Climate Shocks: Inter-Firm Payments

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Abstract

Extreme climate events can transmit operational risk across firms through financial and trade linkages. We study whether these shocks propagate through inter-firm payment networks or are absorbed through payment reallocation. Using proprietary data from the Banco Central do Brasil covering more than 1.7 billion inter-firm payment transactions, we map customer-supplier relationships and their monetary intensity across Brazilian firms. We combine these data with the thirty most severe acute climate events in 2020 and 2021 and estimate a difference-in-differences design comparing firms outside affected areas with different pre-event exposure to affected counterparties. Exposed outside customers reduce payments to affected suppliers by 11.1% after climate shocks, but increase payments to unaffected suppliers by a similar magnitude. Upstream estimates show the same pattern. In both directions, aggregate payment activity remains statistically unchanged. These results show that climate shocks reshape the composition of inter-firm payment flows without generating average aggregate payment losses among exposed firms outside disaster areas. However, sector-level estimates indicate that reallocation is less complete in industries with higher substitution frictions. The findings highlight the role of payment networks in measuring climate risk transmission and firm-level resilience.

Keywords: Climate risk; Inter-firm payment networks; Supply-chains; Risk transmission; Firm resilience.
JEL Classification: QG32; Q54; D85; L14; L23.

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1 Introduction

Inter-firm payment networks are a central source of both economic connectivity and systemic fragility, particularly when climate-related shocks interact with heterogeneous firms and production linkages (Bálint et al., 2017). By connecting firms across regions and sectors, supply chains allow localized shocks to propagate beyond the areas where they initially occur (Carvalho et al., 2021; Kashiwagi et al., 2021). Existing evidence documents the direct effects of extreme climate events on exposed firms and regions, as well as indirect effects through customers, suppliers, and local economic linkages (Elliott et al., 2019). A growing literature further shows that firms adjust supply-chain relationships in response to physical climate risk (Blaum et al., 2026; Pankratz and Schiller, 2024). However, it remains unclear whether such adjustment contains climate-risk transmission by preserving aggregate payment flows outside disaster-hit areas, or whether shocks still propagate through firm networks despite attempts to substitute across counterparties.

We address this gap by asking whether firms outside disaster-affected areas absorb climate shocks through lower inter-firm payment activity or preserve operations by reallocating payments across counterparties. If outside firms with pre-event links to affected suppliers or customers reduce their overall payments after a disaster, climate risk is transmitted beyond the affected region. If instead firms maintain aggregate payment activity while shifting payments away from affected counterparties toward unaffected ones, resilience operates mainly through payment reallocation. This distinction is crucial for understanding whether climate shocks generate broader financial and economic disruption or instead reshape the composition of payment flows within the firm network (Blaum et al., 2026).

We examine this question in Brazil, combining proprietary inter-firm payment data from the Banco Central do Brasil with records on the thirty most severe acute climate events in 2020 and 2021. The payment data cover more than 1.7 billion inter-firm transactions through Pix, boletos, and wire transfers, three major payment instruments that account for a large share of payment activity in Brazil. The key advantage of this setting is that payment flows reveal the monetary intensity of firm-to-firm relationships, allowing us to move beyond whether firms replace trading partners and measure how much activity is redirected across affected and unaffected counterparties.

We implement a difference-in-differences design that compares outside firms with different levels of pre-event exposure to affected counterparties within the same industry, municipality, climate event, and quarter. Exposure is measured from pre-event payment relationships, capturing how strongly an outside firm was connected to suppliers or customers located in the disaster-affected area before the shock. The design estimates whether more exposed outside firms experience a decline in aggregate payment activity or instead reallocate payments from affected to unaffected counterparties after the event. We implement the analysis from two complementary perspectives: downstream, where outside customers are exposed to affected suppliers, and upstream, where outside suppliers are exposed to affected customers.

Our findings reveal a clear payment reallocation pattern. For a one-standard-deviation increase in exposure, outside customers reduce payments to affected suppliers by 11.1% and increase payments to unaffected suppliers by a similar magnitude, while aggregate payments do not change significantly. The upstream results show the same logic: payments received from affected customers fall by about 7%, while payments from unaffected customers rise by about 9%, with no significant decline in total received payments. This adjustment is not uniform across sectors. Most industries show relatively low observed reallocation frictions, while sectors such as construction, accommodation and food services, electricity and gas, and domestic services display more incomplete or costly adjustment patterns.

Together, our findings contribute to the literature in three ways. First, they show how climate shocks are transmitted and absorbed within inter-firm payment networks, complementing evidence that firms adjust supply-chain relationships in response to physical climate risk (Pankratz and Schiller, 2024). Second, they build on evidence documenting direct effects on firms in exposed regions by showing that, outside disaster-hit areas, these shocks are largely absorbed through payment reallocation rather than aggregate payment losses (Silva et al., 2025, 2026). Third, they show that this resilience is uneven across sectors, consistent with evidence that network structure shapes economic robustness to natural disasters and that partner reallocation can be costly (Bisetti et al., 2026; Henriet et al., 2011).

This sectoral heterogeneity matters because climate-risk assessment increasingly requires attention to indirect effects, climate-economy feedbacks, and firm-level determinants of resilience, including sectoral characteristics, financial access, managerial capabilities, and policy support

(Acharya et al., 2023; Grover and Kahn, 2026). Our findings therefore imply that climate-risk management should account for differences in firms' ability to adjust payment relationships after shocks, especially in sectors where counterparty replacement is more costly, slower, or constrained by contractual and operational frictions.

2 Data and empirical design

We use proprietary inter-firm payment data from the Banco Central do Brasil (BCB) covering 2019–2022. The data identify customer-supplier payment flows allowing us to measure both the existence and the monetary intensity of firm-to-firm relationships. We aggregate payments at the quarterly level and apply business-to-business filters. Details on the payment data and sample construction are reported in Appendix A.1.

We combine these data with disaster records from the Sistema Integrado de Informacoes sobre Desastres (S2ID). We focus on acute weather-related events with clearly defined timing and retain the thirty most severe events occurring in 2020 and 2021, ranked by a composite index of human impacts and economic losses. Affected areas are defined at the microregion level to account for local economic integration across neighboring municipalities. Appendix A.2 describes the event selection procedure and the definition of affected areas; the selected events are listed in Table A1.

Our empirical design focuses on firms located outside disaster-affected microregions. Building on the direct-effect specification in Silva et al. (2026), we estimate climate-risk transmission by comparing outside firms with different pre-event exposure to affected counterparties. We implement the analysis from two complementary perspectives: downstream, where outside customers are exposed to affected suppliers, and upstream, where outside suppliers are exposed to affected customers. Within each perspective, the design asks whether more exposed firms experience lower aggregate payment activity or instead reallocate payment flows from affected to unaffected counterparties. Formal definitions of the exposure measures are provided in Appendix A.3, descriptive statistics for the downstream and upstream empirical samples are reported in Table A2, and Appendix A.4 provides a schematic illustration of the downstream case.

We estimate the effect of exposure using a difference-in-differences specification at the event-firm-quarter level:

$$\log(y_{x,f,t}) = \alpha_{x,sector(f),municipality(f),t} + \gamma_{x,f} + \beta Post_{x,t} \times Exposure_{x,f} + \varepsilon_{x,f,t}. \tag{1}$$

where $y_{x,f,t}$ denotes payment activity of outside firm f around event x in quarter t. We estimate Eq. (1) separately for total payments, payments with counterparties located in the affected microregion, and payments with counterparties located outside the affected microregion. The variable $Post_{x,t}$ equals one for quarters at or after event x, and $Exposure_{x,f}$ is the pre-event exposure of outside firm f to counterparties located in the affected microregion. The fixed effect $\alpha_{x,sector(f),municipality(f),t}$ absorbs event-specific shocks that vary over time among firms in the same sector and municipality, while $\gamma_{x,f}$ absorbs time-invariant characteristics of each event-firm pair. Standard errors are clustered at the event-firm level, matching the level of variation of the exposure measure (Abadie et al., 2023).

The coefficient of interest, β, compares post-event changes in payment outcomes between more and less exposed outside firms operating within the same event, sector, municipality, and quarter. Since exposure is standardized in the regressions, β can be interpreted as the effect of a one-standard-deviation increase in pre-event exposure. The identifying assumption is that, conditional on these fixed effects, outside firms with different pre-event exposure would have followed similar payment trajectories in the absence of the climate event. Under this assumption, differences in post-event payment behavior can be interpreted as climate-risk transmission through pre-existing inter-firm payment relationships.

3 Inter-firm payment reallocation after climate shocks

Silva et al. (2026) show that extreme climate events reduce payments to firms located in directly affected regions. We shift attention to firms outside the affected regions and ask how they adjust their payment relationships when part of their counterparty network is exposed to the shock. This question connects to Pankratz and Schiller (2024), who show that firms respond to suppliers' physical climate risk by adjusting supply-chain relationships; our payment data allow us to measure whether such adjustment preserves aggregate payment activity or generates payment losses for outside firms. The results point to three findings. First, outside firms largely preserve aggregate payment volumes, but reallocate payment flows away from affected counterparties and toward unaffected ones. Second, event-study estimates show no evidence of differential pre-trends and indicate that the reallocation persists after the event. Third, the adjustment is uneven across sectors, with some industries displaying larger reallocation frictions.

Table 1 reports the baseline estimates. In the downstream perspective, total payments made by outside customers do not change significantly after the event (Spec.I), suggesting limited climate-risk transmission to firms outside the affected region. However, this aggregate stability masks a sharp reallocation across suppliers. A one-standard-deviation increase in exposure reduces payments to affected suppliers by 11% (Spec.II), while increasing payments to unaffected suppliers by a similar magnitude (Spec.III). Outside customers therefore appear to preserve payment activity by reallocating payments away from suppliers located in affected microregions.

The upstream perspective reveals a similar adjustment on the customer side. Total payments received by outside suppliers remain statistically unchanged (Spec.IV), but the composition of their customer base shifts after the shock. A one-standard-deviation increase in exposure reduces payments received from affected customers by about 7% (Spec.V), while payments received from unaffected customers increase by about 9% (Spec.VI). These findings indicate that outside suppliers compensate for weaker payment flows from affected customers by expanding transactions with customers outside the disaster area.

Our results extend the payment-reallocation mechanism behind supply-chain adjustment documented by Pankratz and Schiller (2024). While that evidence shows that firms adjust supply-chain relationships in response to suppliers' climate risk, our payment data allow us to assess how disruptive this adjustment is for outside firms. The absence of significant changes in total payments, together with offsetting reductions and increases across affected and unaffected counterparties, indicates that payment reallocation occurs, on average, with relatively low friction in Brazil. Our findings also complement the direct payment losses documented by Silva et al. (2026): aggregate payment activity remains stable among firms outside affected regions, suggesting limited climate-risk transmission to these firms because their ability to redirect transactions from directly affected counterparties.

Table 1: *How do climate shocks reallocate inter-firm payments outside affected areas?*

Perspective (f dimension):	Outside customers ($f = c$, downstream)			Outside suppliers ($f = s$, upstream)		
Dependent Variable:	$\log(\text{Payments}_{x,c,t})$			$\log(\text{Received Payments}_{x,s,t})$		
	Total	Affected	Unaffected	Total	Affected	Unaffected
Model:	(I)	(II)	(III)	(IV)	(V)	(VI)
Variable of interest						
Post$_{x,t}$ $\times$ Outside Firm's Exposure$_{x,f}$	-0.0044	-0.1107***	0.1096***	-0.0003	-0.0658***	0.0938***
	(0.0144)	(0.0131)	(0.0272)	(0.0060)	(0.0110)	(0.0117)
Fixed effects						
Extreme climate event $\times$						
$\times$ Time $\times$ Firm's Sector $\times$ Firm's Municipality	Yes	Yes	Yes	Yes	Yes	Yes
$\times$ Firm	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	4,831,233	4,831,233	4,831,233	3,393,784	3,393,784	3,393,784
R^2	0.9924	0.9901	0.9924	0.9963	0.9922	0.9963
Within R^2	0.0001	0.0035	0.0002	0.0001	0.0022	0.0003
Robustness test (removing same municipality constraint):						
Variable of interest						
Post$_{x,t}$ $\times$ Outside Firm's Exposure$_{x,f}$	-0.0035	-0.0600***	0.1039***	0.0035	-0.0476***	0.0837***
	(0.0099)	(0.0141)	(0.0171)	(0.0055)	(0.0053)	(0.0097)
Fixed effects						
Extreme climate event $\times$						
$\times$ Time $\times$ Firm's Sector	Yes	Yes	Yes	Yes	Yes	Yes
$\times$ Firm	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	6,797,829	6,797,829	6,797,829	5,371,979	5,371,979	5,371,979
R^2	0.9878	0.9793	0.9878	0.9917	0.9839	0.9918
Within R^2	0.0001	0.0019	0.0003	0.0001	0.0018	0.0003

Note: The upper section of this table reports the coefficient estimates from Eq. (1). The lower section presents robustness tests by re-running the same empirical specification as in the upper section, but without the constraint of comparing against firm counterparts within the same municipality. The dimension f in Specs. I—III (our downstream perspective) represents outside customers with at least one connection with suppliers located in microregions affected by extreme climate events. Analogously, it indicates in Specs. IV—VI (our upstream perspective) outside suppliers receiving payments from at least one affected customer. The dependent variables correspond to payments aggregated at the firm level (either customer or supplier) into three different forms: total payments (Specs. I and IV), payments made to/received from affected firm counterparts (Specs. II and V), and payments made to/received from unaffected firm counterparts (Specs. III and VI). Data are quarterly and correspond to a one-year window centered on each extreme climate event. The binary variable Post$_{x,t}$ equals 1 if the relative time is at or after the extreme climate event x, i.e., $t \geq 0$, and 0 otherwise. The continuous variable Exposure$_{x,f}$ follows Eq. (1). All specifications contain extreme climate event–firm's sector (7-digit CNAE)–firm's municipality-time and extreme climate event–firm fixed effects. We cluster errors at the extreme climate event $\times$ outside firm level. *, **, *** denote statistical significance of 10%, 5%, and 1%, respectively.

The lower section of Table 1 shows that the results are robust to relaxing the same-municipality comparison. In this specification, firms are compared within the same event, sector, and quarter, but not necessarily within the same municipality. The signs and economic interpretation remain unchanged: exposed outside firms reduce payments with affected counterparties and increase payments with unaffected ones, while aggregate payment volumes remain statistically stable. This robustness exercise suggests that the substitution pattern is not driven by the local comparison restriction.

Figure A2 in Appendix B.1 reports the dynamic version of the baseline specification, replacing $Post_{x,t}$ with quarterly event-time indicators. The estimates show no evidence of differential pre-trends between more and less exposed outside firms before the climate event. After the shock, payments with affected counterparties decline while payments with unaffected counterparties increase, consistent with the reallocation pattern in Table 1. The effects persist over the post-event window, suggesting that substitution reflects a durable adjustment in payment relationships rather than a short-run liquidity response.

To assess sectoral heterogeneity, we re-estimate Equation (1) separately by the industry of the outside firm and compare the coefficients for payments with affected and unaffected counterparties. Appendix B.2 reports these estimates. For most sectors, the decline in payments with affected counterparties is offset by an increase in payments with unaffected ones, indicating relatively low observed substitution frictions.

Some sectors, however, display asymmetric responses. In construction and accommodation and food services, payments to unaffected suppliers rise by more than payments to affected suppliers fall, consistent with higher replacement costs or price premia when firms search for alternative suppliers. In electricity and gas, outside customers continue paying affected suppliers while also increasing payments to unaffected suppliers, suggesting that contractual or operational constraints may limit immediate substitution. In the upstream perspective, domestic services show weaker compensation from unaffected customers, consistent with more localized and relationship-specific demand. These patterns indicate that the average low-friction substitution result masks settings in which replacement is more costly, slower, or operationally constrained, consistent with evidence that shock propagation and supply-chain resilience depend on input specificity, network structure, and the availability of alternative trading partners (Henriet et al., 2011; Kashiwagi et al., 2021).

4 Final considerations

We study whether acute climate shocks propagate to firms outside disaster-affected areas or are absorbed through inter-firm payment reallocation. Using proprietary payment data from Brazil and records on the thirty most severe acute climate events in 2020 and 2021, we measure outside firms' pre-event exposure to affected suppliers and customers. We then estimate a difference-in-differences design comparing outside firms with different levels of pre-event exposure within the same industry, municipality, climate event, and quarter. We show that climate-risk transmission beyond disaster-hit areas is limited, on average, by firms' ability to redirect payment flows across counterparties. Aggregate payment activity remains stable, while payments are reallocated away from affected firms and toward unaffected firms.

Our findings contribute to the literature by showing how climate shocks reshape inter-firm payment networks. We extend evidence on supply-chain adjustment to physical climate risk by measuring whether counterparty replacement is disruptive for exposed firms outside affected areas (Pankratz and Schiller, 2024). The results indicate that, on average, payment reallocation occurs with relatively low friction in Brazil: aggregate payments remain stable while payment flows are redirected away from firms located in affected regions. We also complement evidence documenting direct effects on firms in exposed regions by showing that, outside disaster-hit areas, these shocks are largely absorbed through payment reallocation rather than aggregate payment losses (Silva et al., 2025, 2026).

This average resilience, however, masks sectoral vulnerabilities. In construction, accommodation and food services, electricity and gas, and domestic services, adjustment appears more incomplete or costly, suggesting that reallocation frictions vary with network structure, input specificity, and the availability of alternative counterparties. These findings imply that climate-risk management should account for heterogeneity in firms' ability to replace counterparties and redirect payment flows after shocks. Future research could further examine how contractual relationships, financial constraints, input specificity, and local market structure shape firms' resilience within inter-firm payment networks.

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Appendix

A Data construction and exposure measures

A.1 Inter-firm payment data

We use proprietary inter-firm payment data from the Banco Central do Brasil (BCB) covering 2019–2022. The database contains more than 1.7 billion inter-firm payment transactions through three major payment instruments in Brazil: instant payments (Pix), invoices (boletos), and wire transfers (TEDs).[1] After applying the business-to-business filters described below, the database records approximately R$2.5 trillion in real inter-firm payment flows in 2022. We aggregate payments at the quarterly level and use them to measure both the existence and the monetary intensity of customer-supplier relationships.

Because our focus is on business-to-business transactions, we exclude payments involving individuals, government entities, and financial institutions, as well as transactions between subsidiaries of the same firm, which may reflect internal liquidity management rather than purchases of goods or services. These filters leave an inter-firm payment network better suited to capture commercial transactions between independent firms.

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A.2 Climate events and affected areas

We obtain disaster records from the Sistema Integrado de Informacoes sobre Desastres (S2ID), maintained by the Ministry of National Integration. The data are reported at the municipality level and include indicators of human impacts and economic losses. We restrict the sample to acute weather-related events with clearly defined timing. We exclude Dry Spells and Droughts because their impacts accumulate gradually and are reported only once conditions become severe. We also exclude Viral Infectious Diseases, since most observations refer to COVID-19.

To select the events used in the empirical analysis, we rank disasters by relative severity. Because S2ID damage variables are measured in different units and scales, we transform each

[1]The BCB periodically publishes the Statistics on Payment Methods Bulletin. These three instruments account for approximately 70.6% of payment volume in Brazil.

human and economic loss variable into centile ranks and average them into a composite severity index:

$$D_i = \frac{1}{n} \sum_{j=1}^{n} C_{i,j}, \tag{2}$$

where $C_{i,j}$ is the centile rank of disaster i for damage variable j, and n is the number of variables included in the index. We retain the thirty highest-scoring acute climate events occurring in 2020 and 2021. These events are mostly classified as Intense Rains, Floods, and Flash Floods, as reported in Table A1.

Table A1: *This table lists the thirty most severe acute weather-related events based on our ranking classification, including the rank position (1 to 30), rank score, municipality, state, microregion, date (year and quarter of occurrence), and category of disaster.*

Position	Rank Score	Municipality	State	Microregion	Date	Disaster
1	90.8	Medeiros Neto	BA	Porto Seguro	2021.4	Intense Rains
2	89.6	Alfredo Chaves	ES	Guarapari	2020.1	Floods
3	89.5	Governador Valadares	MG	Governador Valadares	2020.1	Intense Rains
4	89.3	Vereda	BA	Porto Seguro	2021.4	Intense Rains
5	88.5	Manhuaçu	MG	Manhuaçu	2020.1	Intense Rains
6	87.5	Iconha	ES	Guarapari	2020.1	Floods
7	87.1	Jucuruçu	BA	Porto Seguro	2021.4	Floods
8	87.1	Vargem Alta	ES	Cachoeiro de Itapemirim	2020.1	Flash Floods
9	86.3	Três Rios	RJ	Três Rios	2021.1	Intense Rains
10	86.3	Tarauacá	AC	Tarauacá	2021.1	Floods
11	86.1	Iúna	ES	Alegre	2020.1	Intense Rains
12	85.3	Muniz Freire	ES	Alegre	2020.1	Intense Rains
13	84.2	Envira	AM	Juruá	2021.1	Floods
14	84.0	Floresta Azul	BA	Ilhéus-Itabuna	2021.4	Intense Rains
15	82.8	Ibitirama	ES	Alegre	2020.1	Intense Rains
16	82.4	Água Azul do Norte	PA	Parauapebas	2021.1	Intense Rains
17	82.0	Grajaú	MA	Alto Mearim e Grajaú	2020.1	Floods
18	81.7	Rodrigues Alves	AC	Cruzeiro do Sul	2021.1	Floods
19	81.7	Itapitanga	BA	Ilhéus-Itabuna	2021.4	Intense Rains
20	81.5	Coromandel	MG	Patrocínio	2021.4	Flash Floods
21	81.3	Espera Feliz	MG	Muriaé	2021.1	Intense Rains
22	81.3	Manhumirim	MG	Manhuaçu	2020.1	Intense Rains
23	81.1	Muriaé	MG	Muriaé	2021.1	Intense Rains
24	81.0	Valença	BA	Valença	2021.4	Intense Rains
25	80.7	Conceição do Lago-Açu	MA	Baixada Maranhense	2021.1	Floods
26	80.4	Raul Soares	MG	Ponte Nova	2020.1	Intense Rains
27	80.0	Machacalis	MG	Nanuque	2021.4	Intense Rains
28	79.9	Careiro da Várzea	AM	Manaus	2021.2	Floods
29	79.8	Carangola	MG	Muriaé	2020.1	Intense Rains
30	79.6	Feijó	AC	Tarauacá	2021.1	Floods

Although S2ID records are reported at the municipality level, we define affected areas at the microregion level. Microregions are geographic units defined by the Brazilian Institute of Geography and Statistics (IBGE) that group neighboring municipalities with economic and social integration. This aggregation is useful in our setting because economic activity, logistics, and input markets often span neighboring municipalities.

A.3 Exposure measures

For each event, we measure an outside firm's exposure using payment relationships observed during the twelve months before the disaster. The measure captures the share of pre-event payments linked to counterparties located in the affected microregion. We define exposure separately for the downstream and upstream perspectives.

For outside customers in the downstream perspective, exposure is defined as

$$Exposure_{x,c} = \frac{\sum_{s \in S^A_{x,c}} p_{c \to s}}{\sum_{s \in S_{x,c}} p_{c \to s}}, \tag{3}$$

where $S_{x,c}$ is the set of suppliers paid by outside customer c during the pre-event period, $S^A_{x,c}$ is the subset of suppliers located in the microregion affected by event x, and $p_{c \to s}$ denotes total payments from customer c to supplier s.

For outside suppliers in the upstream perspective, exposure is defined as

$$Exposure_{x,s} = \frac{\sum_{c \in C^A_{x,s}} p_{c \to s}}{\sum_{c \in C_{x,s}} p_{c \to s}}, \tag{4}$$

where $C_{x,s}$ is the set of customers from which outside supplier s received payments during the pre-event period, and $C^A_{x,s}$ is the subset of customers located in the microregion affected by event x. In both cases, higher exposure indicates a larger pre-existing share of payment flows linked to counterparties located in the area affected by the climate event.

Table A2 reports descriptive statistics for the resulting downstream and upstream empirical samples.

Table A2: *Summary statistics for the data used to investigate climate-risk transmission through inter-firm payment relationships. The table is divided into two sections: the top shows data from the downstream perspective, and the bottom shows data from the upstream perspective. Total Payments are expressed in thousands of R\$. Payments Paid (Received) refers to the amount in thousands of R\$ for transactions made to (received from) suppliers (customers) affected or unaffected before the event. Exposure measures the pre-event share of outside customers' (suppliers') payment flows linked to affected suppliers (customers), expressed as a percentage.*

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
Downstream (Outside Customer)								
Total Payments	6,524,241	742.935	21,702.530	0.00001	3.578	16.301	77.646	15,331,697.000
Payments Paid (Af.)	6,524,241	11.643	368.523	0.000	0.000	0.000	1.784	231,768.700
Payments Paid (Un.)	6,524,241	731.292	21,653.610	0.000	1.970	13.300	71.608	15,306,026.000
Exposure	853,398	25.041	37.846	0.000	0.000	2.017	37.893	100.000
Upstream (Outside Supplier)								
Total Payments	4,825,722	1,696.857	37,037.830	0.00001	7.269	43.734	254.477	23,480,387.000
Payments Received (Af.)	4,825,722	26.483	709.033	0.000	0.000	0.000	2.500	418,004.700
Payments Received (Un.)	4,825,722	1,670.374	36,829.040	0.000	5.270	39.059	242.466	23,480,147.000
Exposure	614,283	18.079	33.551	0.000	0.000	0.887	12.700	100.000

A.4 Empirical design schematic

Figure A1 illustrates the downstream version of the empirical design. The figure compares two outside customers operating in the same sector and municipality around the same climate event, but with different pre-event exposure to suppliers located in the affected microregion. Customer A has low exposure because only a small share of its pre-event payments went to affected suppliers, whereas Customer B has high exposure because most of its pre-event payments went to affected suppliers.

The empirical design generalizes this comparison across events, firms, and quarters. Conditional on the fixed effects described in Section 2, identification comes from comparing post-event changes in payment outcomes between more and less exposed outside firms within the same event, sector, municipality, and quarter. The upstream analysis follows the same logic, replacing outside customers with outside suppliers and affected suppliers with affected customers.

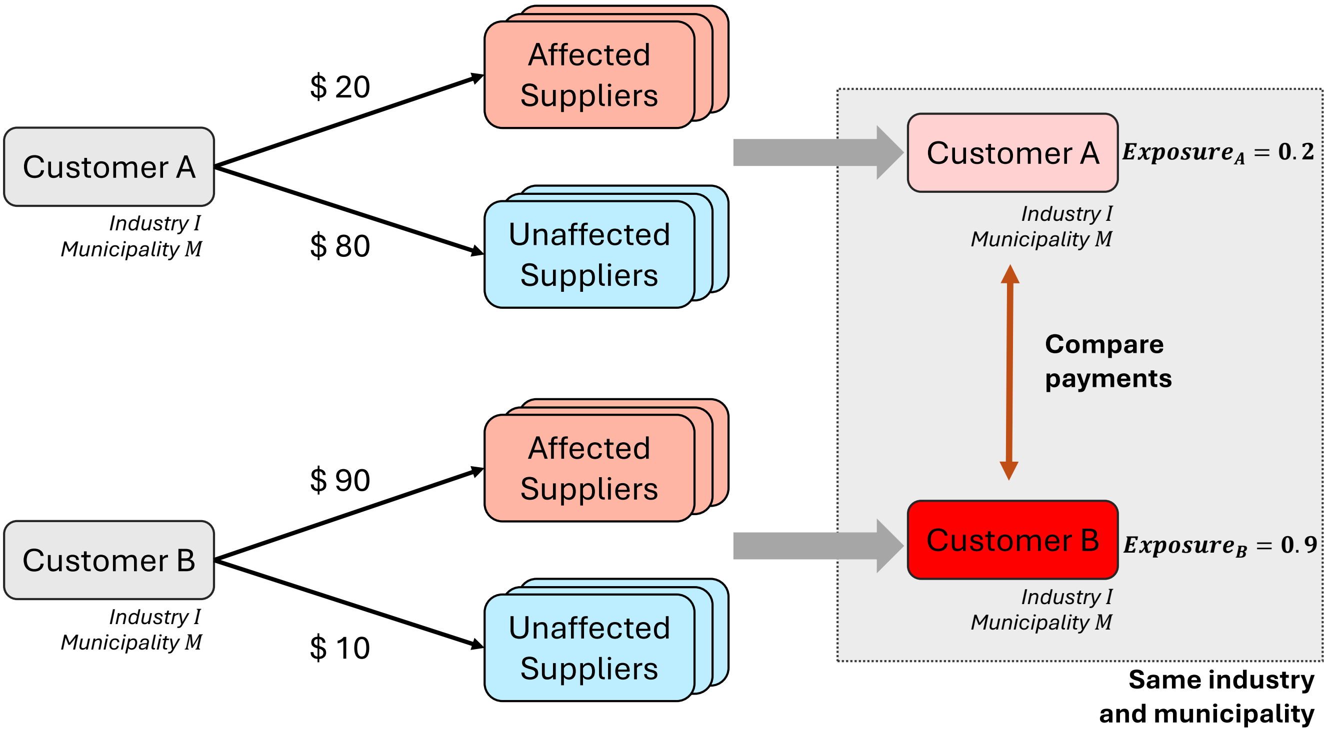


Figure A1: *Schematic of the downstream empirical design. Customer A and Customer B operate in the same sector and municipality but differ in their pre-event exposure to suppliers located in the affected microregion. Customer A pays $20 to affected suppliers and $80 to unaffected suppliers, implying exposure of* $\frac{20}{100} = 0.2$*; Customer B pays $90 to affected suppliers and $10 to unaffected suppliers, implying exposure of* $\frac{90}{100} = 0.9$.

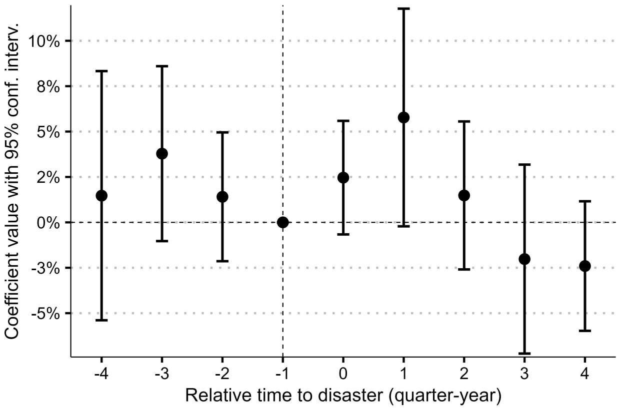
B Additional results

B.1 Event-study estimates

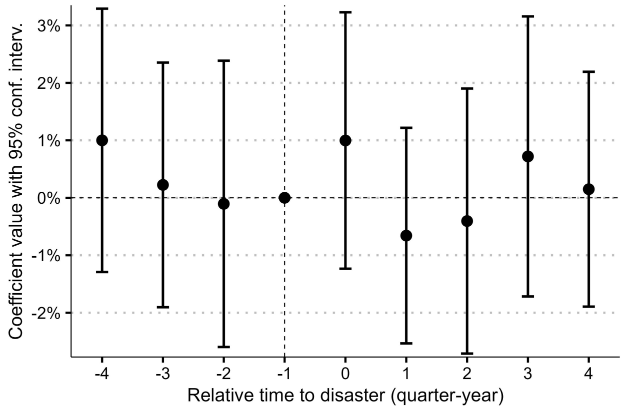
Figure A2 reports the dynamic version of the baseline specification, replacing $Post_{x,t}$ with quarterly event-time indicators. The estimates show no evidence of differential pre-trends between more and less exposed outside firms before the climate event. After the shock, payments with affected counterparties decline while payments with unaffected counterparties increase, consistent with the reallocation pattern documented in the baseline results.

B.2 Sectoral heterogeneity

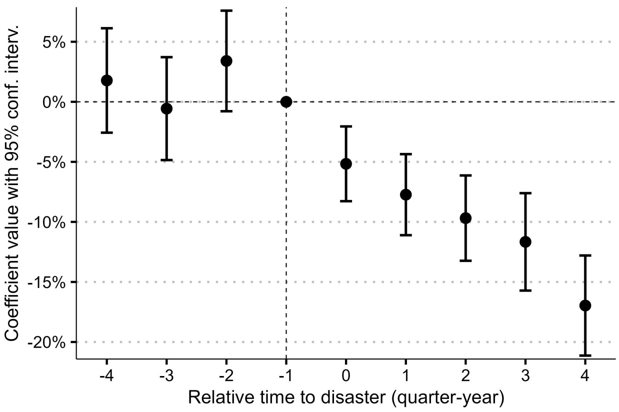
Figure A3 reports sector-specific estimates of Eq. (1), separately for the downstream and upstream perspectives. The figure compares the coefficients for payments with affected and unaffected counterparties within each sector.



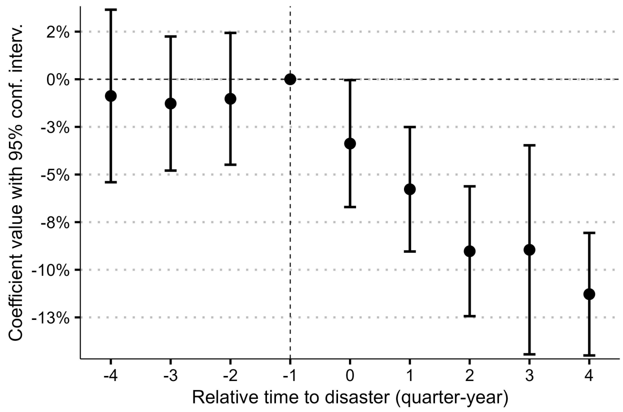
(a) *Downstream – Outside customer's total payments*



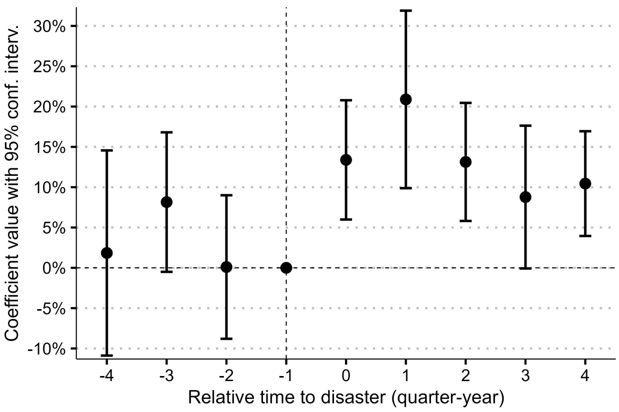
(b) *Upstream – Outside supplier's total payments*



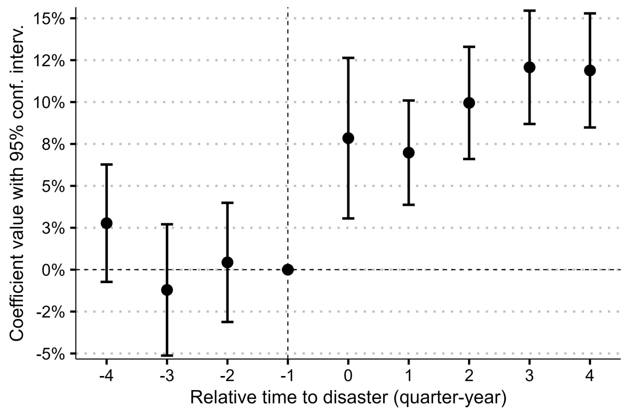
(c) *Downstream – Outside customer's payments to affected suppliers*



(d) *Upstream – Outside supplier's received payments from affected customers*

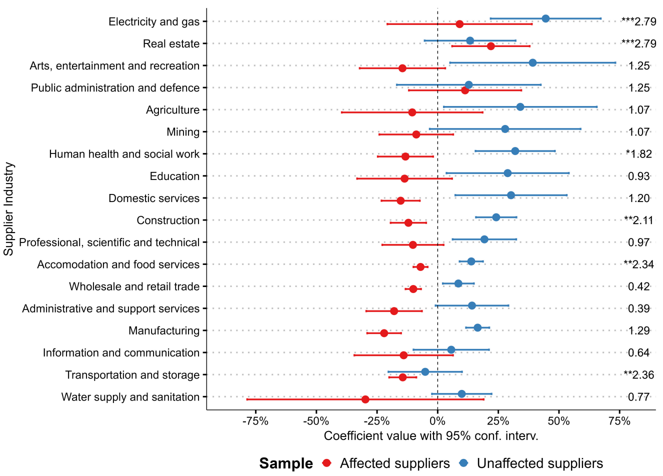


(e) *Downstream – Outside customer's payments to unaffected suppliers*

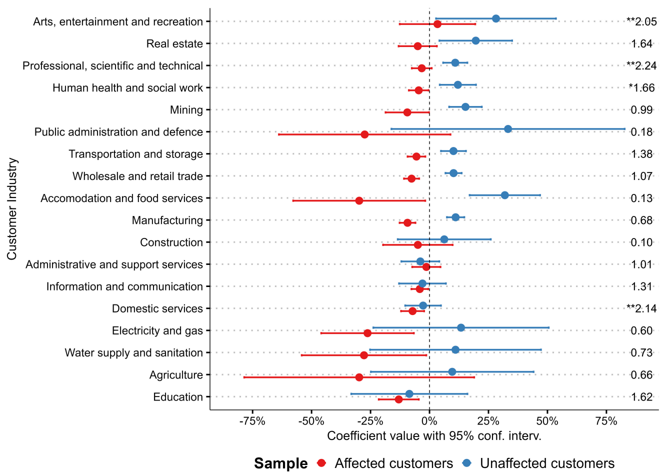


(f) *Upstream – Outside supplier's received payments from unaffected customers*

Figure A2: *Event study (pre-trend and time-varying effects check). We adapt Eq. (1) by replacing the step variable $Post_{x,t}$ with quarterly pulse dummies. We consider the sample of outside customers with affected suppliers in the left panel (our downstream perspective) and outside suppliers with affected customers (our upstream perspective). We use three dependent variables: (a) and (b) total payments, (c) and (d) payments made to/received from affected firm counterparts, and (e) and (f) payments made to/received from unaffected firm counterparts. The figure displays the estimated β coefficients for each relative quarter-year of the extreme event (top 30). Vertical bars denote the 95% confidence interval.*



(a) *Downstream – effects on the suppliers of outside customers*



(b) *Upstream – effects on the customers of outside suppliers*

Figure A3: *Coefficient estimates of Eq. (1) for (a) outside customers and (b) outside suppliers by their corresponding industry (one independent regression for each industry and dependent variable). Panel (a) shows the coefficients for outside customers' aggregate payments to suppliers in affected areas (red) versus those in unaffected areas (blue). Panel (b) swaps the roles of supplier and customer. The figure presents β coefficients for each quarter-year relative to the extreme climate event, with 95% confidence intervals denoted by horizontal bars. The numbers on the right are t-statistics comparing whether the negative coefficient for affected firms is statistically equal to the coefficient for unaffected firms given the same industry. The test assesses whether reallocating payments from affected to unaffected counterparties involves significant friction. Rejection of the null hypothesis (equal coefficients) suggests substitution is not frictionless. *, **, *** denote statistical significance of 10%, 5%, and 1%, respectively.*