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Summary

This paper aims at empirically testing the dynamics of budget outcomes of Italian municipalities in the aftermath of floods, by accounting for heterogeneous levels of resilience and vulnerability to natural disasters. Our findings, based on a dynamic difference-in-difference after propensity score matching, point to substantial impacts in terms of increased capital expenditure and revenues from transfer, which also depend on the degree of resilience and vulnerability. Through our analysis we account for multiple aspects of risk so we can support policy decisions related to both ex-ante and ex-post disaster occurrence management.

Keywords: floods, fiscal policy of local governments, resilience, vulnerability

JEL Classification: H2, H72, Q54

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Chiara Lodi[*] Giovanni Marin[†] Marco Modica[‡]

Abstract

This paper aims at empirically testing the dynamics of budget outcomes of Italian municipalities in the aftermath of floods, by accounting for heterogeneous levels of resilience and vulnerability to natural disasters. Our findings, based on a dynamic difference-in-difference after propensity score matching, point to substantial impacts in terms of increased capital expenditure and revenues from transfer, which also depend on the degree of resilience and vulnerability. Through our analysis we account for multiple aspects of risk so we can support policy decisions related to both ex-ante and ex-post disaster occurrence management.

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1 Introduction

Over the last 50 years, climate-induced disasters accounted for about 50% of worldwide recorded disasters on EM-DAT database and over 70% of all economic losses, which have been estimated at about 3.7 trillion dollars (WMO, 2021). Even if scholars do not still have the smoking gun that indicates the role of human activity in the global increasing occurrence of small-scale extreme weather events in recent times, a growing number of studies points to a causal link between climate change and several extreme weather events, in particular extreme rainfalls that turn into flooding (WMO, 2021; Kirchmeier-Young and Zhang, 2020).

Nowadays, it is well recognized that the climate change (CC henceforth) represents one of the most urgent and fundamental problems that must be faced by both public and private actors in order to reduce the number of victims and injured from extreme climate-induced disasters as well as the associated economic costs, even in a perspective where CC is accelerating (increases in temperatures and global sea levels, more frequent extreme rainfalls and/or droughts). Overall, this context requires a coordinated action to fight the consequences of CC and to be prepared for future extreme events and hazards. Indeed, CC is likely to exert a high impact on future extreme natural events that will consequently damage local areas and communities. However, the amount of damages depends on the combination of the actual occurrence of hazards (probability and magnitude) and the socio-economic inherent characteristics of the affected areas that can be proxied with the (multi-faceted) concepts of resilience, vulnerability and exposure (direct and indirect; see e.g. Marin et al., 2021). For this reason, it would be more correct to talk about 'socio-natural hazards' instead of 'natural disasters' (Hallegatte, 2014a) as "*processes—slow or sudden—that are located in the intersection between "nature and society", resulting from the interaction between a destructive agent (such as an earthquake, a tsunami, a hurricane, a flood) and the socio-cultural and environmental context on which it impacts*' (p. 2, Cannizzaro et al., 2020).

The damage arising from an extreme event does not depend on physical factors only but on the ability of local communities to be prepared, face, mitigate and respond to the catastrophic event too. Furthermore, the occurrence of natural disasters is firstly faced by local public institutions which assess the risk and manage first emergency, search and rescue activities, and these capabilities are strictly connected with their level of proactivity.

In fact, the extant literature shows that under-prepared areas, related to less pro-active institutions, are the most damaged ones (Breckner et al., 2016; Chan et al., 2016; Kahn, 2005; Ostadtaghizadeh et al., 2016; Parsons et al., 2016; Raschky, 2008), while differences in the capacity to adapt to a shock may also vary according to spatial and geographical characteristics such as the degree of rurality.[1] Therefore, even if urgent actions to combat CC and its impacts are in charge of national and supranational entities, local governments should rethink their climate risk assessment framework. This accounts for mitigation and adaptation activities aimed to prevent the effects that changed climate might exert on local territories in an ex-ante perspective and to help post-disaster recovery in an ex-post perspective and this is related to the healthy local public finance conditions.

However, despite few works have highlighted the impact of extreme weather events on public finance (e.g. Heipertz and Nickel, 2008; Lis and Nickel, 2010; Phaup and Kirschner, 2010) less studies have analysed the effect of selected impacts on government budgets (Bachner and Bednar-Friedl, 2019). To our knowledge, little attention has been given to the shocks generated by extreme climate events in terms of local public financing capabilities and fiscal policies. In fact, we argue that areas that are more susceptible to suffer harms by the changed climate will necessarily drain resources to the public local budget to prevent and mitigate the risk and to recover after a shock affects them. This might be particularly detrimental for 'recurrent' disasters such as floods. In the last decades, due to increasing global warming, floods are capturing a higher attention, given that they are constantly rising worldwide, in terms of frequency, severity and intensity (EEA, 2010; IPCC, 2022). From the EU to China, from India to the USA, floods have been responsible for hundreds of deaths and huge socio-economic damages, such as buildings, network (energy, communication and transportation) infrastructure, crops destruction, loss of livestock, worsening of health conditions (IPCC, 2022). This type of hazard has underlined how major urban centres, which have not implemented an adequate risk assessment framework, are the most damaged ones (Benson and Clay, 2004). The European Environmental Agency (EEA) has estimated about 446 billion euros of economic losses caused by climate-related extreme events between 1980 and 2019. By considering the increasing number of floods also in developed countries and the importance of local institutions in facing these events, our work aims at empirically testing the dynamics of local governments' budgetary outcomes in the aftermath of floods in Italy, that is a highly vulnerable country to flood (Faiella and Natoli, 2018).

We take into account the different socio-economic resilience and vulnerability levels of the Italian municipalities to infer whether their capacity to cope with disasters is actually affected

[1] As highlighted by Cutter et al. (2016), the economic capital is much more relevant in increasing the resilience of urban areas, while social capital is much more important in increasing the disaster resilience of rural areas.

by their socio-economic inherent characteristics. Understanding municipality's fiscal response to disasters is fundamental given that some previous decisions about the allocation of financial resources and taxation can be changed (Benson and Clay, 2004; Tulbee, 2019, Miao et al., 2020). In detail, from the expenditure side, it could be possible that planned investments or ongoing projects are postponed or abandoned, while new projects and expenditure might be needed to cope with emergency and post-event reconstruction. From the revenues side, local taxation provisions are generally subjected to negative (tax cuts for post-event recovery or reduced tax base) or positive (additional transfers and taxation to bear new expenditures) changes (Benson and Clay, 2004).

Nowadays, works on the impact of extreme climate-related events on financial and budgetary outcomes of public institutions are scarce, especially at subnational level (Faiella and Natoli, 2018). The extant literature is especially devoted to analyse the consequences of extreme weather events on fiscal policies at country level, with mixed evidence (Heirpertz and Nickel, 2008; Lis and Nickel, 2010; Noy and Nualsri, 2011; Melecky and Raddatz, 2014; Miao et al., 2018). Results depend on several aspects, such as the severity of events, country and public governments' characteristics, model assumptions and variables that are considered. For example, Noy and Nualsri (2011), by using a sample of 42 developed and developing countries over the 1990-2005 period, have shown that natural disasters have a negative effect on revenues and cash surplus of developed countries, while an increase of governments payment and outstanding debt is recorded. For developing countries, all fiscal variables are negatively affected by extreme events, except the cash surplus. Similarly, Lis and Nickel (2010) have asserted that less advanced countries face a larger effect on public nominal budget balance in the aftermath of an extreme weather event than advanced economies. Moreover, the fiscal impact of these events is higher for countries nearer the equator, due to warmer climate that characterises these countries as more vulnerable. Similar conclusions are obtained by Melecky and Raddatz (2014), who have classified countries depending on the level of credit and insurance markets' development. Few studies analysed the fiscal response after extreme climate events at subnational level. Miao et al. (2020) has estimated the dynamic effects of several natural disasters on government finance in thirty Chinese provinces over the period 1994-2014. Their results suggest that expenditures and intergovernmental transfers increase in the aftermath of the event and then gradually decrease over time. This rise in public spending particularly refers to high income and wealthier provinces. Concerning revenues, they have demonstrated a limited effect of natural disasters, while Jerch at al. (2021) and Tulbee (2019) analyse the relationship between natural disasters and local (municipal/county) government finances in the US. Specifically, Jerch et al. (2021) focus their attention on hurricanes' effects on different municipal outcomes measures (expenditures, revenues and debt) at different aggregation levels. Their results show that hurricane exposure causes a decline of revenues and expenditures in the long run. This reduction is primarily connected to the fall in local tax revenues. In the short run, the decrease of revenues is mitigated by the incoming flows generated by intergovernmental transfers. Both results characterise municipalities with lower income and less educated population. Tulbee (2019), instead, estimates the impact of extreme climate events (as declared by the FEMA) on fiscal spendings and revenues of Kentucky counties between 2007 to 2017. Tulbee (2019) finds a significant increase in the intergovernmental transfers and a decrease in incoming taxes, while no significant change in the expenditures per capita are recorded.

Considering the existing literature, we constraint our analysis to floods affecting municipalities in 9 Italian regions in the 2013-2016 period. To estimate the impact of floods we have implemented a dynamic difference-in-differences approach coupled with propensity-score matching over a panel of 4,185 Italian municipalities with monthly data. Since the entity of losses and the ability to react to extreme natural events depend on the initial situation of each municipality, we have investigated in depth the effects of selected floods on budgetary outcomes by distinguishing among high and low resilient and vulnerable municipalities. To the best of our knowledge, our work is the first that assesses the impact of floods on budget outcomes of local (municipal) level by also analysing the vulnerable and resilient conditions of the affected municipalities.

Our results suggest that, on average, Italian municipalities react to floods by especially increasing capital investments. This effect is not counterbalanced by adjustments in their revenues, so substantial imbalances could emerge. Through a deeper analysis of municipality budget breakdowns, we have argued that results greatly depend on the degree of resilience and vulnerability of municipalities themselves. Specifically, we have been able to show that more resilient (and less vulnerable) municipalities have a better capability to face extreme events because they can handle greater flows of already available resources, without waiting for transfers from other government levels.

This paper is organised as follows. The next section provides the general framework for disaster management in Italy and discloses the strategy for relevant flood identification. Section 3 is devoted to the description of the empirical strategy. Disaster risk assessment and implemented propensity score matching are discussed in Section 4. Section 5 provides the main results and Section 6 concludes.

2 General framework for disaster management in Italy

In this paper we focus on a specific policy implemented by the Italian Government. We rely on the decision of the Italian Council of Ministers of 28 July 2016 that allocates funds for reconstruction interventions of 49 flooding events that had national relevance and affected Italian regions over the period 2013 - 2016. More precisely, for all these selected events a state of emergency was declared.

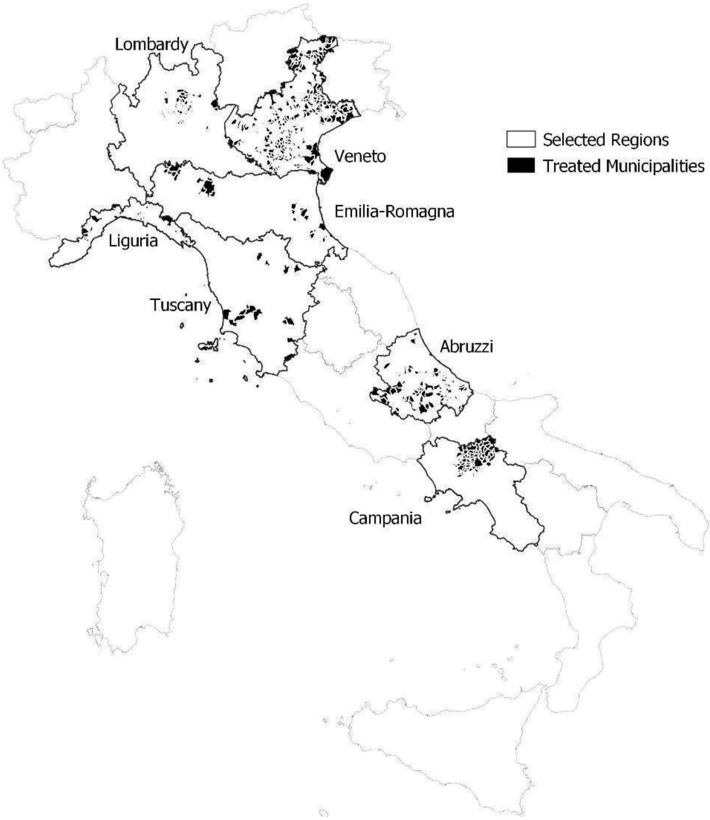
The state of emergency in the Italian legislation can be declared upon the occurrence or imminence of exceptional events such as extreme events, e.g. earthquakes, floods, drought or, more recently, the Covid-19 pandemic. It is strictly regulated by law and it is declared by the Council of Ministers in agreement with the Governors of the affected regions. The declaration of the state of emergency allows public authorities to act urgently and with extraordinary powers. They can protect citizens and repair any damage by derogating from ordinary legislation. Thus, the state of emergency declaration allows a delegate commissioner to recognize the amount of funds necessary for the immediate emergency but also the estimated funds for recovering from the damages suffered by the affected territories. The state of emergency lasts 12 months and can be extended at most for 12 additional months. According to the Civil Protection Department, a state of emergency has been declared in Italy more than 100 times since 2013.

In this specific context, the decision of the Council of Ministers allows for the compensation of the damages related to private assets and economic activities, specifically structural restoration of private buildings and damaged structures, systems, and equipment of economic activities, for which the causal link between the damage suffered and the event is recognized, as well as for the purchase of stocks of raw materials, semi-finished products finished, damaged or destroyed due to the events and no longer usable.

The first set of activities are thus carried out by the Head of Civil Protection, then a regional delegate is typically appointed when the emergency phase is concluded. The Civil Protection system generally differentiates by type of event and type of Operative Centres according to the geographical extension of the event. Overall, a hierarchical structure from municipality to national level is structured with the municipalities' mayor as first responsible for the preliminary civil protection activities.

We have analysed the Civil Protection and Delegate Commissioner Ordinances providing funds for reconstruction of a selection of the 40 flooding events and we have considered all the municipalities that have received funds.[2]

Figure 1. Selected Regions and Treated Municipalities



Note: Sardinia and Basilicata are not reported in the map due to the absence of treated municipalities

In our empirical analysis, we consider a municipality as treated whenever it receives reconstruction funds. For instance, for the events affecting the Campania region in 2015 we have recognized 152 treated municipalities over 647. In general, we have just considered flooding events recognized as states of emergency. Our starting sample includes 4,185 municipalities from 9 Italian regions: Abruzzi, Basilicata, Campania, Emilia-Romagna, Liguria, Lombardy, Sardinia, Tuscany and Veneto, 517 municipalities are classified as treated and their distribution among regions is reported in Figure 1.

3 Empirical strategy

Our aim is to estimate the effect of floods on local governments' budgets by means of a dynamic difference-in-differences approach. However, even if we do not expect any possible

[2] As mentioned at the beginning of Section 2, the document of the Italian Council of Ministers has identified 49 flooding events but, for 9 of them, the estimation of damages is not fully completed.

risk of reverse causality between floods and local governments' budget outcomes, the likelihood that a flood occurs in a specific municipality generating an number of damages that justifies the declaration of a state of emergency might be correlated with some attributes that also influence the dynamics of our outcome variables. For example, local governments in high-hazard areas could increase their investments in the maintenance of water-related infrastructures (e.g. reinforcement of levees) in months prior to usual flooding months or that the patterns of revenues and/or expenditures of more resilient municipalities is more (or less) smooth than the ones of less resilient ones. For this reason, we decided to identify *a priori* a proper counterfactual by matching treated municipalities to non-treated ones based on observable characteristics. Specifically, we estimate the propensity score as the predicted probability of being subject to a flood given pre-treatment observable features of the municipalities and then match each treated municipality with one (or more) non-treated ones that has the closest probability of being treated. We then run a dynamic difference-in-differences model on the matched sample.

We exploit the high frequency (monthly) of our data on local governments' revenues and expenditures to identify the short-term dynamics of our outcome variables in the aftermath of a flood. To limit the issue of seasonality, we group together time periods in semesters: instead of identifying *ex-ante* an arbitrary month as the beginning of semesters (e.g. January and July), for each event we consider the first post-treatment semester to begin the exact month when the flood occurred.[3]

More in detail, the difference-in-difference model can be expressed by the following equation:

$$y_{it} = \alpha_i + \tau_t + \gamma_{jt} + \eta_{t-2} Treated_i + \sum_{s=0}^{3} \beta_{s+t} Treated_i + \varepsilon_{it} \tag{1}$$

where y_{it} is the outcome variable for municipality i in the t semester; α_i is the municipality fixed effect to account (in a flexible way) for all time-invariant characteristics that could be correlated with both outcome variables and the treatment; τ_t is the semester fixed effect; γ_{jt} is

[3] We consider semesters instead of months to account for the seasonality of local governments' expenditures and, especially, revenues. Indeed, in Italy local governments collect or receive the bulk of their revenues in December and in June (i.e. exactly six months away one form the other). The definition of the beginning of the semester is specific to each treated municipality, depending on when the flood occurs. As for the non-treated (matched) municipalities, we align their time index to the one of the municipalities to which they are matched. For example, image that municipality *A* is subject to the flood in October 2014. Then, according to our propensity score matching procedure, municipalities *B* and *C* are matched to municipality *A*. Then, the time index *t* for the three municipalities will be set to 0 for the semester October 2014 – April 2015 (i.e. the 'event semester). This is a peculiar application of a staggered difference-in-differences that accounts for the critiques recently put forward by Baker et al. (2022).

the calendar month dummy for month j, which is allowed to exert a time-varying effect on the outcome variable to account for seasonality. The variable $Treated_i$ is the dummy variable that equals 1 for treated municipalities (as defined in Section 3) and 0 for untreated (and matched) municipalities. We assume that the occurrence of a flood in municipality i in a specific month is exogenous (conditional on matching). The two sets of parameters of interest are η_{t-2} and β_{t+s}, which measure, respectively, pre-trends and the average effect on treated municipalities (ATT) on municipalities' budgetary outcomes. They are indexed for the number of semesters, s, before and after the event semester. The reference semester is the one prior to the event semester. Finally, ε_{it} represents the independently and identically distributed error term.

Table 1. Outcomes description

Variable	Description
Total Expenditures	Total monthly expenditures
Current Expenditures	Monthly current expenditures (personnel, raw materials and consumables procurement, service provisions, use of third-party assets, current transfers, interests and financial charges, taxes and fees, extraordinary charges from current operations, loan repayment charges, expenses from services on behalf of third parties, payment to be settled).
Capital Expenditures	Monthly capital expenditures (real estate acquisition, expropriations and onerous easements, purchase of specific good for in-house production, use of third-party assets for economic activities, Acquisition of furniture, machinery and technical and scientific equipment, external professional appointments, capital transfers, shareholdings, capital contributions, granting of loans and advances).
Total Revenues	Total monthly revenues.
Own Current Revenues	Monthly current revenues (taxes and fees, public services revenues, income from the assets of the municipality, interests on advances and loans, net profits of special and participates companies, dividends of companies).
Own Capital Revenues	Monthly capital revenues (disposal of assets, debt collection, cash advances, short term loans, borrowing and lending, issuance of bonds).
Revenues from Transfers	Monthly revenues from transfers (capital transfers from state, regions, autonomous provinces, public sector, other subjects).
Other Revenues	Monthly other revenues (social security and welfare deductions for staff, withholding taxes, other deductions from staff on behalf of third parties, security deposits, reimbursement of expenses for services on behalf of third-party, repayment of advance payment of funds for the treasury service, deposits for contractual expenses, collections to be regularised).

Our selected dependent variables capture budgetary outcomes of the local (municipal) government. On one hand, since extreme weather events directly affect payments and public financing for disasters (Lis and Nickel, 2010), these measures provide information about the timing and type of policies that were implemented by municipalities in the aftermath of the flood. We have chosen three different variables in this respect: total expenditures, current expenditures and capital expenditures (i.e. public investments). More precisely, local governments react to extreme events by protecting people and by repairing public assets, so at first emergency costs should be borne. On the other hand, this type of events can indirectly affect the revenues side of local institutions' budgets, so their effect on different revenues variables is also considered. At the same time, local governments also have some room to intervene to increase or decrease local taxes by changing the local tax rates and by granting exceptional full tax exemptions in order to allow a quicker and prompt recovery of the economic activities and to (partially) refund suffered costs. Thus, in the aftermath of an extreme climate event, the structure of local governments' revenues can change, in terms of' financial autonomy and transfers (Heirpertz and Nickel, 2008; Noy and Nualsri, 2011). By considering these aspects, we consider the following revenue variables as dependent variables: total revenues, current revenues, capital revenues, revenues from transfers and other revenues. A detailed description of each dependent variable is reported in Table 1.

Information on monthly municipalities budgets is collected from the Bank of Italy "*Sistema Informativo delle Operazioni degli Enti Pubblici (SIOPE)*" dataset. Information is recorded with a monthly frequency on a cash basis. Given that information on the declaration of state of emergency refers to the period 2013-2016, our timespan covers up to 42 months.

4 Disaster Risk Assessment and Propensity Score Matching

The choice of the variables to be used in the estimation of the propensity score is strictly connected with the concept of extreme climate risk. The risk of a specific climate-related disaster represents the probability of value losses in different aspects, especially in terms of damages to economic activity and wellbeing of the affected areas. The risk is thus a function of vulnerability, resilience, exposure and hazard of the municipality under analysis (Hallegatte, 2014b, Marin et al., 2021) formally:

$$R_i = f(V_i, Res_i, E_i, H_i) = V_i \times (1 - Res_i) \times E_i \times H_i \tag{2}$$

where V_i corresponds to the vulnerability of the municipality i, Res_i is its resilience, E_i represents its exposure and H_i is the flood hazard. Each variable ranges between 0 and 1, so if at least one of them assumes a low value (or a high one for resilience), the obtained risk is low. Consequently, for example, in absence of flood hazard or exposure, risks are negligible or zero. Moreover, if a municipality reaches a high resilience and/or a low vulnerability, a mitigation of risks occurs, even in presence of high hazard and exposure, so the local system is expected to be weakly affected by a flood. Conversely, the risk is likely to be high when the municipality shows a low resilience and/or high vulnerability.

In order to fully understand the framework and the meaning of these risk components, we here define the various components of Equation 2, as considered in the literature, and how we have measured them.

Vulnerability (V_i). is defined as the set of municipality's characteristics that can potentially generate harms, independently of the flood risk occurrence (Sarewitz et al., 2003). This concept is generally measured by a composite indicator since it can capture several facets of a local institution, such as wealth, level of urbanisation, population, public and private behaviours, entrepreneurs' strategies, financial and physical resources, etc. (Marin et al., 2021; Khan et al., 2020). By adopting the same approach of Modica et al. (2019) and Marin et al., (2021), a composite vulnerability index, which considers 17 municipality features, is built. Each feature is weighted with the number of times the specific measure was used in the literature to measure vulnerability. Each variable has been normalised to range between 0 and 1 and, then, the composite indicator is further normalised to range between 0 (low vulnerability) and 1 (high vulnerability). Finally, in order to consider the more important differences only among municipalities, we have implemented a dummy variable for this measure, which equals 1 if the municipalities have a vulnerability higher than its median value, 0 otherwise.

Resilience (Res_i). is considered as the ability of a system to resist, recover, renew and realign after disturbances or shocks (Pimm, 1984; Rose, 2005; Martin, 2012; Zhou and Chen, 2020). The higher is the level of resilience, the lower is the impact of shocks on the system. As for vulnerability, resilience is measured by starting from a composite index following Modica et al. (2019) and Marin et al., (2021), which accounts for 13 socio-economic variables.[4] Aggregation, weighting and normalisation follows the same procedure used for vulnerability, leading to an indicator of resilience ranging from 0 (low resilience) and 1 (high resilience). As for vulnerability, we have included a dummy variable which equals 1 if the resilience of the municipality is higher than its median value, 0 otherwise. Please note that even if, conceptually, vulnerability and resilience have two different meanings, their theoretical relation is not univocal and it depends on the reference frameworks (see Cutter et al, 2008 for details).

[4] The indicator of resilience is composed of 13 variables: density of business; income; debt; poverty; homeownership; unemployment; productivity; sectoral dependence; government effectiveness; institutional capacity; education and health. Vulnerability is, instead, composed of 17 variables: extension of agricultural sector; dependence on agriculture; age; wealth; poverty; inequality; unemployment; institutional capacity; political rights; population pressure; urbanisation; building characteristics; ecosystem conversion; education; family structure; female condition and health.

Without entering into this debate, our research framework considers the two concepts as different aspects. This gives rise to distinct but quite strongly correlated indicators.

Exposure (E_i). can be identified as the set of all the assets and the population that can be affected by a hazard (Hallegatte, 2014b). It includes socio-economic and geographical/physical features of municipalities. Municipality level of exposure has been quantified by collecting socio-economic and geographical data from different data sources. From the socio-economic perspective, population and households' taxable income have been considered. These data have been obtained by the Italian National Institute for Statistics (ISTAT) and the Italian Department of Finance (MEF) database respectively.[5] Concerning geographical characteristics, a set of three variables have been considered: altitude, coastal/island classification and land area. Altitude is conventionally measured as the location, in terms of metres over sea level, of the municipality's city hall. Referring to coastal or island classification, being a coastal municipality requires that part of the territorial area overlooks the sea while, if a municipality is classified as an island, the area is surrounded by the sea. Finally, the land area defined by the administrative units' boundaries corresponds to the area of a municipality and it is measured in square kilometres. Data on 15th ISTAT Census, which refers to 2011, are considered for measuring these exposure variables.

Hazard (H_i). It is the probability of occurrence of an extreme event that can create perturbations to the economic system. In our study, as above-mentioned, the hazard specifically refers to floods. The flood probability of occurrence for each municipality is measured as the share of the total area at risk of floods (hydrological risk). Three degrees of hydrological risk have been identified by ISPRA: high probability scenario with return period of 20-50 years (frequent floods), medium probability risk with return period of 100-200 years (less frequent floods) and low probability risk of floods or other extreme events (ISPRA, 2021). The hazard measure ranges between 0 and 1 according to the area that lies in each of the three groups and a weighted average has been calculated and again normalised between 0 and 1 in order to get a comprehensive flood hazard variable of the municipality.

Municipality risk variables (vulnerability, resilience, exposure and hazard) are considered as time-invariant covariates in our estimation of the propensity score.[6] Moreover, to account for possible differences in pre-trends of outcome variables between treated and controls, we

[5] Concerning households' taxable income, the MEF database supplies information on the sum of incomes declared by residents of the municipality to be subject to the general income tax for individuals (IRPEF). We include the lagged value of income in our estimation of the propensity score.

[6] Income and population, instead, are time-varying variables. However, given that we just have information on yearly change and the high persistency of these variables, we include them in our propensity score with a 1 year.

estimate a separate propensity score for each dependent variable, including as a covariate the 6-month change in (log) outcome prior to the treatment. Finally, as we also want to provide evidence about the heterogeneous effect for municipalities with different levels of resilience and/or vulnerability, we also interact these pre-trends with our dummies for resilience and vulnerability. With the aim of being as flexible as possible in the identification of good matches, we estimate each probit separately for each month where at least one event occurred.[7]

Table 2. Propensity Score Matching variables description

Variable	Description
Population	Annual resident municipal population on 1st January.
Income	Lagged per capita general income tax IRPEF.
Land Area	Area of a municipality expressed in square kilometres.
Altitude	Metres over sea level of the municipality's city hall.
Island	Dummy equals 1 if part of the territorial area of the municipality overlooks the sea, 0 otherwise.
Coastal	Dummy equals 1 if the municipality area is surrounded by the sea, 0 otherwise.
Resilience	Dummy equals 1 if the resilience of the municipality is above or equal to the third quartile, 0 otherwise.
Vulnerability	Dummy equals 1 if the vulnerability of the municipality is above or equal to the third quartile, 0 otherwise.
Hazard	Share of the total area (in squares kilometres) at hydrogeological risk.

We match each treated municipality to the two nearest neighbours in terms of predicted propensity score and impose a caliper to limit the bias arising from 'bad' matching.[8] An exact matching between treated and controls in terms of resilience and vulnerability is imposed.[9]

To test the validity of the matching based on propensity score, we test whether treated and controls share the same average characteristics by means of simple t-tests. We contrast these mean comparisons with mean comparison between treated municipalities and all (both matched and unmatched) untreated municipalities, to understand whether the matching improves the homogeneity in the two groups of treated and controls. Results, reported in Appendix A Tables A.1.1 and A.1.2, suggest that the matching reduces substantially the bias that could arise if municipalities with systematically different characteristics would have systematically different trends in outcome variables. Overall, all observable characteristics are not statistically different, on average, between treated and matched municipalities at conventional levels of statistical significance after matching on propensity score. Instead, differences were generally

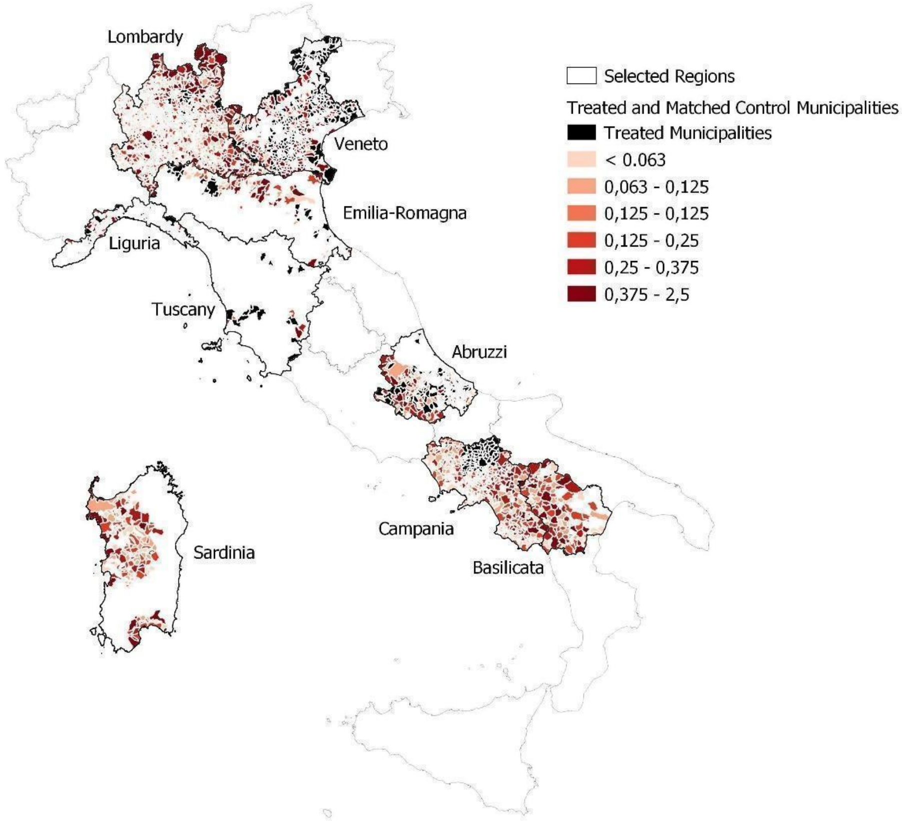
[7] February 2014, March 2014, September 2014, October 2014, November 2014, February 2015, March 2015, September 2015, October 2015. Results based on a single propensity score for all events are very similar to the ones reported in the paper and remain available upon request.

[8] We apply the usual rule of thumb to set the caliper to 1/4 of the standard deviation of the predicted propensity score.

[9] As an additional robustness check, we add one additional dimension to the exact matching, that is the quartile of the outcome's 6-months pre-trend. Results are reported in Appendix B.

significantly different from zero if we considered all untreated municipalities as control groups (see Table A.1.1).

Figure 2. Treated and Matched Control Municipalities



Note: Treated municipalities are filled in black. Matched control municipalities are filled with different shades of red, to account for the average contribution (weight) of each municipality to building the counterfactual across all different events and outcome variables.

Figure 2 maps treated and matched control municipalities. As underlined in Section 2, treated municipalities are 517[10] while, by estimating propensity score matching, we have identified 2,117 matched control municipalities (for at least one outcome variable).

5 Results

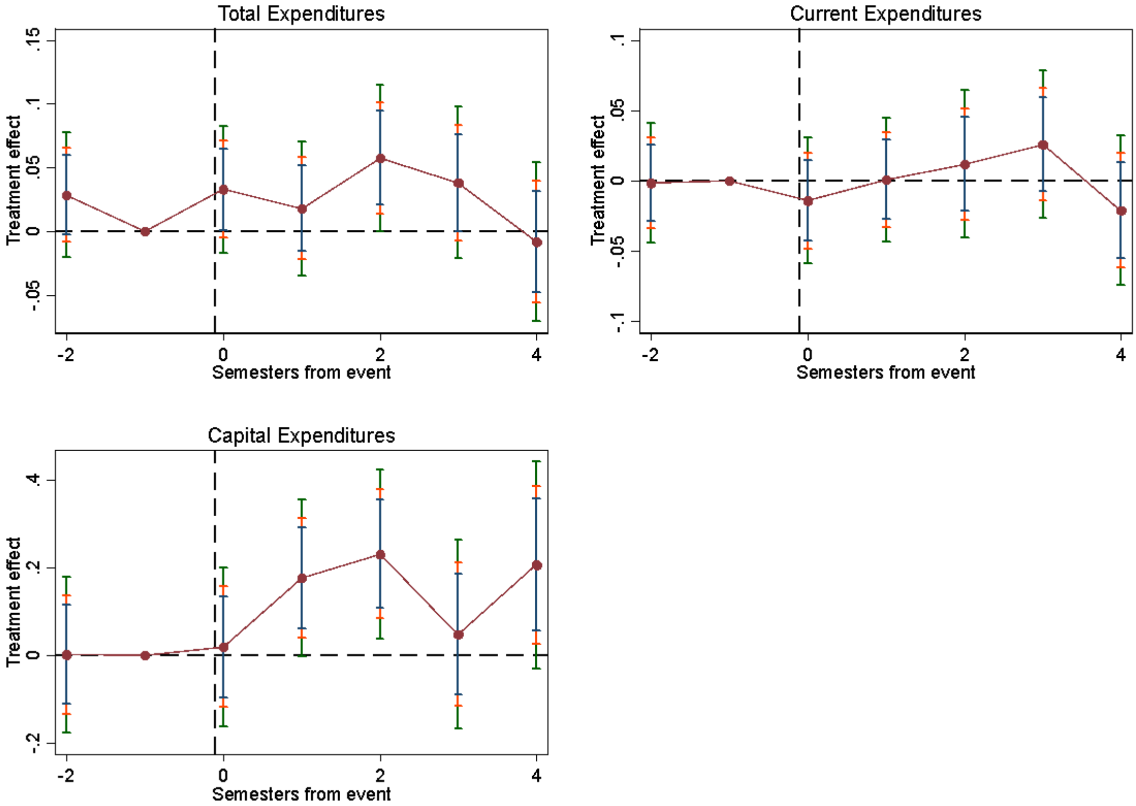
5.1 Baseline results

The dynamics of our estimated average treatment effect of floods on municipalities' budgetary outcomes is reported in Figure 3 (expenditures) and 4 (revenues). Overall, no significant pre-

[10] Specifically, the whole sample of treated municipalities has 785 observations; despite this, we account for 517 treated municipalities only because their pre and post trends can be fully observed in our reference period 2013-2016. In this way, we avoid the risk of including in the pool of non-treated municipalities those that were affected by a flood prior to 2013 or after 2016, for which we have no information.

trend exists, which allows us to consider any post-treatment deviation of trends between treated and the counterfactual as an additional effect induced by the flood.

Figure 3. Difference-in-differences baseline estimations - Expenditure

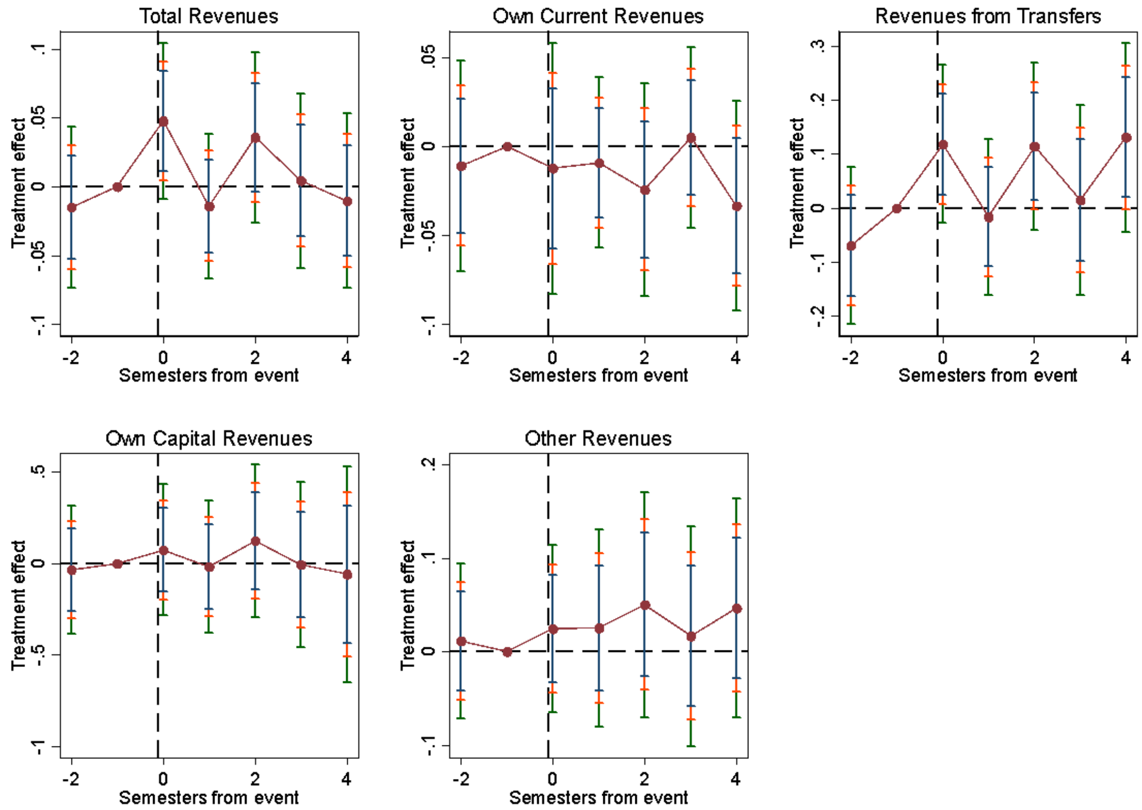


Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

In all figures, when "semesters from event" equals 0 (t=0), we are referring to 'event semester'. The treatment effect on total expenditures is positive until the third semester after a flood and then it goes back to zero in the fourth semester. In terms of magnitude, the effect is sizeable: +3.4 percent the event semester up to +6 percent in the third post-treatment semester. For what concerns the precision of estimates, the effects are statistically different from zero in the event semester (p-value<0.1), second (p-value<0.01) and third (p-value<0.1) semesters. These results indicate that local governments react to floods quite soon by increasing expenditures, even though the full potential is reached 1 year after the flood occurrence. However, it seems that this effect tends to fade away quite rapidly.

To dig deeper into the drivers of this overall effect, we consider expenditures in fixed capital and current expenditures separately. Public investments represent a large part of expenditures aimed at boosting the recovery and reconstruction of infrastructure and buildings that were directly hit by the flood. The effect of floods on capital expenditures (bottom-left panel of Figure 3) only shows up in the second semester (t=1) after the flood and further grows in the third semester (t=2). This effect is statistically different from zero (p-value<0.1) and quite large in magnitude: it corresponds to an increase (compared to the counterfactual) of 19 percent in the second semester and 26 percent in the third semester. Considering current expenditures (e.g. personnel expenditures), we do not find any significant effect on treated municipalities in the aftermath of a flood and this might be the signal that climate disasters provoke immediate impacts on the municipal capital and physical assets that wear off when these assets are replaced.

Figure 4. Difference-in-differences baseline estimation - Revenues



Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

Focusing on revenues (Figure 4), we observe that the effect of floods on total revenues is characterised by a non-monotonic trend. An instantaneous (t=0) significant increase of total revenues happens when the shock occurs, corresponding to a +4.9% increase (significant at 5%); this effect is immediately reabsorbed in the following semester (t=1). In the third semester (t=2), revenues are subject to a new increase (not statistically significant) and then start to steadily decline.

By adopting the same approach of expenditures, we break down the total revenues value into its main components. Interestingly, no significant effects are found for own current revenues, capital revenues and other revenues. This is in line with Miao et al. (2020), who find no statistically significant impact of floods on fiscal outcomes in Chinese provinces. However, when considering revenues from transfers we estimate a positive and significant impact in the event semester and the third semester. This effect suggests that at least part of the additional expenditures born by local governments are financed by national or other subnational governments. At the same time, it seems like local governments do not significantly change their own revenues by suspending or postponing the collection of local taxes to support the different economic agents (citizens, workers, companies) affected by the flood. Furthermore, floods do not seem to have a substantial influence on the local tax base.

In sum, local governments in flooded municipalities in Italy tend to respond to extreme events by boosting the level of public investments (with a 6-months delay) which are (at least partly) financed by increased transfers from other levels of government. This result suggests a good capacity to cope with extreme events and to act with the aim of boosting the post-flood recovery. On the other hand, no change is observed in terms of current expenditure and in other revenues, which means that the considered events did not erode substantially the tax base and that local governments did not change local tax rates.

5.2 Heterogeneous effects: high vs. low resilience municipalities

Since municipalities could react differently to extreme natural events depending on their characteristics, we provide evidence about the heterogeneity of the effect depending on the level of resilience and vulnerability. Standard studies on economic resilience and vulnerability, often provide support for the statement that any kind of system, even the socio-economic one, would react and cope to shocks, more or less well, according to given characteristics of the system itself. Thus, empirical studies analysed systems by looking at selected proxies - of economic, resilience and vulnerability - and if their performances were positive in the aftermath of a shock, then scholars argue that these systems are resilient and not vulnerable. However, to our knowledge, there are not many studies that show the mechanism through which a system is able to cope with unpredicted shocks. In our work we show how the *ex ante* more resilient and less vulnerable municipalities are able to cope with unforeseen events through their better capacity to use internal budgetary resources, while less resilient and more vulnerable municipalities mostly depend on state transfers. Overall, our work is a sort of explicit test of the resilient capacity of municipalities to cope with unpredicted shocks.

We consider the median value of resilience and vulnerability, respectively, as the threshold to identify high vs. low resilience/vulnerability municipalities. As shown in Table 2, 35.20% of treated municipalities are highly resilient and less vulnerable to floods. Less resilient and more vulnerable damaged municipalities are similarly represented in the sample (38.88%). The residual 26% is equally distributed between less resilient/less vulnerable (14.12%) and high resilient/high vulnerable (11.80%) treated municipalities.

Table 2. Treated Municipalities by vulnerability and resilience level

Resilience/Vulnerability	Low	High	**Total**
Low	**73** 14.12%	**201** 38.88%	**274** 53%
High	**182** 35.20%	**61** 11.80%	**243** 47%
Total	**255** 49.32%	**262** 50.68%	**517** 100%

As a first step, we consider the breakdown of our sample by resilience: results are reported in Figures 5 (expenditures) and 6 (revenues). Overall, less resilient municipalities hit by floods do not change their pattern of (total, current and capital) expenditures: the effects are not statistically different from zero with the sole exception of an increase of total expenditures in the second semester post the event semester (at conventional 5%). On the other hand, we find large and significant effects for resilient municipalities, especially so for capital expenditure and total expenditure, while we also estimate a positive and significant effect on current expenditure in the third post-treatment semester. In sum, flooded municipalities with high resilience respond quite promptly to the flood by boosting spending in infrastructures and other capital expenditures to favour post-disaster recovery. Moreover, these municipalities also boost current expenditures in the longer run, while the response to floods of less resilient municipalities is much weaker. Indeed, this is one of the first pieces of evidence, that shows the mechanism through which more resilient (and less vulnerable) municipalities are able to better face extreme events through their higher capacity to handle greater flows of (internal) resources, without waiting for external aids. In some sense, this is a process that is similar to the one experimented in Emilia-Romagna region after the earthquake of 2012. This area is characterised by high resilient municipalities and, as stated by the President of the General Federation of Italian Commerce and Tourism of Emilia Romagna (Confcommercio), "The recovery was the result of a synergy between public and private. The entrepreneurs immediately invested in the restart, without waiting for public funds which, after following the bureaucratic process, arrived anyway".[11] This evidence highlights two important points of this work: 1) more resilient subjects have higher capacity to quickly spend money immediately starting the recovery process; 2) more resilient subjects are more aware that investments are important to facilitate the post-disaster recovery.

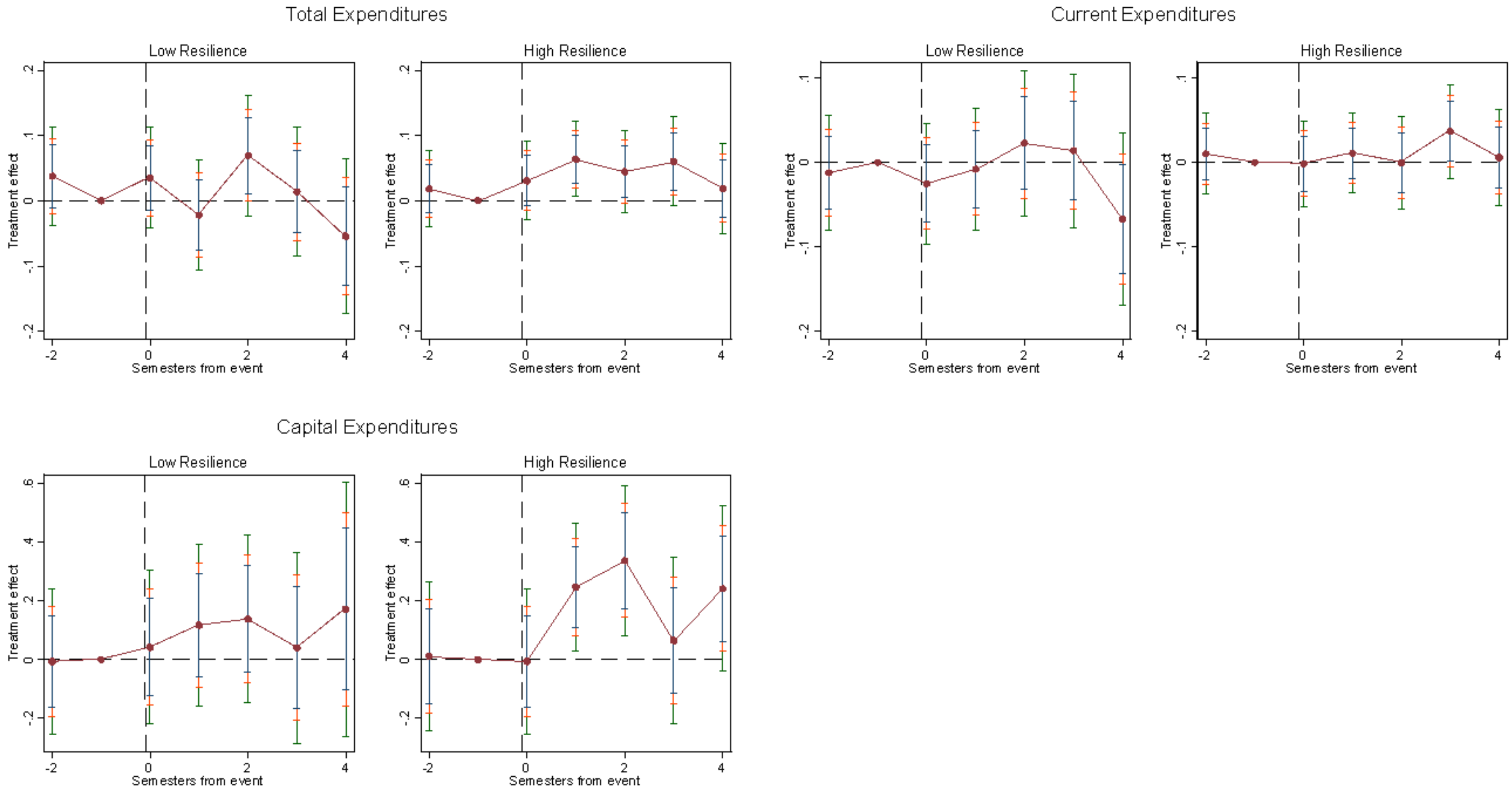
Results for revenues, broken down by level of resilience and revenue type (Figure 6), indicate that less resilient treated municipalities record a statistically significant (at 1%) and substantial increase of total revenues in the semester of the flood with respect to the corresponding counterfactual, which is mostly driven by a substantial increase in transfers from higher or equal levels of government. This does not happen, instead, for more resilient municipalities, for which we find no immediate increase in total revenues and a smaller (and not significantly different from zero) increase in transfers compared to less resilient ones, while some evidence of significant increase in transfers appears in the last observed semester only.[12]

In sum, our results suggest that other national or subnational governments (e.g. NUTS2 regions) immediately transfer funds to support less resilient municipalities. However, it seems like that these transfers are not effectively used by local governments of municipalities with poor resilience. At the same time, highly resilient municipalities promptly respond to a flood by boosting capital expenditures, even without any significant transfer of resources from other levels of government.

[11] Available in Italian only here: https://www.quotidiano.net/inchieste/terremotoemilia/la-ripartenza/

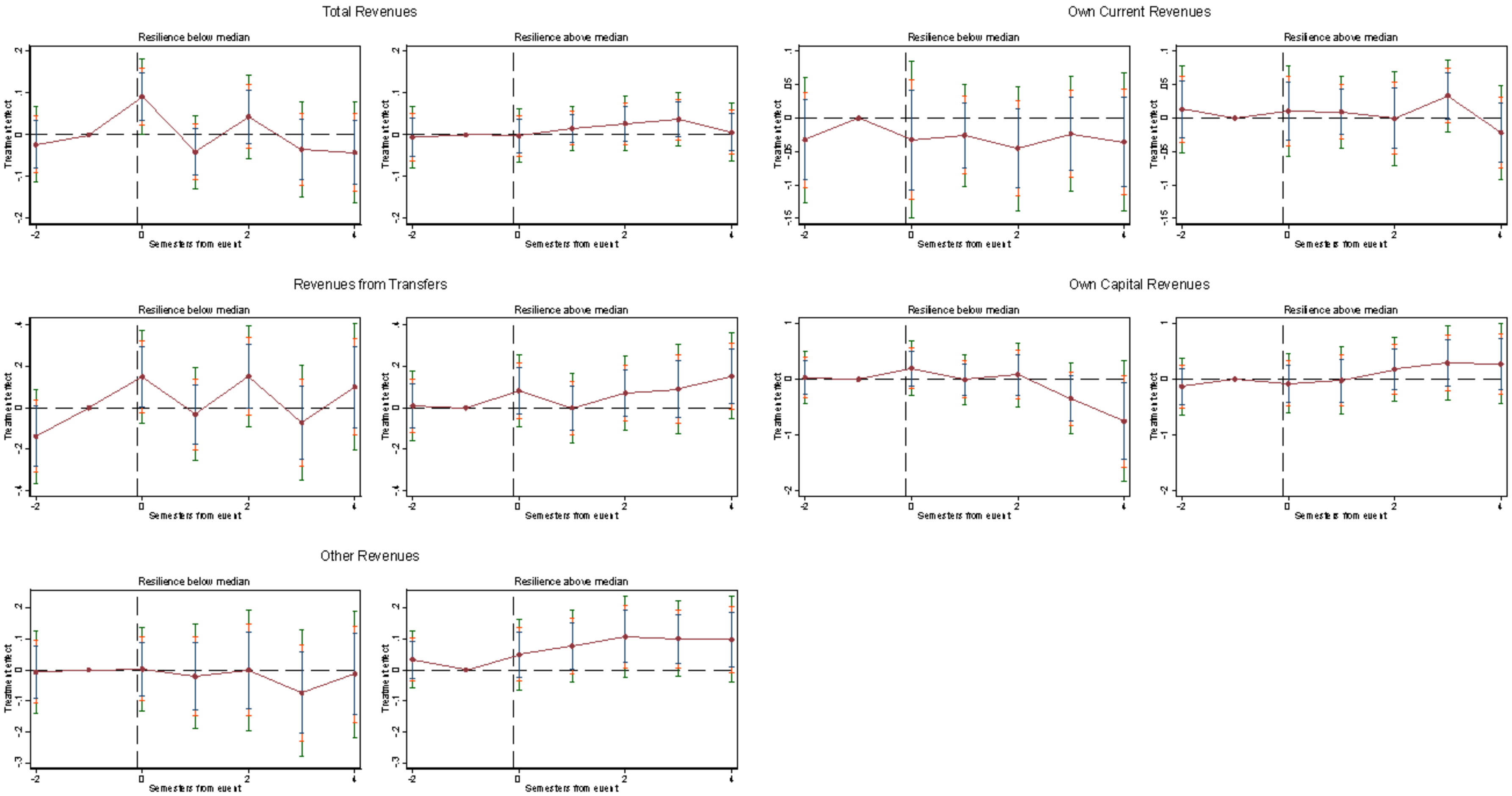
[12] For what concerns "other revenues", that are mainly connected to revenues from services on behalf of third parties, they appear to be positively affected by a flood in highly resilient municipalities.

Figure 5. Difference-in-Difference estimations by resilience level - Expenditures



Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

Figure 6. Difference-in-Difference estimations by resilience level - Revenues



Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

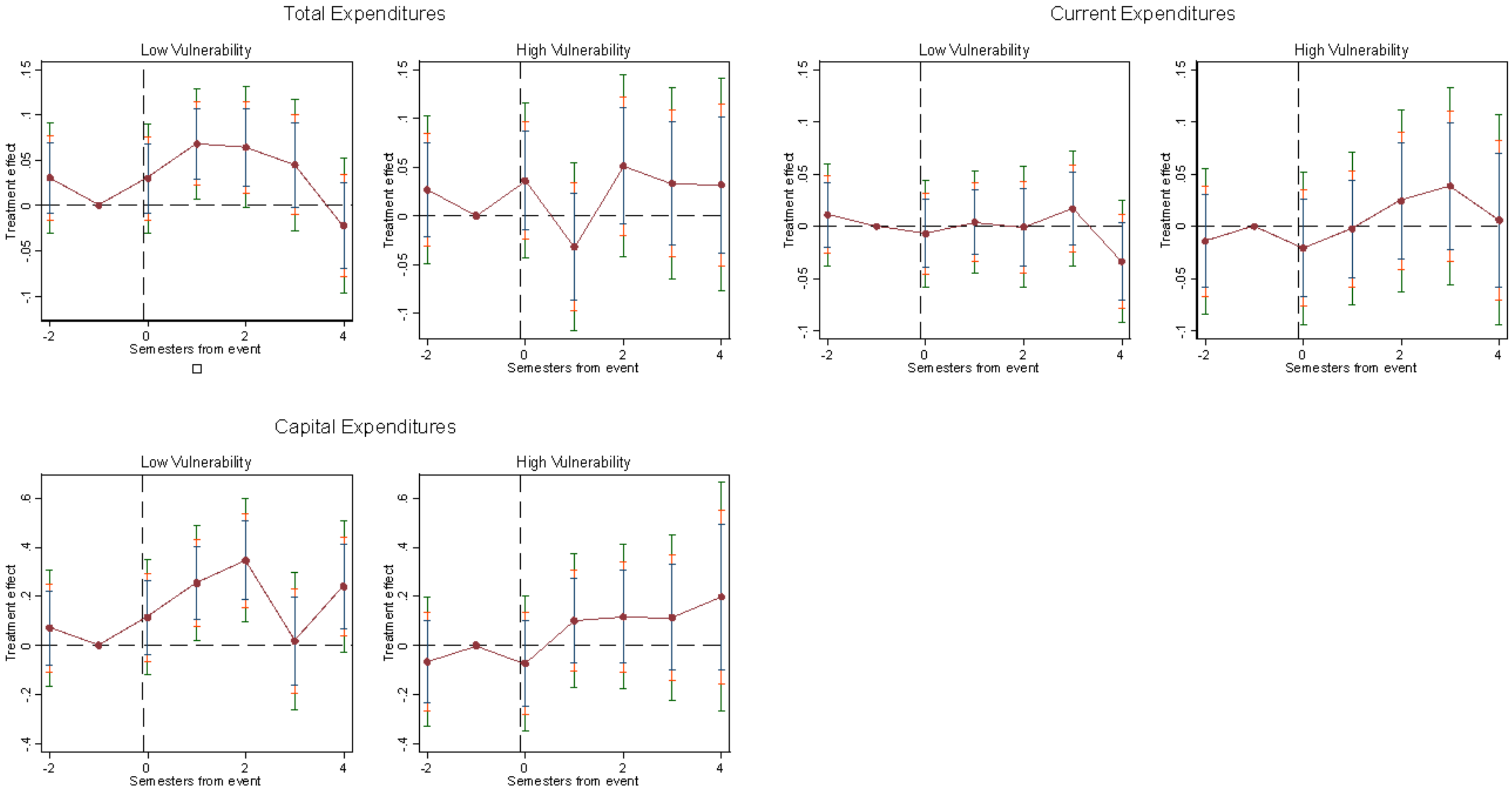
5.3 Heterogeneous effects: high vs. low vulnerability municipalities

In order to corroborate our results on resilience, we replicate our analysis by looking at the vulnerability of municipalities. As mentioned before, resilience and vulnerability are strongly negatively correlated (correlation coefficient of -0.77). However, in our perspective, resilience and vulnerability, even if they share some common characteristics, are two separate concepts that are able to capture socio-economic differences between municipalities. This is reflected in the composition of the two indicators of resilience and vulnerability. Roughly speaking, we can affirm that resilience, in this context, is able to capture the capacity of a municipality to avoid that the damages will be 'embedded' into the economic system by shifting down the economic growth trajectory, while vulnerability is related to the capacity of the municipalities to suffer socio-economic losses.

Figure 7 reports differential effects broken down by level of vulnerability for expenditures. As expected, results for expenditure, broken down by level of vulnerability, mirror the ones broken down by resilience (Figures 5 and 6). We estimate a substantial increase of total expenditures, driven by capital expenditures, in the aftermath of a flood (compared to the counterfactual) for municipalities with a low level of vulnerability. On the other hand, no significant effect is found for current expenditures, nor for high or low vulnerability municipalities.

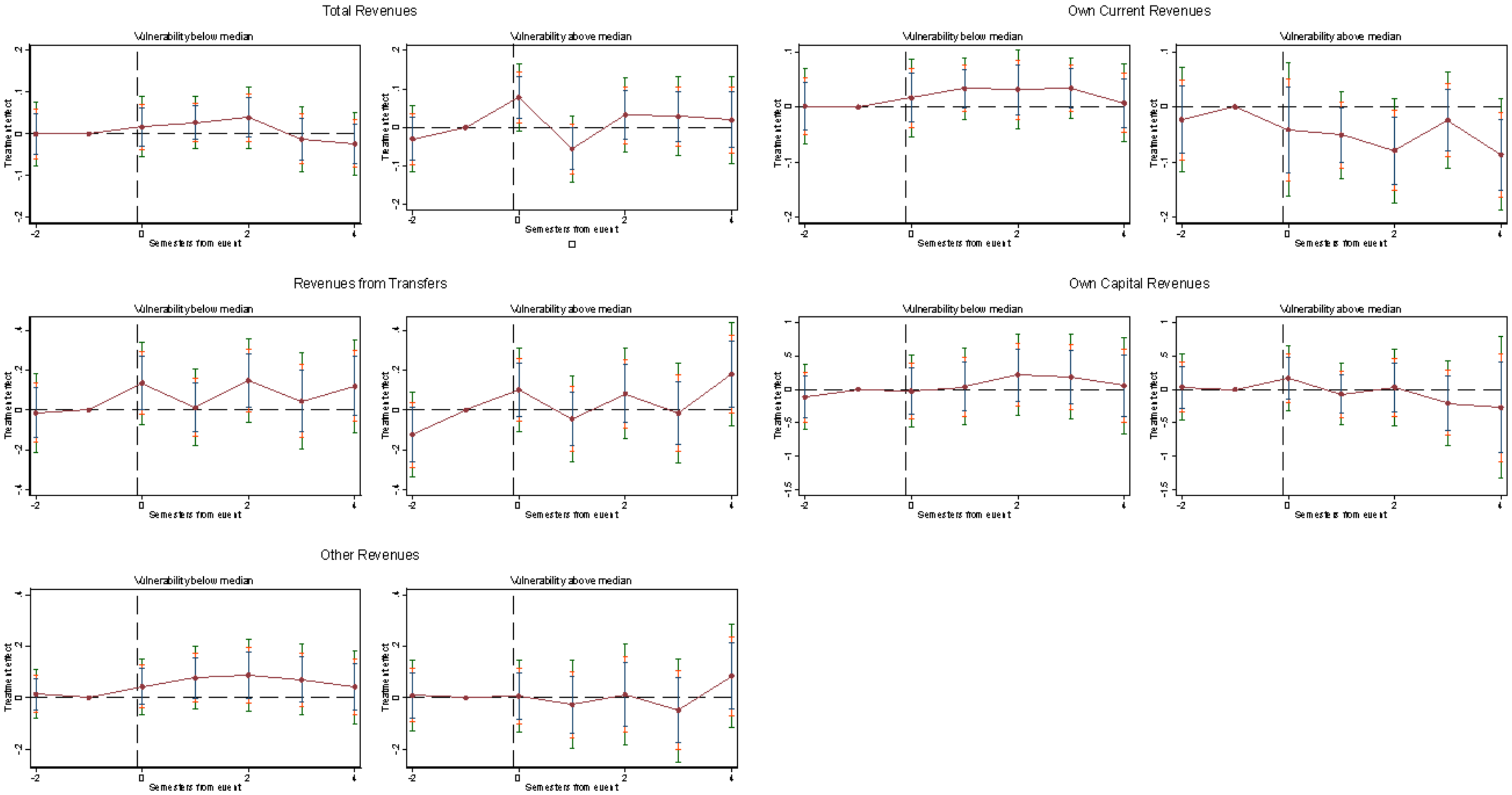
Focusing on revenues side (Figure 8), by comparing less vulnerable treated municipalities with the corresponding counterfactual, they experienced an increase in total revenues until the second semester post event semester and then they started to decrease. We do find some specificities when considering vulnerability instead of resilience. In the aftermath of the flood, vulnerable municipalities show an increase in revenues (not entirely explained by an increase in transfers, which is not statistically different from zero), while less vulnerable ones experience an increase in transfers. We also observe a negative and significant post-flood effect on own current revenues for more vulnerable municipalities and this might be the sign of a higher impact of the flooding in more vulnerable municipalities by shrinking the tax base (e.g. because of reduction of economic actors present in the territories and/or prolonged tax cuts or exemptions).

Figure 7. Estimations by vulnerability level - Expenditures



Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

Figure 8. Estimations by vulnerability level - Revenues



Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

6 Conclusions

Starting with the observation that a growing number of floods have affected Italy in the recent decades and considering their impact on local economies, in this paper we have investigated the effect of floods on short-term budgetary choices of local (municipal) governments, focusing on 4,185 flooded municipalities in 9 Italian regions over the 2013-2016 period. We have developed a dynamic difference-in-differences with an *a priori* identification of proper counterfactuals through a propensity score matching framework.

On average, we estimate that Italian flooded municipalities respond to extreme events by fostering public investments and this expenditure increase is partly financed by increased transfers from other levels of government. This result highlights the ability of municipalities to cope with floods and to react by boosting the post-flood recovery. Moreover, the considered floods did not affect tax base and municipalities did not change local tax rates. We then extend our analysis to considering heterogeneous effects based on the *ex ante* resilience and vulnerability of affected municipalities. It seems evident that more resilient and less vulnerable municipalities can cope with unforeseen events because they have a better capacity to use available internal budgetary resources. These municipalities do not have to wait for external aid. Less resilient and more vulnerable municipalities highly depend on transfers from other national and subnational governments.

Our results bear interesting policy implications, for instance they might support policymakers that aim to draw general disaster management but also the relationship between national and local governments in the disasters and (eventual) reconstruction management. For instance, Italy is nowadays discussing the draft law for the adoption of a "Code of reconstruction" and we believe that our results might be pivotal for at least two reasons.

First, as local governments respond to floods by increasing their capital investments without an adjustment of their own revenues, substantial imbalances can be generated in their accounts. This result points to the need to grant some degree of flexibility to incur in deficits in the aftermath of a disaster. Second, the prompt response in terms of increased capital expenditures appears to be larger for more resilient and less vulnerable municipalities. *Ex ante* capacity to cope with extreme events and to limit the damages is a good predictor of municipality post-disaster recovery ability. In this respect, the implication is not straightforward. On the one hand, the long-term strategy for local and regional-national governments should be to enhance the resilience of municipalities and to reduce their vulnerability. On the other hand, in the short term there is room for a direct intervention of regional or national governments in terms of direct capital spending in flooded less resilient and more vulnerable areas. Linked to this, our results highlight that the transfer of funds to local governments in less resilient and more vulnerable municipalities is not enough to boost local capital expenditures. This points to the fact that the failure to increase capital expenditures in these municipalities does not depend on tight financial or regulatory constraints but on the inability to operationalise additional spending in the short run.

This work can represent a starting point for future research. For instance, it would be of particular interest to consider political economy mechanisms behind municipality's budgetary dynamics, for example accounting for mayor's characteristics and for the electoral cycle. It can be also possible to apply the same econometric approach to estimate the effect of other extreme natural events, such as earthquakes, that strongly affect the Italian peninsula too. Furthermore, a similar approach can be applied to private sector (firms) to investigate if it analogously responds to extreme events.

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Appendix A – Balancing test of matching based on propensity score and difference-in-difference estimates tables

Table A.1.1. Balancing test of matching based on propensity score – Unmatched

	Population	Income	Area	Altitude	Island	Coastal	Hazard	Resilience	Vulnerability
Control	7.969	17.25	2.839	5.012	0.005	0.113	0.072	0.517	0.517
Treated	8.059	17.34	3.223	4.734	0.006	0.182	0.077	0.445	0.468
Difference	0.090	0.086	0.385	-0.278	0.001	0.069	0.006	-0.073	-0.050
t-stat	2.030**	1.740*	12.13***	-4.491***	0.502	4.944***	1.090	-4.070***	-2.768***
N. obs.	52865	51245	51121	51076	51121	51121	51121	52870	52870

Table A.1.2. Balancing test of matching based on propensity score - Matched

Outcome: Total Expenditure	Population	Income	Area	Altitude	Island	Coastal	Pre-Trend	Hazard
Control	8.007	17.28	3.161	4.903	0.006	0.0974	0.157	0.064
Treated	8.047	17.32	3.154	4.862	0.004	0.0875	0.125	0.062
Difference	0.040	0.033	-0.006	-0.041	-0.002	-0.010	-0.032	-0.002
t_Stat	0.558	0.412	-0.121	-0.383	-0.501	-0.570	-1.699*	-0.214
N. Observations				1319				
Outcome: Current Expenditure	Population	Income	Area	Altitude	Island	Coastal	Pre-Trend	Hazard
Control	8.031	17.31	3.191	4.791	0.007	0.100	0.094	0.065
Treated	8.050	17.32	3.154	4.830	0.004	0.087	0.086	0.064
Difference	0.019	0.013	-0.037	0.040	-0.003	-0.014	-0.008	-0.002
t-stat	0.260	0.169	-0.718	0.364	-0.656	-0.774	-0.528	-0.260
N. Observations				1315				
Outcome Capital Expenditure	Population	Income	Area	Altitude	Island	Coastal	Pre-Trend	Hazard
Control	8.020	17.30	3.184	4.815	0.002	0.090	0.309	0.080
Treated	8.069	17.34	3.151	4.823	0.004	0.094	0.287	0.065
Difference	0.048	0.043	-0.033	0.008	0.002	0.004	-0.022	-0.016
t-stat	0.669	0.546	-0.649	0.077	0.633	0.228	-0.321	-1.905
N. Observations				1316				
Outcome: Total revenues	Population	Income	Area	Altitude	Island	Coastal	Pre-Trend	Hazard
Control	8.070	17.35	3.134	4.808	0.005	0.103	0.257	0.072
Treated	8.050	17.32	3.149	4.845	0.004	0.0895	0.265	0.063
Difference	-0.020	-0.036	0.015	0.037	-0.001	-0.014	0.008	-0.008
t-stat	-0.279	-0.458	0.291	0.343	-0.259	-0.776	0.330	-1.104
N. Observations				1300				
Outcome: Own current revenues	Population	Income	Area	Altitude	Island	Coastal	Pre-Trend	Hazard
Control	8.048	17.33	3.170	4.882	0.006	0.102	0.225	0.060
Treated	8.063	17.33	3.159	4.841	0.004	0.089	0.236	0.064
Difference	0.014	0.004	-0.011	-0.040	-0.002	-0.013	0.011	0.004
t-stat	0.197	0.0453	-0.208	-0.371	-0.472	-0.711	0.448	0.554
N. Observations				1322				
Outcome: Revenues from transfers	Population	Income	Area	Altitude	Island	Coastal	Pre-Trend	Hazard
Control	8.065	17.34	3.136	4.826	0.006	0.087	0.384	0.067
Treated	8.045	17.31	3.146	4.846	0.004	0.083	0.438	0.060
Difference	-0.020	-0.030	0.010	0.020	-0.002	-0.004	0.055	-0.006
t-stat	-0.284	-0.388	0.185	0.180	-0.472	-0.232	0.854	-0.857
N. Observations				1281				
Outcome: Capital Revenues	Population	Income	Area	Altitude	Island	Coastal	Pre-Trend	Hazard
Control	8.089	17.34	3.179	4.872	0.003	0.081	-0.038	0.068
Treated	8.174	17.42	3.225	4.780	0.006	0.097	0.047	0.071
Difference	0.085	0.083	0.046	-0.092	0.003	0.016	0.085	0.002
t-stat	1.036	0.909	0.768	-0.692	0.633	0.736	0.631	0.262
N. Observations				914				
Outcome: Other Revenues	Population	Income	Area	Altitude	Island	Coastal	Pre-Trend	Hazard
Control	8.014	17.29	3.148	4.878	0.004	0.110	0.177	0.056
Treated	8.051	17.32	3.147	4.837	0.004	0.093	0.153	0.062
Difference	0.037	0.029	-0.001	-0.041	-0.000	-0.017	-0.024	0.006
t-stat	0.510	0.362	-0.027	-0.378	-0.000	-0.889	-0.787	0.900
N. Observations				1317				

Table A.2. Baseline Estimations - Expenditures

Treatment Effect	Total Expenditures	Current Expenditures	Capital Expenditures
1st Semester (pre)	0.029	-0.002	0.001
	(0.019)	(0.016)	(0.069)
Semester of the event	0.033*	-0.014	0.019
	(0.019)	(0.017)	(0.070)
1st Semester (post)	0.018	0.001	0.177**
	(0.021)	(0.0171)	(0.070)
2nd Semester (post)	0.058***	0.012	0.231***
	(0.022)	(0.020)	(0.075)
3rd Semester (post)	0.038*	0.026	0.048
	(0.023)	(0.020)	(0.084)
4th Semester (post)	-0.008	-0.021	0.206**
	(0.024)	(0.021)	(0.092)
N. Observations	8496	8481	8453

Notes: Fixed effect model. Standard errors clustered by municipalities in parenthesis. * p<0.1, ** p<0.05, *** p<0.01.

Table A.3. Baseline Estimations – Revenues

Treatment Effect	Total Revenues	Current Revenues	Revenues from Transfers	Capital Revenues	Other Revenues
1st Semester (pre)	-0.015	-0.011	-0.069	-0.035	0.012
	(0.023)	(0.023)	(0.057)	(0.137)	(0.032)
Semester of the event	0.048**	-0.012	0.119**	0.074	0.024
	(0.022)	(0.027)	(0.057)	(0.139)	(0.035)
1st Semester (post)	-0.014	-0.009	-0.017	-0.018	0.025
	(0.021)	(0.019)	(0.056)	(0.140)	(0.041)
2nd Semester (post)	0.036	-0.024	0.115*	0.124	0.050
	(0.024)	(0.023)	(0.060)	(0.162)	(0.047)
3rd Semester (post)	0.004	0.005	0.015	-0.006	0.016
	(0.025)	(0.020)	(0.068)	(0.176)	(0.046)
4th Semester (post)	-0.010	-0.033	0.131*	-0.059	0.047
	(0.025)	(0.023)	(0.068)	(0.229)	(0.046)
N. Observations	8370	8514	8261	5194	8481

Notes: Fixed effect model. Standard errors clustered by municipalities in parenthesis. * p<0.1, ** p<0.05, *** p<0.01.

Table A.4. Estimations by resilience level - Expenditures

		Below Median			*Above Median*	
Treatment Effect	Total Expenditures	Current Expenditures	Capital Expenditures	Total Expenditures	Current Expenditures	Capital Expenditures
1st Semester (pre)	0.038	-0.012	-0.007	0.018	0.010	0.011
	(0.029)	(0.027)	(0.095)	(0.023)	(0.019)	(0.099)
Semester of the event	0.035	-0.025	0.042	0.030	-0.002	-0.007
	(0.030)	(0.028)	(0.102)	(0.023)	(0.020)	(0.095)
1st Semester (post)	-0.022	-0.008	0.117	0.064***	0.011	0.247***
	(0.033)	(0.028)	(0.108)	(0.022)	(0.018)	(0.084)
2nd Semester (post)	0.069*	0.023	0.138	0.044*	-0.001	0.338***
	(0.036)	(0.033)	(0.111)	(0.025)	(0.021)	(0.099)
3rd Semester (post)	0.014	0.014	0.040	0.060**	0.037*	0.065
	(0.038)	(0.035)	(0.126)	(0.026)	(0.022)	(0.110)
4th Semester (post)	-0.054	-0.067*	0.171	0.019	0.006	0.242**
	(0.046)	(0.040)	(0.168)	(0.027)	(0.022)	(0.109)
N. Observations	4291	4168	4278	4205	4313	4175

Notes: Fixed effect model. Standard errors clustered by municipalities in parenthesis. * p<0.1, ** p<0.05, *** p<0.01.

Table A.5. Estimations by vulnerability level - Expenditures

Treatment Effect	*Below Median* Total Expenditures	Current Expenditures	Capital Expenditures	*Above Median* Total Expenditures	Current Expenditures	Capital Expenditures
1st Semester (pre)	0.031	0.011	0.070	0.027	-0.014	-0.067
	(0.024)	(0.019)	(0.092)	(0.029)	(0.027)	(0.102)
Semester of the event	0.030	-0.007	0.113	0.036	-0.021	-0.074
	(0.023)	(0.020)	(0.091)	(0.031)	(0.028)	(0.107)
1st Semester (post)	0.068***	0.004	0.253***	-0.032	-0.002	0.101
	(0.024)	(0.019)	(0.091)	(0.033)	(0.028)	(0.105)
2nd Semester (post)	0.064**	-0.001	0.346***	0.051	0.024	0.117
	(0.026)	(0.022)	(0.098)	(0.036)	(0.034)	(0.114)
3rd Semester (post)	0.045	0.017	0.018	0.033	0.039	0.114
	(0.028)	(0.021)	(0.109)	(0.038)	(0.037)	(0.131)
4th Semester (post)	-0.022	-0.034	0.239**	0.032	0.006	0.198
	(0.029)	(0.023)	(0.103)	(0.042)	(0.039)	(0.181)
N. Observations	4551	4480	4534	3945	4001	3919

Notes: Fixed effect model. Standard errors clustered by municipalities in parenthesis. * p<0.1, ** p<0.05, *** p<0.01.

Table A.6. Estimations by resilience level - Revenues

Treatment Effect	*Below Median* Total Revenues	Current Revenues	Revenues from Transfers	Capital Revenues	Other Revenues	*Above Median* Total Revenues	Current Revenues	Revenues from Transfers	Capital Revenues	Other Revenues
1st Semester (pre)	-0.023	-0.032	-0.138	0.029	-0.007	-0.0056	0.013	0.010	-0.129	0.033
	(0.035)	(0.037)	(0.089)	(0.183)	(0.052)	(0.029)	(0.026)	(0.066)	(0.199)	(0.036)
Semester of the event	0.092***	-0.032	0.150*	0.194	0.003	-0.002	0.010	0.083	-0.082	0.049
	(0.035)	(0.046)	(0.088)	(0.189)	(0.053)	(0.025)	(0.026)	(0.068)	(0.206)	(0.044)
1st Semester (post)	-0.041	-0.026	-0.031	-0.010	-0.021	0.016	0.009	-0.000	-0.025	0.077*
	(0.034)	(0.030)	(0.088)	(0.170)	(0.066)	(0.020)	(0.021)	(0.065)	(0.233)	(0.045)
2nd Semester (post)	0.043	-0.045	0.153	0.079	-0.001	0.027	-0.000	0.071	0.177	0.108**
	(0.039)	(0.036)	(0.095)	(0.223)	(0.075)	(0.025)	(0.027)	(0.069)	(0.226)	(0.051)
3rd Semester (post)	-0.035	-0.023	-0.072	-0.348	-0.075	0.037	0.033	0.090	0.292	0.101**
	(0.044)	(0.033)	(0.109)	(0.244)	(0.080)	(0.025)	(0.021)	(0.084)	(0.255)	(0.048)
4th Semester (post)	-0.042	-0.036	0.101	-0.753*	-0.014	0.006	-0.022	0.153*	0.274	0.098*
	(0.047)	(0.040)	(0.119)	(0.420)	(0.079)	(0.027)	(0.027)	(0.081)	(0.278)	(0.054)
N. Observations	4253	4308	4087	2751	4240	4117	4206	4174	2443	4241

Notes: Fixed effect model. Standard errors clustered by municipalities in parenthesis. * p<0.1, ** p<0.05, *** p<0.01.

Table A.7. Estimations by vulnerability level - Revenues

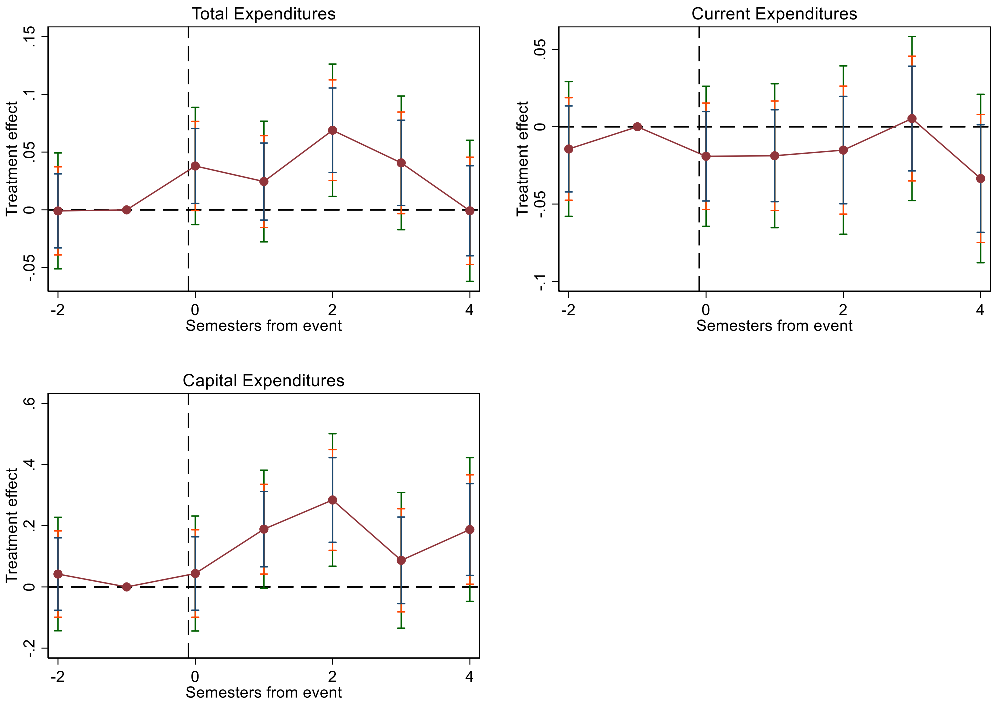
Treatment Effect	*Below Median* Total Revenues	Current Revenues	Revenues from Transfers	Capital Revenues	Other Revenues	*Above Median* Total Revenues	Current Revenues	Revenues from Transfers	Capital Revenues	Other Revenues
1st Semester (pre)	-0.000	0.001	-0.0135	-0.117	0.014	-0.030	-0.023	-0.124	0.033	0.010
	(0.030)	(0.026)	(0.076)	(0.189)	(0.037)	(0.034)	(0.037)	(0.083)	(0.192)	(0.053)
Semester of the event	0.017	0.017	0.136*	-0.026	0.043	0.078**	-0.041	0.102	0.167	0.006
	(0.028)	(0.027)	(0.081)	(0.209)	(0.043)	(0.034)	(0.047)	(0.081)	(0.186)	(0.055)
1st Semester (post)	0.028	0.033	0.012	0.038	0.077	-0.055*	-0.051*	-0.044	-0.069	-0.027
	(0.024)	(0.021)	(0.075)	(0.222)	(0.048)	(0.033)	(0.030)	(0.083)	(0.177)	(0.066)
2nd Semester (post)	0.039	0.031	0.149*	0.217	0.088	0.032	-0.079**	0.082	0.029	0.013
	(0.029)	(0.027)	(0.082)	(0.237)	(0.055)	(0.038)	(0.037)	(0.088)	(0.221)	(0.076)
3rd Semester (post)	-0.012	0.034	0.045	0.185	0.070	0.029	-0.024	-0.016	-0.206	-0.048
	(0.030)	(0.021)	(0.094)	(0.246)	(0.053)	(0.040)	(0.034)	(0.097)	(0.248)	(0.078)
4th Semester (post)	-0.023	0.007	0.121	0.056	0.042	0.020	-0.086**	0.180*	-0.272	0.084
	(0.029)	(0.027)	(0.091)	(0.279)	(0.055)	(0.044)	(0.039)	(0.101)	(0.412)	(0.078)
N. Observations	4436	4501	4410	2548	4458	3934	4013	3851	2646	4023

Notes: Fixed effect model. Standard errors clustered by municipalities in parenthesis. * p<0.1, ** p<0.05, *** p<0.01.

Appendix B – Robustness Analysis

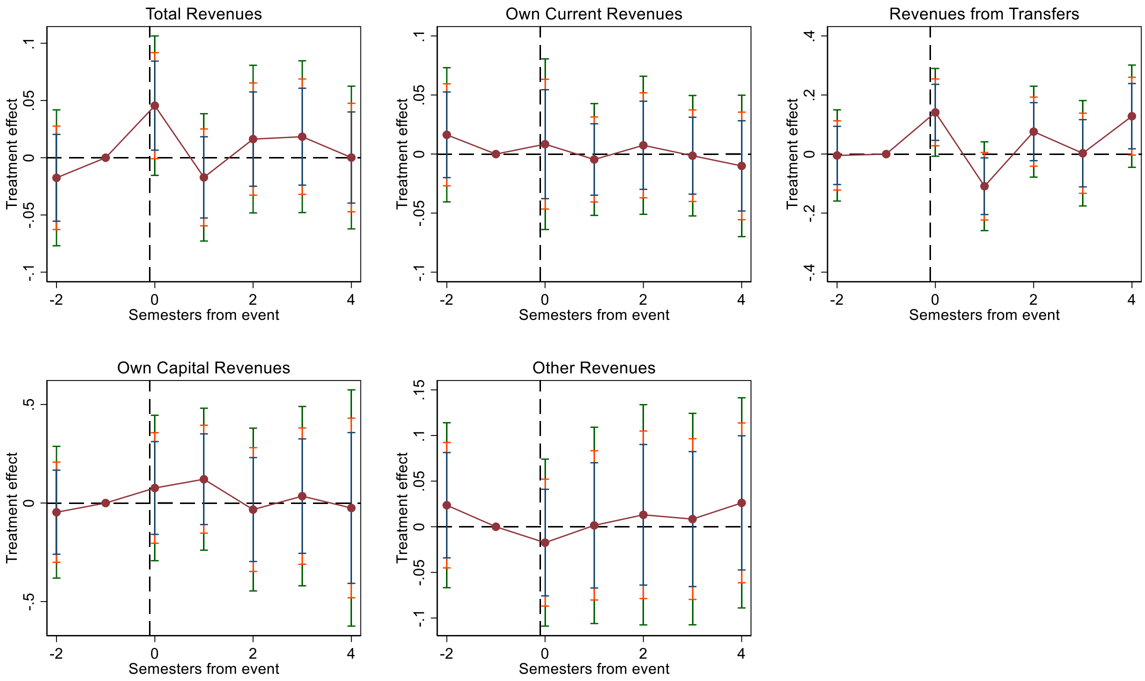
In order to check the robustness of our analysis, we have estimated the municipalities budgetary outcomes by applying a propensity score matching where municipalities are matched by considering the exact value of their level of resilience and the quartile of their 6-month pre-trend. Obtained results are reported from Figure B.1 to B.6 and are robust.

Figure B.1. Difference-in-differences baseline estimations - Expenditures



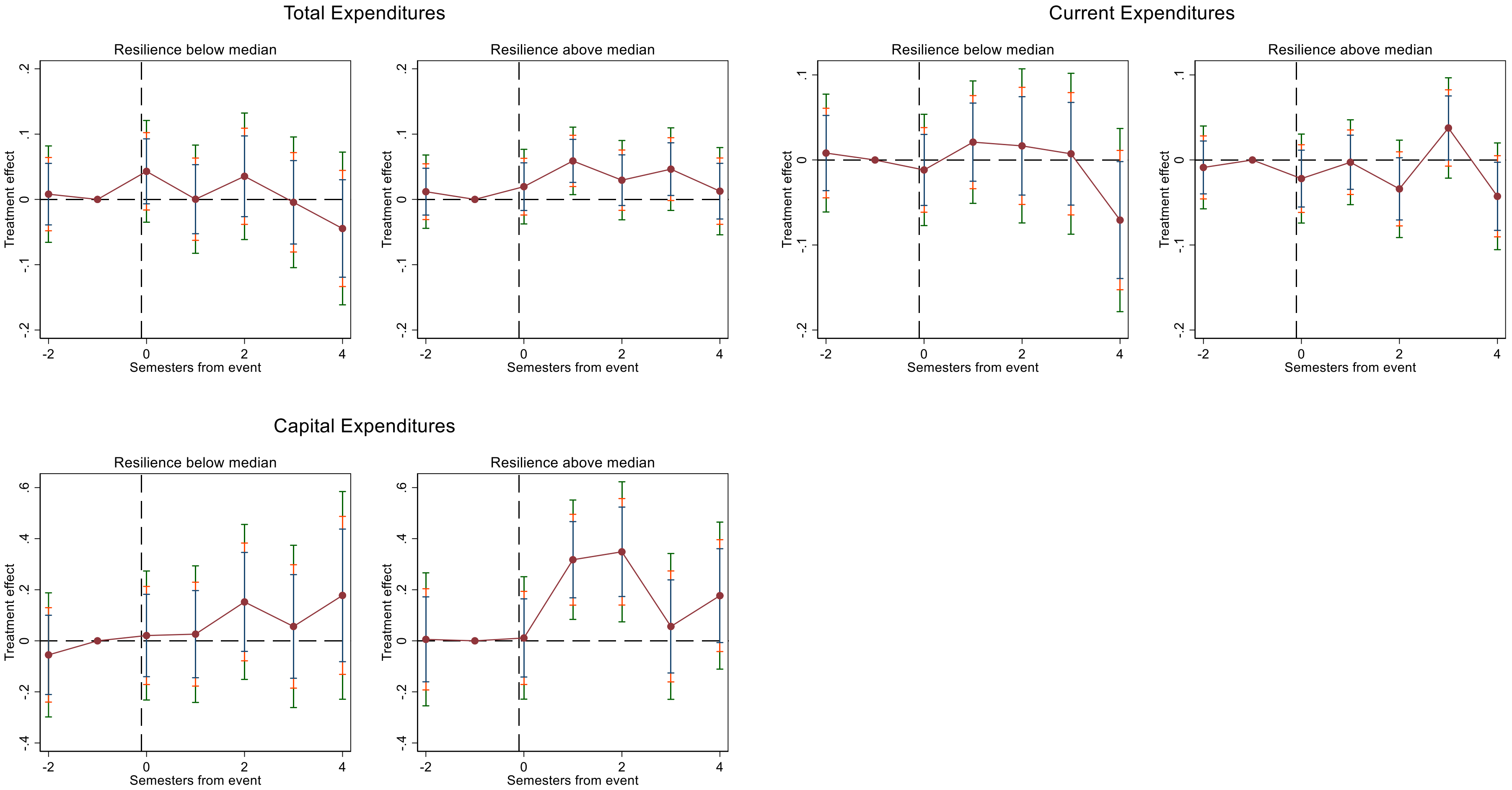
Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

Figure B.2. Difference-in-differences baseline estimations - Revenues



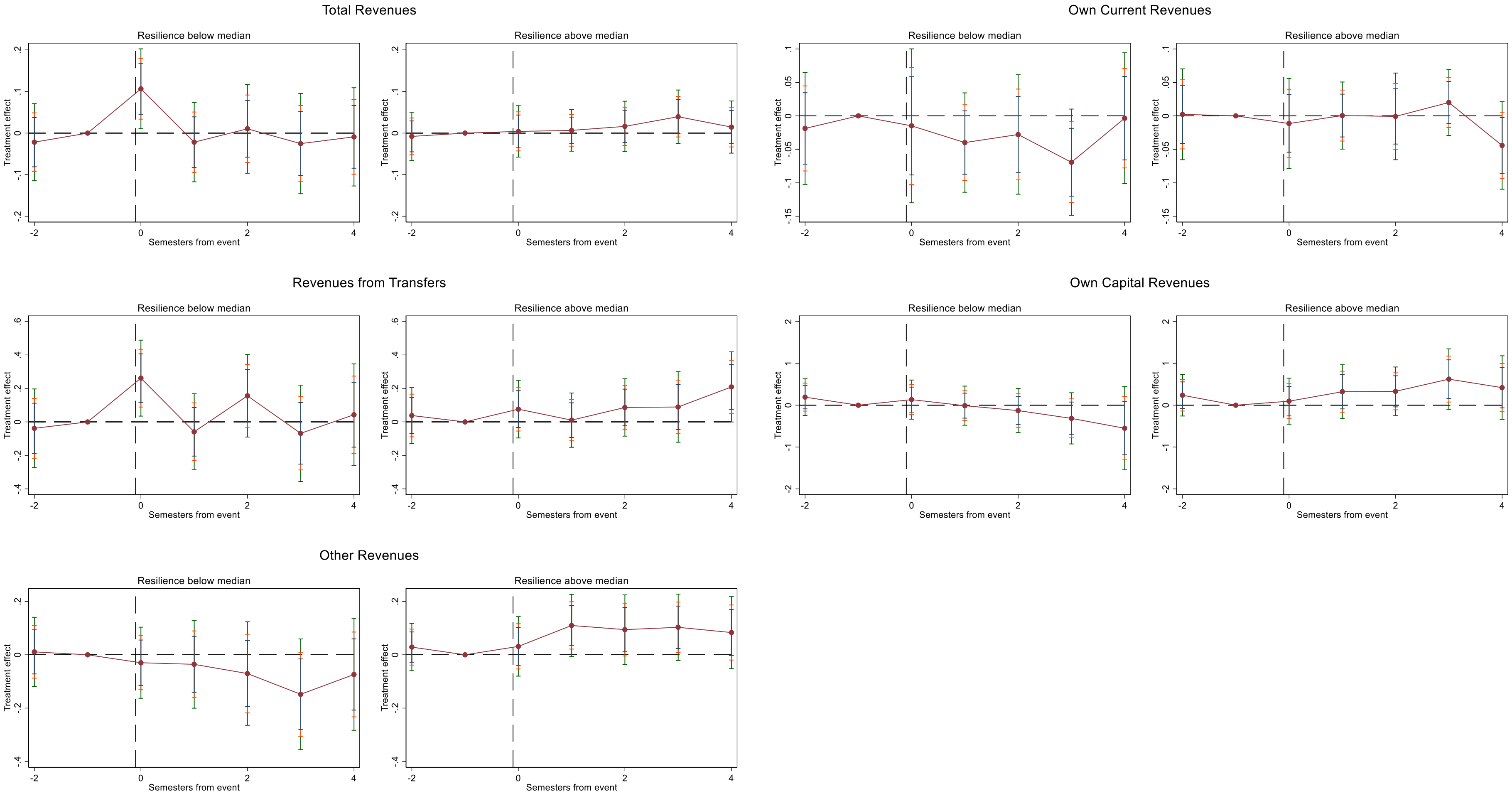
Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

Figure B.3. Difference-in-Difference estimations by resilience level - Expenditures



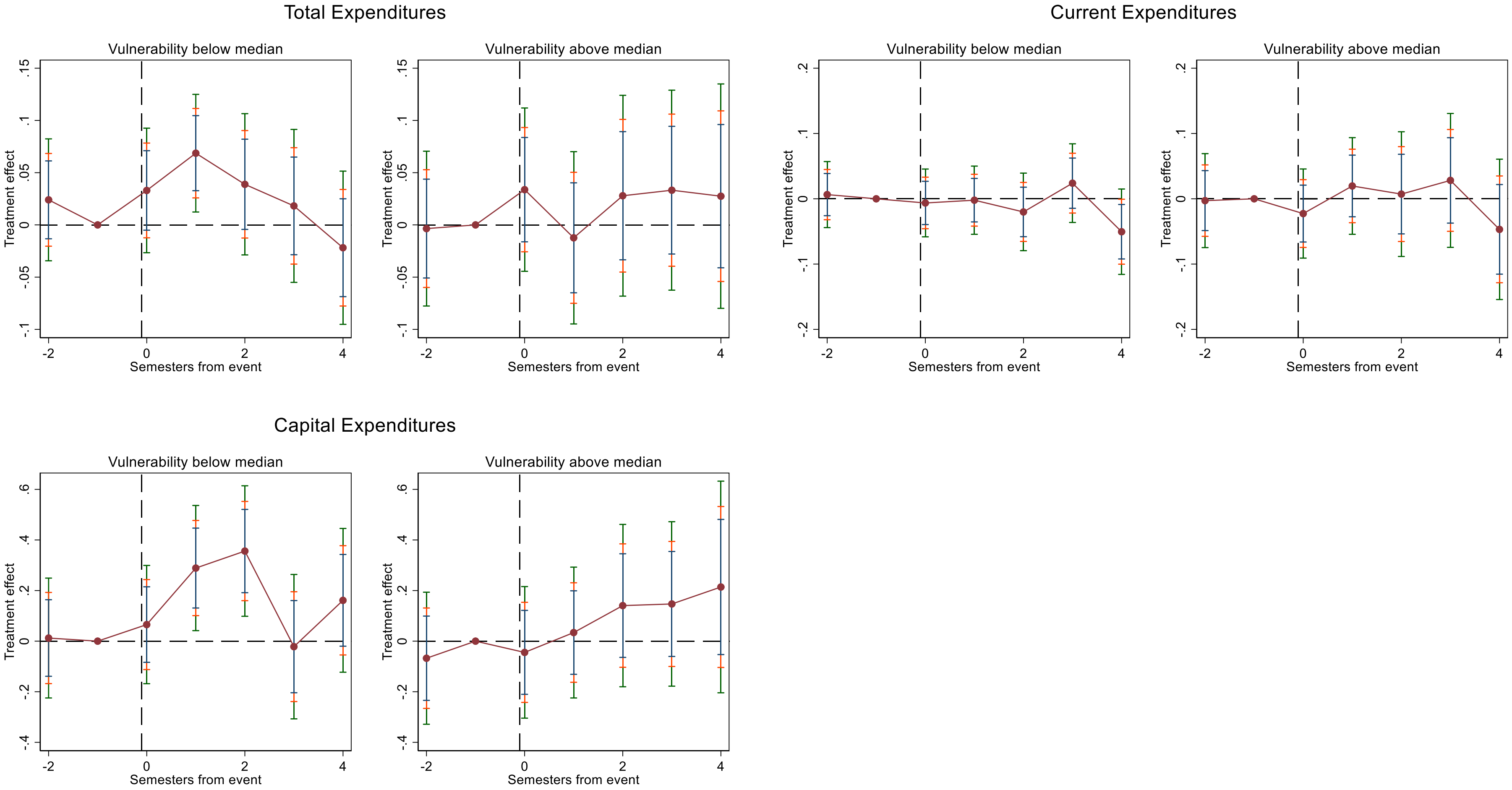
Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

Figure B.4. Difference-in-Difference estimations by resilience level - Revenues



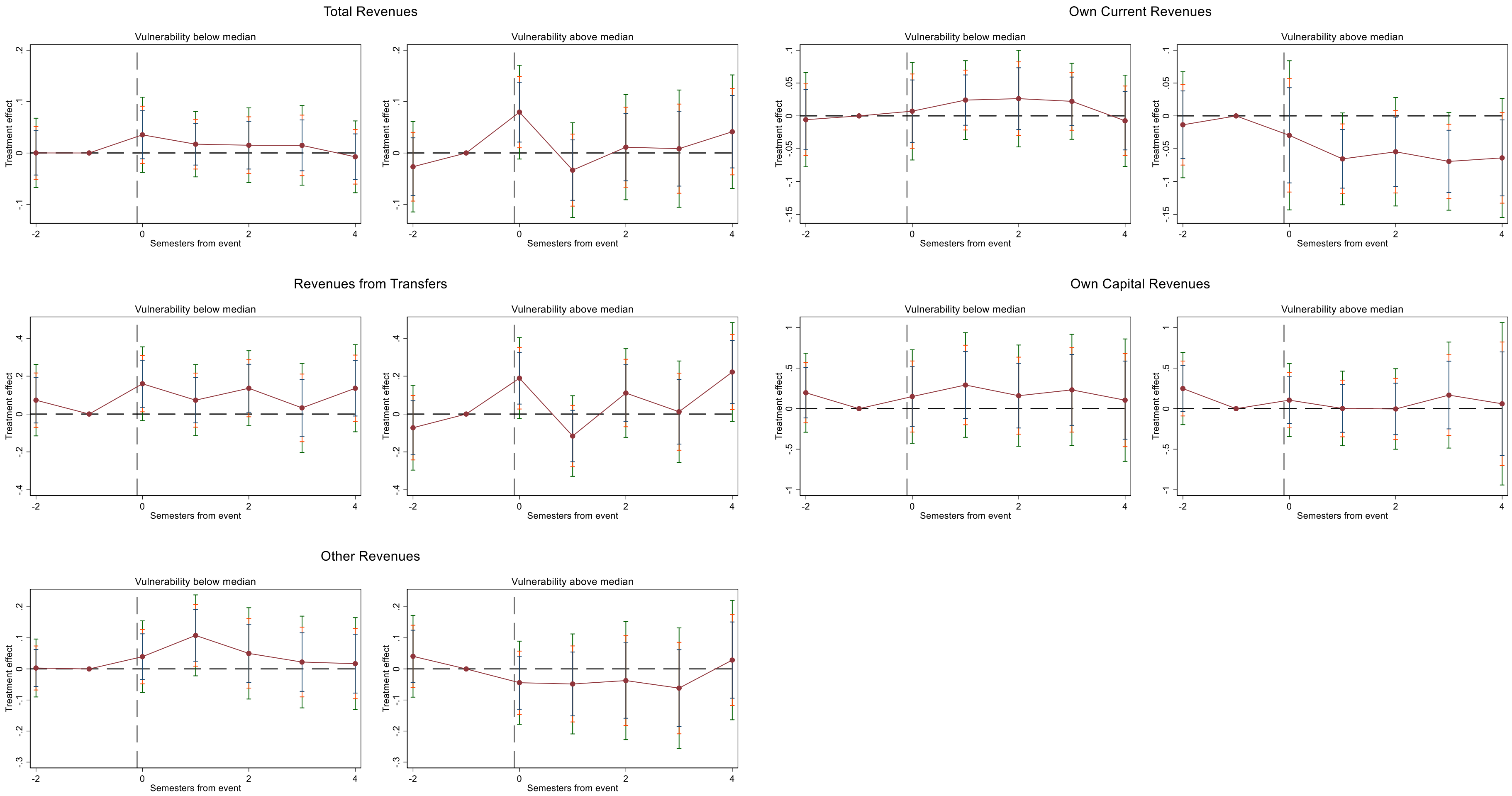
Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

Figure B.5. Difference-in-Difference estimations by vulnerability level - Expenditures



Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

Figure B.6. Difference-in-Difference estimations by vulnerability level - Revenues



Notes: three levels of statistical significance are reported. Blue p-value<0.1; Orange p-value<0.05; Green p-value<0.01.

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