The Impact of Floods on Firm Performance and Relocation

Nicoletta Berardi*, Elie Malhaire , Jules Tapin , Paul Vertier*, and Chloé Zapha*

*Banque de France

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Abstract

This paper investigates the effects of floods on firms in France, combining their financial information and exact location with administrative data on floods at the municipality level between 2004 and 2024. For firms located in municipalities hit by a flood, sales and survival rates decrease up to 6 years following the event. Moreover, these firms are more likely to relocate to safer areas. These effects are driven by severe floods. We find evidence of both exposure and adaptation effects: firms located in riskier areas experience stronger impacts, and those located in municipalities with a prevention plan are less affected.

Codes JEL: L20, Q54, G30, D22

Keywords: firm performance, floods, natural disasters, location decision

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1 Introduction

Climate change is expected to increase the frequency and severity of floods and has already started to generate sizable economic damage (Fernandez and Parker (2025)). While a large literature has highlighted the macroeconomic effect of floods, with largely converging results (Felbermayr and Gröschl (2014); Noy (2009); Costa and Hooley (2025)), their effects on firms are still partially documented.

In particular, while effects on firm performance and financial ratio have been documented, less is known regarding the location of firms. Yet, this is crucial, as endogenous location decision of firms may represent an important adaptation lever to climate change.

In this paper, we document the effects on both firm performance and location, using extensive firm-level data for companies with more than 750 K€ of annual sales, covering their location and financial information in France over 20 years (2004-2024). We merge the latter with French administrative data on natural disasters at the municipality level. This dataset reports all declared states of natural disasters by ministerial authorities following significant events, where states of natural disasters are declared at the municipality level.

Our results are the following. First, we find that firms located in affected municipalities are more likely to exit the sample and have reduced performance, up to 8 years after a flood. In particular, firms located in flooded municipalities have lower sales, employment and total assets. These results are more pronounced for more severe events (i.e., lasting at least one week). We also find evidence of both exposure and adaptation channels. The effects are stronger for firms located in 1-in-100 years floodplain (exposure effect), but mitigated for firms located in municipalities with a natural risk prevention plans (adaptation effect).

Second, we find that affected firms are more likely to change their location. They are more likely to move to a municipality with lower risk, or to another area within the same municipality. When they change municipality, they tend to change urban area, but not county and employment area. Affected firms are also more likely to change their sector of activity.

Our contributions are threefold. First, we are among the first papers to document

the effect on firm location[1]. Exceptions are Indaco et al. (2021), focusing on a single event (hurricane Sandy), Castro-Vincenzi (2022) in the case of car MNEs, and Balboni et al. (2023) in Pakistan. French open-source administrative data, which track the history of firms' locations, makes this analysis possible.

Second, we not only study a wide range of indicators of firm performance, but we complement it with survival analysis, finding results coherent with those of the literature (Fatica et al. (2024), Clò et al. (2024), Bijnens et al. (2024)).

Our third contribution is methodological. Indeed, a challenge in this literature relates to how we identify whether a firm is affected or not by a flood. Seminal contributions use administrative data indicating regions affected by natural disasters, without a clear identification of affected firms within the region (Leiter et al. (2009); Coelli and Manasse (2014); Noth and Rehbein (2019)). However, given the highly localized nature of floods (James and Schumacher (2024); Stephens et al. (2015)), the use of such indicators is likely to yield measurement errors biases. In fact, most papers using this type of approach showed positive effects on firms' activity, likely due to displacement effects of economic activity which cannot directly be estimated through this methodology. Additionally, administrative reporting of natural disasters is prone to biases, as they rely on the availability of estimations of economic damages and on insurance coverage (Felbermayr and Gröschl (2014), Grislain-Letrémy (2018)).

Other contributions use only exposure, notably using flood maps or number of past events in a location. While having its own merits, this approach is likely to yield very different results from those using actual events (Jia et al. (2022)). Alternative approaches combine these methods, using both data on the occurrence of actual disasters in a region and data on ex-ante exposure based on flood hazard maps (Fatica et al. (2024)), allowing to show a displacement of economic activity toward non-affected areas. Yet another method consists in using directly precipitation data (Noth and Rehbein (2019)). However, flash floodings are particularly hard to predict and non-linear in the level of precipitations (James and Schumacher (2024); Stephens et al. (2015)), and their occurrence does not mechanically predict economic damages, as the latter depend, for instance, on the degree of urbanization (Noy (2009)).

[1] Thi et al. (2025) in France and Bernard et al. (2024) in Australia explore residential mobility after a flood.

While no method is perfect, combining them can yield rich information (Gautier et al. (2024)). This is what we propose in this paper. The use of administrative data at a municipality-level serves as a benchmark, which separates directly, within a region affected by floods, which municipalities are affected and which are not[2]. From this standpoint, the closest paper from our baseline methodology is the one of Clò et al. (2024), using administrative data at the municipality-level[3]. However, we augment the latter with information related to the intensity of the event (based on the duration of the flood) and on the ex-ante exposure (using the geolocation of 1-in-100 years floodplains). We also show that, at the municipality level, flood occurrence can be very well predicted by ground-level precipitation, providing an alternative methodology for estimating intensity effects. These different methodologies yield coherent results, suggesting that the municipal-level is a relevant starting point for evaluating the effects of natural disasters, which however needs to be augmented with additional information.

This paper is organized as follows. Section 2 describes the data and our empirical approach. Section 3 presents the main results. Section 4 assesses the robustness of the findings. Section 5 concludes.

2 Data and empirical approach

2.1 Natural disasters and floods in France

Our analysis relies on flood data drawn from the GASPAR database[4], the national administrative register of natural risks in France. Available since 1982, it compiles exhaustive information on all natural disasters at the municipality level that have led to the issuance of an official decree. For each disaster, it provides information about its type, location (municipality identifying code), start and end dates.

GASPAR also provides information on the existence of natural risk prevention

[2]France is an interesting case from this standpoint, with a high number of small municipalities comparatively to other European countries.

[3]Our work also relates to that of de L'Estoile et al. (2025), who estimate effects of floods with dummies for the municipalities, but only for real estate, equipment, cash, and EBITDA, and without estimating how ex ante flood risk affects the results. Their paper also focuses on flood risks, without linking it explicitly to flood occurrence in their econometric specification.

[4] *"Gestion Assistée des Procédures Administratives relatives aux Risques".*

plans (PPRN)[5] within the municipality, as well as information on the exposure of municipalities to major natural risks[6]. This last information allows us to characterize municipalities according to their ex ante flood risk exposure, independently of realized flood events.

We restrict our analysis to flood events, namely coastal flooding, flooding caused by rising groundwater levels, and marine submersion. While GASPAR does not provide a direct measure of flood magnitude, the availability of event dates allows us to construct a measure of flood duration, which we use as a proxy for flood intensity. More precisely, we define municipalities as affected by severe floods when the sum of days during which floods where declared in a given year is above seven. As documented in Table 1, conditionally on being hit by a flood, 10% of firms are affected by severe floods in a given year. We further restrict the analysis to mainland France including Corsica and focus on the period starting in 2004 until 2024.[7]

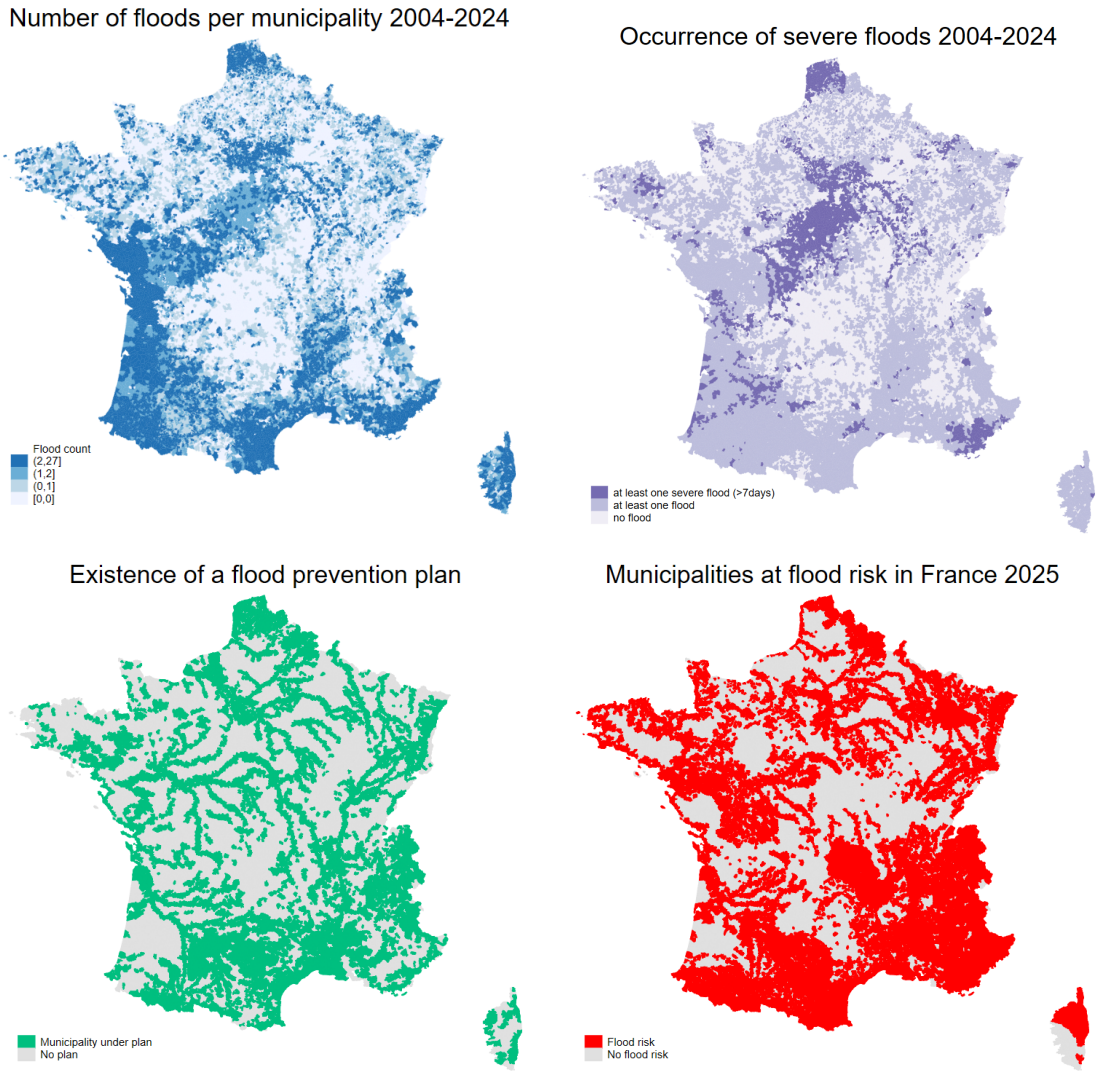
Panel a of Figure 1 maps the cumulative number of flood events at the municipality level over the past twenty years across France. Flood exposure is particularly concentrated in coastal areas, the Provence–Alpes–Côte d'Azur (PACA) region, and along major river basins. Panel (b) displays the spatial distribution of severe floods, defined as municipalities affected by floods for seven days or more within a year. Under this definition, the central and northern regions appear to be the most frequently affected. Panel (c) maps the municipalities that have had a natural risk prevention plans for flood within the period, and panel (d) the firm that are considered at risk in 2025.

[5] *Plans de Prévention des Risques Naturels* is a French state-led regulatory instrument designed to reduce the vulnerability of people and property exposed to natural hazards (e.g., floods, landslides, avalanches, seismic risks). Once approved by prefectural decree, the PPRN becomes a public easement and restrict land use and construction permits. Plans can target a single hazard (e.g., PPRi for floods) or cover multiple hazards.

[6] The *Dossier Départemental sur les Risques Majeurs*, or DDRM, is compiled at the departmental level by the prefect and identifies all municipalities exposed to significant natural or technological hazards and for which preventive information measures are required. GASPAR does not provide the history of the information but only the current level of risk.

[7] This choice avoids contamination from the exceptional 1999 storms, which affected approximately 80% of municipalities.

Figure 1: Flood maps



Note: Figure 1, municipalities affected by severe floods are those affected by floods for 7 days or more within a year. The flood prevention plan map indicates the municipalities which had at least one year with an active prevention plan during the period. The municipalities at flood risk map represents the existence of a flood risk at the municipality level as assessed in GASPAR in October 2025.

Table 1: Firms descriptive statistics

	Mean	SD	D1	Q1	Q2	Q3	D9	Number of obs.
Sales	5,460	44,891	918	1,188	1,898	3,778	8,855	2,978,531
Assets	5,165	12,7301	406	633	1,138	2,363	5,643	2,978,531
Employees	19	43	3	6	10	19	39	2,890,269
Wage	968	2,754	147	267	472	897	1,811	2,978,531
EBITDA	349	2,948	-18	39	115	278	658	2,978,531
Investment	267	5,010	0	5	26	95	316	2,795,012
Long-term assets	3,947	126,238	72	195	492	1,258	3,195	2,978,531
Floods (%)	11	32	-	-	-	-	-	2,978,531
Floods cumul. duration (days) †	3.66	5.99	1	1	2	3	7	338,949
Prob. relocation (%)	3	17	-	-	-	-	-	2,581,807
Relocation distance (km) ‡	14.25	47.92	0.25	0.87	3.08	8.49	20.97	74,113
Prob. municipality change (%) ‡	48	50	-	-	-	-	-	74,861

Note: The table presents yearly descriptive statistics for the main variables of interest in the period 2004-2024. All financial variables are presented in K€. D1 is the first decile of the distribution, Q1 the first quartile, Q2 the median, Q3 the third quartile and D9 the last decile. Sample period: 2004-2024. †: among firms hit by a flood. ‡: among relocating firms.

2.2 Firms location and financial information

Our dataset covers the period between 2004 and 2024. We exclude firms located in the biggest French cities (Paris, Lyon and Marseille), those that we are not able to localize, and those belonging to municipalities which either were merged to other municipalities or were split between several municipalities. Some companies are in multiple locations because they have several establishments and are, therefore, excluded.[8] Finally, we drop real estate investment companies[9] and firms whose main activity is financial, agriculture, public administration, education, health, social action, as well as other services, such as entertainment and recreational activities.

The location of firms results from combining information on the geo-localized SIRENE dataset and financial statements. Firm-level financial statements are drawn from the FIBEN database, the Banque de France's firm registry covering non-financial corporations with annual turnover exceeding 750 K€. FIBEN provides detailed balance-sheet and income-statement information and captures, on average, approximately 72% of total value added and 65% of total employment in France.

[8]Firms with only one establishments represent 70 % of firms with sales above 750 thousand euros.

[9]In French, *Société Civile Immobilière* (SCI).

Table 1 reports the main descriptive statistics for our variables of interest. Our sample includes 2,978,531 observations, with 5 millions euros yearly sales and 19 employees, on average. 11% of observations concern firms located in a municipality hit by a flood during the year, and conditional on the occurrence of a flood, the average duration is of 3.7 days (with a top decile of 7 days). Each year, an average of 3% of firms relocate. Here, we consider that a firm relocates if we observe a change in its latitude-longitude coordinates. We then use municipality identifying codes to determine whether the firm changed of municipality: nearly half of relocating firms move to a different municipality. They move 14 km away on average, but only 3 km at the median.

2.3 Empirical sample and specification

To quantify the impact of floods on firm outcomes, our empirical specification follows Jordà (2005) and relies on local projections to estimates the effect at different horizons:

$$\Delta y_{i,t-1,t+h} = \beta_h flood_{i,t} + \sum_{j=1}^{3} \gamma_{h,j} \Delta y_{i,t-j-1,t-j} + \sum_{j=0}^{3} \delta_{h,j} X_{t-j} + FE_i + FE_t + \varepsilon_{i,t+h} \quad (1)$$

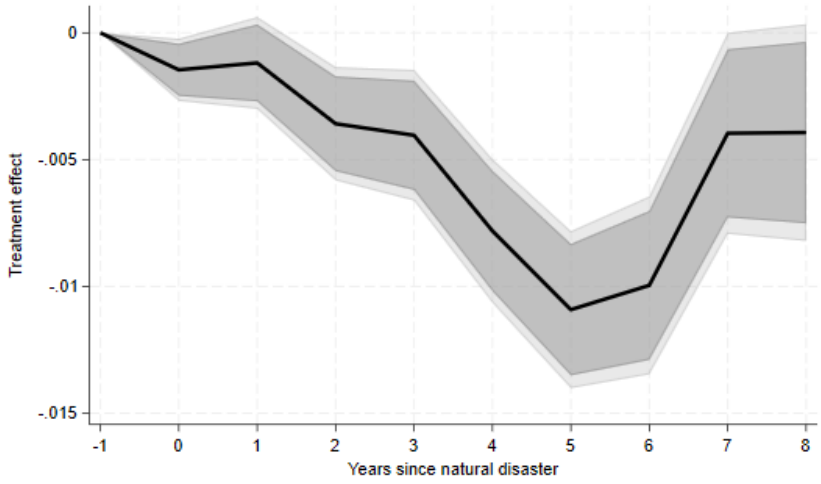
The main outcome variable of interest is the yearly variation of sales, $\Delta y_{i,t-1,t+h} = \frac{y_{i,t+h} - y_{i,t+h-1}}{y_{i,t+h-1}}$. The coefficients of interest are β_h at different time horizons h up to $h = 8$. They convey the impact over time of the dummy variable $flood_{i,t}$, that is the event of a flood in the municipality where firm i is located in t. We control for a vector of control variables, $X_{i,t}$, as well as for fixed effects at the firm (FE_i) and year (FE_t) level. $X_{i,t}$ notably includes dummy variables indicating the occurrence of landslides, droughts or other natural disasters, as well as three lags of each of these indicators. Our benchmark specification also controls for three lags of the dependent variable, as well as three lags of the control variables, as recommended by Montiel Olea and Plagborg-Møller (2021). Since the treatment varies at the municipality-year level, standard errors are clustered at the municipality-year level.

3 Results

3.1 Impact of floods on firms' outcomes and survival

Floods have a significant negative impact on firm performance. Figure 2 shows that the estimated effect of a flood on sales growth is negative, though not very statistically significant, between the year of the event and the following one. After two years the negative effect amplifies and reaches its maximum (-1 p.p.) five years after the event. After seven years the impact of the flood fades and firms' total sales recover close to its pre-flood level.

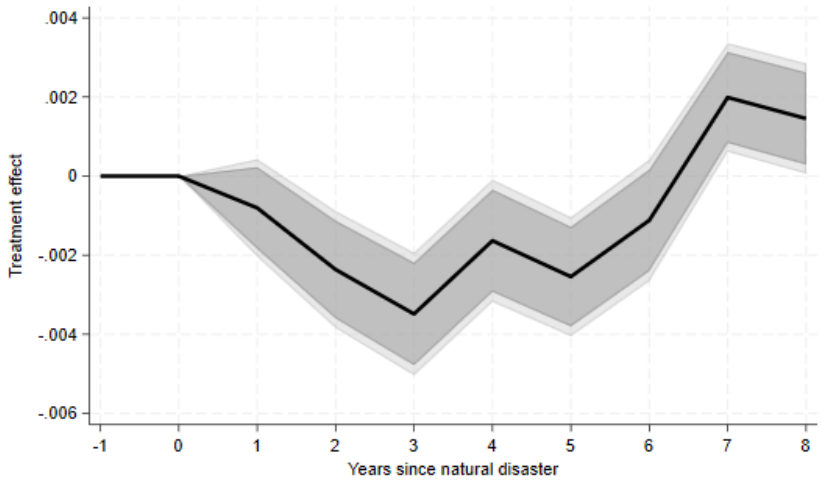
Figure 2: Benchmark: effect of floods on sales



Note: Plotted is the cumulative impulse response of sales to a flood occurring in the municipality where the firm is located (solid line). Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

This negative effect on sales affects the survival of the firm. Figure 3 shows that, on average, floods durably decrease the probability of survival of firms, with a maximum effect three years after the event: a firm hit by a flood is 0.3 p.p. less likely to stay in our sample.

Figure 3: Benchmark: effect of floods on survival



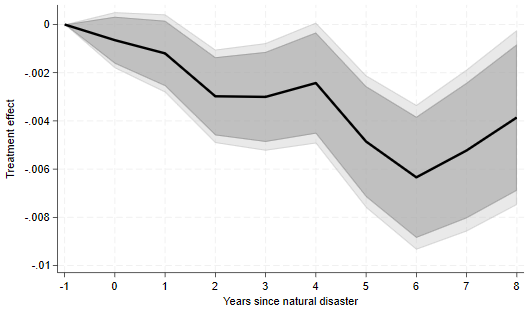
Note: Plotted is the cumulative impulse response of a dummy variable indicating whether a firm present in the sample in $h=0$ is also present in the sample at horizon h, to a flood occurring in the municipality where the firm is located (solid line). Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

The event of a flood in the municipality where a firm is located has a negative impact on several firm indicators. Figure 4 highlights a negative effect on employment and staff costs (Panels a and b). The negative impact on sales growth is at least partly compensated by cost adjustments, so that EBITDA does not significantly decrease on average, except in the very first year after the event (Panel c). Consistently with the resilience of EBITDA, investment is preserved (Panel d). The growth of total assets is not immediately affected, but a negative effect becomes statistically significant three years after the flood (Panel e). This effect is however not driven by long-term total assets (Panel f).

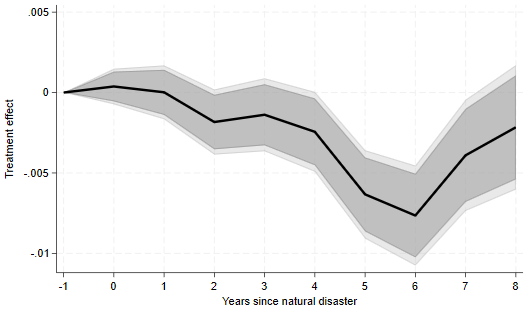
3.2 Exposure and adaptation

Two important factors might affect the extent to which firms are affected by floods. On the one hand, firms located in more flood-prone areas are more likely to be

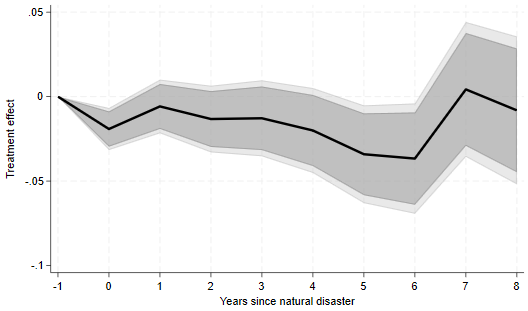
Figure 4: Employment and wage.



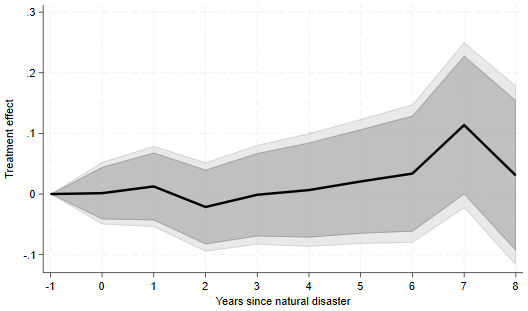
(a) Employment



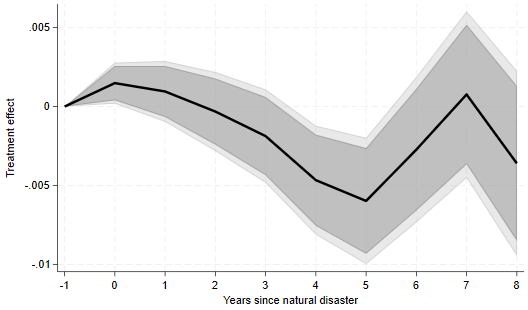
(b) Staff costs



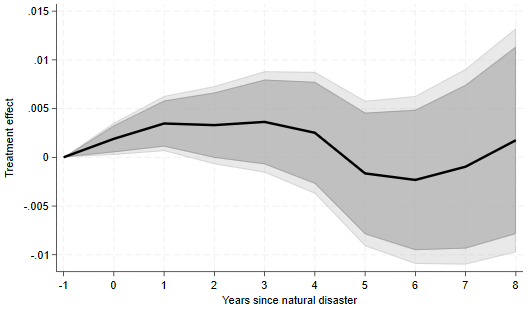
(c) EBITDA



(d) Investment



(e) Total assets

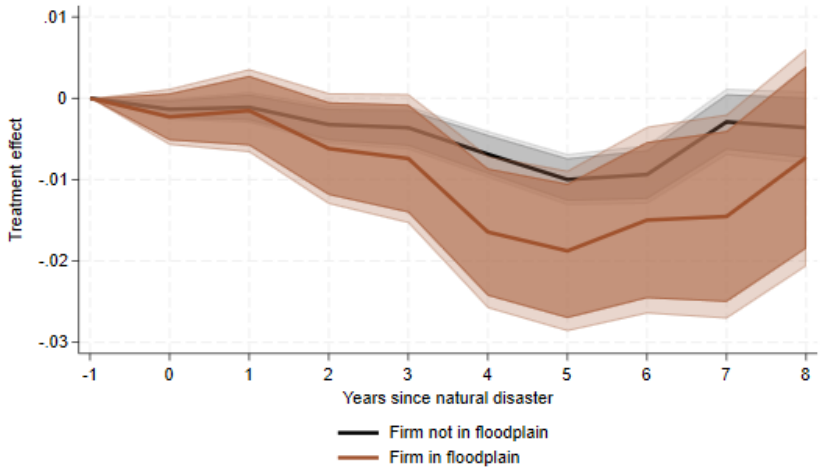


(f) Long-term assets

Note: Plotted are the cumulative impulse response of different firm-level outcomes to a flood occurring in the municipality where the firm is located (solid line). Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

severely affected by a given event (exposure effect). On the other hand, firms located in areas which implemented some adaptation plans might be more resilient (adaptation effect). We find evidence for both these channels.

Figure 5: Exposure: sales



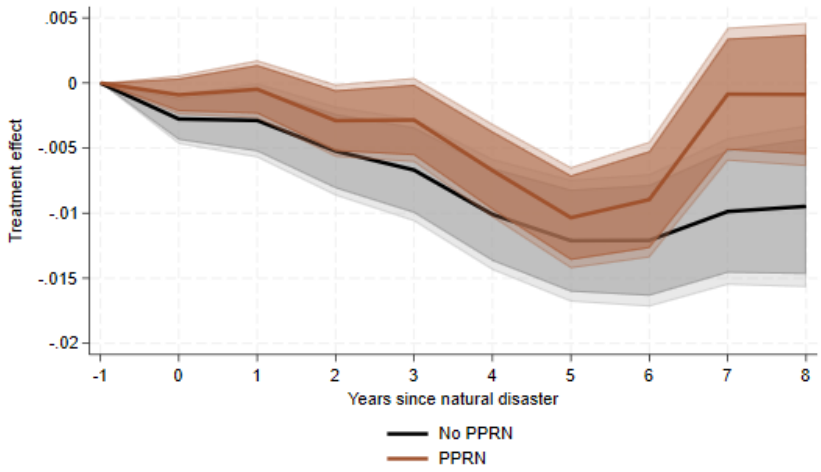
Note: Plotted are the cumulative impulse response of sales to a flood occurring in the municipality where the firm is located. The brown line is the response for firms located in 1-in-100 years floodplains , while the black line is the response for other firms. Shaded areas show respectively 90 % confidence interval (dark brown and grey) and 95 % confidence interval (light brown and grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

First, we test the exposure effect by identifying firms located in 1-in-100 years floodplain, using the dataset of Dottori et al. (2021), matching it with the exact geolocation of the firm, regardless of municipal boundaries.[10] Figure 5 shows that, for a given flood, the negative effect on sales is stronger for firms located in a floodplain.[11] Second, we test the adaptation effect by distinguishing firms located in municipalities with a natural risk prevention plan for floods (PPRN) and those without. Figure 6 shows that the negative impact on sales growth is mitigated for firms that are located in municipalities with a PPRN, which may have engaged in

[10] 1-in-100 floodplains are identified, at a 100-meters spatial raster level, as the areas that would be inundated by 1-in-100 flood (that is, a flood event that has a 1% chance of occurring in any given year).

[11] This effect is coherent with those found by Fatica et al. (2024).

Figure 6: Adaptation: sales



Note: Plotted are the cumulative impulse response of sales to a flood occurring in the municipality where the firm is located. The brown line is the response for firms located in municipalities with a prevention plan for floods (PPRN), while the black line is the response for other firms. Shaded areas show respectively 90 % confidence interval (dark brown and grey) and 95 % confidence interval (light brown and grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

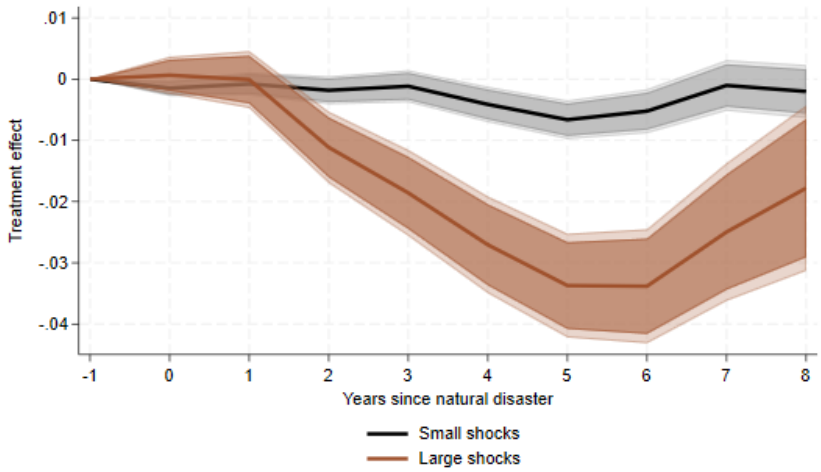
adaptation measures that can lessen the negative effect of a new flood.

3.3 Severe floods

Above, we examined the extensive margin impact of floods on sales. In this section, instead, we evaluate their impact at the intensive margin. To do so, among all floods, we distinguish those lasting longer than seven days from the other ones. On average, among firms hit by floods, 10% are affected by severe floods each year.

Figure 7 shows that the intensity of a flood crucially determines its impact on a firm. Short lasting floods don't have a significant impact on firms' sales growth. However, more severe floods have a very strong negative effect. Two years after event, the estimated negative effect is -1 p.p. and then amplifies, reaching its maximum (-3 p.p.) three years later. The latter compares with a 1 p.p. effect estimated in section 3.1 for all floods.

Figure 7: Severe floods and other floods: sales

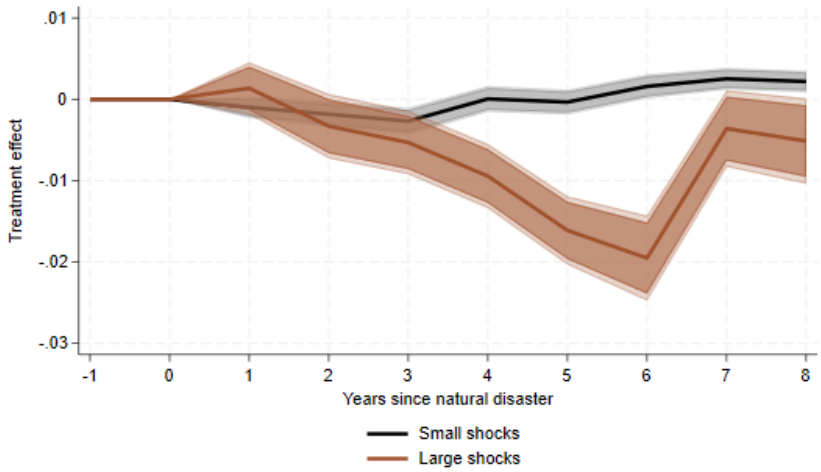


Note: Plotted are the cumulative impulse response of sales to floods occurring in the municipality where the firm is located. The brown line is the response to severe flooding (municipalities flooded more than 7 days), while the black line is the response to less severe flooding. Shaded areas show respectively 90 % confidence interval (dark brown and grey) and 95 % confidence interval (light brown and grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

Consistently, Figure 8 shows that, on average, lasting floods do not have a significant impact on firms' survival. Instead, the negative impact of severe floods amplifies after three years and reaches its maximum (-2 p.p.) six years after the event. This compares with a 0.3 p.p. effect estimated in section 3.1 for all floods.

Severe floods result in stronger negative effects for several indicators (Figure 9). While their effect on employment is comparable to short-lasting floods (Panel a), their impact on staff costs are stronger (Panel b). These stronger cost adjustments, however, only partially compensate the sizable negative impact on sales, so that EBITDA significantly decreases on average, while this is not the case for shorter-lived floods (Panel c). For the severe floods, investment, total assets and long-term assets tends to decrease (Panels d to f), with negative effects lasting up to four to six years, while short-lasting floods have no impact on these outcomes.

Figure 8: Severe floods and other floods: survival



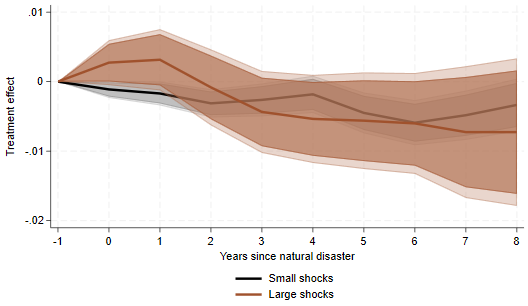
Note: Plotted are the cumulative impulse response of a dummy variable indicating whether a firm present in the sample in $h{=}0$ is also present in the sample at horizon h to floods occurring in the municipality where the firm is located. The brown line is the response to severe flooding (municipalities flooded more than 7 days), while the black line is the response to less severe flooding. Shaded areas show respectively 90 % confidence interval (dark brown and grey) and 95 % confidence interval (light brown and grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

3.4 Impact of floods on firms' relocation

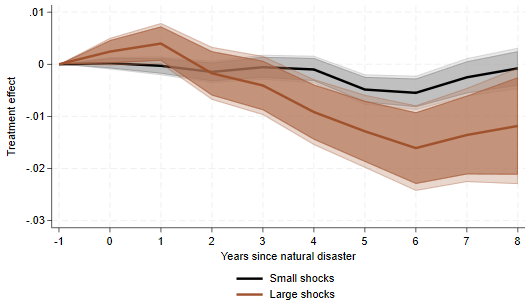
If floods have a negative impact on firms, as shown in section 3.1, they may contribute to a firm's decision to relocate to an area with lower risk.

Figure 10 (Panel a) shows that, one year after a flood, firms are more likely to decide to relocate to a municipality with a lower risk of flood, defined as those with a lower count of floods in the 20 years before the flood. The probability of relocating increases year after year, reaching its maximum four years after a flood (almost +0.3 p.p.). Quantitatively, this relocation effect entails that a firm located in a municipality hit by a flood is 10% more likely to move to a lower risk area. Indeed, at a four-year horizon, about 3% of firms change for a municipality with a lower risk. This relocation effect is largely driven by severe floods. Indeed, six years after a flood lasting more than a week, the probability of relocating increases by 0.5

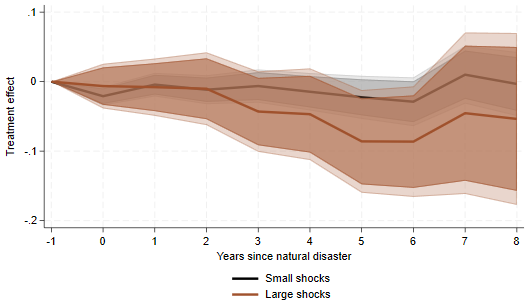
Figure 9: Severe floods and other floods: other variables



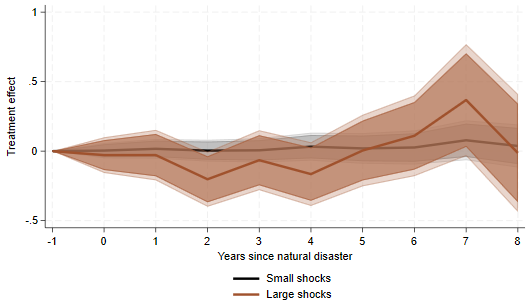
(a) Employment



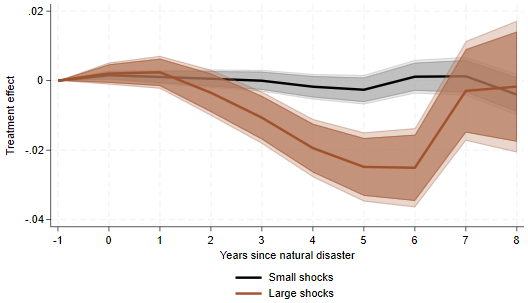
(b) Staff cost



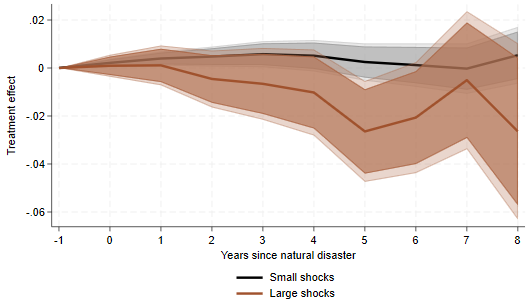
(c) EBITDA



(d) Investment



(e) Total assets

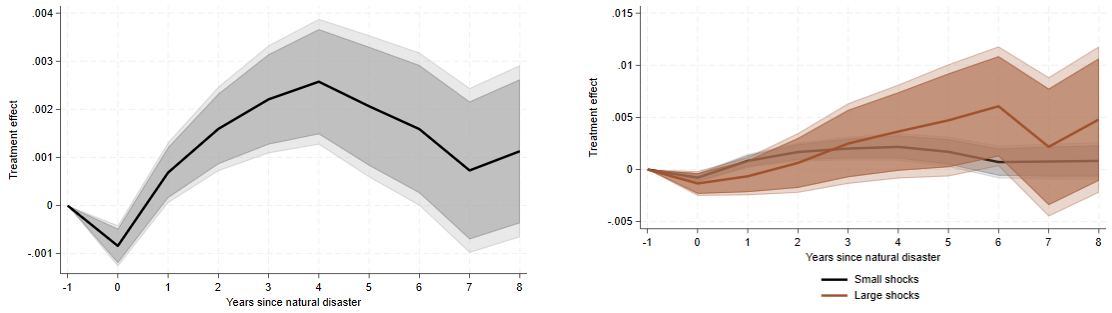


(f) Long-term assets

Note: Plotted are the cumulative impulse response of different firm-level outcomes to floods occurring in the municipality where the firm is located. The brown line is the response to severe flooding (municipalities flooded more than 7 days), while the black line is the response to less severe flooding. Shaded areas show respectively 90 % confidence interval (dark brown and grey) and 95 % confidence interval (light brown and grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

p.p. (Panel b).

Figure 10: Moving to municipalities with less floods in previous 20 years



(a) Benchmark effect

(b) Severe floods and other floods

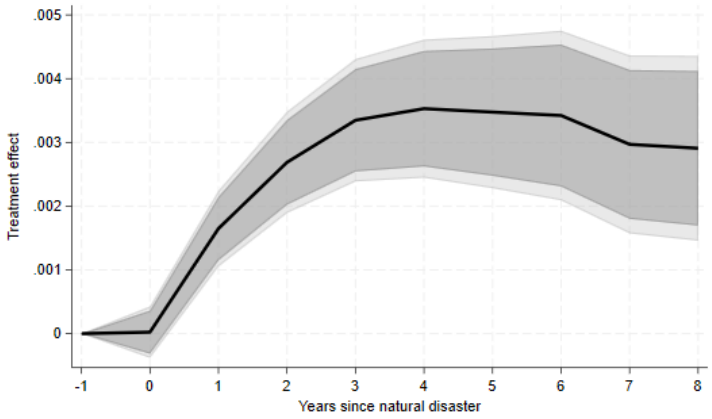
Note: Plotted are the cumulative impulse response of a dummy variable indicating whether the firm is located in a municipality with a lower flood risk than in *h=-1*, where flood risk corresponds to the cumulative number of floods in the past 20 years, to floods occurring in the municipality where the firm is located. Panel a presents the effects for all floods. Panel b distinguishes the response between severe flooding (brown line, municipalities flooded more than 7 days), and less severe flooding (dark line). Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

We test the robustness of the flood relocation effect to alternative proxies of flood risk. In particular, beyond relying on the definition of flood risk based on the flood occurrence of the past 20 years, we proxy lower flood risk as municipalities with higher altitude. Figure 11 shows that, after a flood, firms are more likely to relocate to a municipality with higher altitude. Figure 21 in the Appendix also shows that, after a flood, firms are more likely to relocate to a municipality with lower flood risk (as identified by a dummy variable indicating whether, as of 2025, the municipality was classified as having a flood risk in GASPAR), not on the coast (absence of *Loi Littoral*)[12], and areas that are not 100-year floodplains.

We also test the robustness of the relocation effect, independently on the flood risk of the new location. Figure 12 shows that, after a flood, firms are more likely to

[12]Enacted in 1986, the *Loi Littoral* was passed by the French Parliament to manage urban development along the coast in a sustainable way. It applies to more than 1,200 coastal municipalities in mainland France and overseas territories—those bordering seas, large lakes (>1000 ha), estuaries, or deltas.

Figure 11: Moving to higher altitude



Note: Plotted is the cumulative impulse response of a dummy variable indicating whether a firm in horizon h is located in a municipality with higher average altitude than the municipality it was located in during h=*-1*. Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

relocate to another municipality, or urban unit.[13] Firms sometimes relocate within the same municipality, but most importantly, they remain in the same employment area[14] or county[15] In other words, while firms are more likely to relocate after a flood, they typically don't move away from their local market.

A flood does not only increase the probability that a firm chooses a new location, but also changes its activity. Figure 13 shows that, five years after a flood, a firm is on average 0.1 p.p. more likely to change its 4-digit NACE. While some of these changes may simply reflect minor administrative corrections, they often represent an at least partial changes in the nature of a firm's activity.[16]

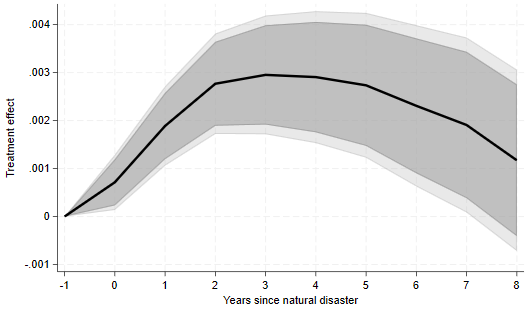
[13]There are about 2500 urban units in France.

[14]There are about 300 employment areas in France.

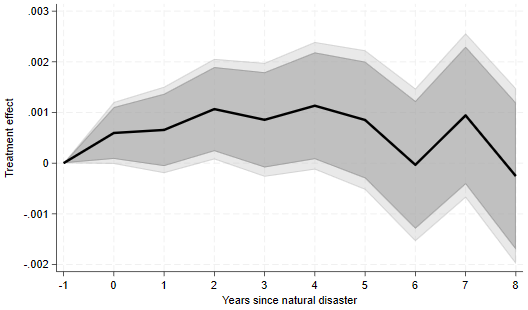
[15]Among the 3% of firms relocating every year, only 11% change county (i.e., a total of 0.3%).

[16]Indeed, Figure 22 in the Appendix shows that five years after a flood, a firm is on average 0.08 p.p. more likely to change its sector (defined at the A38-level), while at the same time rarely entirely changing macro-sector (defined at the A10 level).

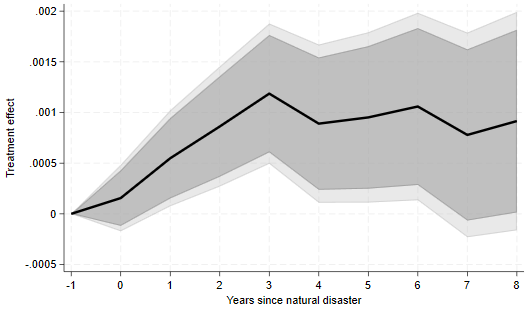
Figure 12: Robustness to alternative definition of relocating.



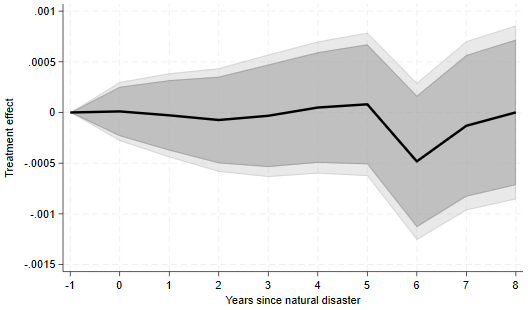
(a) Moving to another municipality



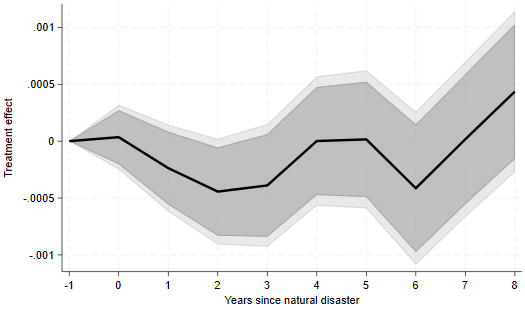
(b) Moving to another location in same municipality



(c) Moving to another *unité urbaine*



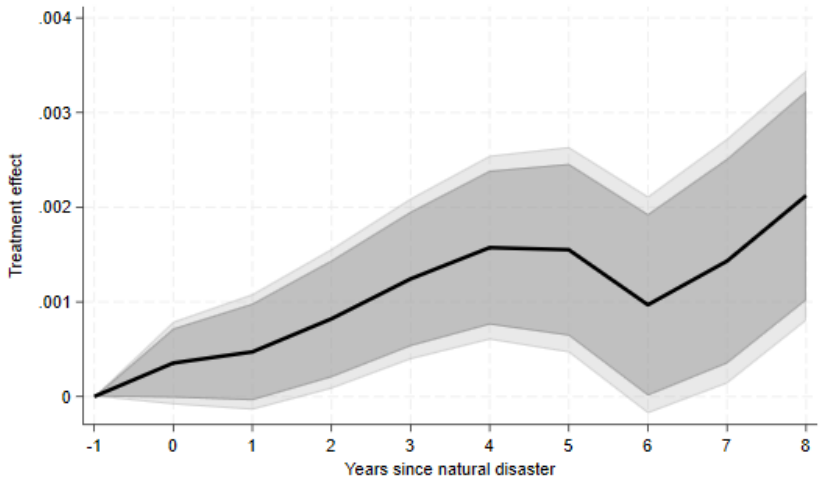
(d) Moving to another employment area (French *zone d'emploi*)



(e) Moving to another county (French *département*)

Note: Plotted are the cumulative impulse response of a dummy variable indicating whether a firm in horizon h is located in a different municipality (panel a) or in a municipality with different characteristics compared to the one in *h=-1*. Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

Figure 13: Probability of changing sub-sector (NACE 4-digit) after a flood.



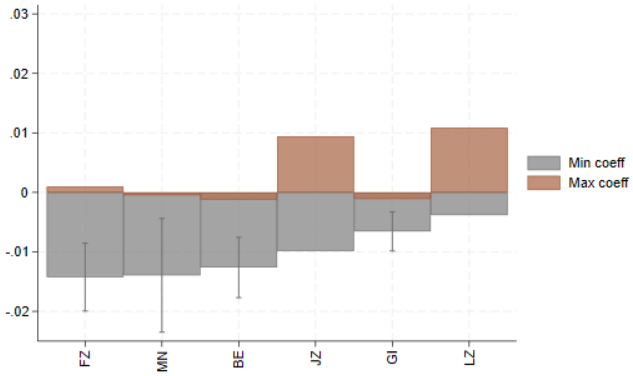
Note: Plotted is the cumulative impulse response of a dummy variable indicating whether a firm in horizon h has a different sub-sector than the one it had in h=*-1*. Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

3.5 Sectoral and regional heterogeneity

The negative impact of floods on firm's sales growth is heterogeneous across sectors. Figure 14 shows that the estimated coefficients are always negative in the case of manufacturing, consulting and scientific services, and trade, transportation, and accommodation. Despite the estimation of some positive coefficients in construction, the vast majority is negative, and the among the most severe ones, together with manufacturing, consulting and scientific services. The effect of a flood is instead less clearcut in the case of the information and communication sector. Indeed, for some firms belonging to this sector the impact is negative and for others is positive. Finally, for firms in the real estate sector, the impact of a flood on their sales growth can actually be very positive.

We also investigate the heterogeneity of the impact of floods on firm's sales growth across French regions. Figure 15 suggests that the sales growth of firms on Atlantic regions can be strongly hindered (e.g., Poitou-Charentes, Haute Normandie,

Figure 14: Sectoral heterogeneity: sales.

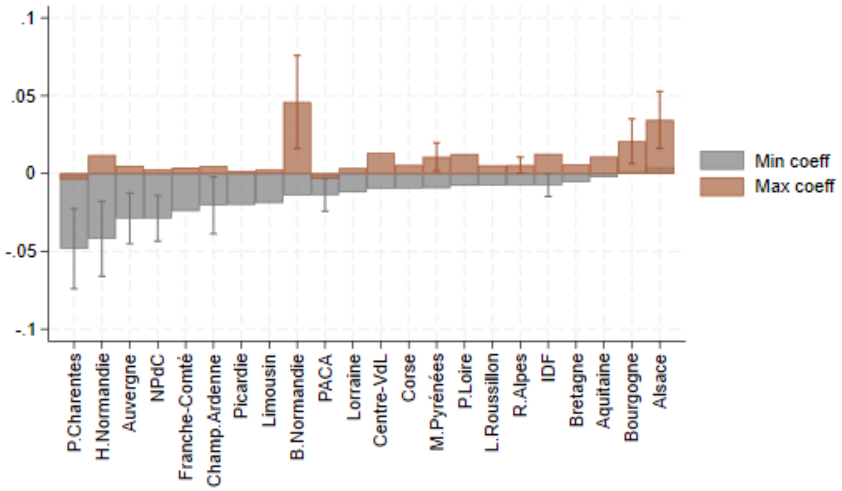


Note: Plotted are the maximum (brown bars) and minimum (grey bars) estimated cumulated effects of a flood on sales, between *h=0* and *h=8*, broken down by sector. Caps indicate 95 % confidence interval. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024. FZ = construction; MN = consulting and scientific services; BE = manufacturing; JZ= information and communication; GI = trade, transportation, and accommodation; LZ = real estate.

Nord-Pas-de-Calais, Picardie), in other regions the effects can be positive, like in Bourgogne and Alsace.

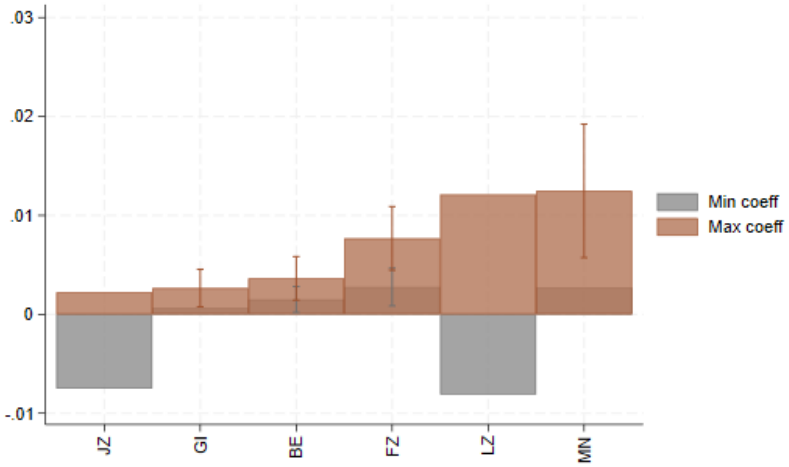
Finally, we examine the sectoral heterogeneity of the flood impact on a firm's decision to relocate. Figure 16 shows that firms of almost all sectors are more likely to move, but particularly so in the consulting and scientific services, construction, manufacturing, and trade, transportation and accommodation. In the real estate sector, as well as in the information and communication, some firms are likely to change location after a flood, but others on the contrary are less likely to do so.

Figure 15: Regional heterogeneity: sales.



Note: Plotted are the maximum (brown bars) and minimum (grey bars) estimated cumulated effects of a flood on sales, between *h=0* and *h=8*, broken down by region. Caps indicate 95 % confidence interval. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

Figure 16: Sectoral heterogeneity: relocating.



Note: Plotted are the maximum (brown bars) and minimum (grey bars) estimated cumulated effects of a flood on the probability of relocating, between *h=0* and *h=8*, broken down by sector. Caps indicate 95 % confidence interval. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024. FZ = construction; MN = consulting and scientific services; BE = manufacturing; JZ= information and communication; GI = trade, transportation, and accommodation; LZ = real estate.

4 Robustness

The vast majority of firms is located in only one place. However, some firms have multiple establishments located in different municipalities. In the event of a flood affecting only one location, we cannot examine the impact separately by establishment. Indeed, financial statements consolidates the information of establishments. It is not obvious that the effect of a natural disaster is stronger or weaker in the case of multi-establishment companies. Indeed, the effect could amplify or mitigate. For instance, on one hand, a manufacturing company whose activity is organized with a chain of several establishments, each one producing an input necessary to another one, could propagate the negative impact of a flood on one of its upstream establishments and the effect on the originally affected establishment could even amplify over the production chain. On the other hand, a service company whose activity is spread across several establishments, like a restaurant chain, could absorb the negative impact on one establishment affected by a flood and even neutralize it. Consistently, Figure 17 shows that, on average, for companies with multiple establishments, the impact of a flood occurring in the municipality of the headquarter is similar to that of single-establishment companies.

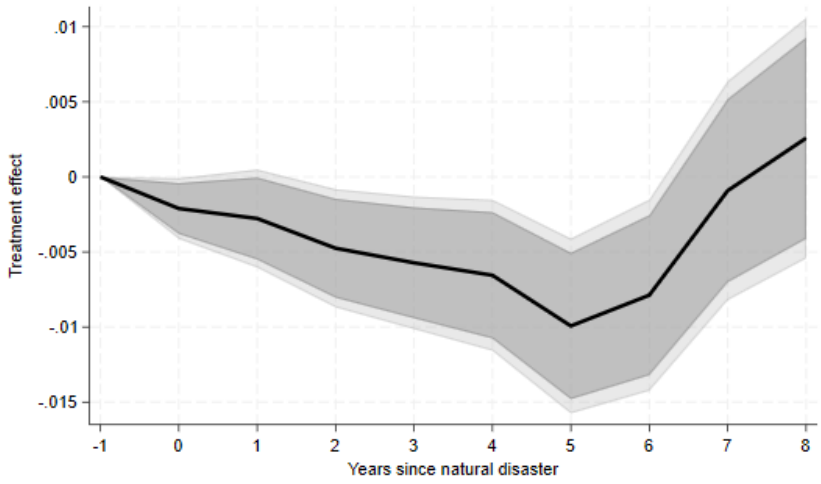
We also adopt an IV approach to take into account that there might be some measurement errors in the declaration of natural disasters, as the latter are notably correlated with the insurance coverage (Grislain-Letrémy, 2018). To do so we instrument the event of a flood with the maximum monthly rain level registered at the closest of the 900 observatories in France[17]. Figure 18 shows that, even accounting for endogeneity, a firm's sales growth is negatively affected by floods. The maximum effect is even much stronger than in the benchmark regression (about -4 p.p.), which suggests that this circumvents well potential attenuation biases due to measurement errors, and captures intensity effects [18].

Finally, we test the robustness of the negative effect of floods on firms' sales growth to alternative specifications. In particular, the left panel of Figure 19 shows that the result is robust to the inclusion of sector-year and county-year, instead of

[17]The first stage of this regression is highly relevant, as the Kleibergen-Paap rk Wald F statistic is above 500

[18]The fact that such an IV setting captures intensity effects is coherent with results from Gautier et al. (2024)

Figure 17: Multi-establishment companies: sales

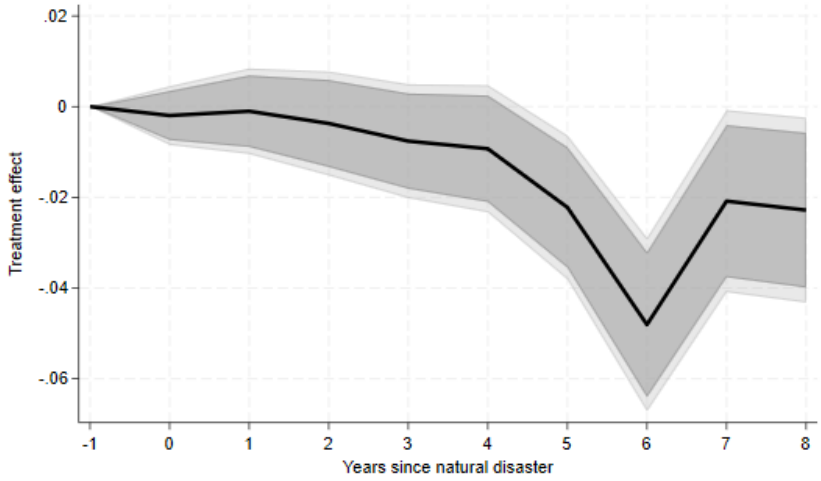


Note: Plotted is the cumulative impulse response of sales to a flood occurring in the municipality where the headquarter of the firm is located (solid line). Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024. The sample is restricted to multi-establishment companies.

firm and year, fixed effects. The right panel suggests that the result is qualitatively robust even combining firm fixed effects with sector-year and and region-year fixed effects, though part of the effect is absorbed.

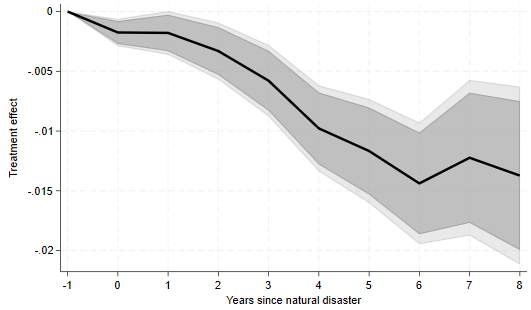
Finally, the left panel of Figure 20 shows that the result is also robust to the inclusion of forwards, while the right panel suggests that, when dropping lags from specification (1) there are no visible pre-trends.

Figure 18: IV: sales

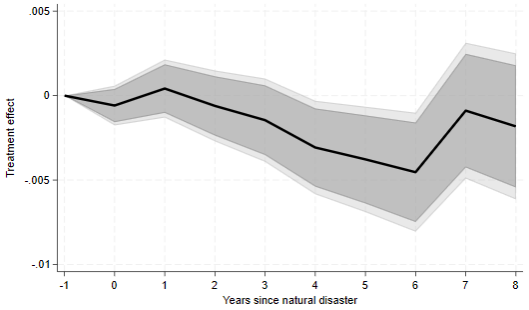


Note: Plotted is the cumulative impulse response of sales to a flood occurring in the municipality where the firm is located (solid line). The dummy indicating the occurrence of a natural disasters is instrumented by the maximum monthly rainfall during the year, in the closest meteorological station to the centroid of the municipality. Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

Figure 19: FE variants: sales.



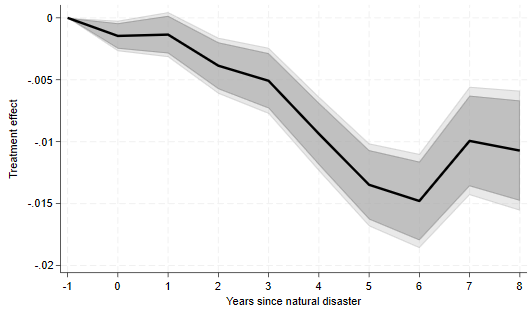
(a) With sector-year and county-year FE: sales



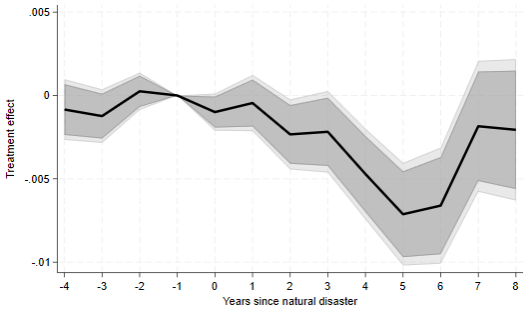
(b) With firm, sector-year, region-year FE: sales

Note: Plotted are the cumulative impulse response of sales to a flood occurring in the municipality where the firm is located (solid line). Panel a contains no firm fixed effect, but sector-year and county-year fixed effects. Panel b contains firm fixed effects, sector-year fixed effects and region-year fixed effects. Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

Figure 20: Specification variants: sales.



(a) Control for forwards: sales



(b) No lags, with pre-trends

Note: Plotted are the cumulative impulse response of sales to a flood occurring in the municipality where the firm is located (solid line). Panel a controls, on top of the baseline controls, for dummmies indicating whether floods occured betwen h=*-1* and the horizon h of estimation. Panel b controls for no lags of the endogenous variable or the shock, but plots the cumulative response functions for up to 4 backward horizons. Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

5 Conclusion

This paper provides evidence that firms located in municipalities affected by floods suffer lower sales. Their reduced performance is consistent with their higher probability of exiting the sample. Floods' impact of firms is more pronounced for severe events and for firms located in floodplains, but mitigated for firms located in municipalities with a natural risk prevention plan. We also find that flooded firms are more likely to move to a municipality with lower risk or to another area in the same municipality. When they change municipality, they tend to change urban area, but not county and employment area. Affected firms are also more likely to change their sector of activity.

It is important to consider that our estimates are likely lower-bound effects. First, the analysis is restricted to surviving firms, which introduces a downward bias since firms that exited likely suffered the strongest impacts. Second, if the insurance system is at least partially effective, its existence mitigates the losses, if the system is at least partially effective. Therefore, the estimated effect is likely to be lower that relative to the true economic cost.

While we find that floods significantly affects on firms' performance, so that the insurance system in place does not fully compensate floods' damages, future research should evaluate the degree of effectiveness of the insurance system in the face of increasingly recurrent and severe natural disasters.

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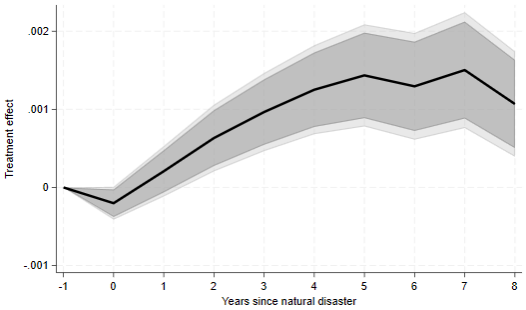
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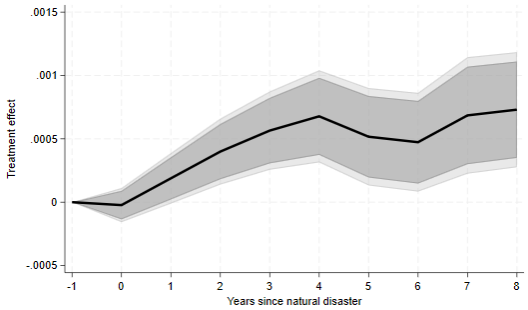
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Appendix

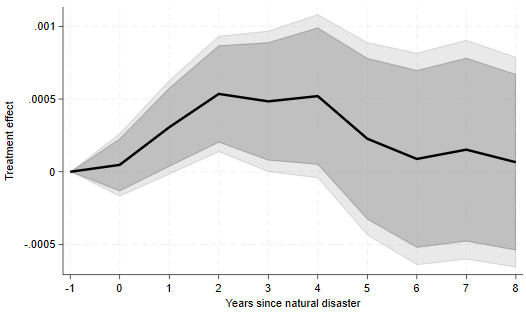
Figure 21: Robustness to alternative definition of lower flood risk.



(a) Moving to a lower risk municipality



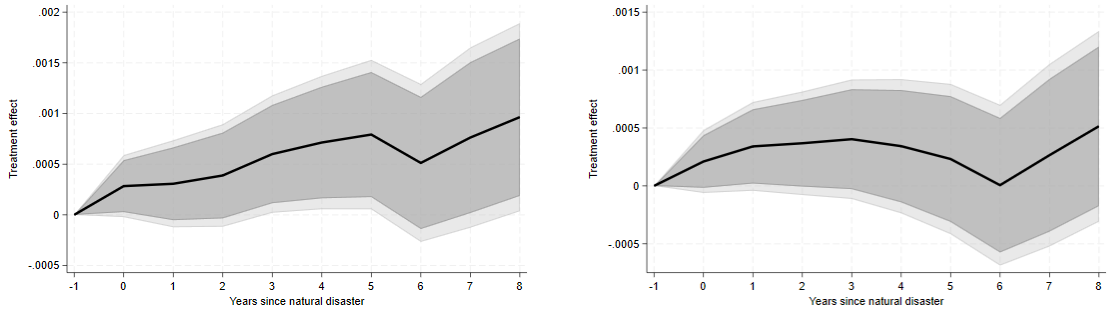
(b) Moving away from *loi litoral* municipality



(c) Moving away from floodplain

Note: Plotted are the cumulative impulse response of different indicators of firm relocation to a flood occurring in the municipality where the firm is located in *h=-1* (solid line). Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

Figure 22: Probability of changing sector (A38 and A10) after a flood.



(a) Changing sector A38 (b) Changing sector A10

Note: Plotted are the cumulative impulse response of firms' sector change following a flood occurring in the municipality where the firm is located (solid line). Shaded areas show respectively 90 % confidence interval (dark grey) and 95 % confidence interval (light grey). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.