The effect of hurricane Otis on card payments in Mexico*

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*The conclusions and opinions expressed in this document are the responsibility of the authors and are not part of statistics or official positions of Bank of Mexico.
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1. Paper overview

- Using weekly cumulative data at municipality level, we analyze how card payments responded to the inland arrival of the category-five hurricane Otis in the coastal state of Guerrero, Mexico, in late October 2023.
- We employ an event study design to document heterogenous effects in the two most important municipalities of Guerrero.
- According to our estimations, Acapulco, the most affected and the most economic important municipality in terms of volume of transacted card payments, experienced a deeper and a more persistent fall in the volume and transacted amounts in debit and credit card payments.
- Chilpancingo, the second in volume of transacted card payments, showed a positive but shorter impact originated by the additional demand possibly coming from people from Acapulco.
- Moreover, through the lens of card payments, we identified which business retail lines showed to be more vulnerable to business continuity in Acapulco. In the other hand, we identified which business retail lines took more advantage of the additional demand in Chilpancingo.

2. Literature Review

This paper belongs to two branches of the economic literature.

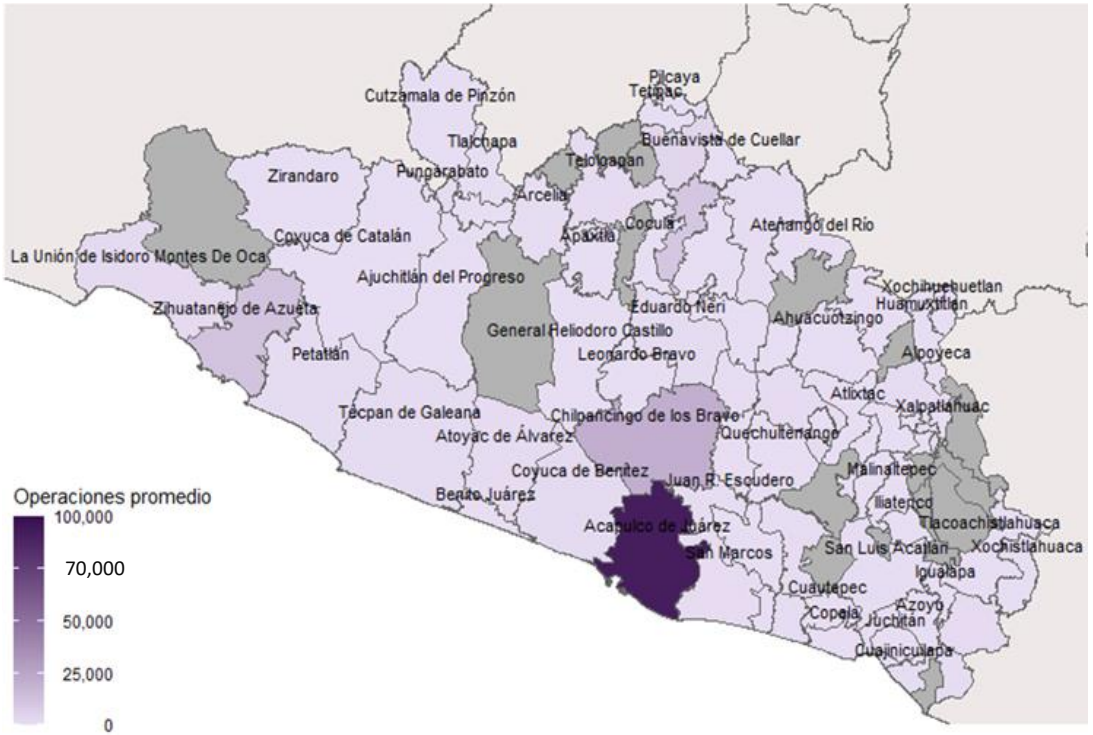
- The literature that studies the effects of extreme natural (tropical cyclones) events on economic activity:
  - ✓ Samuelson (2010), Hsiang (2012), Hsiang & Jina (2014) and Juarez-Torres and Puigvert, (2021).
  - ✓ However, the dimension of the analysis is aggregated and the opportunity of monitoring in real time is low.
- High-frequency electronic data have proved being a highly effective instrument to infer the behavior and the dynamics of certain economic variables with high opportunity.
- In the context of the Pandemics of COVID-19, authors have used electronic payment data to document changes of consumers' expenditure due lockdowns.
  - ✓ Chetty et al. (2020), Andersen et al. (2020), Baker et al. (2020), Carvalho et al. (2022).
  - ✓ Campos and Esquivel (2021).

3. Stylized facts of hurricane Otis on card payments

- In the third quarter of 2023, daily card payments in Guerrero were in average 119,135 in debit and 40,630 in credit. In Acapulco with 70,187.9 in debit and 23,997.2 in credit. In Chilpancingo: 15,018.3 in debit and 5,050.8 in credit.
  - ✓ In Acapulco, average daily transactions reduced from 92,768 in prior week to 705 in one week after the event.
  - ✓ In Chilpancingo, average daily transactions increased from 21,310 in prior week to 35,967 one week after the event.

Map of average daily card transactions

Week of October 15th to – 21st



Week of October 29th to November 4th

Source: Authors' elaboration using data collected by Banco de México and *National Hurricane Center of* the *National Oceanic and Atmospheric Administration of the United States*.

3. Stylized facts of hurricane Otis on card payments

Cumulative weekly card transactions and transacted amounts
(Previous-week 15th – 21th October vs. post-week of October 29th – 4th November)

	State Guerrero		Acapulco		Chilpancingo		Rest of the municipalities	
	Week before	Week after	Week before	Week after	Week before	Week after	Week before	Week after
	Thousand of transactions							
Total transactions	1,128.8	626.9	649.4	4.9	149.2	251.8	330.3	370.2
Transactions debit	864.2	488.4	497.6	3.5	114.0	196.2	252.6	288.7
Transactions credit	264.6	138.5	151.8	1.4	35.1	55.6	77.7	81.5
	*Million Mexican pesos of October 2023**							
Total amounts operated	707.2	469.0	394.9	15.5	90.0	191.2	222.3	262.3
Amounts operated debit	461.9	331.4	250.6	4.9	64.0	142.2	147.3	184.3
Amounts operated credit	245.3	137.5	144.3	10.6	25.9	49.0	75.0	77.9

Source: Banco de México.
Note: */ Second fortnight of October, 2023.

3. Data and sources

- We use daily transactions and transacted amount in debit and credit cards at the municipality level of the state of Guerrero.
  - ✓ Data is collected on regular basis and managed by the Central Bank of Mexico.
  - ✓ Period is from August 1st, 2023 to April 31st, 2024 that corresponds to 10 weeks prior to Otis arrival and 25 weeks after this event.
  - ✓ We consider information for 51 of the 85 municipalities that satisfy two conditions:
    - ✓ First, data on card transactions must be recorded on regular basis.
    - ✓ Second, municipalities must transact at least an average of 100 daily transactions per week.
  - ✓ Weekly cumulative data were aggregated starting Sunday to next Saturday, which means that the week 43 of the Otis arrival considers from Sunday 22nd October to Saturday 28th October.

- Caveat. Geographical location of this data corresponds to the administrative records of end users (merchants) that perform card payments. Thus, records of transactions and transacted amounts are associated to municipalities where point of sale terminals are registered for administrative purposes and such information, in some cases, might differ from the location where effectively transactions are done.

4. Econometric Models

- To estimate the effect of Hurricane Otis on weekly card transactions and transacted amounts we use panel data that considers weekly cumulative observations for 51 of the 85 existing municipalities that record at least a mean of 100 weekly transactions in regular basis to estimate two models.

Differences-in-differences model

$$\ln P_{it} = \beta\, OTIS_t + \rho OTIS_t * Treat_i + \alpha_i + \delta_t + \varepsilon_{it} \quad (1)$$

Event Study model

$$lnP_{it} = \sum_{j\epsilon(-m,\ldots 0,\ldots,m)} \gamma_j\, OTIS_{i,t-j} * Treat_i + \alpha_i + \delta_t + \varepsilon_{it} \quad (2)$$

- ✓ $\ln P_{it}$ outcome of interest that are card payments, debit and credit, at the municipality level i in week t.
- ✓ $OTIS_i$ is a dummy variable, takes value of one from fourth week of October to the last week of April 2024 and zero otherwise.
- ✓ $Treat_i$ is a dummy of the treated municipality (Acapulco or Chilpancingo) interacted with $OTIS_t$ which estimates the effect of the shock for the treated municipality.
- ✓ α_i municipality fixed effects.
- ✓ δ_t are time-fixed effects to control for seasonal fluctuations.
- ✓ ε_{it} error term.

- Estimation is carried out using fixed effects model con OLS, errors are clustered at the municipality level and we used wildbootstrap following the method of Ferman and Pinto (2019) for inference to improve correction of heteroskedastic errors.

4. Identification strategy

- This is a natural experiment.
- The identification strategy assumes that the geographic trajectory and evolution in intensity of hurricane Otis are unexpected and random.
- Damage caused to communications infrastructure that prevent card payments, are unlikely spatially or temporally correlated with any other spatial variable that could affect the behavior of card payments in the municipalities of the State of Guerrero.
  - ✓ This is specially truth because hurricane Otis underwent explosive intensification up to 115 mph in less than 24 hours reaching 165 mph in total winds and heavy rain that produced urban flooding and mudslides, in contrast to a regular tropical cyclone that evolve about 35 mph in a 24-hour period.
  - ✓ It is highly unlikely that due to the unanticipated shock of hurricane Otis, merchants moved their business or point-of-sale machines from location, from Acapulco to Chilpancingo.

5.1. Results on parallel trends

Parallel Trends Assumption

Logarithm of the weekly cumulative transactions and operated volume of card payments

Acapulco

Source: Authors' elaboration using information from Banco de México.

5.1. Results on parallel trends

Parallel Trends Assumption

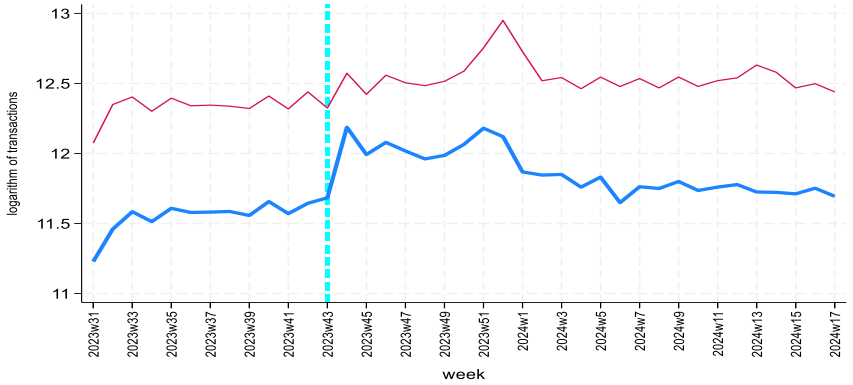
Logarithm of the weekly cumulative transactions and operated volume of card payments

Chilpancingo

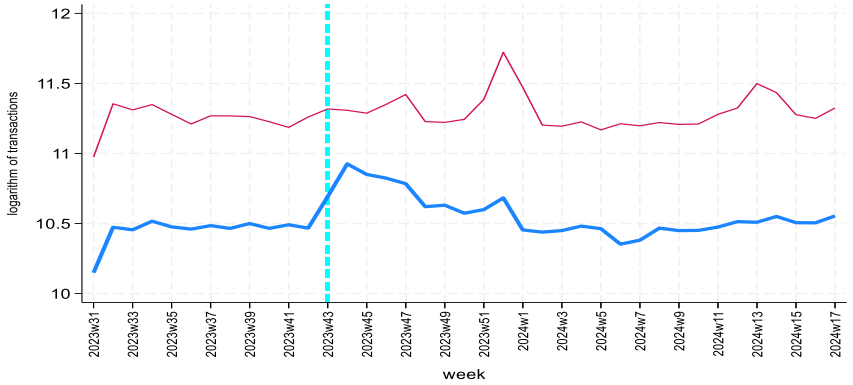
Treatment Control

treatment Chilpancingo vs. control neighboring municipalities, except Acapulco

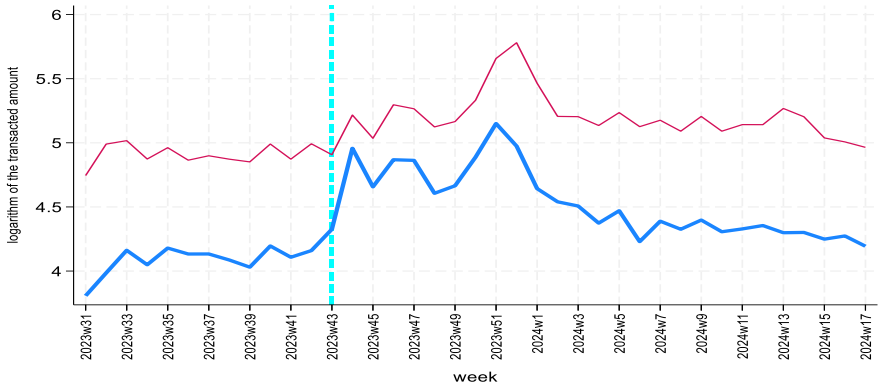
Transactions in debit cards



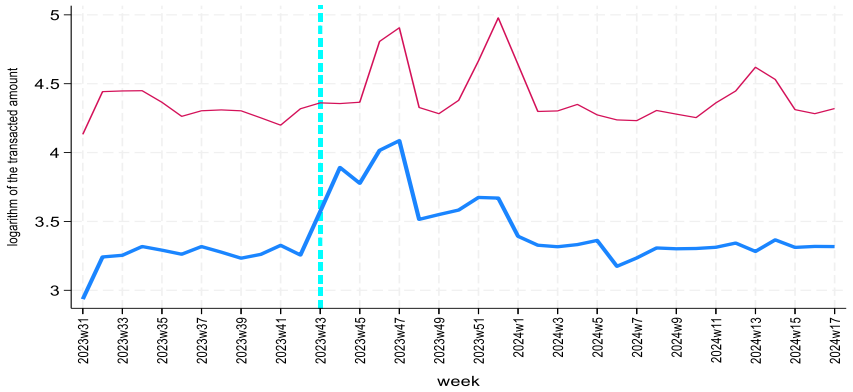
Transactions in credit cards



Transacted amount in debit



Transacted amount in credit



Source: Authors' elaboration using information from Banco de México.

5.2. Results for model Differences in differences

Results of difference in difference model specification

	Treatment Acapulco				Treatment Chilpancingo			
	Transactions Debit	Transactions Credit	Amount Debit	Amount Credit	Transactions Debit	Transactions Credit	Amount debit	Amount Credit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Otis*Treatment	-0.7070***	-0.8986***	-0.5928***	-0.6395***	0.0837***	0.0483*	0.0832**	0.1252***
	(0.0204)	(0.0258)	(0.0328)	(0.0367)	(0.0204)	(0.0258)	(0.0328)	(0.0367)
Hurricane Otis	-0.9426***	-1.0481***	-0.8699***	-1.2822***	-0.9547***	-1.0595***	-0.8785***	-1.2877***
	(0.0430)	(0.0407)	(0.0764)	(0.0941)	(0.0418)	(0.0391)	(0.0761)	(0.0935)
R^2	0.4865	0.4169	0.4414	0.2899	0.5701	0.4531	0.4764	0.2939
Observations	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
Baseline FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors' elaboration using information collected by Banco de México, *National Hurricane Center of* the *National Oceanic and Atmospheric Administration of the United States.*

5.2. Results for Event Studies

Transactions

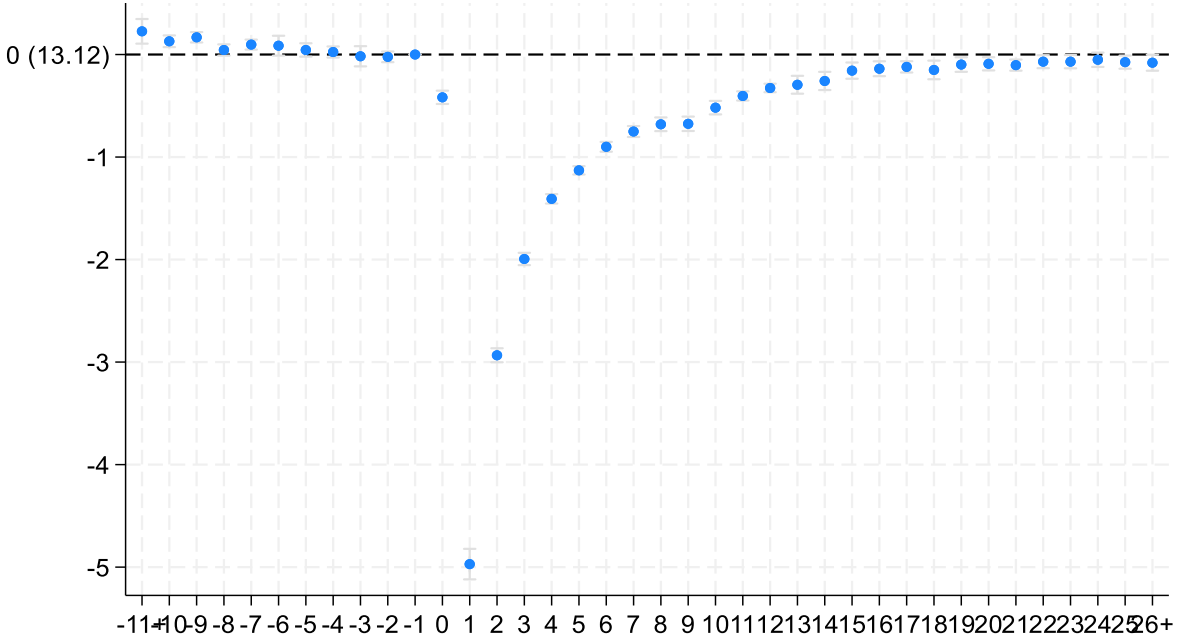
- One week after Otis' arrival, transaction volume reduced its lowest –37% for both, debit and credit, below the level of operations recorded the previous week of the event.
- The most negative effect in magnitude for card transactions lingers below -10% about the first four weeks for debit and about the first six weeks for credit; henceforth fall moderate in both cases.
- Negative effects on transactions tend to dilute faster for debit than for credit.

Estimates of the average effect on card payments in terms of changes in weekly transactions

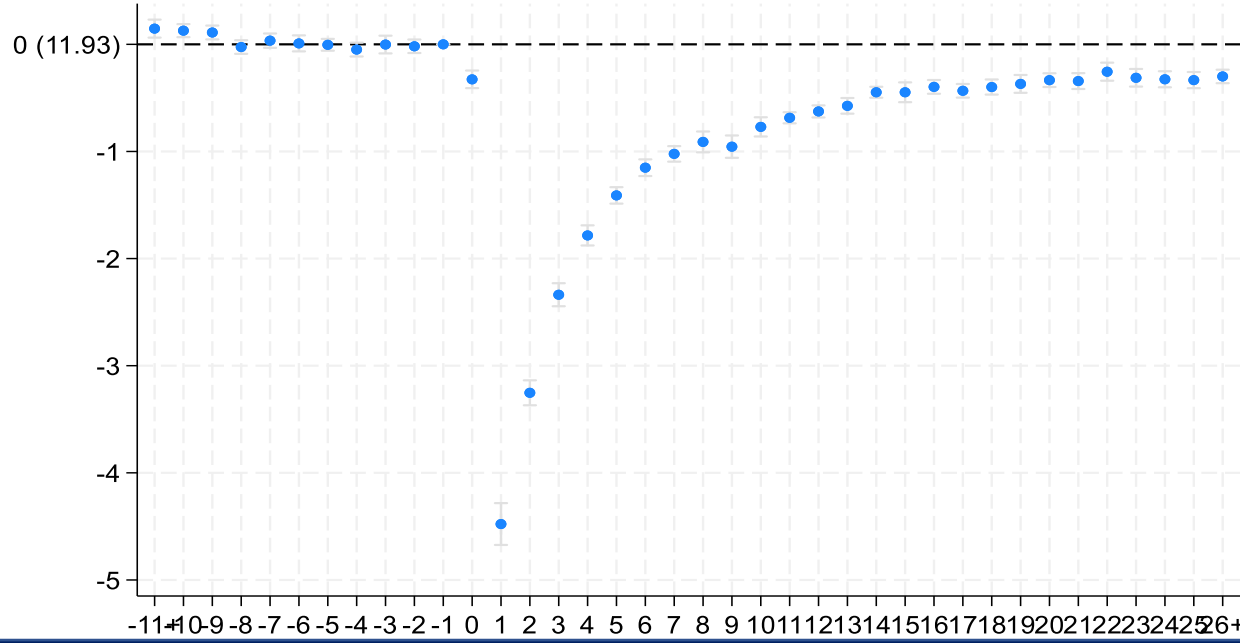
(Logarithm of cumulative weekly operations)

Treatment Acapulco vs. control rest of municipalities with exception of Chilpancingo

Debit



Credit

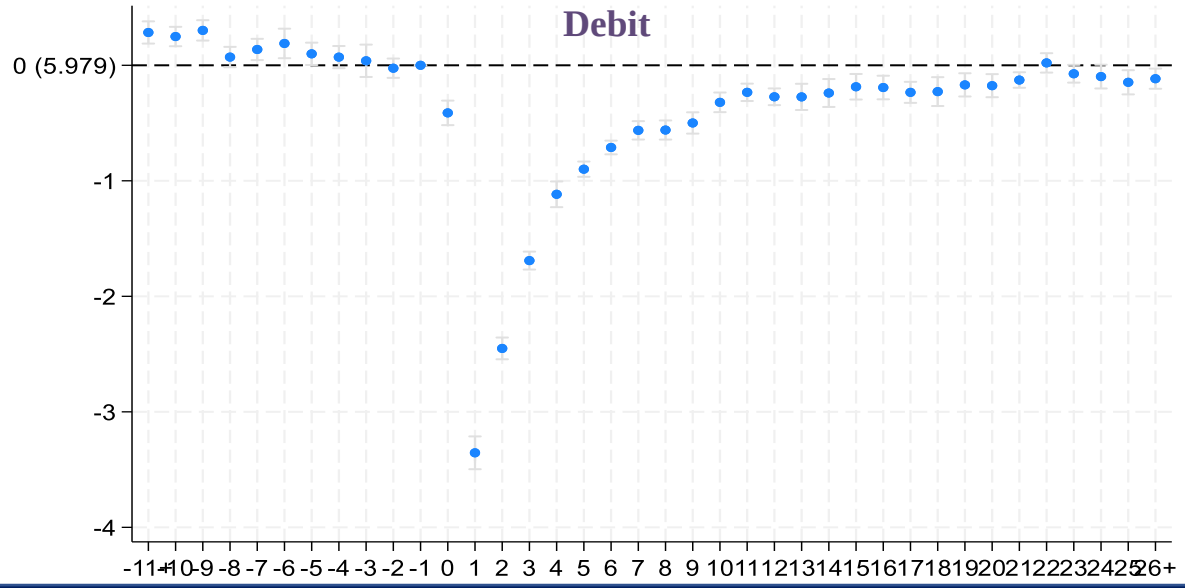


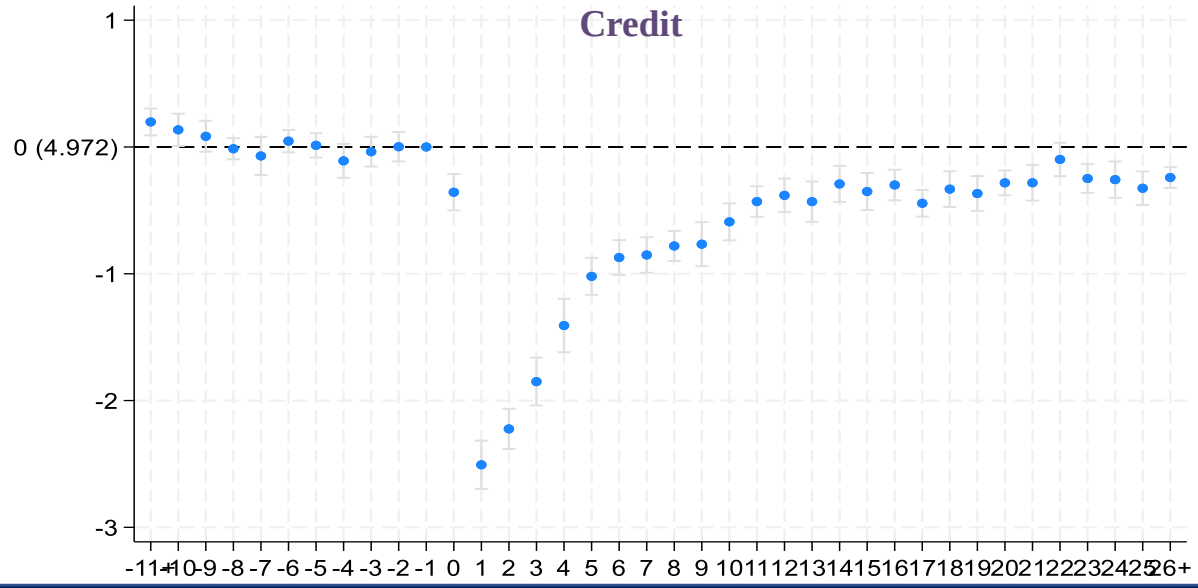
5.2. Results for Event Studies

Transacted amounts

- One week after Otis' arrival, transactions reduced its lowest –74% for debit and -50% for credit, below the level of operations recorded the previous week of the event.
- Negative effects on transacted amount tend to dilute faster for debit than for credit.
- The most negative effect in magnitude for transacted amounts in credit remained below -10% for ten weeks; in contrast, for debit the effect lingered below -10% for the first six weeks. Henceforth, tend to dilute and loose statistical significance.

Estimates of the average effect on card payments in terms of changes in weekly transacted amounts
(Logarithm of cumulative weekly million pesos)
Treatment Acapulco vs. control rest of municipalities with exception of Chilpancingo



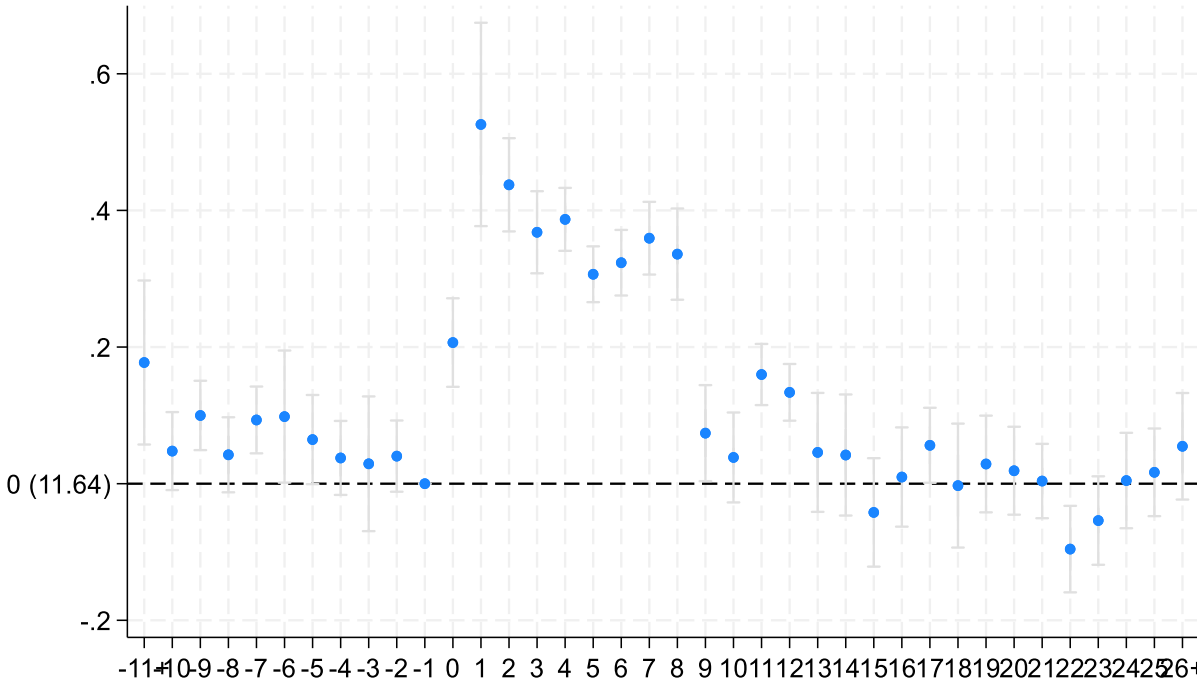


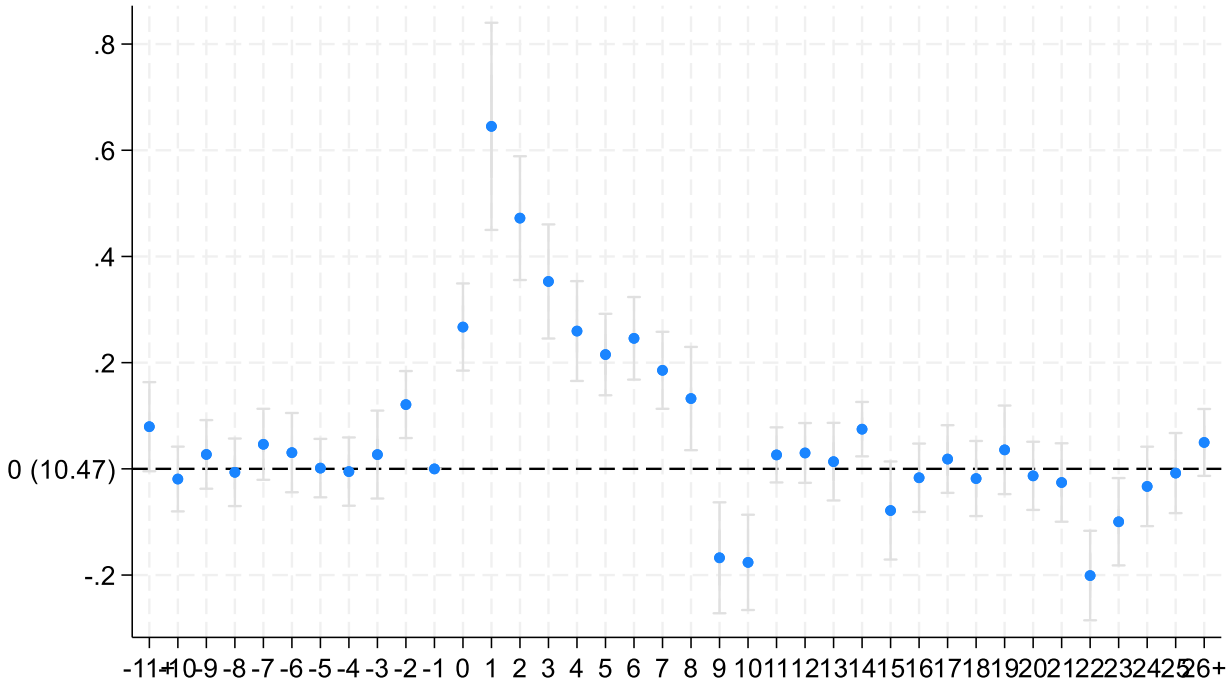
5.2. Results for Event Studies

Transactions

- During the first week after the event, transactions boosted maximum magnitudes of 4.56% and 6.16% in debit and credit card, respectively, effects remain below 3% up to the fifth week for both (credit and debit) after the event and impact loose statistical significance in the eleventh week for credit and in twelfth week for debit.

Estimates of the average effect on card payments in terms of changes in cumulative weekly transactions
(Logarithm of cumulative weekly operations)
Treatment Chilpancingo vs. Control rest of municipalities with exception of Acapulco



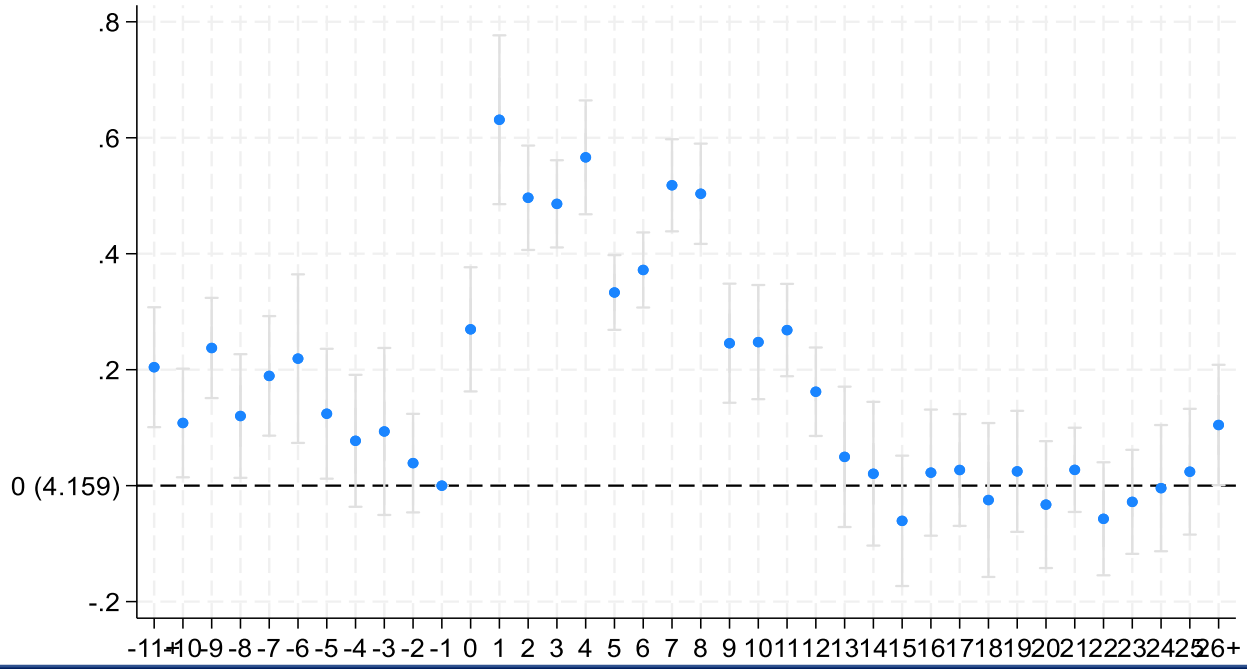


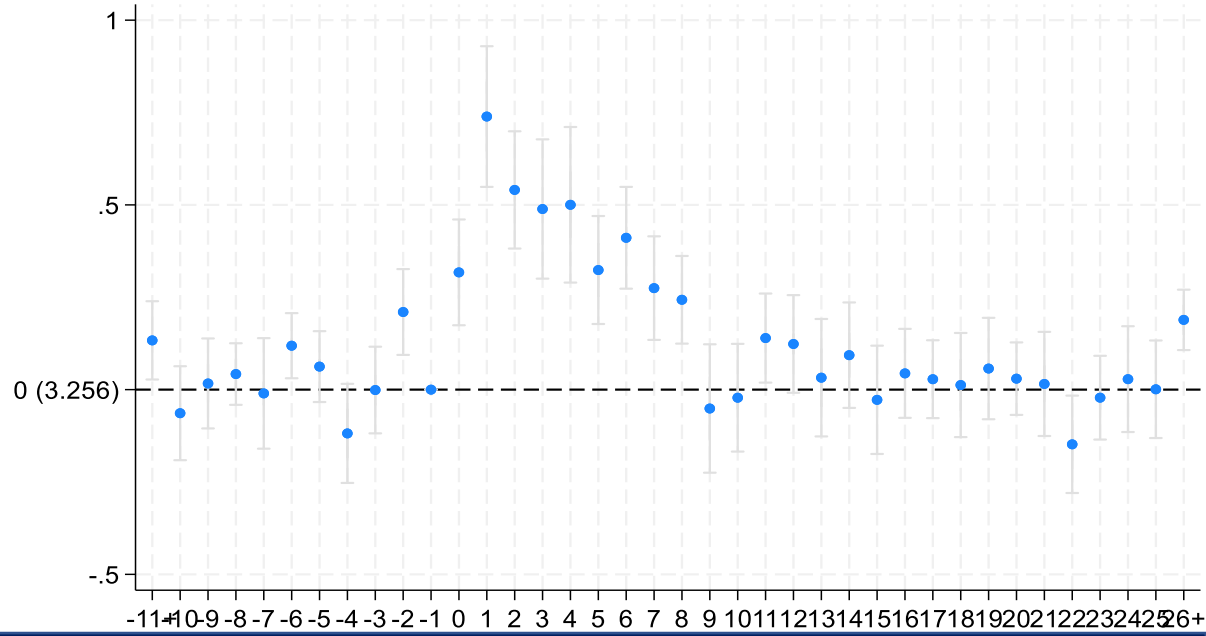
5.2. Results for Event Studies

Transacted amounts

- One week after Otis' arrival, transacted amount reached its peak with 14.1% and 22.7% in debit and credit, respectively.
- For debit, effect remain above 10% up to the fourth week, while for credit remain above 10% up to the six week and in the eight week loose statistical significance.

Estimates of the average effect on card payments in terms of changes in weekly amounts operated
(Logarithm of cumulative weekly million pesos)
Treatment Chilpancingo vs. Control rest of municipalities with exception of Acapulco



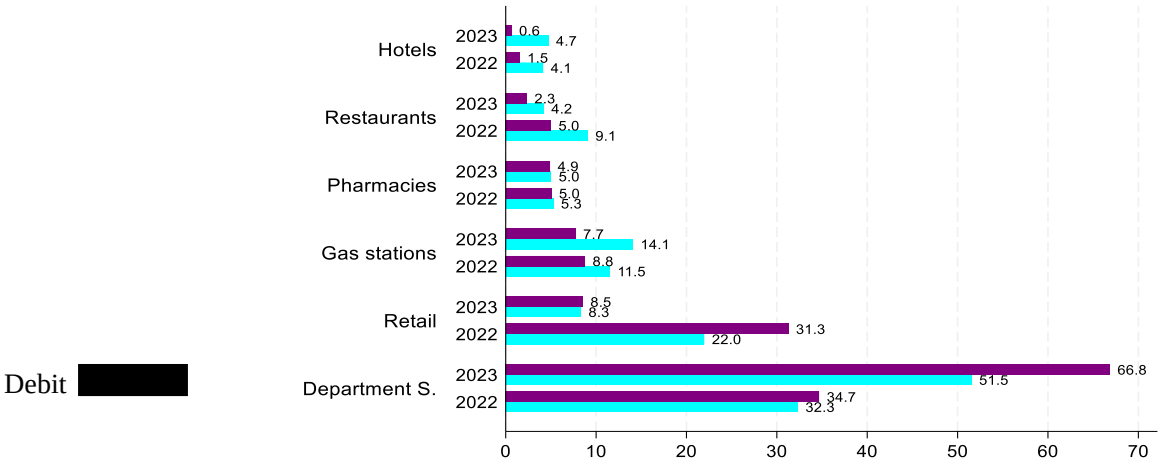


6. Disentangling consumer spending behavior after hurricane Otis

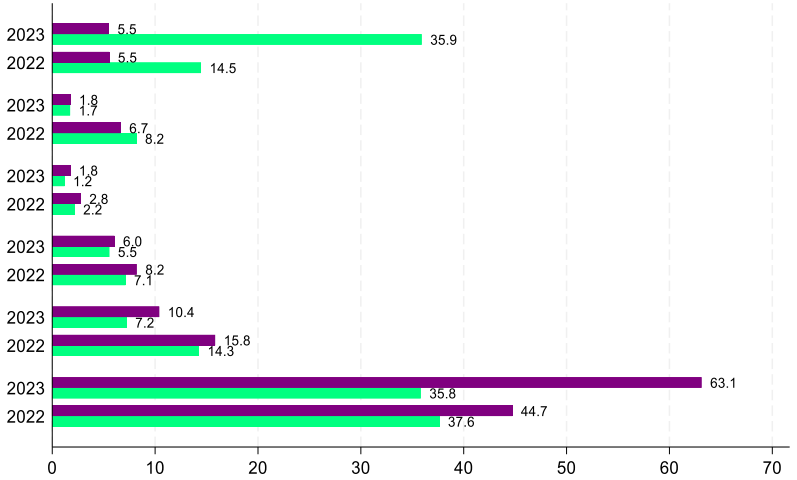
- After the shock, in Acapulco consumers concentrated their remaining transactions and expenditure in Department s.; while for Chilpancingo in Department s., Retail, Gas stations and Pharmacies attended the extra demand for transactions/expenditure.

Acapulco November 2023 vs. November 2022

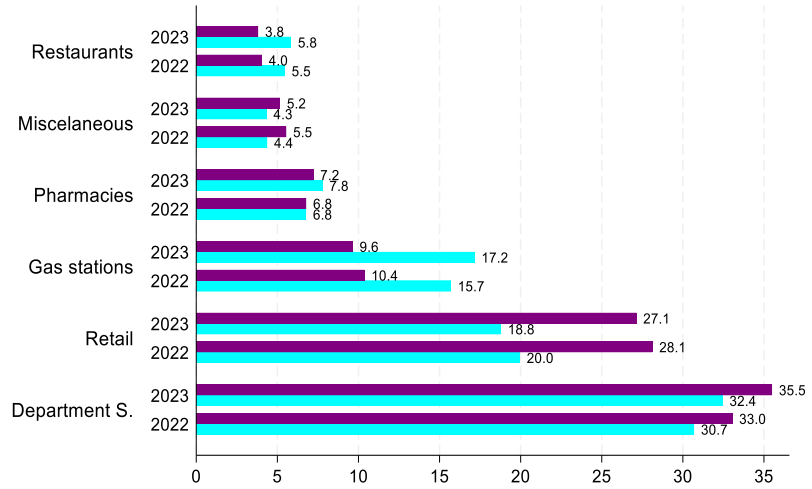
Share of operations in debit and credit by top retail business lines

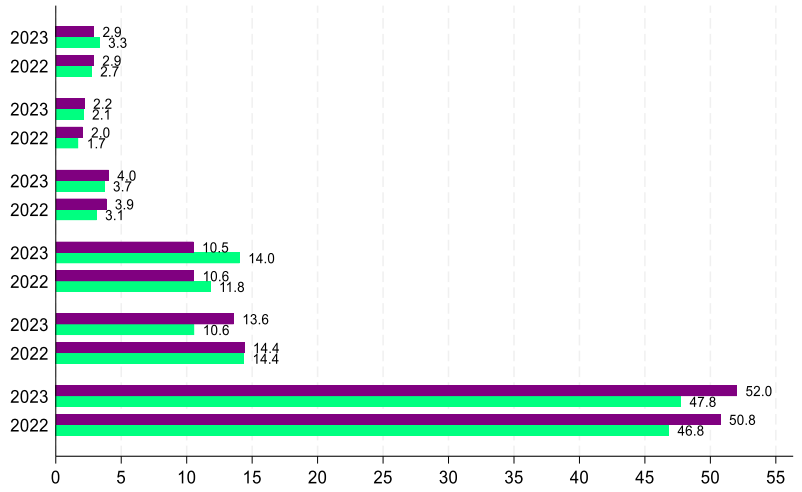


Share of expenditure in debit and credit by top retail business lines



Chilpancingo





Authors' elaboration using information from Banco de México.

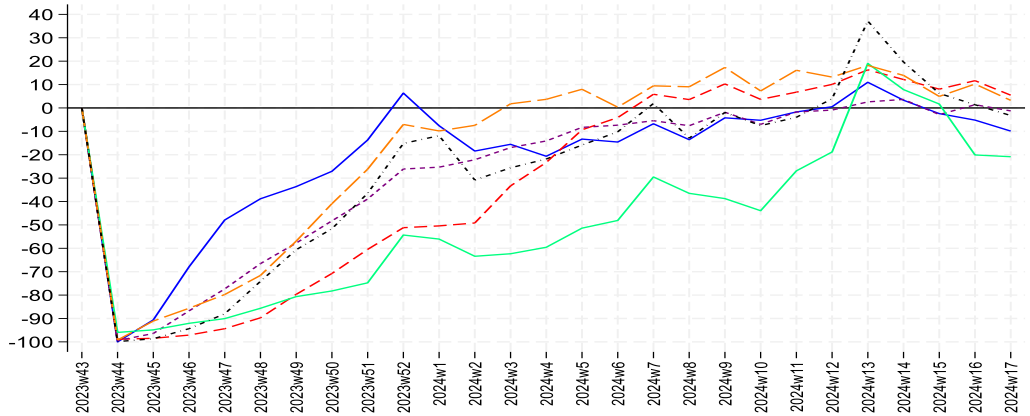
6. Disentangling consumer spending behavior after hurricane Otis

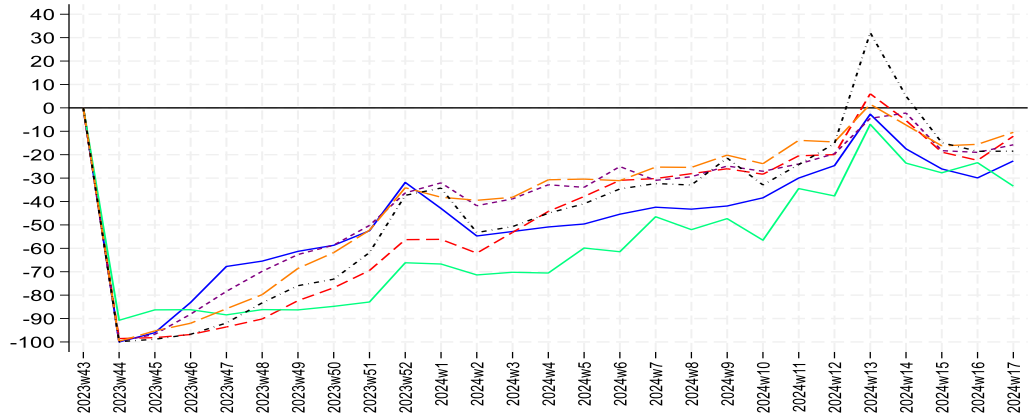
- After the shock, in Acapulco the recovery of transactions and expenditure in debit cards was faster than in credit, in the first nine weeks especially for Department s., Pharmacies and Restaurants.
- In Chilpancingo the boost lasted ten weeks in debit and about nine weeks.

Weekly growth of cumulative transactions and expenditure of debit and credit cards for the top six retail business lines

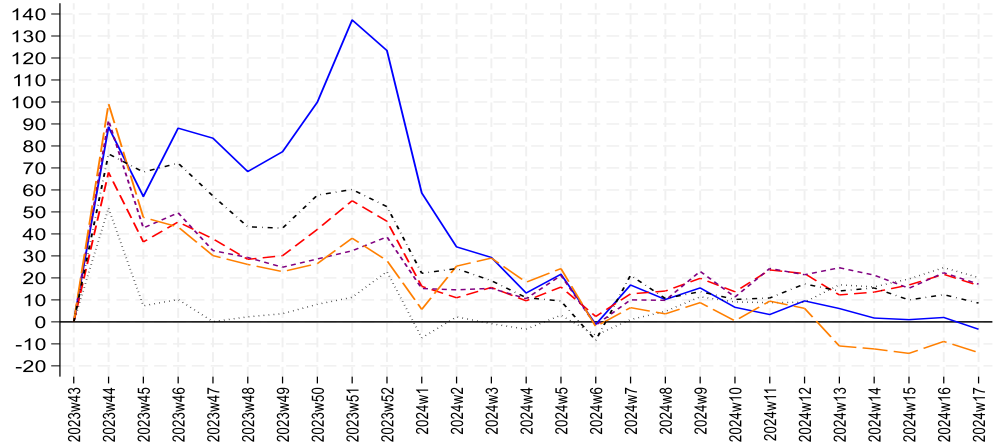
Department & self-serv. Sto. Hotels Retail Gas stations Pharmacies Restaurants Miscelaneous

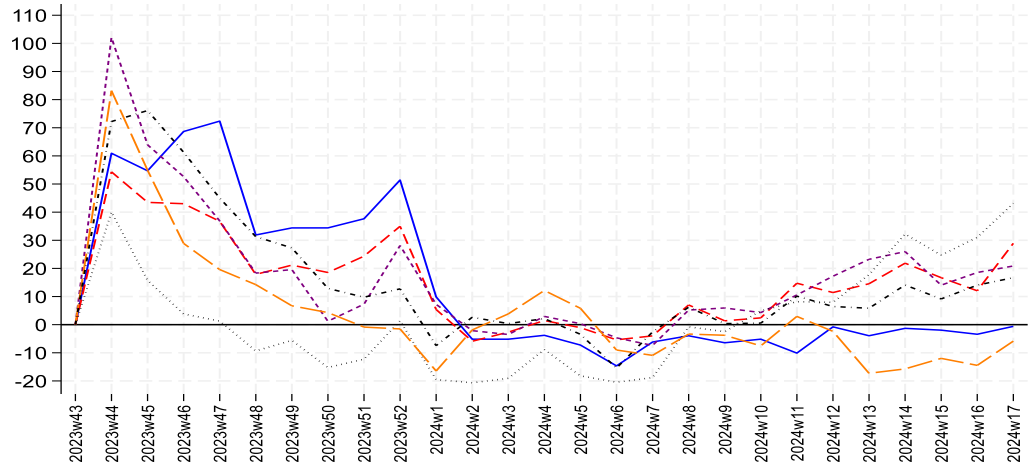
Acapulco





Chilpancingo





Authors' elaboration using information from Banco de México.

10. Conclusions

- To the extent that the occurrence of extreme events damage infrastructure, the operation of electronic payment systems is temporarily compromised affecting the business continuity of local firms and economic activity.
- This paper documents the heterogeneous effects following the arrival of Hurricane Otis on the coast of Acapulco in Guerrero in late October 2023. Findings show differentiated dynamic effects on the transactions volume and transacted amounts of card payments for two municipalities of Guerrero: Acapulco and Chilpancingo.
- In Acapulco, the volume of these operations and transacted amount in card payments notably fell after the shock. Acapulco experienced a persistent reduction in transaction volume that remained for ten weeks and then it moderated. The effect was deeper for credit cards
- In contrast, in Chilpancingo municipality, where no relevant damages of infrastructure were reported, card transactions and transacted amount boosted after the shock. Credit transactions and transacted amounts considerably increased during the first weeks after the event; while for debit the effect was more moderated.

10. Conclusions

- A deeper analysis in terms expenditure dynamics by business retail lines in card payments allowed understand how consumer dealt with their purchase needs.
  - ✓ In Acapulco, Retail, Restaurants, Gas stations, and Hotels showed to be more vulnerable for business continuity. In contrast, Department and self-service stores played were more resilient.
  - ✓ In Chilpancingo, Departmental and self-service stores and Retail are some of the businesses retail lines that might be playing an important role for business continuity and taking advantage of the additional demand. Other retail business lines like Gas stations, Pharmacies and Restaurants increased their sales in the short-term immediately after the shock.

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