with the package csdid of Stata 15 will be collected in the Git-Hub link and the dataset will be uploaded to the Harvard Dataverse, both when the paper is accepted.

References

Allen, T. and Donaldson, D. (2020): "Persistence and path dependence in the spatial economy," NBER Working Paper No 28059.

Ambrus, A., Field, E. and Gonzalez, R. (2020): "Loss in the time of cholera: Long-run impact of a disease epidemic on the urban landscape," American Economic Review 110, 475-525.

Barredo, J. I., Saurí, D., Llasat, M. C. (2012): "Assessing trends in insured losses from floods in Spain 1971–2008," Natural hazards and earth system sciences, 12(5): 1723-1729.

Bosker, M. (2022): "City origins," Regional Science and Urban Economics, 94, 103677.

Boustan, L. P., Kahn, M. E., Rhode, P. W., Yanguas, M. L. (2020). The effect of natural disasters on economic activity in US counties: A century of data. Journal of Urban Economics, 118, 103257.

Brakman, S., Garretsen, H., Schramm, M. (2004). The strategic bombing of German cities during World War II and its impact on city growth. Journal of Economic Geography, 4(2), 201-218.

Brakman, S., Garretsen, H., Van Marrewijk, C. (2019). An introduction to geographical and urban economics: A spiky world. Cambridge University Press.

Burke, M., Driscoll, A., Lobell, D. B., Ermon, S. (2021). Using satellite imagery to understand and promote sustainable development. Science, 371(6535), eabe8628.

Callaway, B., Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. Journal of Econometrics, 225(2), 200-230.

Castells-Quintana, D., Krause, M., McDermott, T. K. (2021). "The urbanising force of global warming: the role of climate change in the spatial distribution of population". Journal of Economic Geography, 21(4): 531-556.

Castells-Quintana, D., del Pilar Lopez-Uribe, M., McDermott, T. K. (2022): Population displacement and urban conflict: Global evidence from more than 3300 flood events. Journal of Development Economics, 158, 102922.

Cavallo, E., Galiani, S., Noy, I., Pantano, J. (2013). Catastrophic natural disasters and economic growth. Review of Economics and Statistics, 95(5), 1549-1561.

Ciccone, A. (2021). Gibrat's Law for Cities: Evidence from World War I Casualties, Working Paper 9006. Munich: CESifo.

Cirone, A., Pepinsky, T. B. (2022). Historical persistence. Annual Review of Political Science, 25, 241-259.

Davis, D. R., Weinstein, D. E. (2002): Bones, bombs, and break points: the geography of economic activity. American economic review, 92(5): 1269-1289.

De Chaisemartin, C., D'Haultfoeuille, X. (2022). Difference-in-differences estimators of intertemporal treatment effects (No. w29873). National Bureau of Economic Research. Deryugina, T. (2017): The fiscal cost of hurricanes: Disaster aid versus social insurance. American Economic Journal: Economic Policy, 9(3), 168–198.

Deryugina, T. (2017): "The fiscal cost of hurricanes: Disaster aid versus social insurance". American Economic Journal: Economic Policy, 9(3), 168–198.

Elliott, J. R. (2015): Natural hazards and residential mobility: General patterns and racially unequal outcomes in the United States. Social Forces, 93: 1723–1747.

Fatica, S., Kátay, G., Rancan, M. (2021): Floods and firms: vulnerabilities and resilience to natural disasters in Europe, mimeo.

Fussell, E., Curran, S. R., Dunbar, M. D., Babb, M. A., Thompson, L., Meijer-Irons, J. (2017): Weatherrelated hazards and population change: A study of hurricanes and tropical storms in the United States, 1980–2012. Annals of the American Academy of Political and Social Science, 669, 146–167.

Gallagher, J. (2014): Learning about an infrequent event: evidence from flood insurance take-up in the United States. American Economic Journal: Applied Economics, 206-233.

Gandhi, S., Kahn, M. E., Kochhar, R., Lall, S., Tandel, V. (2022): Adapting to Flood Risk: Evidence from a Panel of Global Cities (No. w30137). National Bureau of Economic Research.

Gaubert, C. (2018): "Firm sorting and agglomeration. American Economic Review," 108(11): 3117-53.

Glaeser, E. L. (2022). Urban resilience. Urban studies, 59(1): 3-35.

Grossman, G. M., Krueger, A. B. (1995): “Economic growth and the environment,” The Quarterly Journal of Economics, 110(2), 353-377.

Hubbard, R. G., Skinner, J., Zeldes, S. P. (1995): Precautionary saving and social insurance. Journal of political Economy, 103(2), 360-399.

Intergovernmental Panel on Climate Change (IPCC, 2022): Summary for Policymakers (SPM) Working Group I (WGI) contribution, Sixth Assessment Report (AR6) on the physical science basis of climate change.

Kahneman, D., Tversky, A. (1979): Prospect Theory: An Analysis of Decision under Risk. Econometrica, 47(2): 263-292.

Kocornik-Mina, A., McDermott, T. K., Michaels, G., Rauch, F. (2020). Flooded cities. American Economic Journal: Applied Economics, 12(2): 35-66.

Lindersson, S., Brandimarte, L., Mård, J., Di Baldassarre, G. (2020): A review of freely accessible global datasets for the study of floods, droughts and their interactions with human societies. Wiley Interdisciplinary Reviews: Water, 7(3), e1424.

Logan, J. R., Issar, S., Xu, Z. (2016): Trapped in place? Segmented resilience to hurricanes in the Gulf Coast, 1970–2005. Demography, 53: 1511–1534.

Magontier, P. and Martinez-Mazza, R. (2021): Business as usual? The Dynamics of Land Development Around Floodplains, mimeo.

Masiero, G., Santarossa, M. (2020): Earthquakes, grants, and public expenditure: How municipalities respond to natural disasters. Journal of Regional Science, 60(3): 481-516.

Olcina, J., Saurí Pujol, D., Hernández, M., Ribas Palom, A. (2016). Flood policy in Spain: a review for the period 1983-2013. Disaster Prevention and Management, 2016, vol. 25, núm. 1, p. 41-58.

Pécastaing, N., Chávez, C. (2020): The impact of El Niño phenomenon on dry forest-dependent communities' welfare in the northern coast of Peru. Ecological Economics, 178, 106820.

Peña, G., Puente-Ajovín, M., Ramos, A., Sanz-Gracia, F. (2022): Log-growth rates of CO2: An empirical analysis. Physica A: Statistical Mechanics and its Applications, 588, 126550.

Peri, G., Robert-Nicoud, F. (2021): On the economic geography of climate change. Journal of Economic Geography, 21(4): 487-491.

Raker, E.J. (2020): Natural hazards, disasters, and demographic change: The case of severe tornadoes in the United States, 1980–2010. Demography, 57(2), 653-674.

Redding, S.J., and D.M. Sturm (2016): “Estimating Neighborhood Effects: Evidence from War-time Destruction in London”, mimeo, see https://personal.lse.ac.uk/sturmd/papers/wp/LWW2-9Mar16.pdf.

Roth, J., Sant'Anna, P. H., Bilinski, A., Poe, J. (2022). What's Trending in Difference-in-Differences? A Synthesis of the Recent Econometrics Literature. arXiv preprint arXiv:2201.01194.

Sanso-Navarro, M., Sanz, F., Vera-Cabello, M. (2015). The impact of the American Civil War on city growth. Urban Studies, 52(16), 3070-3085.

Sanso-Navarro, M., Sanz-Gracia, F., Vera-Cabello, M. (2019). The demographic impact of terrorism: Evidence from municipalities in the Basque Country and Navarre. Regional Studies, 53(6), 838-848.

Schultz, J., Elliott, J. R. (2013): Natural disasters and local demographic change in the United States. Population and Environment, 34: 293–312.

Strobl, Eric. 2011. “The Economic Growth Impact of Hurricanes: Evidence from US Coastal Counties.” The Review of Economics and Statistics, 93(2): 575–589.

Testa, P. A. (2021). Shocks and the spatial distribution of economic activity: The role of institutions. Journal of Economic Behavior and Organization, 183, 791-810.

Tol, R. S. (2018). The Economic Impacts of Climate Change. Review of Environmental Economics and Policy, 12(1): 4-25.

Tollefson, J. (2020): How not will Earth get by 2100?, Nature 580, 443–445 (doi.org/10.1038/d41586-020-01125-x).

Zhang, C., Tao, R., Yue, Z., Su, F. (2023): "Regional competition, rural pollution haven and environmental injustice in China," Ecological Economics, 204: 107669.