WORKING paper

BANQUE DE FRANCE
EUROSYSTÈME

The Impact of Floods on Firm Performance and Relocation[1]

Nicoletta Berardi, Paul Vertier, Chloé Zapha, Elie Malhaire and Jules Tapin [2][3]

May 2026, WP #1047

Abstract

This paper investigates the effects of floods on firms, combining their financial information and exact location with administrative data on floods at the municipality level between 2004 and 2024 in France. For firms located in municipalities hit by a flood, both survival rates and sales deteriorate: their chances of survival drop by 2%, and their sales by 8%, for up to five years after the event. Moreover, these firms are more likely to relocate to safer areas in other municipalities. These effects are driven by intense floods, lasting at least one week. We find evidence of both direct and indirect effects: firms in 1-in-100 years floodplain are more affected than others, but even floods occurring in neighboring municipalities decrease firms' economic performance, with magnitudes attenuating as distance increases.

Keywords: Firm Performance, Floods, Natural Disasters, Location Decision

JEL classification: L20, Q54, G30, D22

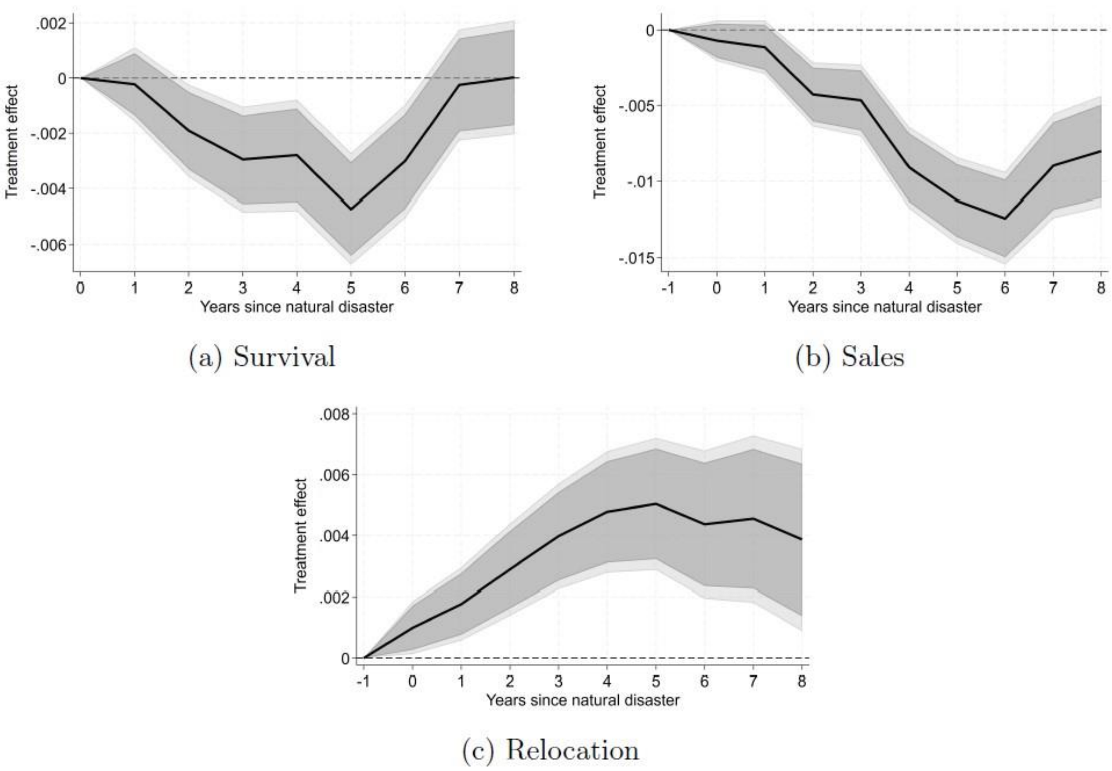
[1] The authors would like to thank Helia Costa, Erwan Gautier, Eric Jondeau, Mathias Lé, Josepa Miquel-Florensa, Sarah Mouabbi, Loriane Py, Paul Seabright and colleagues at the Companies Observatory. The views expressed in this article are those of the authors and do not necessarily reflect those of Banque de France or the Eurosystem. All remaining errors or omissions are our own.
[2] Banque de France : nicoletta.berardi@banque-france.fr, paul.vertier@banque-france.fr, chloe.zapha@banque-france.fr
[3] Banque de France at the time of contributing to the paper: elie.malhaire@ens-lyon.fr, julestapin@gmail.com

NON-TECHNICAL SUMMARY

Climate change is expected to increase the frequency and intensity of floods and has already started to generate sizable economic damage. However, the impact of floods on firms is only partially documented. In particular, while some contributions provide evidence of their effects on firm performance, less is known regarding flood effects on firms' relocation.

This paper documents simultaneously the effects of flood on firms' survival, financial ratios, and location. It combines extensive firm-level financial information data for companies with more than 750,000 EUR of annual sales, with their precise location and administrative data on natural disasters at the municipality level, for the period 2004-2024 in France.

Figure: Effects of floods on firm survival, sales, and relocation



Note: Plotted are the cumulative impulse response of survival (panel (a)), sales (panel (b)), and relocation probability (panel (c)) to floods occurring in the municipality where the firm is located. Shaded areas show respectively 90% (dark grey) and 95% (light grey) confidence intervals. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

Using local projections to account for dynamic effects, and focusing on single-establishment firms, we observe persistent negative effects of floods on firm performance. First, firms located in flooded municipalities are less likely to survive: 5 years after a flood, their exit rate is 2% higher. Second, surviving firms have lower economic performance: 5 years after a flood, their sales are 8% lower. Negative effects are also observed for their number of employees, staff costs, EBITDA, and investment. Finally, firms adapt to floods by relocating: 5 years after a flood, they are 4% more likely to have changed of location. Most of this effect can be explained by firms relocating to other municipalities, and, among them, by firms relocating to municipalities with a lower level of risk – as measured by the number of floods in the previous 20 years or by the altitude of the municipality. Firms that relocate tend to change urban area, but not employment area – i.e. broader zones where residents both live and work – suggesting they avoid receding from their local labour market and economic environment. However, the effects on survival and sales are not markedly different between firms that relocate and those that do not, suggesting that the costs of moving offset the benefits of pulling away from floods.

The effects are markedly stronger for intense events, as proxied by higher duration (floods lasting at least one week) or frequency (floods occurring more than once a year). Direct effects also appear stronger than indirect ones: firms located in 1-in-100 year floodplains – where productive capital is more likely to be destroyed or impaired – face more negative effects than firms outside, which are more likely to be indirectly affected through disruptions to local economic activity. In particular, directly affected firms face negative effects on their long term assets and are markedly more likely to relocate. Finally, we also find negative indirect effects on firms of floods occurring in neighbouring municipalities, although these effects decay with distance. The results are robust to a wide variety of alternative specifications, and also hold for multi-establishments firms.

Policymakers are increasingly aware of the rising costs associated to floods, and emphasize that firms' adaptation will be key to their resilience. While we confirm the significant adverse impact of floods, we also find that firms respond to floods by relocating to less risky areas, which constitutes a form of adaptation strategy. However, because firms chose to remain within their local market, they tend to relocate nearby, where they may still suffer from negative spillover effects. This suggests relocation might not be a sufficient strategy and should be complemented by additional adaptation measures.

L'impact des inondations sur la performance des entreprises et leur localisation

RÉSUMÉ

Cet article documente l'effet des inondations sur les entreprises. Il combine les bilans sociaux des entreprises et leur localisation avec des données administratives répertoriant les inondations à l'échelle des communes entre 2004 et 2024 en France. Les entreprises situées dans une commune touchée par une inondation voient leur taux de survie et leur chiffre d'affaires diminuer : leur chance de survie baissent de 2% et leur chiffre d'affaires de 8% jusqu'à cinq ans après l'évènement. De plus, les entreprises touchées ont une probabilité plus élevée de déménager vers des communes ayant un risque d'inondation plus faible. Ces effets sont plus forts pour les inondations intenses, qui durent une semaine ou plus. Nous documentons l'existence d'effets directs et indirects : les effets sont plus marqués pour les entreprises situées dans des zones inondables, mais les inondations ayant lieu dans des communes voisines réduisent également les performances des entreprises, l'ampleur de l'impact diminuant avec la distance.

Mots-clés : performances des entreprises, inondations, catastrophes naturelles, choix de localisation

1 Introduction

Climate change is expected to increase the frequency and intensity of floods and is already generating sizable economic damage (Fernandez and Parker (2025)).

While a large literature has examined the macroeconomic effect of floods, with largely converging results (Felbermayr and Gröschl (2014); Noy (2009); Costa and Hooley (2025)), their effects at the firm level are only partially documented. In particular, while the impact of floods on firm performance has been studied, less is known regarding the relocation 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 investigate flood effects on both firm performance and location, using comprehensive firm-level data for companies with more than 750,000 € of annual sales, covering their location and financial information over 20 years (2004-2024) in France. We merge the latter with French administrative data on natural disasters at the municipality level.

Based on local projections (Jordà (2005)) to account for dynamic effects, we find that floods affect a firm's performance, both at the extensive and intensive margin, as well as its probability to relocate. First, we find that firms located in flooded municipalities are less likely to survive at the extensive margin, and that surviving firms experience a decline in performance at the intensive margin. These effects build up during about five years following the shock and most of them persist until the end of the projection horizon, that we set to 8 years. Five years after being hit by a flood, affected firms have a 2% higher probability of becoming inactive, and surviving firms suffer a 8% drop in their sales. Consistently, also other indicators are negatively affected, notably the number of employees, staff costs, EBITDA, and investment.

Second, floods trigger firm-level adaptation. We indeed find that firms located in flooded municipalities are more likely to relocate, as measured by a change in their exact geolocation. This effect is also persistent and its magnitude is about 4% after 5 years. We show that it is driven by firms that change municipality, and specifically by firms that relocate to municipalities with lower levels of flood risk, i.e., municipalities that experienced fewer floods in the preceding 20 years or located at higher altitudes. Firms that relocate following a flood tend to move within close proximity to their original location, remaining within their local market. However, relocation does not appear to mitigate the effects of floods: if anything, following a flood, the sales of moving firms decrease slightly more compared to firms that do not move, suggesting they may face considerable costs to avoid being hit again.

Third, we find that the estimated effects are strongly heterogeneous depending on the intensity of the shock. For firms hit by intense floods lasting at least one week, the effect on survival is four times larger than the baseline one and the effect on sales is three times larger. Consistent patterns characterize firms hit by multiple floods within a given year.

We also identify indirect effects within municipalities and spillovers effects between municipalities. Within flooded municipalities, the effects are about twice as strong for firms located in a 1-in-100 years floodplain, which are more likely to be hit directly by the flood, compared to firms outside, which are more likely to incur indirect effects due to the disruption of economic activity. Consistently, floods occurring in neighboring municipalities affect a firm's performance, with magnitudes attenuating as distance increases. Specifically, this decay is observed for sales up to 20 km, while for survival and relocation the effects are muted at most distances.

Our results are robust to a variety of robustness checks and alternative specifications. Moreover, while our analysis focuses primarily on single-establishment firms, our findings are robust to the sample of multi-establishment companies.

Our contributions are threefold. First, this paper is among the first to document the impact of floods on relocation of firms.[1] Exceptions are Indaco et al. (2021) focusing on a single event (hurricane Sandy), Castro-Vincenzi (2022) in the case of the car industry, and Balboni et al. (2023) for Pakistan. French open-source administrative data, which track the history of firms' locations, make this analysis possible.

Second, we do not only examine a broad range of indicators of firm performance at the intensive margin, but we complement this at the extensive margin with a survival analysis, finding results consistent with other studies (Fatica et al. (2024), Clò et al. (2024), Bijnens et al. (2024)).

Our third contribution is methodological. Indeed, a challenge in this litera-

[1] Among others, Thi et al. (2025), Bernard et al. (2024), Hornbeck and Naidu (2014) and Vigdor (2008) explore residential mobility after a flood.

ture relates to identifying whether a firm is affected or not by a flood. Influential early work used 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 regional indicators is likely to induce bias due to measurement error. In fact, most papers using this type of approach found 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 could be prone to bias when it relies on the availability of estimations of economic damages and on insurance coverage (Felbermayr and Gröschl (2014), Grislain-Letrémy (2018)). Other studies, therefore, rely only on other sources of information to circumvent these potential biases. Some use measures of exposure, notably maps of floodplains or the number of past events. 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 exposure based on flood hazard maps (Fatica et al. (2024)), pointing to a displacement of economic activity toward non-affected areas. Yet another method consists in using precipitation data (Usman et al. (2025), Noth and Rehbein (2019)). However, flash floodings are particularly hard to predict and non-linear in precipitation levels (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)). Finally, while some recent work leverages maps of actual floods from the Global Flood Database (Chang and Zheng (2026)), this dataset focuses only on the largest events, and in the case of France, it records only 12 events between 2003 and 2010.

While no method is perfect, combining them can yield richer 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 distinguishes, within a flooded region, between municipalities that are affected and those that are not.[2]

[2]France is an interesting case due to its high number of small municipalities, compared to other countries.

From this standpoint, the closest paper to our baseline methodology is Clò et al. (2024), that uses administrative data at the municipality-level.[3] However, we augment those data with information related to the intensity of the events (based on the duration of the flood or their number within a given year) and on the exposure (using the geolocation of 1-in-100 years floodplains). We also show that, at the municipality level, flood occurrence can be accurately predicted by ground-level precipitation, providing an alternative methodology for estimating heterogeneous effects by flood intensity. These different methodologies yield consistent results, suggesting that the municipal-level is a relevant reference 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 Section 3 our empirical approach. Section 4 presents our main results. We explore in detail relocation in Section 5. Heterogeneous effects by flood intensity and firm exposure are examined in Sections 6 and 7, respectively. Finally, Section 8 extends the analysis to multi-establishments companies and Section 9 concludes.

2 Data and descriptive statistics

2.1 Natural disasters and floods in France

Data source 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 interministerial decree. For each event, it provides information about its type, start and end dates, and location at the municipality level. It also includes information on the exposure of municipalities to major natural risks.[5] The latter allows us to characterize municipalities according to their ex ante

[3]Our work also relates to that of de L'Estoile et al. (2025), who estimate the effects of floods with dummies for the municipalities, but only for real estate, equipment, cash, and EBITDA, and without estimating how 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* in French.

[5]The underlying *Dossier Départemental sur les Risques Majeurs* (DDRM) is compiled at the departmental level by the prefect. It identifies all municipalities exposed to significant natural

flood risk exposure, independently of realized flood events.

We restrict our analysis to flood events, comprising: coastal flooding, flooding caused by rising groundwater levels, and marine submersion. We focus on mainland France including Corsica over the period from 2004 until 2024.[6]

Measure of flood intensity While GASPAR does not provide a direct measure of flood magnitude, the dates of the event allow us to construct a measure of flood duration, which we use as a proxy for flood intensity. More precisely, within a year, we define municipalities as affected by intense floods when the longest flood event during the year is superior or equal to 7 days. As documented in Table 1, conditionally on being hit. In the Appendix F, we explore an alternative definition of intense flood as experiencing two floods or more within the same year.

Mapping of floods Panel (a) of Figure 1 maps the cumulative number of flood events at the municipality level across France over the past twenty years. Flood exposure is particularly concentrated in coastal areas, the Provence–Alpes–Côte d'Azur (PACA) region, and along major river basins. Panel (b) maps the municipalities affected at least once by an intense flood, lasting a week or more. Under this definition, the central and northern regions appear to be the most affected. Our alternative definition of flood intensity points at the same regions, with in addition the Atlantic coast and the western Mediterranean coast (Figure F.1). Finally, Panel (c) maps the municipalities that are considered at flood risk in 2025, according to GASPAR's measure of natural risk.

2.2 Firms' financial information, location and survival

Data sources Firm-level financial statements are drawn from the Banque de France's FIBEN database, covering non-financial corporations with annual sales exceeding 750,000 €. FIBEN provides detailed balance-sheet and income-statement

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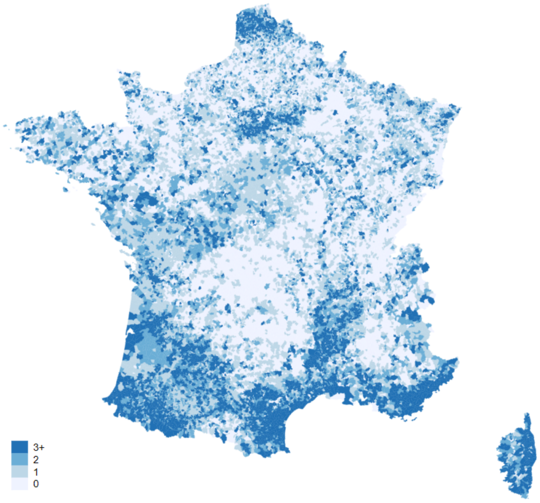
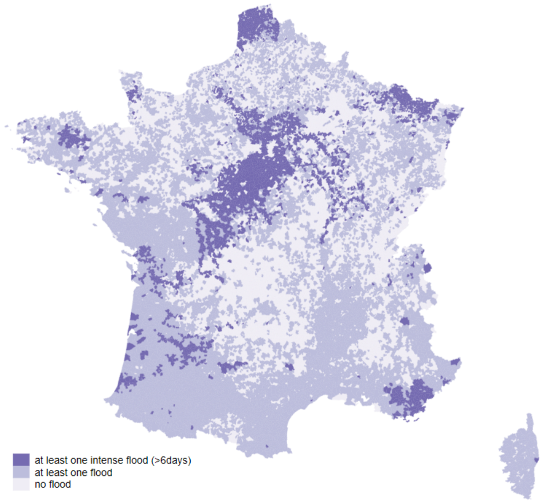
hazards and describes the required preventive measures. Notice that GASPAR provides the current level of risk, but not its previous values.

[6]The choice of starting in 2004 avoids contamination from the exceptional 1999 storms, which affected approximately 80% of municipalities.

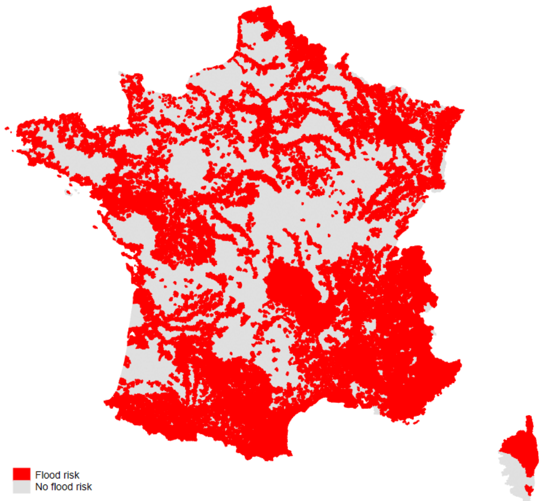
Figure 1: Flood maps



(a) Years of flooding per municipality



(b) Municipalities affected by intense floods



(c) Municipalities at flood risk in 2025

Note: Figure 1, panel (a), represents the number of times a municipality has been hit by at least one flood in a year between 2004 and 2024. In panel (b), municipalities affected by intense floods are those affected at least once by a flood lasting a week or more. Panel (c) represents the municipalities considered at risk of flood as assessed in October 2025.

information and captures, on average, approximately 72% of total value added and 65% of total employment in France.

Firm location and information about their establishments are drawn from the SIRENE[7] database. It provides exhaustive, geolocalized records of all legally registered firms and their establishments in France along with their opening and closing dates.

Sample selection Our dataset covers the period between 2004 and 2024. We apply a set of sample restrictions to ensure clean identification of flood impacts.

First, our baseline analysis focuses on single-establishment firms, defined as legal entities operating out of a single site in a single location. This restriction ensures a direct correspondence between the establishment-level flood treatment and the totality of a firm's economic activity, since financial statements consolidate the information of establishments at the firm level. Single-establishment firms represent about 70% of firms with sales above 750,000 €.[8]

Second, we exclude firms that we are unable to precisely geolocate in SIRENE, and firms belonging to municipalities that were either merged to other municipalities or were split between several municipalities within the period.Third, we also exclude firms located in France's three largest urban agglomerations: Paris, Lyon, and Marseille. The reason for this exclusion is that floods occurring in these cities are not declared by district, but embrace the entire city, making a single flood impacts a very large number of firms at once because of the density of the economic activity.[9]

Finally, we drop real estate investment companies[10] 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.

[7] *Système d'Identification du Répertoire des ENtreprises et des Établissements* in French.

[8] We extend the analysis to multi-establishment firms in Section 8, where we discuss the more complex mechanisms through which a flood affecting one establishment may propagate to the firm's overall performance.

[9] As a robustness, in Appendix D we include Paris, Lyon, and Marseille and find very similar results.

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

Firm survival We define a firm as active in a given year if that year is comprised between the minimum and maximum year for which a financial statement is available in our data. We apply this definition of survival because the FIBEN database provides financial statement for firms above 750,000 € of annual sales. Thus, a firm might disappear from our sample because it fell below this collection threshold, but could still be active, and reappear in our sample later on. We therefore consider that a firm exits our sample if it has no record in the FIBEN dataset until the end of the sample period.

In Appendix D, we test the robustness of our results with two alternative approaches. First, we restrict our sample to firms with sales above 1 million €, to reduce potential noise due to temporary absences of financial statement information in the FIBEN database for firms that in some years may have fallen below the threshold of 750,000 € of annual sales. In a second test, we use the registration status in SIRENE as an alternative measure of firm exit, that is not subject to the sales threshold of the FIBEN database: a firm is defined as active if it remains registered in the SIRENE registry, irrespective of whether it meets the 750,000 € annual sales threshold.

Firm location The SIRENE registry records the complete set of active establishments for each legal entity at any point in time, along with their current and past geolocalized coordinates. For single-establishment firms, it is straightforward to assign a firm to a single location. A firm is then defined as relocating whenever a change in its geo-coordinates is observed. We also examine relocation at coarser geographic scales, from the municipality up to urban unit and employment areas level.[11] The case of multi-establishment firms is discussed in Section 8.

2.3 Descriptive statistics

Table 1 reports the main descriptive statistics for our variables of interest. Our sample includes 2,905,542 observations. 11.1% of observations concern firms located

[11] Urban units (*unités urbaines* in French) are groupings of contiguous municipalities with at least 2,000 inhabitants, while employment areas (*zones d'emploi* in French) are zones defined such that the majority of residents both live and work within the same area, capturing local labor market boundaries. There are about 2500 urban units and 300 employment areas in France.

in a municipality hit by at least one flood during the year. Conditional on the occurrence of at least one flood, the average cumulated duration is of 3.9 days (with a top decile of 8 days). The average duration of the longest event within a year is of 3.7 days. 93% of firms are still active the following year. On average, firms in our sample have 5 millions € yearly sales and 19 employees. Their average yearly variation of sales is of 3%.

Each year, an average of 2.6% of firms relocate, as reflecting a change in their latitude-longitude coordinates. They move 17 km away on average, but only 3 km at the median. About half (57%) of relocating firms move to a different municipality. In Table A.1 in the Appendix, we present additional descriptive statistics for horizons $h = 0$ to $h = 8$, in order to facilitate the comparison of our results with the average variations in the sample.

Table 1: Firms descriptive statistics

	Mean	SD	D1	Q1	Q2	Q3	D9	Number of obs.
Floods (%)	11.119	31.437	-	-	-	-	-	2,905,542
Duration of the longest flood (days) †	3.717	7.635	1	1	2	3	7	323,075
Number of floods †	1.375	0.721	1	1	1	2	2	323,075
Floods cumul. duration (days) †	3.901	6.825	1	1	2	4	8	323,075
Active in t+1 (%)	93.001	25.214	-	-	-	-	-	2,740,681
Sales - Level	5,475	45,214	918	1,189	1,896	3,768	8,850	2,905,542
Sales - Δlog	0.030	0.215	-0.270	-0.055	0.026	0.116	0.238	2,449,071
Assets - Level	5,174	128,634	406	631	1,131	2,343	5,591	2,905,542
Assets - Δlog	0.036	0.232	-0.181	-0.065	0.024	0.132	0.273	2,449,068
Employees - Level	19	43	3	6	10	19	39	2,819,215
Employees - Δlog	0.013	0.240	-0.182	-0.050	0	0.080	0.223	2,306,416
Staff cost - Level	971	2,762	147	268	473	899	1,814	2,905,542
Staff cost - Δlog	0.035	0.223	-0.144	-0.044	0.031	0.111	0.218	2,408,652
EBITDA - Level	350	2,985	-17	40	115	277	655	2,905,542
EBITDA - Δlog	0.018	0.804	-0.795	-0.300	0.025	0.348	0.817	2,006,088
Investment - Level	267	5,012	0	5	26	95	315	2,727,302
Investment - Δlog	-0.033	2.328	-2.079	-0.961	0	0.928	1.974	1,901,353
Long-term assets - Level	3,960	127,591	73	196	492	1,252	3,163	2,978,531
Long-term assets - Δlog	0.060	0.344	-0.091	-0.006	0.017	0.094	0.264	2,431,107
Prob. relocation (%)	2.572	15.832	-	-	-	-	-	2,449,071
Relocation distance (km) ‡	17.090	68.875	0.240	0.844	2.969	8.164	19.829	63,008
Prob. municipality change (%) ‡	0.575	0.494	-	-	-	-	-	63,008

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€(Level) and as yearly variation of their logarithm (Δlog). 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.

3 Empirical specification

We estimate the causal effect of floods on firm performance along the extensive margin (survival) and intensive margin (key financial indicators, notably sales). Beyond these two core outcomes, we also investigate firms' location choices following a flood. Our identification strategy account for the potentially dynamic effects of natural disaster by relying on the local projections method of Jordà (2005).

All our estimations build on the following general specification:

$$f(y_{i,t+h}, y_{i,t-1}) = \beta_h F_{i,t} + \sum_{j=-3, j\neq t}^{H\leq h} \theta_{j,h} F_{i,t+j} + \sum_{k\in K} \sum_{j=-3}^{H\leq h} \delta_{j,h}^k D_{i,t-j}^k + \gamma_{h,j} X_{i,t-1} + FE_i + FE_t + \varepsilon_{i,t+h} \tag{1}$$

where $f(y_{i,t+h}, y_{i,t-1})$ is a function of the variable of interest y observed for a firm i in years $t+h$ and $t-1$. This function takes different forms depending on the type of outcome we consider.

Survival Specifically, for the survival analysis (i.e., the extensive margin), $y_{i,t}$ is a dummy equal to 1 if firm i is active in year t and 0 otherwise. Therefore, in our specification to evaluate the impact of floods on firms' survival, $f(y_{i,t+h}, y_{i,t-1})$ takes the following form:

$$f(y_{i,t+h}, y_{i,t-1}) = \begin{cases} 1 & \text{if } y_{i,t+h} = 1 \text{ and } y_{i,t-1} = 1 \\ 0 & \text{if } y_{i,t+h} = 0 \text{ and } y_{i,t-1} = 1 \end{cases} \tag{2}$$

Activity In our specification to evaluate the impact of floods on firms' activity (i.e., the intensive margin), we define $y_{i,t} = log(Y_{i,t})$, where $Y_{i,t}$ is an indicator of firm's i performance based on its financial statement, mainly sales. We then compute $f(y_{i,t+h}, y_{i,t-1}) = y_{i,t+h} - y_{i,t-1}$.

Relocation Finally, in our specification to evaluate the impact of floods on firms' choice to move to another location, $y_{i,t}$ is a variable indicating the location of firm i in year t. Therefore, $f(y_{i,t+h}, y_{i,t-1})$ takes the following form:

$$f(y_{i,t+h}, y_{i,t-1}) = \begin{cases} 1 & y_{i,t+h} = y_{i,t-1} \\ 0 & y_{i,t+h} \neq y_{i,t-1} \end{cases} \equiv m_{i,t+h,t-1} \tag{3}$$

On the right-hand side of equation (1), $F_{i,t}$ is our flood variable: it is equal to 1 if firm i is located in a municipality hit by at least one flood in year t and zero otherwise. The coefficient of interest is therefore β_h, estimated at different time horizons h, up to $h = 8$.

Our specifications control for lags and leads of $F_{i,t}$, from horizon $t-3$ to $t+H$, where $H \leq h$. Note that horizon H depends on the outcome we focus on. For the survival analysis, H is equal to -1, that is, we do not include forwards of the flood variable. Indeed, if a firm is not active at horizon $j \leq h$, subsequent floods are irrelevant. For the intensive margin and the relocation analysis, H is equal to h. These controls aim at taking into account shocks occurring in years different from treatment years t, that could also dynamically affect firms.

$D^k_{i,t}$ are variables equal to 1 if disasters k other than floods hit the municipality of firm i in year t. The set of non-flood disasters, K, includes landslides, droughts, and other natural disasters. For each of these variables D^k, we control not only for occurrence in treatment years t, but also for lags or leads, from horizon $t-3$ to $t+H$, where $H \leq h$.

$X_{i,t-1}$ is a set of lagged firm-level controls. All specifications control for the logarithm of total assets and the leverage ratio. Moreover, the estimations at the intensive margins also control for up to three lags of $y_{i,t} - y_{i,t-1}$. Finally, we systematically control for fixed effects at the firm (FE_i) and year (FE_t) level. Since the treatment varies at the municipality-year level, standard errors are clustered at that level.

Following Montiel Olea and Plagborg-Møller (2021), our specifications are lag-augmented, as they include at least one lag of the variable of interest[12] and of the treatment variable. Note that the standard local projection setting, augmented with leads and lags when applicable, has the advantage of being flexible enough to estimate all of our effects of interest within the same framework, described by equation (1). Moreover, it allows to investigate the potentially mitigating channel of relocation.

In Section 4, we test the robustness of our results and compare our baseline results to those of other approaches, which could have been used separately for one outcome of interest or another, but lack the same flexibility as local projections. Specifically, we compare our survival analysis results with those of a standard Cox model, implemented for example by Clò et al. (2024) and Fatica et al. (2024). Additionally, we compare our results on firm's activity and relocation with those of a local difference-in-differences approach, based on Dube et al. (2025).

[12]Indeed, all the outcome variables are defined as a difference between an outcome in year $t+h$ and an outcome in year $t-1$.

4 Main results

In Section 4.1, we organize the presentation of results around three main outcomes: (i) at the extensive margin, we examine whether flood exposure affects the probability that a firm remains active in subsequent years, (ii) at the intensive margin for surviving firms, we document the effects on sales and related financial outcomes, and (iii) we finally examines firms' location choices in the aftermath of a flood. Section 4.2 presents robustness checks for the three sets of results.

4.1 Impact of floods on firms' outcomes : survival, sales and relocation

Firm survival We first examine whether floods affect the probability that a firm remains active in the years following the event.[13]

Panel (a) of Figure 2 reports the estimated impulse response function from equation (1). The effect of flood exposure on survival is not immediate. First, the point estimate at $h = 0$ is close to zero ; the negative effect builds gradually and reaches its maximum at $h = 5$, at which point firms located in flooded municipalities are approximately 0.5 percentage points (p.p.) less likely to remain active relative to the counterfactual. Given a baseline exit rate of 25% in our sample (Table A.1), this represents a roughly 2% increase in the exit hazard at the five-year horizon. The estimated coefficient partially attenuates from $h = 6$ onward and becomes statistically not different from zero from $h = 7$.

These findings are cross-validated by the Cox proportional hazards model reported in Table B.1. Hazard ratios are consistently and significantly above one for the contemporaneous and first-lagged flood indicators across all specifications, with maximum effects ranging between 2 and 3%. Taken together, the local projection and Cox estimates provide mutually consistent and statistically robust evidence that flood exposure raises the probability of firm exit over a medium-term horizon.

[13]For the record, we define a firm as active in a given year if that year is comprised between the minimum and maximum year for which a financial statement is available in our data (Section 2). Robustness tests in the Appendix present alternative measure of survival: Figure D.1, panel (d), presents the results on a sample restricted to firms with sales above 1 million € and shows negative and significant effects of the same order of magnitude as our baseline. Figure D.1, panel (e), uses the presence of the firm in a different database (SIRENE) and shows nearly identical results.

Firm activity Having established that floods increase exit probabilities, we turn to the performance of surviving firms. Panel (b) of Figure 2 reports the impulse response function for the log-change in sales relative to the pre-event year. The immediate impact of flood exposure on sales growth is negative but modest in magnitude, and is not statistically different from zero in the year of the event ($h = 0$) or the year immediately after ($h = 1$).

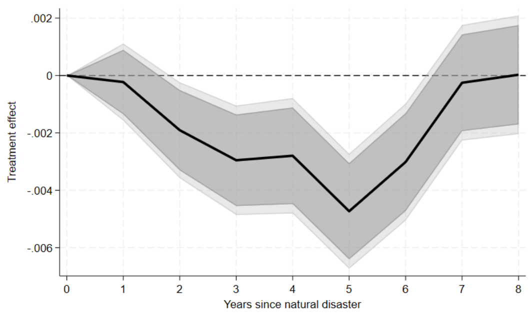
This negative effect on sales amplifies over time. By $h = 2$, the estimated coefficient becomes statistically significant at the 5% level, and the effect progressively deepens. The maximum estimated effect, at horizon $h = 6$, is of -1.2 p.p. Given an average increase of sales of 15% at $h = 6$ (Table A.1) this corresponds to an effect of about 8%. Signs of partial recovery appear only at $h = 7$, though the estimated effect remains negative and statistically significant through the end of our horizon at $h = 8$.

In Appendix C, we develop the impact of floods on several firms indicators. Specifically, Figure C.1 highlights a negative effect on the number of employees (panel (a)), staff costs (panel (b)), EBITDA (panel (c)) and investment (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 does not appear to be driven by long-term total assets (panel (f)).

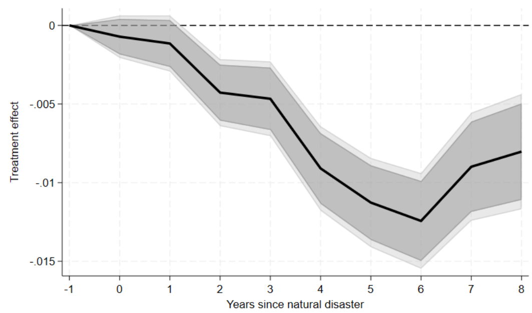
These results are conservative estimates of the true economic cost of flooding for several reasons. Indeed, the sample is restricted to surviving firms, which arguably excludes those that suffered the most severe damage and exited the market. Moreover, insurance payouts and government transfers may also partially offset revenue losses in the near term.

Firm relocation If floods have a negative impact on a firm's activity, as shown previously, they may contribute to its decision to relocate. Panel (c) of Figure 2 reports the effect on the the probability that a firm changes its geographic location, relative to year $t - 1$. The estimated effect rises progressively from $h = 0$ onward, reaching its maximum of approximately 0.5 p.p. at $h = 5$. Against a relocation rate of 13% in our sample at a 5-year horizon (Table A.1), this translates into a roughly 4% higher propensity to move, a quantitatively meaningful response that unfolds over a time horizon closely mirroring that of the survival and sales effects documented above.

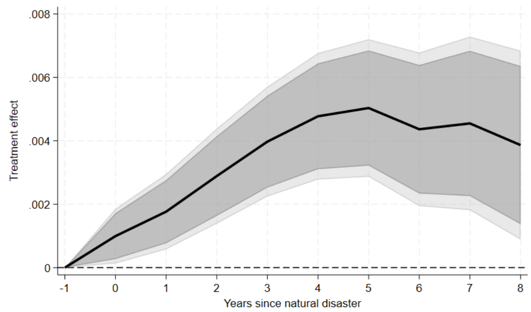
Figure 2: Main effect of floods



(a) Survival



(b) Sales



(c) Relocation

Note: Plotted are the cumulative impulse response of survival (panel (a)), sales (panel (b)) and relocation probability (panel (c)) to floods occurring in the municipality where the firm is located. Shaded areas show respectively 90% (dark grey) and 95% (light grey) confidence intervals. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

4.2 Robustness of the main effects

In this section, we discuss several robustness checks for our main effects. In Appendix D, we present the results on the three main outcomes of interest: survival (Figure D.1), sales (Figure D.2), and relocation (Figure D.3).

Replacing firm fixed effects with country × sector-specific year fixed effects Our baseline specification relies on firm fixed effects to absorb time-invariant unobserved heterogeneity at the firm level. As a first robustness check, we replace firm fixed effects with county-year and sector-year fixed effects. This alternative specification captures aggregate shocks that are specific to a given location or industry in a given year.

Panels (a) show that the results are similar with this alternative specification, though with larger confidence intervals for survival and sales (Figures D.1 and D.2) and with a stronger relocation effect (Figure D.3).

Restricting the sample to firms experiencing only one flood or none The baseline estimation takes into account the possibility for a firm to experience multiple floods within the period by including leads and lags of floods. However, firms experiencing repeated events may exhibit dynamics that differ from those exposed to a single one. To assess whether our main results are driven by multiply-treated firms, we restrict the estimation sample to firms that experienced either no flood or exactly one flood over the sample period.

Panels (b) show that, overall, our estimates remain quite stable, suggesting that our findings are not driven by the behavior of frequently flooded firms. The impact on survival (Figure D.1) appears immediately after the first year and persists until $h = 5$ before returning to the pre-flood level. This shorter effect suggest that the repeated floodings may explain the long-lasting effects on firm survival, up to $h = 7$, in the baseline results. The effects on sales (Figure D.2) and relocation (Figure D.3) follow patterns similar to the baseline.

Instrumenting floods by rainfall The data we use to identify floods are administrative declaration of natural disasters, which may be prone to bias. Indeed, they may be correlated with the insurance coverage or level of economic activity(Grislain-Letrémy (2018), Felbermayr and Gröschl (2014)) and subject to measurement errors. To address this concern, we instrument the occurrence of a flood in a given municipality-year with the maximum monthly rainfall level recorded at the nearest meteorological station among the approximately 900 observatories operating in France. Rainfall provides a plausibly exogenous source of variation in flood risk that is orthogonal to local administrative and insurance characteristics. The first stage of this approach (Table D.1 in the Appendix) is highly relevant, with a Kleibergen-Paap rk Wald F-statistic above 500.

In panels (c), we find that accounting for potential endogeneity, a firm's sales growth is negatively affected by floods (Figure D.2). The maximum effect is even stronger than in the benchmark regression (about -4 p.p.), which is consistent with the correction of attenuation bias due to measurement errors, and with the interpretation that the instrument captures flood intensity effects (Gautier et al. (2024)). Similary, the effects on survival and relocation (Figures D.1 and D.3) have overall larger magnitudes than our baseline ones, although with lower precision.

Omitting controls for lags and forwards The baseline estimation for sales and relocation includes lags and leads of the treatment variable in order to control for other shocks that could dynamically affect firms' outcomes.[14] However, by construction, these controls prevent any test for the pre-trend hypothesis. We then exclude leads and lags of floods. Panels (e) of Figures D.2 and D.3 show that there are no significant pre-treatment trends and that our results are robust in pattern and magnitude to the exclusion of such controls.

Local projection difference-in-differences As a further check on the robustness of our identification strategy, we estimate a local projection difference-in-differences (LP-DiD) specification, following Dube et al. (2025). While Dube et al. (2025)'s approach has the advantage of using a clean-control condition (i.e., dropping from the estimation sample firms that have been treated between the year of treatment and the projection horizon), it requires setting a stabilization horizon L, after which the treatment effect is assumed to stop increasing. This stabilization horizon plays an important role in the estimation, as any firm having received a treatment in the L years before the event are dropped from the sample. Since our baseline results suggest rather persistent effects, the clean-control condition results in strong constraints on the sample size. We implement this approach for sales and relocation outcomes anyway,[15] with a stabilization horizon equal to 4 years, to challenge the robustness of our results. Panels (d) of Figures D.2 and D.3 display stronger effects in magnitude and rule out the concern that our results may be driven by control

[14] This is not the case for survival analysis, for which the inclusion of leads does not apply, as detailed in Section 3.

[15] Again, such an approach is not suitable for survival analysis, as using forwards is inappropriate.

firms subsequently treated.

Including Paris, Marseille and Lyon Finally, we run the baseline estimation on survival, sales, and relocation, but including the cities of Paris, Marseille and Lyon. Figure D.4 shows that results are unaffected.

5 Firm relocation: Destinations and implications for performance

5.1 Where do firms relocate?

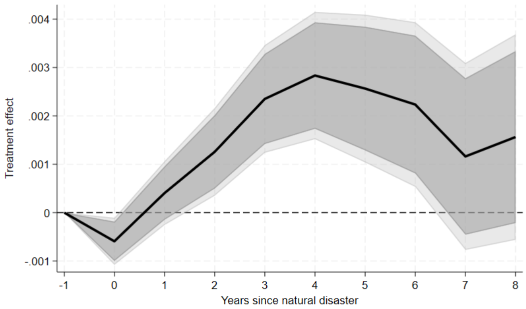
A natural question is whether flood-induced relocation is random, or whether firms select safer locations in a pattern that would be consistent with adaptation to climate risk. In Figure 3, we provide evidence that most of the relocation effect is due to firms relocating to safer places. More precisely, firms hit by a flood are more likely to move to municipalities with a lower risk of flood, defined either as those with a lower count of floods in the 20 years before the treatment (panel (a)), or through a dummy variable indicating whether a municipality is classified as at flood risk (panel (b))[16]. They are also more likely to move to municipalities at higher altitude (panel (c)) and not on a coast (panel (d))[17], as well as to areas that are not 1-in-100 year floodplains (panel (e)).

In Figure E.1 in the Appendix, we provide additional details on firms' relocation. Panels (a) and (b) decompose the overall effect on relocation between firms relocating across municipalities and those relocating within municipalities. For an overall increase in the probability of relocating of about +0.5 p.p. at horizon $h = 5$ (panel (c) in Figure 2), +0.4 p.p. can be explained by firms moving across municipalities (panel (a) in Figure E.1), and +0.1 p.p. can be explained by firms moving in the same municipality (panel (b) in Figure E.1). The within-municipality effect is

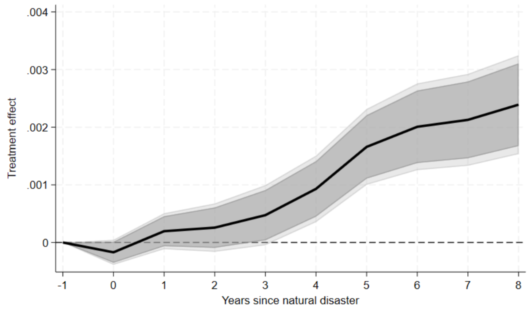
[16]The classification of municipalities as at the flood risk is based on information contained in the GASPAR data and refers to 2025.

[17]Municipalities not on the coast are defines as those without *Loi Littoral*. 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.

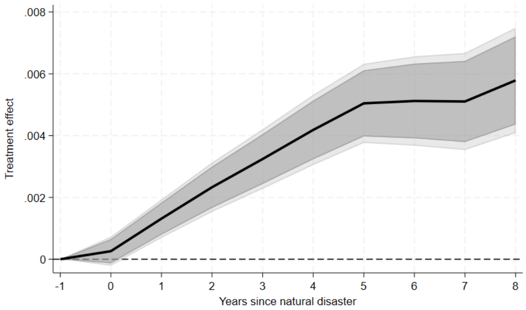
Figure 3: Firms move to less risky areas



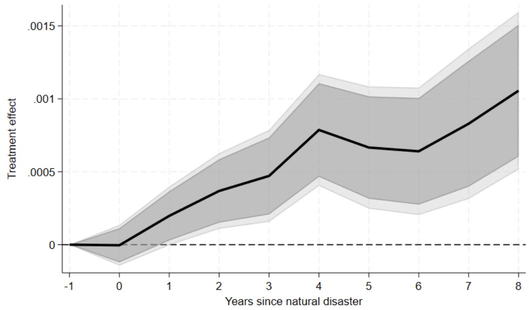
(a) Moving to a municipality with less floods in the past 20 years



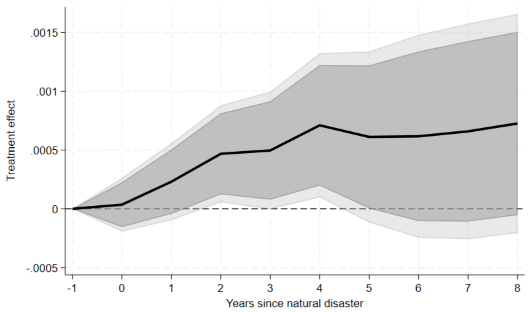
(b) Moving to a municipality not classified at flood risk



(c) Moving to a municipality with higher altitude



(d) Moving to non-coastal municipality



(e) Moving out of a floodplain

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

however not statistically significant. The +0.4 p.p. higher probability of moving to another municipality can be compared with a +0.3 p.p. higher probability of moving to a municipality with less floods in the past 20 years (panel (a) of Figure 3): this suggests that, following a flood, 75% of the increased relocation of firms across municipalities is explained by firms relocating to safer areas. Panel (c) shows that the increased relocation of firms across municipalities is partly driven by an increased probability of moving to another urban unit. However, firms affected by a flood are not more likely to move to another employment area (panel (d)), suggesting they typically do not move away from their local market.

5.2 Does relocation mitigate flood effects on firm performance?

The previous section provided evidence that, when firms relocate after being hit by a flood, they tend to choose safer locations. In other words, relocating firms prefer reducing the risk of being hit again by a flood. In this section, we test whether or not relocation following a flood also mitigates the estimated effects of this flood on firm performance, both at the extensive and intensive margin.

In principle, relocation could affect firm performances in two countervailing ways. On the one hand, it could weigh on a firm's business, since it may entail reorganizing its logistics and suppliers or loosing some customers in the short term. On the other hand, relocating after a flood could allow to avoid disrupted infrastructures or struggling supplier chains and getting access to new customers, that have not been hit by the natural disaster.

To evaluate the net impact of relocating on firms' performances, we estimate an additional specification, testing whether the flood effect at the extensive and intensive margins on firm i between year $t-1$ and $t+h$ differs between firms that change municipalities between $t-1$ and $t+h-1$ and those that do not. Specifically, we estimate the following specification, in which the dummy for moving between $t-1$ and $t+h-1$, $m_{i,t+h,t-1}$, is fully interacted with the variables of the baseline specification:

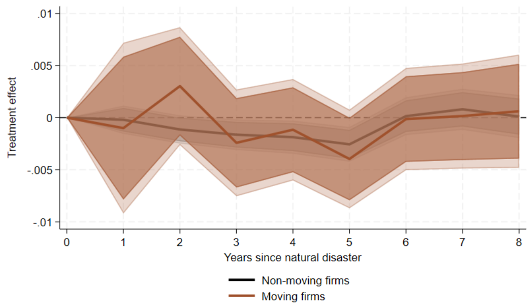
$$
\begin{aligned}
f(y_{i,t+h}, y_{i,t-1}) = & \\
& \mu_{m,h} m_{i,t+h-1,t-1} + \\
& \beta_{h,m0} F_{i,t} + \beta_{h,m1} F_{i,t} \times m_{i,t+h-1,t-1} + \\
& \sum_{j=-3, j\neq t}^{H\leq h} (\theta_{j,h,m0} F_{i,t-j} + \theta_{j,h,m1} F_{i,t-j} \times m_{i,t+h-1,t-1}) + \\
& \sum_{k\in K} \sum_{j=-3}^{H\leq h} (\delta^k_{j,h,m0} D^k_{i,t-j} + \delta^k_{j,h,m1} D^k_{i,t-j} \times m_{i,t+h-1,t-1}) + \\
& \gamma_{h,m0} X_{i,t} + \gamma_{h,m1} X_{i,t} \times m_{i,t+h-1,t-1} + \varepsilon_{i,t+h}
\end{aligned} \tag{4}
$$

In this specification $\beta_{h,m0}$ are the estimated effects for non-moving firms, and $\beta_{h,m1}$ are the estimated effects for moving firms. The controls and fixed effects are identical to those of the baseline specification.

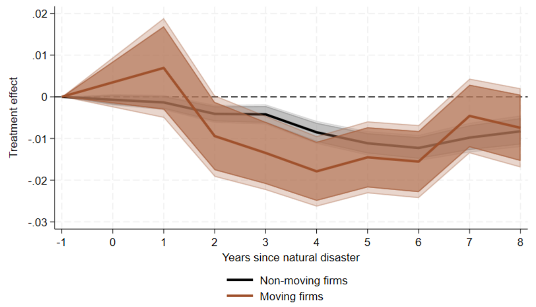
Figure 4 summarizes the results. At the extensive margin, the estimated effects appear to be similar for moving and non-moving firms. However, the confidence intervals for moving firms are large, making the effect non-significant. In this context, it is challenging to assess whether the estimated effect for moving firms is different from the one for non-moving firms. This low level of statistical significance is likely to be driven by the fact that identification relies on a very small subset of firms (i.e., those that both relocate and eventually do not survive). At the intensive margin, the results are more clearly interpretable: floods entail a stronger negative effect on sales for firms that relocate. At horizon $h = 4$, the estimated effect is of -2 p.p. for relocating firms, against -1 p.p. for non-relocating firms. This significant difference is however temporary and fades at the end of the horizon.

Overall, these effects tend to indicate that firms which relocate following a flood do not have better performances that those which do not. If anything, it is the opposite: the sales of moving firms react more negatively than those of non-moving firms. There can be several interpretations for this result. One possibility is that the cost of moving at least temporarily seems to overtake the benefits of being in a less-risky area. Another interpretation is that relocating firms would be more severely affected, had they not relocate. Finally, such relocation may actually have a mitigating effect on a longer run that we may not capture, by shielding relocating firms from future floods.

Figure 4: Effects of floods on firm's performance at the extensive and intensive margin, depending on whether it relocated



(a) Mitigating effect of relocating: extensive margin



(b) Mitigating effect of relocating: intensive margin

Note: Plotted are the cumulative impulse response of a dummy variable indicating whether firm is open in horizon h (panel (a)) and of the log change in sales between years h and -1 (panel (b)). The response in grey corresponds to firms which did not relocate between year -1 and year $h-1$, and the response in brown corresponds to firms that relocated between those two years. Shaded areas show respectively 90% confidence interval (dark) and 95% confidence interval (light). Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

6 Heterogeneous effects by flood intensity

The average effects documented in Section 4 may mask substantial heterogeneity across flood events of varying intensity. This section investigates whether the consequences for firm survival, activity, and relocation differ depending on the intensity of the flood experienced. We define flood intensity based on duration. In a given year, 50% of firms hit by floods are located in municipalities where the longest flood lasts at least 2 days, while 10% are in municipalities where the longest flood lasts at least 7 days (Table 1). We define firms as exposed to high-intensity floods if the longest flood occurring in their municipality within a given year lasts at least one week, corresponding to the top decile of the distribution.[18]

[18] In a similar spirit, Clò et al. (2024) define severe floods as those belonging to the top decile of the distribution of the per capita number of news. Alternative measures of flood intensity are

To compare the effects of floods depending on their intensity, we estimate the following regression:

$$
\begin{aligned}
f(y_{i,t+h}, y_{i,t-1}) = & \\
& + \beta_h^{HI} F_{i,t}^{HI} + \beta_h^{LI} F_{i,t}^{LI} \\
& + \sum_{j=-3, j\neq t}^{H\leq h} \theta_{j,h}^{HI} F_{i,t+j}^{HI} + \sum_{j=-3, j\neq t}^{H\leq h} \theta_{j,h}^{LI} F_{i,t+j}^{LI} \\
& + \sum_{k\in K} \sum_{j=-3}^{H\leq h} \delta_{j,h}^{k} D_{i,t-j}^{k} + \gamma_{h,j} X_{i,t-1} + FE_i + FE_t + \varepsilon_{i,t+h}
\end{aligned}
\tag{5}
$$

where $F_{i,t}^{HI}$ (respectively, $F_{i,t}^{LI}$) is a dummy equal to one if firm i is located in a municipality hit by a flood of high intensity (respectively, lower intensity) in year t. The controls and fixed effects are the same as in the baseline equation, and we control for both leads and lags of high intensity and lower intensity floods. The coefficients of interest are β_h^{HI} and β_h^{LI}, estimating respectively the effect of high intensity and lower intensity floods.

Figure 5 presents the cumulative impulse response functions for the two groups on our three main outcomes of interest: survival, sales, and relocation.

Firm survival Panel (a) reveals a significant heterogeneity by flood intensity. For firms exposed to high-intensity floods, the negative impact on survival is statistically significant after two years and intensifies progressively, peaking at approximately -2 p.p. six years after the event. This magnitude is nearly four times larger than the corresponding estimate of -0.5 p.p. obtained for the full sample in Section 4. Given an average exit rate of 28% at $h = 6$ (Table A.1), it translates into an effect on the exit rate of about 7%. The effect is persistent, and keeps hovering around +1.5 p.p. at $h = 8$. By contrast, floods of lower intensity generate maximum effects of about

possible. For instance, the number of events in a given year could also be adopted as a proxy. However, this entails less variability than the duration of the longest flood within a year. Indeed, as reported in Table 1, among flooded firms in a given year, the median number of floods is 1. Only 25% are hit more than once during the year. Figure F.2 in the Appendix shows that results presented in this section are robust to considering that firms hit by high-intensity floods are those hit by at least two floods within a year.

+0.02 p.p., which are significant only until $h = 3$, and which then return to zero at the end of the projection horizon. Firm closure, therefore, is a risk that materializes predominantly in the aftermath of high-intensity flood events.

Firm activity Consistently, panel (b) shows that the baseline sales response documented in Section 4 is actually driven by firms hit by most intense floods. The estimated effect on sales is negligible in the year of the event but deteriorates significantly thereafter, reaching -2 p.p. two years out and deepening to a trough of approximately -4 p.p. by year five. This is roughly three times the effect estimated on the full sample. Given an average increase of sales of 15% at $h = 6$, the estimated decrease in sales is about 25%. Like for survival, the effect is highly persistent, as it is still equal to about -3 p.p. at $h = 8$. Firms exposed only to minor flooding also exhibit a significant decline in sales over the entire horizon, but the maximum magnitude is of about -0.5 p.p., and the effect is less persistent.

Other results on firms financial outcomes in the Appendix C, Figure C.2, point to the same conclusion: firms impacted by high-intensity floods suffer greater losses. In particular, regarding investment, total assets, and long-term assets, significant negative effects are observed only for high-intensity floods, while floods of lower intensity mostly entail insignificant effects[19]. For the number of employees, staff costs, EBIDTA, floods of lower intensity yield significant negative effects, but of a much lower magnitude than high-intensity floods.

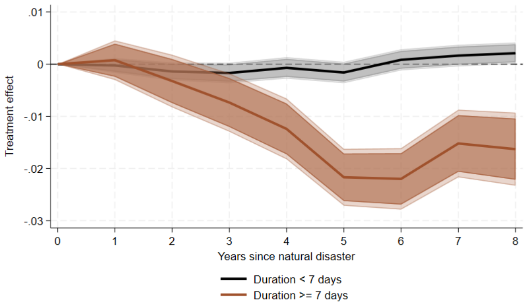
Firm relocation While flood effects on a firm's survival and activity are strongly heterogeneous by flood intensity, the propensity to relocate is similar between firms hit by floods of high intensity and those hit by floods of lower intensity (panel (c)). In both cases, the magnitude of the effect is about +0.5 p.p. and statistically significant. If anything, the speed of relocation appears to be slightly higher for firms hit by floods of high intensity, but the difference is weakly significant, as indicated by the overlapping confidence intervals.

In conclusion, the results of this section point to heterogeneous effects by flood

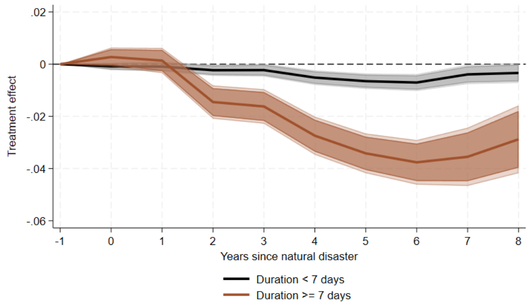
[19]This is in line with Fatica et al. (2024), who find that firms exposed to major events experience asset losses approximately four times larger in the immediate aftermath than those exposed to milder episodes.

intensity at the extensive and intensive margin: the adverse consequences for survival and activity identified in the main analysis are mostly driven by the most intense floods. However, this does not appear to be true regarding relocation: firms hit by a flood tend to relocate more regardless of the intensity of the event.

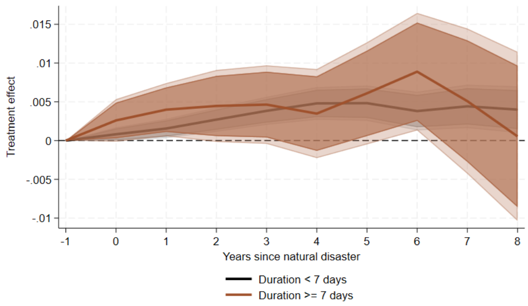
Figure 5: Heterogeneity of the effects depending on flood intensity, based on the duration of the longest flood within the year



(a) Survival



(b) Sales



(c) Relocation

Note: Plotted are the cumulative impulse response of survival (panel (a)), sales (panel (b)) and relocation probability (c) to floods occurring in the municipality where the firm is located. The brown line is the response to high intensity flooding (municipalities where the longest flood lasted 7 days or more), while the black line is the response to less intense 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.

7 Firm exposure: Direct effects and spillovers

In our baseline, identification relies on the variation in flood occurrence between municipalities. Such an approach has two implications. First, it ignores within-municipality heterogeneity in the effects of floods: indeed, all firms located in a flooded municipality are considered as being treated in the same way. However, in a given municipality, some firms might be directly hit, because there premises were flooded, while others might only incur indirect effects through secondary channels — road closures, disruptions to local suppliers and customers, or broader demand contractions — without sustaining direct damage. Second, our baseline approach compares municipalities located in different areas, and therefore does not measure potential spillovers of flood effects between neighboring municipalities. In this section, we address both these issues using two different methodologies.

7.1 Direct and indirect effects within municipalities

An ideal setting to disentangle direct and indirect effects of floods would require information on which firms were physically hit by a flood. In the absence of such information, we resort to a proxy based on firms' precise location, identifying whether they are located in flood-prone areas. The underlying hypothesis is that firms located within a floodplain face a substantially higher probability of being directly hit during a flood event in their municipality, and hence constitute the group most likely to be directly affected. By contrast, we hypothesize that firms located in the same municipality, but outside the floodplain area, face a lower probability of incurring direct damage, though they may still be affected through indirect channels.

To implement this approach, we match firms' exact GPS coordinates with the floodplain raster constructed by Dottori et al. (2022), which covers Europe and the Mediterranean basin at a spatial resolution of 100 meters. We classify a firm as directly exposed if its location falls within a 1-in-100 years floodplain (that is, an area that would be flooded by a flood event with a 1% annual exceedance probability) and as indirectly exposed otherwise.[20] This classification allows us to identify within-

[20]The use of the 1-in-100 threshold follows the recommendation of Dottori et al. (2022), who note that lower return periods tend to overestimate actual floodplain extents.

municipality heterogeneity in physical exposure.[21]

To compare the effects of floods for firms located within or outside floodplains, we estimate the following regression:

$$
\begin{aligned}
f(y_{i,t+h}, y_{i,t-1}) = & \\
& + \beta_h F_{i,t} + \mu_h P_{i,t} + \omega_h F_{i,t} P_{i,t} \\
& + \sum_{j=-3, j\neq t}^{H\leq h} \theta^F_{j,h} F_{i,t+j} + \sum_{j=-3, j\neq t}^{H\leq h} \theta^P_{j,h} P_{i,t+j} + \sum_{j=-3, j\neq t}^{H\leq h} \theta^{FP}_{j,h} F_{i,t+j} P_{i,t+j} \\
& + \sum_{k\in K} \sum_{j=-3}^{H\leq h} \delta^k_{j,h} D^k_{i,t-j} + \gamma_{h,j} X_{i,t-1} + FE_i + FE_t + \varepsilon_{i,t+h}
\end{aligned}
\tag{6}
$$

where $P_{i,t}$ is a dummy variable indicating firm i is located in a 1-in-100 year floodplain in year t. The controls and fixed effects are the same as in the baseline specification, but we also control for lags and forwards of the floodplain dummy and for its interaction with past and future shocks. Notice that $F_{i,t}$ is identical for all firms belonging to a given municipality in year t, while $P_{i,t}$ can vary within that municipality. Therefore, this specification separates, for a shock occurring within a given municipality, the effects for firms within a floodplain, and those for firms out of a floodplain. The associated coefficients of interest are β_h, which indicates the effect of a flood occurring in t at horizon $t+h$ for firms out of floodplain in the year shock, and $\beta_h + \omega_h$ which indicates the effect of a firm occurring in t for firms in a floodplain in the year of the shock.

Figure 6 presents the results for the two groups across all three outcomes. Panel (a) shows that firms located within a floodplain — those most likely to have sustained direct damage — experience a more pronounced and persistent decline in survival probability than firms outside it. This divergence becomes statistically significant from the third year onward. The maximum effect for firms located in a floodplain (about -1 p.p.), is twice the maximum effect estimated for firms located out of a

[21] The approach is conceptually consistent with the methodology in Fatica et al. (2024), who similarly rely on flood hazard maps to separate directly flooded firms from those in the wider affected county, and who find this distinction to be central to identifying the strongest effects on firm assets.

floodplain (about -0.5 p.p.), and at the end of the projection horizon the effect remains significantly negative only for the former ones.

Panel (b) presents similar results regarding firms' activity: firms in a floodplain experience a significantly larger contraction in sales, with the gap widening progressively over the post-event horizon. The maximum effect estimated for firms in a floodplain (about -2 p.p.) is again twice the maximum effect estimated for firms out of a floodplain (about -1 p.p.)

The stronger effects for firms directly hit by floods, both at the extensive and intensive margins, suggest these firms are more likely to have their productive capital impaired or destroyed. This is what is also suggested in the Appendix C, Figure C.3, with results on additional financial indicators. In particular, regarding long term assets (panel (f)), firms located in floodplains incur significant negative effects following a flood, while this is not the case of firms located out of floodplains. Regarding the other financial indicators, most are more strongly affected when the firm is hit directly directly.[22] Notice, however, that also indirectly hit firms record significant decline in activity, a finding consistent with spillover mechanisms that we will investigate in the next section.

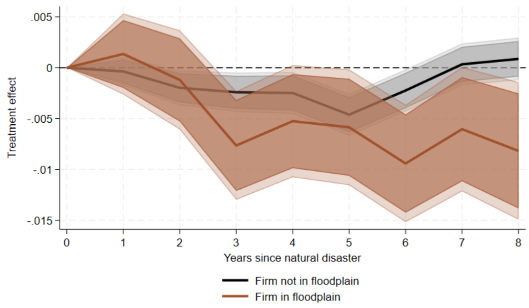
Finally, panel (c) of Figure 6 shows that the propensity to relocate is considerably higher for firms located in floodplains, and that this differential persists over the eight-year horizon. The maximum effect for firms located in floodplains (about +1.2 p.p.) is about three times the maximal effect for firms located out of floodplains (about +0.4 p.p.). This finding is consistent with results presented in panel (e) of Figure 3, suggesting that firms tend to move away from floodplains, when they relocate. Taken together with absence of significant differences in relocation rates depending on the intensity of the disaster (panel (c) of Figure 5), being directly hit by a flood appears to matters more than flood intensity in explaining firms' decision to relocate.

Overall, these results indicate that the baseline effects documented in Section 4 are stronger for firms located in flood-prone areas, and most likely to be directly hit by floods. At the same time, firms outside the floodplain are also impacted. While

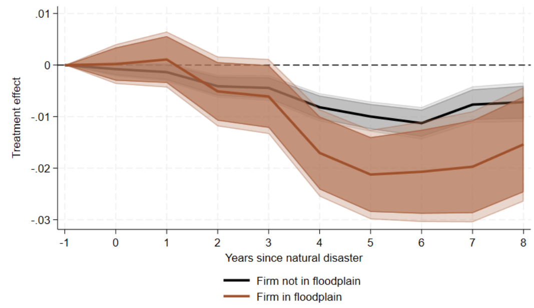
[22]One exception is the absence of significant effect on investment for directly hit firms. This may result from two countervailing mechanisms: on the one hand, the reduced economic activity could negatively affect investment, but on the other hand, the negative effect on long-term assets could increase the need for investment, in order to rebuild what has been impaired or destroyed.

the indirect effects estimated in this section are only within a given municipality, the next section focuses on spillovers across municipalities.

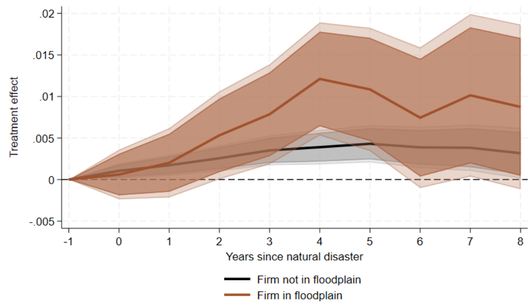
Figure 6: Direct vs indirect effects



(a) Survival



(b) Sales



(c) Relocation

Note: Plotted are the cumulative impulse response of survival (panel (a)), sales (panel (b)) and relocation probability (c) 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 (direct effect), while the black line is the response for other firms (indirect effect). 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.

7.2 Spillover effects across municipalities

To assess whether flood effects propagate beyond the boundaries of a municipality hit by a flood, we extend the baseline specification to account for potential geographic spillover effects on firms located in non-flooded municipalities nearby a flooded municipality. For each firm located in a non-flooded municipality in a given year, we identify the closest municipality affected by a flood, and assign it to four concentric rings, with distance bins of 5 km each, up to 20 km away from the firm's municipality.

The estimated regression is of the following form:

$$
\begin{aligned}
f(y_{i,t+h}, y_{i,t-1}) = \\
& + \beta_h F_{i,t} + \sum_{r \in R} \omega_h^r F_{i,t}^r \\
& + \sum_{j=-3, j \neq t}^{H \leq h} \theta_{j,h} F_{i,t+j} + \sum_{j=-3, j \neq t}^{H \leq h} \sum_{r \in R} \theta_{j,h}^r F_{i,t+j}^r \\
& + \sum_{k \in K} \sum_{j=-3}^{H \leq h} \delta_{j,h}^k D_{i,t-j}^k + \gamma_{h,j} X_{i,t-1} + FE_i + FE_t + \varepsilon_{i,t+h}
\end{aligned}
\tag{7}
$$

where $F_{i,t}^r$ is a dummy indicating whether the closest flooded municipality from that of firm i in year t is located in ring r among a set R of four rings: km $]0, 5[$, $[5, 10[$, $[10, 15[$, and $[15, 20[$. By construction, $F_{i,t}^r$ is null for every r if $F_{i,t}$ is equal to zero. The controls and fixed effects are the same as in the baseline specification, and we control for both leads and lags of $F_{i,t}^r$ and of $F_{i,t}^r$.

Figure 7 reports the cumulative impulse responses for survival, sales and relocation across the four distance rings, alongside the baseline effect estimated for firms located in a flooded municipality. At the extensive margin (panel (a)), floods occurring in the closest ring have an effect close to that of floods occurring in the firm's municipality. For floods occurring beyond 5 km, the effects on the firm's survival is close to zero.

The results at the intensive margin (panel (b)) also entail spatial attenuation, which is however more progressive than for survival: floods located in neighboring municipalities generate negative effects on the firm's sales, but the effects progressively weakens as distance increases, becoming close to zero beyond the 10–15 km range. This spatial attenuation pattern is theoretically consistent with indirect effects due to several factors. Beyond disruption of local transportation networks and shared infrastructure, it could arise from, on the households side, the reduction of local demand via income effects. On the firms side, it could result from negative demand and/or supply externalities propagating throughout the local market. Indeed, when firms in a flooded municipality reduce their activity or exit, also a firm located in a neighboring non-flooded municipality faces a contraction in its own sales, as it may depend on flooded firms as customers or as suppliers of intermediate inputs,[23] and the intensity of such network effects diminishes with geographic distance. Spatially attenuated effects on survival and activity are also estimated by Clò et al. (2024) and Chang and Zheng (2026).[24]

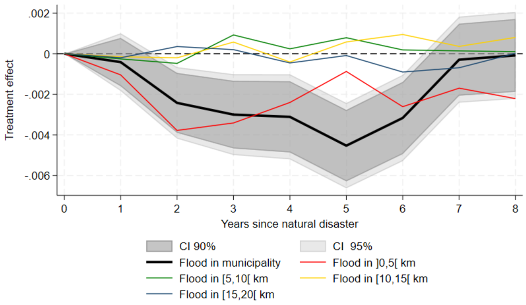
Finally, regarding relocation (panel (c) of Figure 7), the effects of floods in neighboring municipalities is not statistically different from zero, even for close municipalities. This absence of effect is coherent with the result presented in panel (c) of Figure 6, showing that relocation is primarily driven by firms directly hit by a flood.

In conclusion, the existence of spillover effects implies that the aggregate economic cost of flooding is not limited to directly hit firms, but extends to a broader set of firms located in the surrounding area. These findings show that the social cost of floods estimated from direct effects alone constitutes a lower bound on the true impact, and that policies aimed at reducing flood risk should account for these indirect effects.

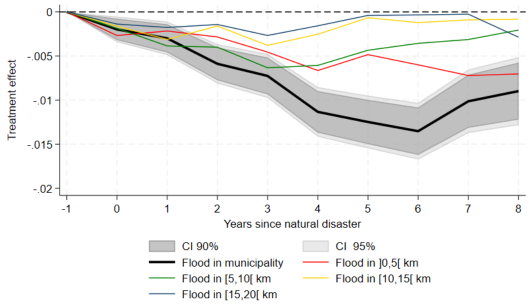
[23]This mechanism echoes the findings of Barrot and Sauvagnat (2016) on supply chain propagation.

[24]Clò et al. (2024) find attenuating effects for neighboring municipalities. Chang and Zheng (2026) find negative spillovers within 6 km and positive spillovers farther away from the flood.

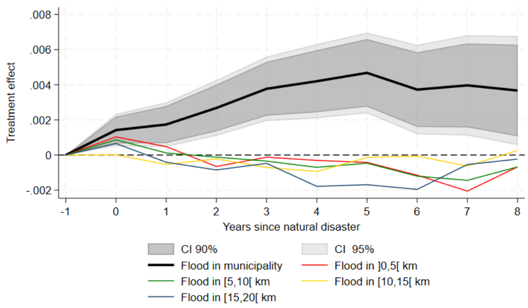
Figure 7: Effects of floods occurring in neighboring municipalities



(a) Survival



(b) Sales



(c) Relocation

Note: Plotted are the cumulative impulse response of survival (panel (a)), sales (panel (b)) and relocation probability (c) to a flood occurring in the municipality where the firm is located (black line) and to the nearest flood occuring in 4 rings of 5 kms around the firm's municipality. Shaded areas show respectively 90% (dark grey) and 95% (light grey) confidence intervals. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

8 Extension to firms with multiple establishments

The analysis so far focuses on firms operating out of a single site, so that firm and establishment coincide. Single-establishment firms represent 70% of firms in our original data. The remaining share of firms operates through multiple establishments spread across different municipalities.

It is not obvious whether the effect of natural disasters should be expected stronger or weaker in the case of multi-establishment companies. Indeed, two countervailing mechanisms may be at work. On the one hand, a 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 company whose activity is spread across several establishments, like a restaurant chain, could absorb the negative impact on one establishment hit by a flood and even neutralize it.

Comparing the effects of floods between firms with single and multiple establishments would therefore be useful. However, data limitations prevent us from implementing our baseline estimation framework at the establishment level. At the intensive margin, we cannot examine the impact of a flood affecting one location separately by establishment, but only on the overall economic situation of the firm. Indeed, financial statements consolidate the information of establishments at the firm level. At the extensive margin, we cannot distinguish between a relocation and a closure of one establishment followed by the opening of another one. Indeed, while a firm is characterized by a permanent identifier, each of its establishments is identified with a code that is tied to a specific address.[25]

Despite these constraints, in this section we focus on the sample of firms with at least two establishments[26] and we present three sets of results for multi-establishment firms.[27] We first conduct the analysis at the firm level, treating a firm as exposed

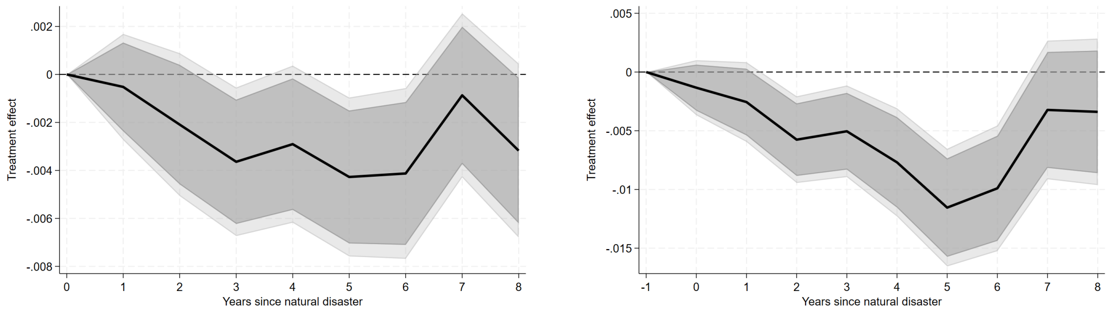
[25] In France, the firm identifier is called SIREN, while the establishment identifier is called SIRET.

[26] We identify multi-establishment firms through the administrative SIRENE registry, which records the complete set of active establishments for each legal entity at any point in time.

[27] Table A.2 in the Appendix presents some descriptive statistics about these firms. On average 22% of them have at least one of their establishments hit by a flood in a given year, and among them, the share of affected establishments is about 50%. The evolution of sales and survival is comparable to that of single-establishment firms.

if the municipality of its headquarter is flooded. Figure 8 presents the estimated impulse response functions for survival (panel (a)) and sales (panel (b)) at the firm-level. The responses of survival and sales are comparable to that of single-establishment firms, both in terms of magnitude and time profile, to the baseline results in Section 4.1.

Figure 8: Multi-establishment firms: survival and sales at the company level, for a flood in the headquarter's municipality



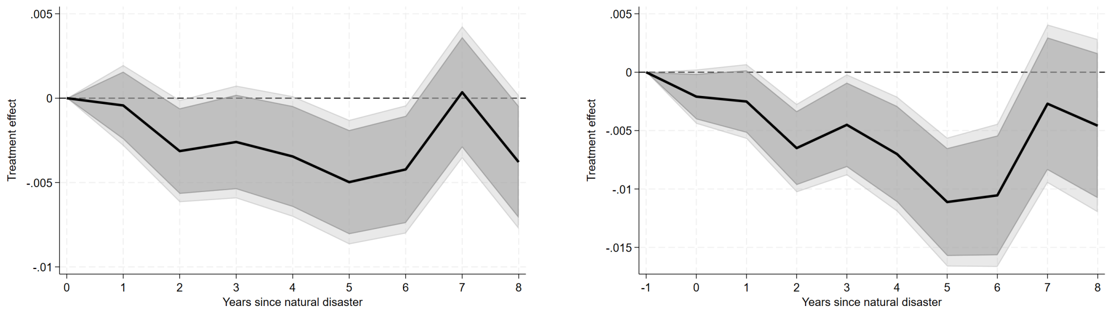
(a) Survival (b) Sales

Note: Plotted are the cumulative impulse response of survival (panel (a)), sales (panel (b)) to a flood occurring in the municipality where the firm's headquarter is located, focusing on firms with multiple establishments. Shaded areas show respectively 90% (dark grey) and 95% (light grey) confidence intervals. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

Second, we estimate the effects on survival and sales depending on the share of establishments located in a flooded municipality. The results are presented in Figure 9. For both survival and sales, we find that an increase in the share of affected establishments decreases both the survival and the sales of the whole firm.

Finally, we turn to the establishment level, and examine the survival of flooded establishments in multi-establishment firms. Figure 10 shows that the survival probability of a flooded establishment declines significantly in the years following the event, tracing a pattern similar to the baseline firm-level survival results for single-establishment firms. Therefore, on average, a flooded establishment does not seem to benefit from protection from the broader establishment network.

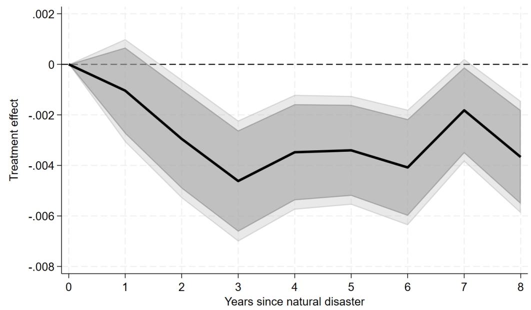
Figure 9: Multi-establishment firms: survival and sales at the company level, depending on the share of establishments hit by a flood



(a) Survival (b) Sales

Note: Plotted are the cumulative impulse response of survival (panel (a)), sales (panel (b)), to an increase from 0 to 1 of the shares of establishements affected by a flood. Shaded areas show respectively 90% (dark grey) and 95% (light grey) confidence intervals. Robust standard errors. Sample period: 2004-2024.

Figure 10: Multi-establishment firms: survival at the establishment level



(a) Survival

Note: Plotted are the cumulative impulse response of survival (panel (a)), sales (panel (b)) to a flood occurring in the establishment's municipality, focusing on firms with multiple establishments. Shaded areas show respectively 90% (dark grey) and 95% (light grey) confidence intervals. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

9 Conclusion

Policymakers are increasingly aware of the rising costs associated to floods and emphasize that firms' adaptation will be key to their resilience (Bénassy-Quéré (2025), Demerliac et al. (2025)).

In this paper, we confirm the significant impact of floods: affected firms have a lower survival rate, and conditionally on surviving, suffer lower economic performance. Importantly, these adverse flood effects are highly persistent in time and spread spatially beyond directly flooded firms. These dimensions should thus not be overlooked when designing policies to support firm recovery.

We also find that firms respond to floods by relocating. Because they move to less risky areas, relocation may prevent them from being hit by future floods and thus constitutes a form of adaptation strategy. However, firms tend to relocate within close proximity to their original location, remaining within their local market, where they may still suffer from negative spillover effects. Moreover, relocated firms do not show improved performance. This suggests relocation might not be a sufficient strategy and should be complemented by additional adaptation measures.

It is important to consider that our estimates should be regarded as lower-bound effects for several reasons. 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, it should mitigates the losses. Therefore, the estimated effect is likely to be lower than the true economic cost.

While we show that floods significantly affect firms' survival and 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 intense natural disasters.

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Appendix

A Additional descriptive statistics

Table A.1: Firms descriptive statistics

	h=0	h=1	h=2	h=3	h=4	h=5	h=6	h=7	h=8	Nobs h=0	Nobs h=8
Sales - Δlog	0.030	0.060	0.086	0.104	0.114	0.132	0.152	0.168	0.183	2,449,071	845,358
Assets - Δlog	0.036	0.076	0.114	0.149	0.181	0.210	0.241	0.272	0.301	2,449,068	845,355
Employees - Δlog	0.013	0.023	0.031	0.035	0.036	0.038	0.041	0.042	0.042	2,306,416	793,716
Staff cost - Δlog	0.035	0.066	0.091	0.111	0.124	0.142	0.162	0.179	0.194	2,408,652	833,925
EBITDA - Δlog	0.018	0.041	0.064	0.083	0.090	0.105	0.121	0.135	0.154	2,006,088	680,294
Investment - Δlog	-0.033	-0.024	-0.007	0.009	0.014	0.038	0.057	0.076	0.089	1,901,353	667,637
Long-term assets - Δlog	0.060	0.115	0.165	0.211	0.253	0.292	0.333	0.372	0.411	2,431,107	840,586
Active in h	-	93.001	87.720	83.165	79.024	75.132	71.567	68.141	65.490	2,905,542	1,600,562
Prob. relocation (%)	2.572	5.013	7.273	9.319	11.187	12.956	14.623	16.212	17.720	2,449,071	845,358
Relocation distance (km) ‡	17.090	16.836	16.740	16.742	16.947	17.173	17.252	17.362	17.420	63,008	149,799
Prob. municipality change (%) ‡	0.575	0.578	0.579	0.579	0.580	0.581	0.581	0.581	0.582	63,008	149,799

Note: The table presents descriptive statistics for the main variables of interest in the period 2004-2024, for different horizons ranging between $h = 0$ and $h = 8$. Sample period: 2004-2024. †: among firms hit by a flood. ‡: among relocating firms.

Table A.2: Descriptive statistics - Multi-establishment firms

	Mean	SD	D1	Q1	Q2	Q3	D9	Number of obs.
Number of establishments (%)	2.97	2.60	2	2	2	3	5	978,462
Share of firms with flooded HQ (%)	12.13	32.64	-	-	-	-	-	978,462
Share of firms with at least one establishment flooded (%)	22.11	41.50	-	-	-	-	-	978,462
Share of flooded establishments (%) †	52.96	27.86	20.00	33.33	50.00	66.67	100	216,393
Active in t+1 (%)	92.43	26.44	-	-	-	-	-	920,477
Sales - Level	16,885	108,719	1,023	1,516	3,131	8,901	27,474	978,462
Sales - Δlog	0.031	0.216	-0.163	-0.053	0.027	0.113	0.231	822,907

Note: The table presents yearly descriptive statistics for the main variables of interest in the period 2004-2024, for firms with multiple establishments. All financial variables are presented in K€(Level) and as yearly variation of their logarithm (Δlog). 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.

B Cox model of survival

To cross-validate our results based on the local projection framework developed in Section 4, we estimate an extended Cox proportional hazards model of firm survival.

The analysis is conducted over the full sample period, 2004–2024. Consistent with the baseline analysis, we restrict the sample to single-establishment firms, excluding the largest French metropolitan areas (Paris, Lyon, and Marseille) as well as firms operating in financial services, agriculture, public administration, education, healthcare, and real estate. We define firm exit as a binary indicator taking the value of one whenever firm i permanently disappears from the FIBEN database — that is, when it files no financial statement for the remainder of the sample window.

Our empirical model posits that the instantaneous hazard of firm i exiting our sample at time t satisfies:

$$\begin{aligned} h_i(t \mid Z_i) \; = \\ & h_0(t) \; \times \; \exp\left(\sum_{\tau=0}^{h} \varphi_\tau F_{i,t-\tau} \; + \; \sum_{k \in K} \sum_{\tau=0}^{h} \varrho_{k,\tau} D_{k,i,t-\tau} \; + \; \gamma X_{i,t} \right), \\ & h_0(t) > 0 \end{aligned} \tag{8}$$

where $F_{i,t}$ is a dummy indicating whether there was a flood in the municipality of firm i in year t, $D_{k,i,t}$ is a dummy indicating whether there was another disaster of type k (among droughts, landslides and other disasters) in year t, and $X_{i,t}$ are the same control variables as in our baseline specification (namely log of total assets and leverage ratio). We estimate models with h ranging from 0 to 5.

Table B.1: Survival analysis

Hazard ratio	(1)	(2)	(3)	(4)	(5)	(6)
Flood	1.027***	1.024***	1.014***	1.008*	1.006	1.005
	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
Flood(-1)		1.031***	1.021***	1.019***	1.011*	1.010
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Flood(-2)			1.029***	1.025***	1.021***	1.016**
			(0.007)	(0.006)	(0.007)	(0.007)
Flood(-3)				1.013***	1.011**	1.010**
				(0.004)	(0.004)	(0.004)
Flood(-4)					1.027***	1.023***
					(0.006)	(0.006)
Flood(-5)						1.005
						(0.007)
N	2,547,752	2,448,051	2,083,437	1,776,360	1,515,463	1,292,286
Controls	Y	Y	Y	Y	Y	Y
Firm charac.	Y	Y	Y	Y	Y	Y
Other disasters	Y	Y	Y	Y	Y	Y

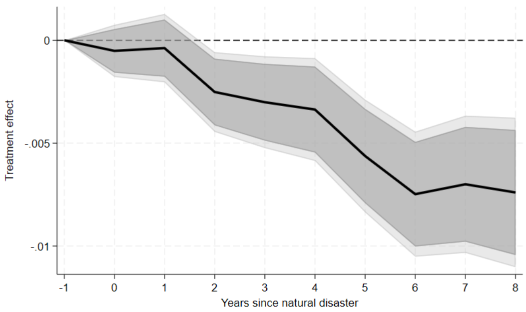
Standard errors clustered at the municipality-year level in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

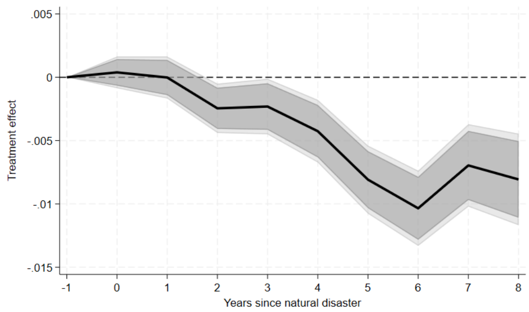
Note: The table presents the effect of contemporaneous and lagged floods on firms hazard ratio in a Cox model, where hazard refers to a firm exiting the dataset. Each regression controls for the log of total assets and the leverage ratio. Other disasters are added with the same number of lags as floods.

C Additional financial indicators

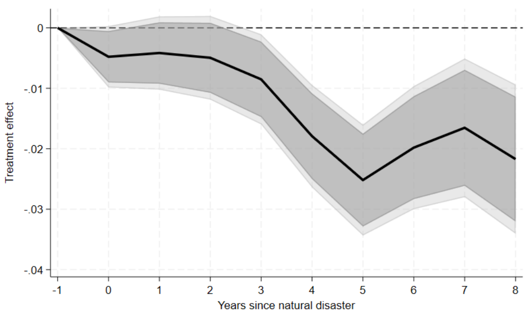
Figure C.1: Baseline results: additional financial statement indicators



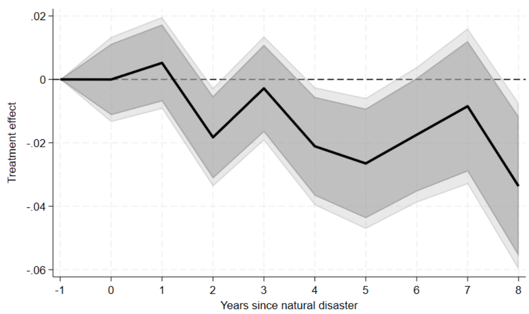
(a) Number of employees



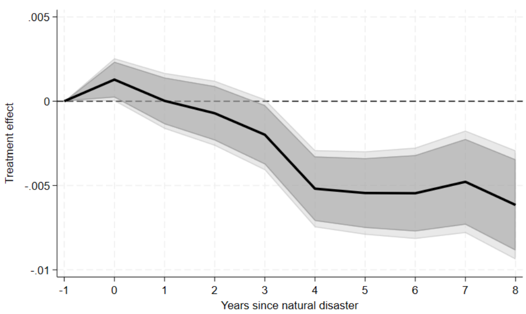
(b) Staff costs



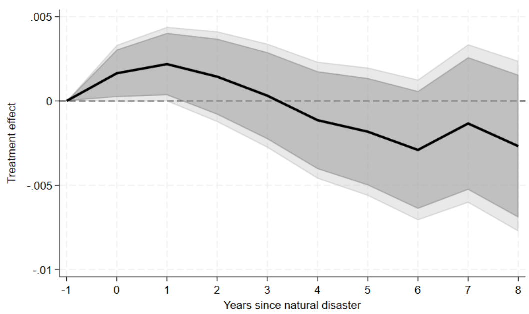
(c) EBITDA



(d) Investment



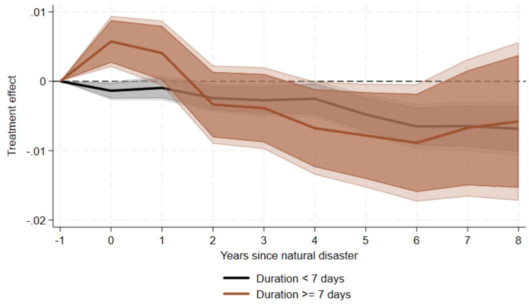
(e) Total assets



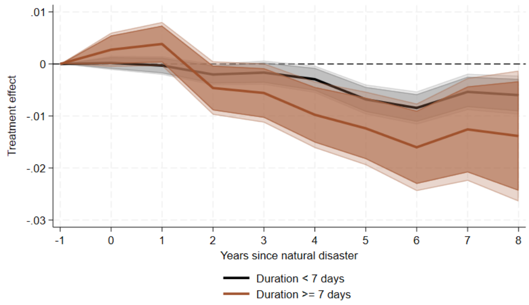
(f) Long-term assets

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% (dark grey) and 95% (light grey) confidence intervals. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

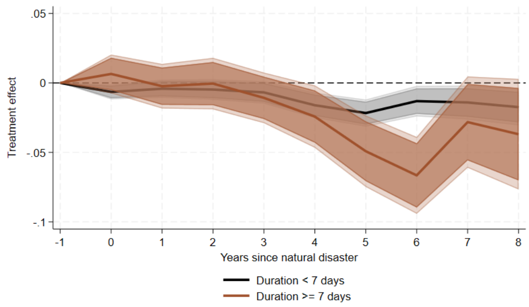
Figure C.2: Flood intensity based on the duration of the longest flood within the year: additional financial indicators



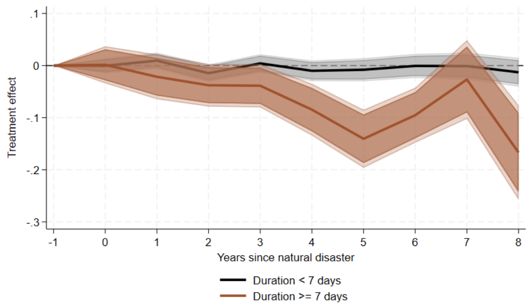
(a) Number of employees



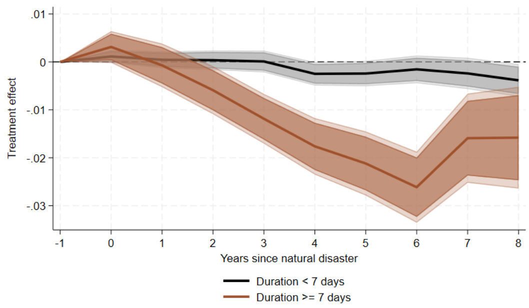
(b) Staff costs



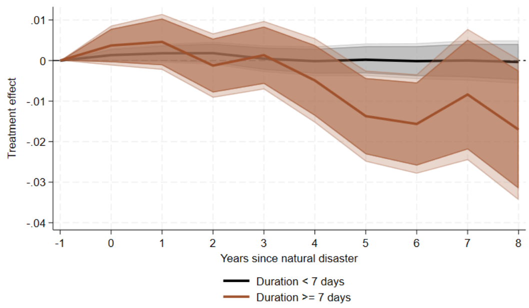
(c) EBITDA



(d) Investment



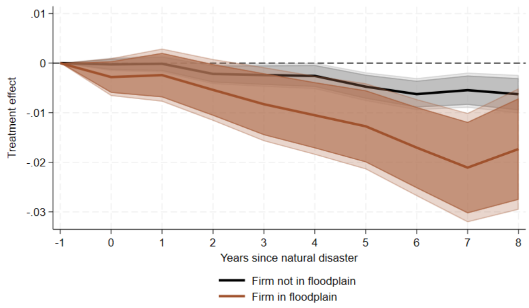
(e) Total assets



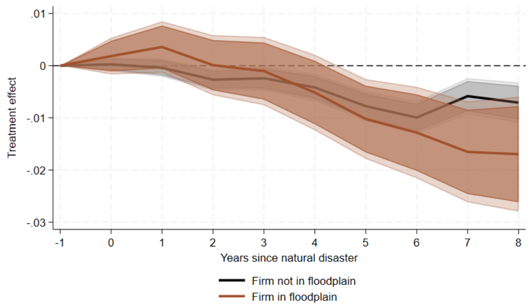
(f) Long-term assets

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). The brown line is the response to intense flooding (municipalities where the largest flood lasted 7 days or more), while the black line is the response to less intense 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.

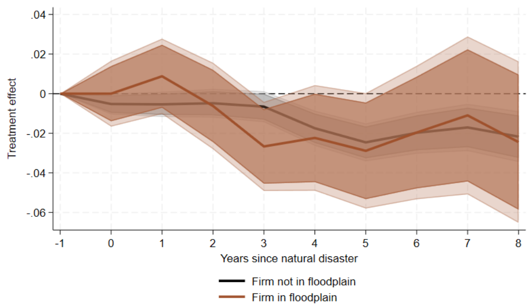
Figure C.3: Direct vs indirect effects: additional financial indicators



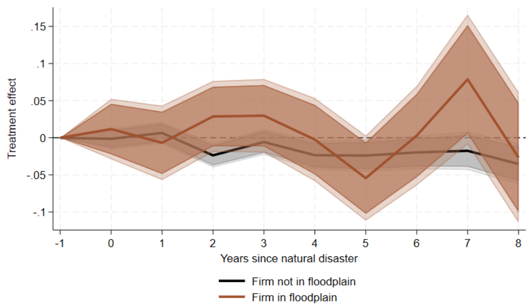
(a) Number of employees



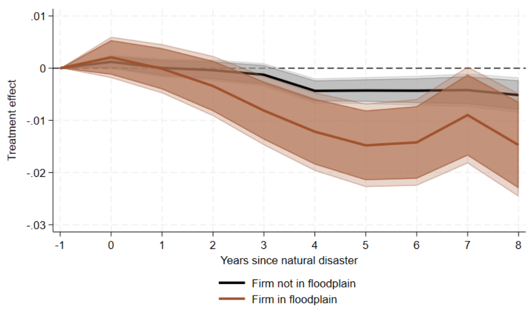
(b) Staff costs



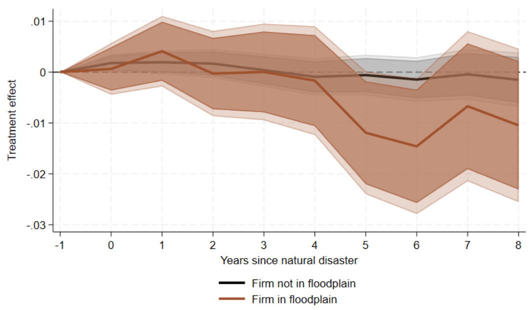
(c) EBITDA



(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). The brown line is the response for firms located in 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.

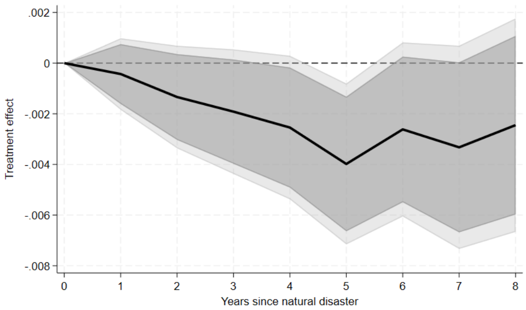
D Robustness to alternative specifications and sample selection

Table D.1: First stage regressions: predicting floods with rainfall

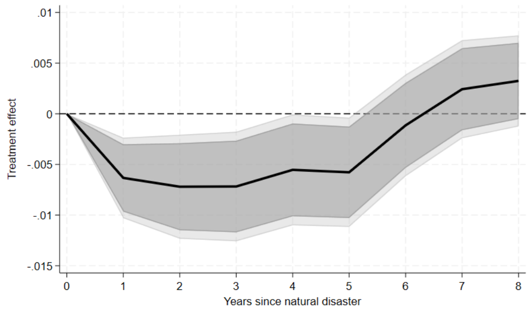
Maximum monthly rainfall (mm)	0.0014***	0.0014***	0.0014***
	(0.00006)	(0.00006)	(0.00006)
N	1,487,062	1,746,032	1,611,816
KP F-stat	572.94	612.02	579.22
Second stage outcome	Sales	Relocation	Survival

Note: The table presents the result of the first stage regression for regressions at horizon $h = 0$ (sales and relocation), and horizon $h = 1$ (survival). In all regressions, the explained variable is a dummy equal to 1 if the municipality in which the firm is located was hit by a flood during the year, and 0 otherwise. The explanatory variable is the maximum monthly rainfall reported during the year in the closest meteorological station of the firm's municipality. The regression controls for the baseline controls and fixed effects. Standard errors clustered at the municipality-year level in parentheses. *** p $<$0.01. Sample period: 2004-2024.

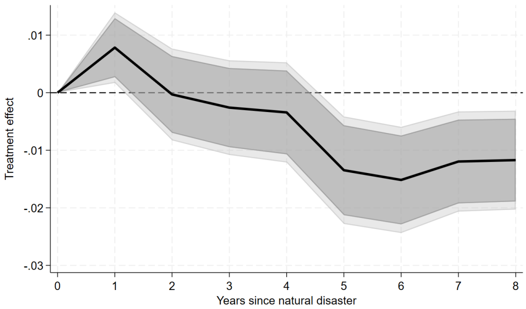
Figure D.1: Robustness to alternative specifications: survival



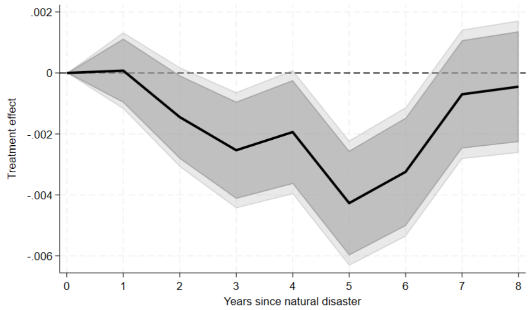
(a) Replacing firm FE by county and sector specific year FE



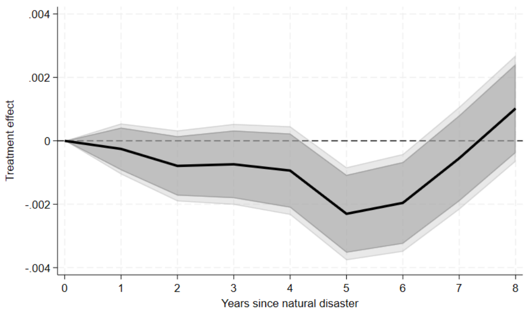
(b) Restricting to firms with no or one event



(c) Instrumental variable



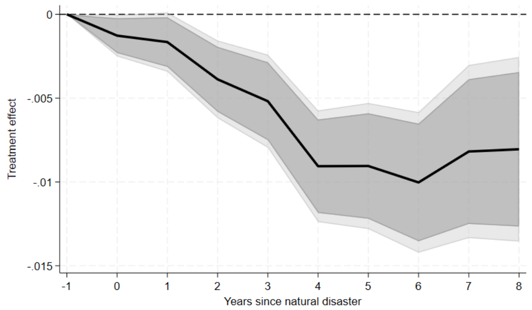
(d) Firms with sales above 1M EUR



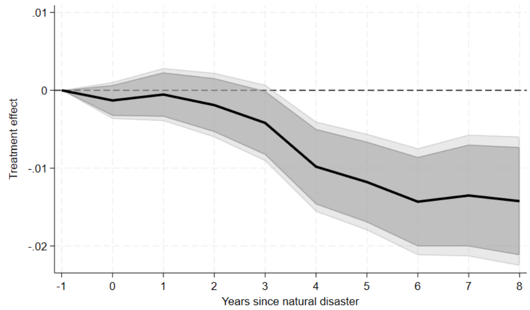
(e) Alternative definition of survival

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

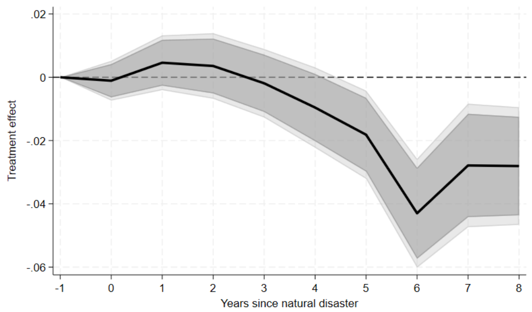
Figure D.2: Robustness to alternative specifications: sales



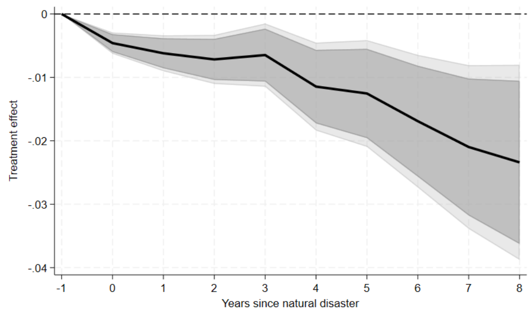
(a) Replacing firm FE by county and sector specific year FE



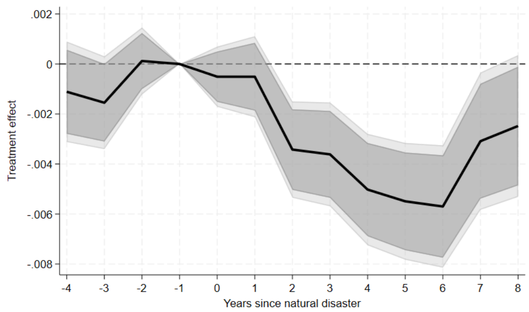
(b) Restricting to firms with no or one event



(c) Instrumenting floods by rainfall



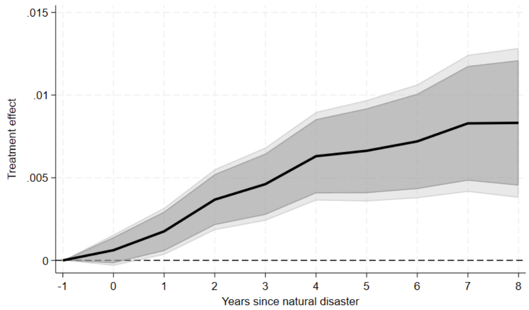
(d) Local projection DiD



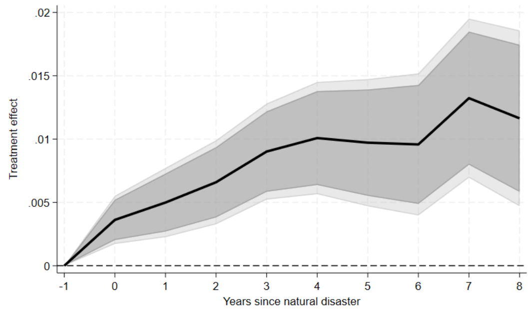
(e) No controls for lags and forwards

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

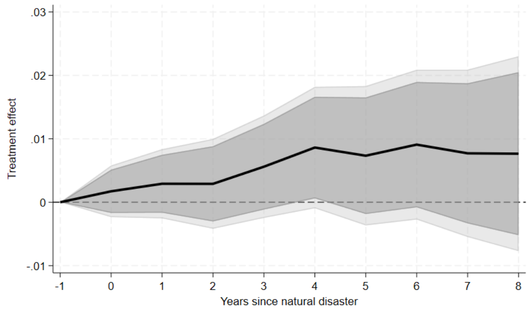
Figure D.3: Robustness to alternative specifications: relocation



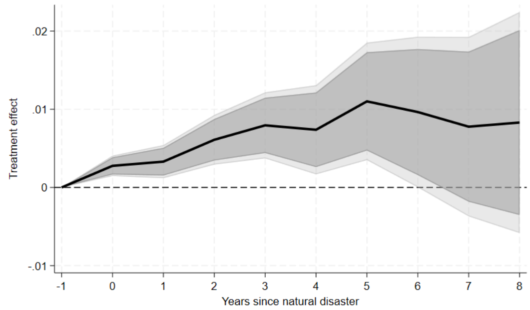
(a) Replacing firm FE by county and sector specific year FE



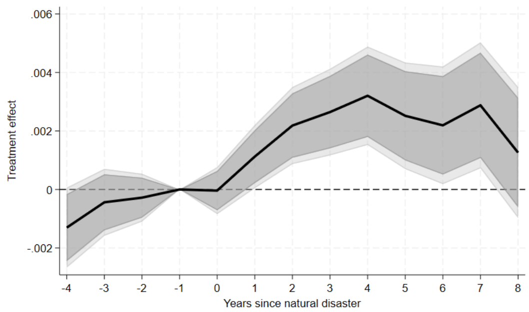
(b) Restricting to firms with no or one event



(c) Instrumenting floods by rainfall



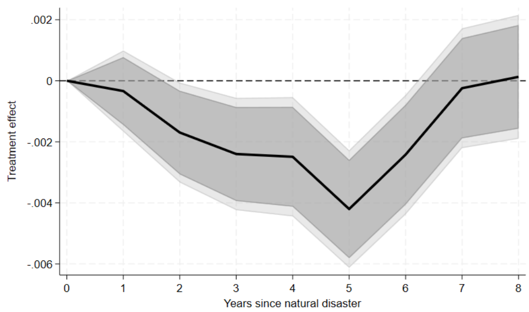
(d) Local projection DiD



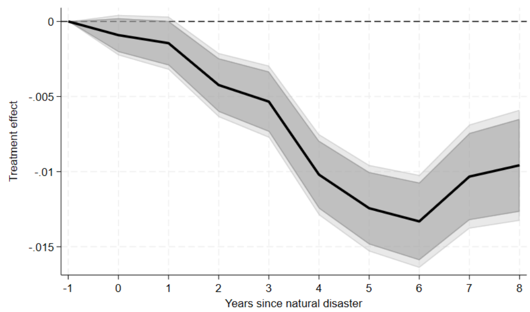
(e) No controls for lags and forwards

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

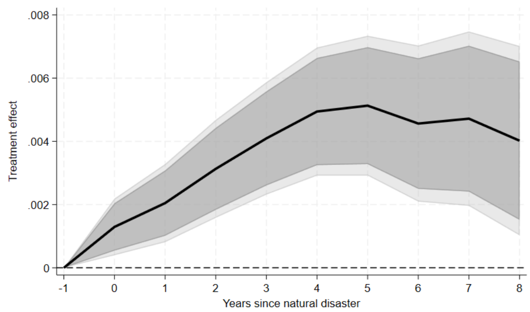
Figure D.4: Baseline results including Paris, Marseille and Lyon



(a) Survival



(b) Sales

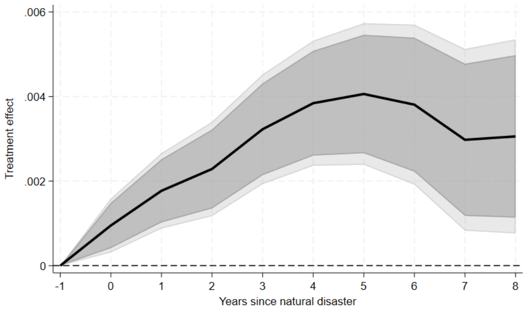


(c) Relocation

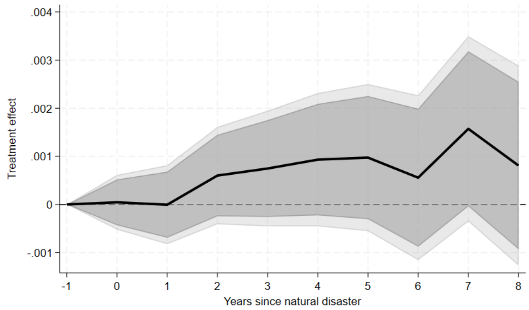
Note: Plotted are the cumulative impulse response of survival (panel a), sales (panel b) and relocation probability (panel c) to floods occurring in the municipality where the firm is located. Compared to the baseline sample, this sample includes firms located in Paris, Marseille and Lyon. Shaded areas 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.

E Additional results on firm relocation

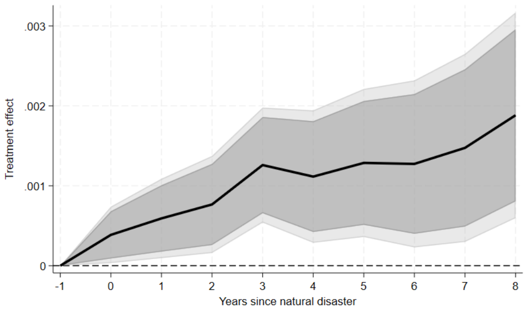
Figure E.1: Alternative definition of relocating



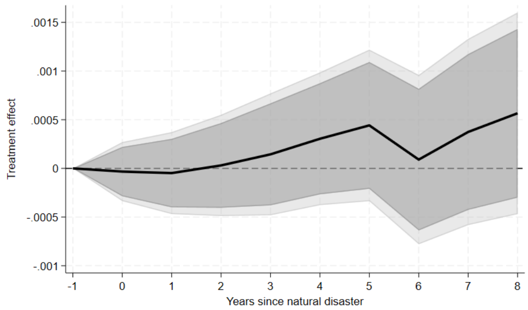
(a) Moving to another municipality



(b) Moving to another location in same municipality



(c) Moving to another urban unit

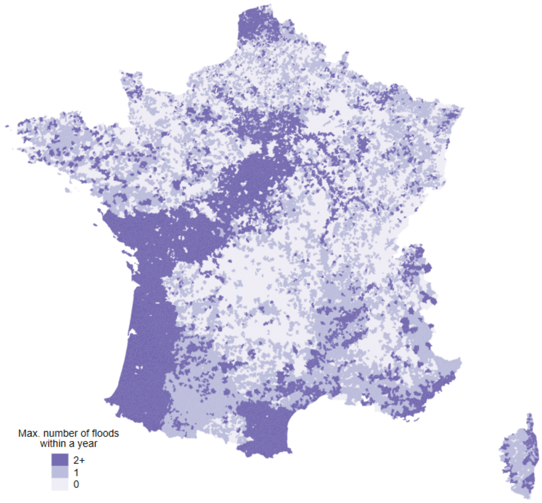


(d) Moving to another employment area

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% (dark grey) and 95% (light grey) confidence intervals. Standard errors are clustered at the municipality-year level. Sample period: 2004-2024.

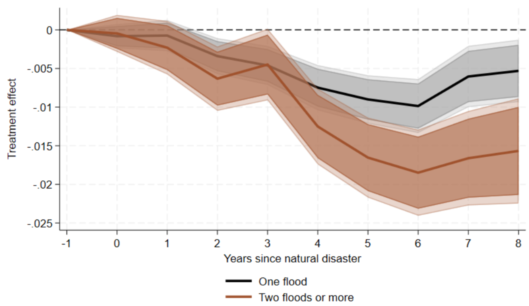
F Alternative measure of flood intensity

Figure F.1: Flood intensity measured by the number of floods within the year

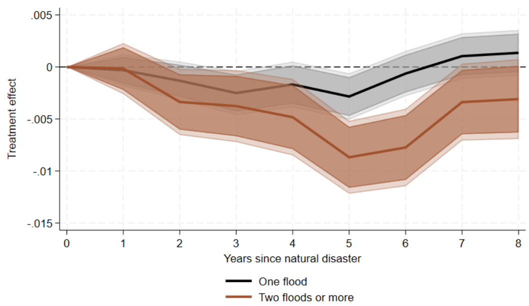


Note: Figure F.1 presents an alternative measure of flood intensity: dark regions represent municipalities that have been it by two floods or more in a given year within the period 2004-2024.

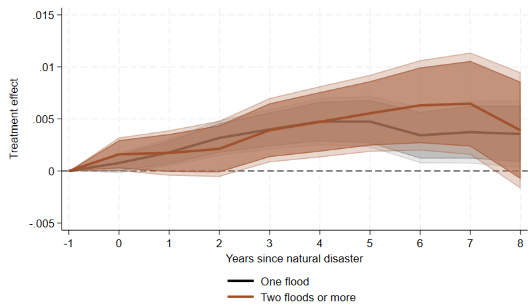
Figure F.2: Heterogeneity depending on the number of floods within the year



(a) Survival



(b) Sales



(c) Relocation

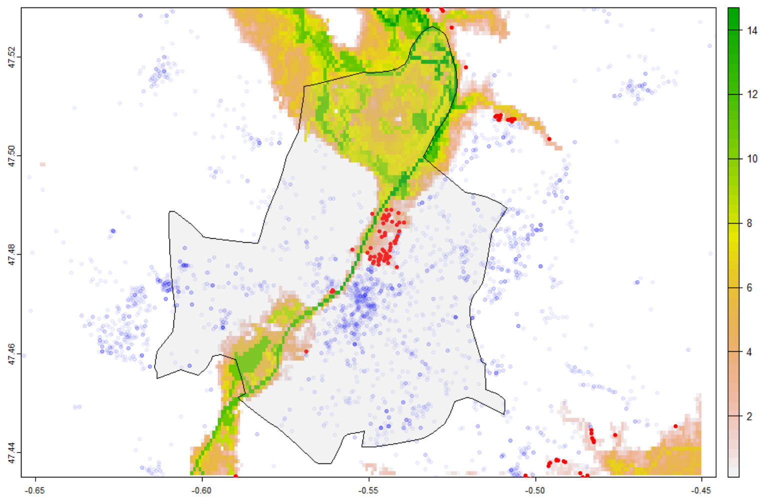
Note: Plotted are the cumulative impulse response of survival (panel (a)), sales (panel (b)) and relocation (panel (c)) to floods occurring in the municipality where the firm is located. The brown line is the response to two floods or more within the same year, while the black line is the response to a single flood. 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

G Mapping firm geolocation with floodplains

Floodplain data are from Dottori et al. (2022), which covers Europe and the Mediterranean basin. We use floodplains for 1-in-100 years floods because, as indicated by the authors, below this resolution, flood-prone area are overestimated.

Using the GPS coordinates of firms based on the SIRENE geolocation database, provided by INSEE, we clip firms to the floodplain raster. Figure G.1 plots, for the city of Angers and its surroundings, the geolocation of firms in our final sample, distinguishing those located out of any floodplain (in blue) and those located within a floodplain (i.e. those with floodplain water height strictly greater than 0, in red). The analysis of direct vs indirect effect (Section 7) therefore distinguishes the impact of a flood between firms located in or outside of a floodplain, within a municipality that has issued a flood decree.

Figure G.1: Floodplain map: Angers



Note: Plotted is a map of the city of Angers and its surroundings, displaying, in the orange-to-green scale, 1-in-100 years floodplains (with orange indicating water height of 2 meters, and green indicating water height of up to 14 meters). Over the floodplain map are plotted the location of firms in our sample: blue firms are located in non-floodplain areas, while red firms are located in floodplain areas (with water height >0).