

# On the Resilience of Payment Methods

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Preliminary  
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# Outline

## Motivation

Facts about Payments During Natural Disasters

Event Studies

Surveys: US, Spain, Sweden

Experiment

Conclusions

Appendix

# Motivation

- ▶ Outages can disrupt all electronic forms of payments (e.g. cards, P2P)
  - ▶ Hurricane Katrina, US 2005  
FFIEC: “be prepared to operate in a cash only environment”
  - ▶ Hurricane Otis, Mexico 2023  
Plan Billetes: deployed military planes with mobile ATMs
  - ▶ Kenya: national blackouts 2023 + IT outages 2024  
CB of Kenya: bill making it illegal for businesses to reject cash
  - ▶ In Case of Crises or War, Sweden 2024  
How to prepare for IT outages, power cuts and extreme weather: keep cash at home
  - ▶ Outage in Iberic Peninsula, 2025  
Spending residing in the affected areas was 41 percentage points below average

## US: Do you have any plans to stop using cash in the future?

No, I do not have any plans to stop using cash	0.918
Yes, I have already stopped using cash	0.048
Yes, in the next 2 years	0.014
Yes, 2 to 5 years from now	0.009
Yes, more than 5 years from now	0.012

Source: 2023 Survey and Diary of Consumer Payment Choice

## Why would you find it hard to cope in a cashless society?

I use cash in case of power outages or other events that make other payment methods unusable	0.590
I need cash for when other payment methods are not accepted, for example to pay workers, community groups, or charities	0.546
I use cash to monitor my spending or as a budgeting tool	0.337
I get paid in cash	0.072
I don't have access to a debit card or credit card, so cash is the only payment method that is accessible to me	0.034
Other	0.172

Source: 2023 Survey and Diary of Consumer Payment Choice

## This paper

- ▶ Study resilience of payments during outages and extreme weather events  
Scarce data on payment methods and cash holdings

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  - ▶ Large drops in expenditures during extreme weather events
  - ▶ Shift from digital payments (e.g. P2P, cards) to cash
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- ▶ Survey evidence from Sweden, Spain, and the US: cash holdings
  - ▶ Cash holdings provide a fallback when digital payments fail
  - ▶ Once economy goes cashless, reverting to cash becomes difficult

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- ▶ Experimental evidence: NielsenIQ panel ( $\approx 21K$ ) in May-June 2024
  - ▶ Info. treatment: DHS advice to hold cash during natural disasters
  - ▶ Compare changes in expenditures across treatment groups (not today)

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  - ▶ Info. treatment: DHS advice to hold cash during natural disasters
  - ▶ Compare changes in expenditures across treatment groups (not today)
- ▶ Benefits of offline payments (e.g. CBDCs) during natural disasters

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**Facts about Payments During Natural Disasters**

Event Studies

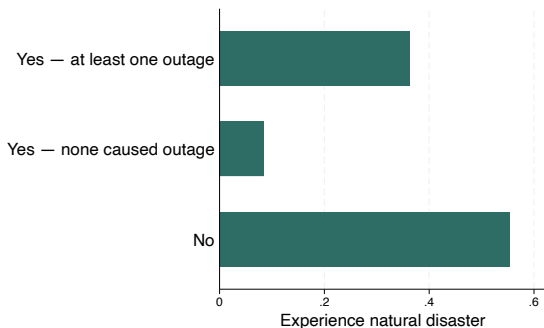
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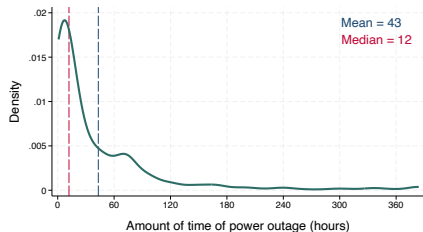
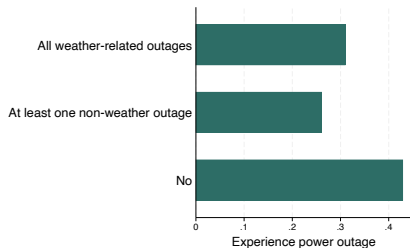
Appendix

## Natural disasters trigger outages



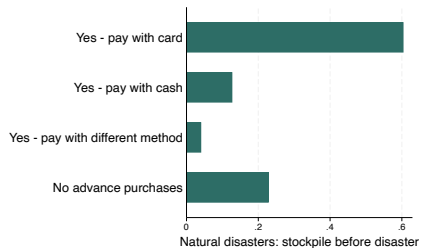
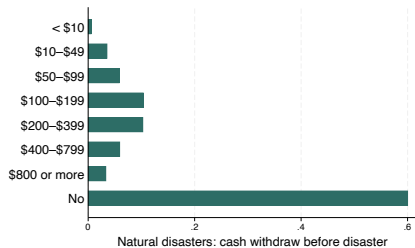
- ▶ We run a representative survey using YouGov in US ( $N = 6000$ )
  - ▶ Cash holdings, demographics, disasters, and payments during outage
- ▶ 45% of people have experience a natural disaster
  - ▶ 81% of natural disasters result in outages

# Outages are frequent and often prolonged



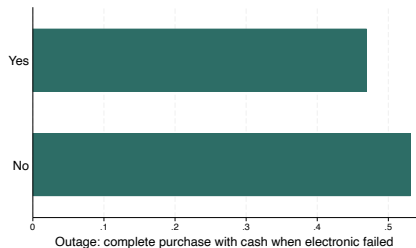
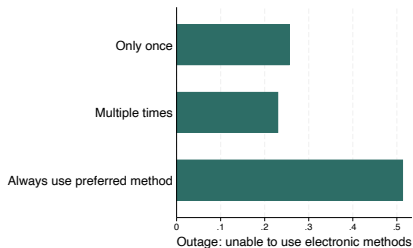
- ▶ 57% of people have experienced an outage
- ▶ 25% of people have experience outages lasting 2 days

## Cash holdings rise in anticipation of disasters



- ▶ 40% of people withdraw cash before extreme weather event
- ▶ Stockpiling before natural disasters, mostly paid for with credit cards

## Outages force a shift from digital payments to cash



- ▶ 49% unable to use preferred payment method during outage
- ▶ 47% complete purchase with cash when digital payments fail

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# NOAA: Storm events

- ▶ Information on weather events across the U.S.
  - ▶ E.g. tornadoes, hurricanes, floods, winter storms
  - ▶ Details: event type, date, location, magnitude, fatalities, injuries, property damages
- ▶ Covers events from 1950 to today
- ▶ Available at the *county* level

# County-level electricity outage data

- ▶ 15-minute outage estimates (2014-2024)
- ▶ Coverage: ~92% of customers across all states
  - ▶ Most comprehensive U.S. outage dataset to date
  - ▶ Includes share of customers affected
- ▶ Source: Environment for Analysis of Geo-Located Energy Information (EAGLE-ITM), Oak Ridge National Laboratory (Anderson et al., 2024)

# County-level store data - PDI Technologies

- ▶ SKU-level data on U.S. [convenience stores](#) (07/2019 – 08/2024)
- ▶ Coverage (~80% of market):
  - ▶ 2572 counties
  - ▶ 13K stores
- ▶ Transaction-level information:
  - ▶ Expenditures
  - ▶ Stores
  - ▶ Items
  - ▶ [Payment method: cash, debit, credit, checks, etc.](#)

# Debit and credit card data

## ▶ MBHS3 Data

- ▶ De-identified information on credit and debit card transactions since 2019
- ▶ Covers substantial portion of U.S. households (county level)
  - ▶ Consumers: > 180 M
  - ▶ Transactions: 37B per year
  - ▶ Chain Merchants: Every one
  - ▶ Number of Stores: > 1 M
  - ▶ Frequency: Daily

## ▶ Facteus Data

- ▶ Challenger banks: newer banks targeting underbanked consumers (e.g., payroll direct deposits, limited access to traditional banks)
- ▶ Expenditures, ATM withdrawals, number transactions from 2017 to 2020
  - ▶ Debit cards:  $\approx 10$  M
  - ▶ Frequency: Daily
  - ▶ Counties: 3200

# Nielsen Consumer Panel (HMS)

- ▶ Tracks shopping behavior of approximately 60K households each year
- ▶ Covers 49 states and approx 2.7K counties in the US
- ▶ 40% of consumption in 1K categories (approx. \$460 billion in 2015)
- ▶ **Method of payment information from 2013-onward**
  - ▶ Cash, check, credit (e.g. visa, mastercard), debit, others
  - ▶ Fraction of unclassified methods decrease with time (main results 2018 onward)

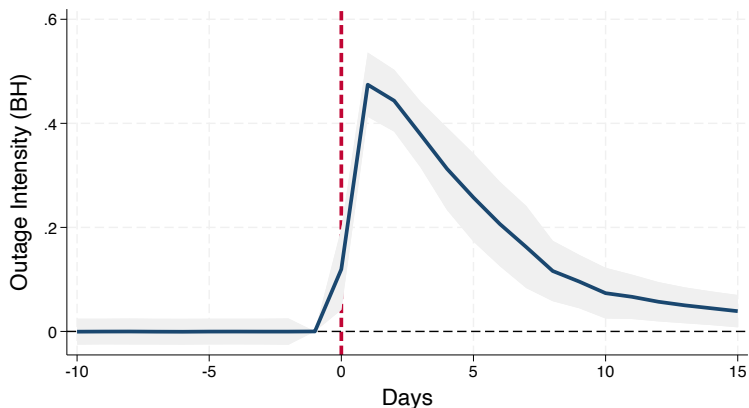
# Event study framework

- ▶ Daily data at the county-level, different time span for different data sets.
- ▶  $Y_{it}$ : outcome variable for county  $i$  and time  $t$  (e.g. outages, log expenditures, share of cash, etc).

$$Y_{it} = \alpha + \sum_{k=-\infty}^{\infty} \gamma_k \mathbb{1}\{K_{it} = k\} + \theta_i + \lambda_t + \epsilon_{it}$$

- ▶  $\theta_i$ : county fixed effects.
- ▶  $\lambda_t$ : time fixed effects.
- ▶  $K_{it}$ : number of periods relative to extreme weather event (hurricane)
- ▶ Standard errors clustered at county level

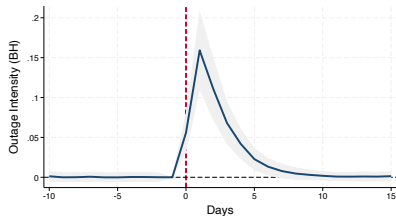
## Outages after hurricanes are large and long lived



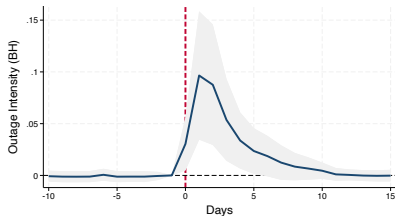
- ▶ Outage intensity: fraction of total population business hours w/outage.

# Outages: other natural disasters

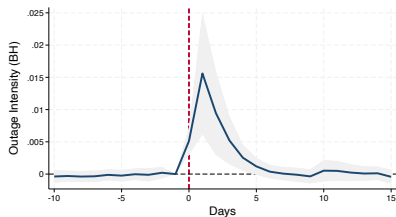
► Other



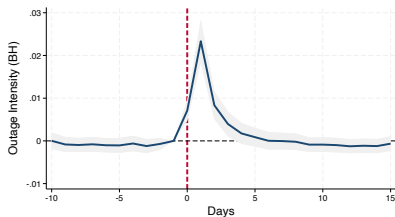
(a) Tropical Storm < Hurricane



(b) Storm Surge/Tide < Hurricane



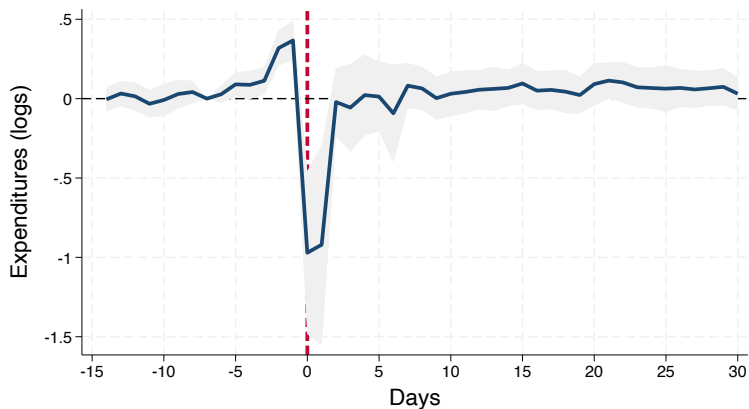
(c) Flash Flood << Hurricane



(d) Tornado << Hurricane

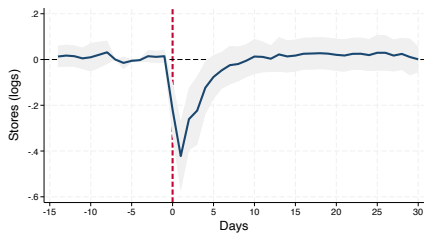
# Hurricane: Expenditures at stores

► Categories

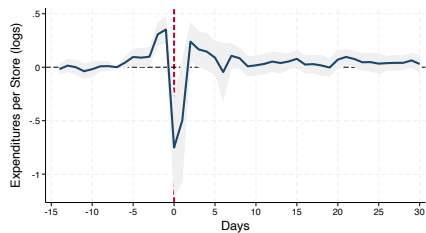


- Spending rises before hurricanes (e.g. stockpiling) and drop sharply after

# Hurricane: Extensive and intensive margins

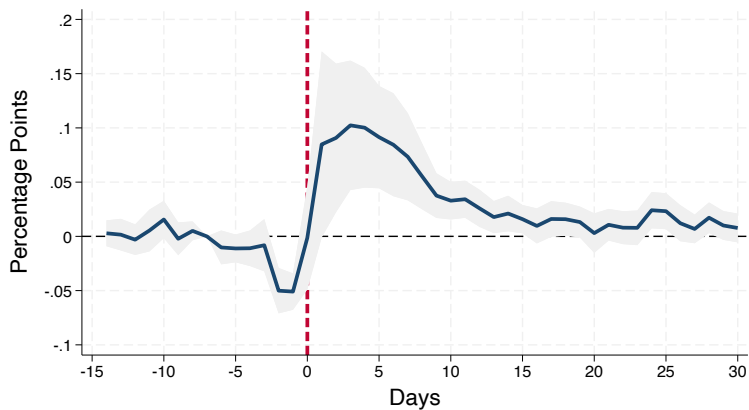


(a) Number of Stores



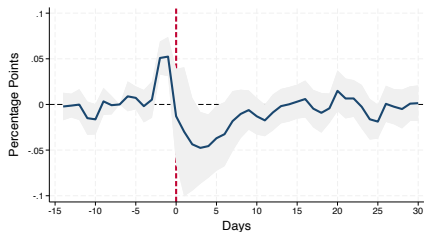
(b) Expenditures per Store

## Hurricane: Cash share at stores

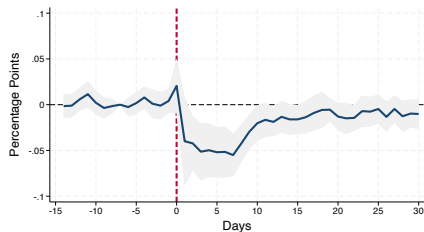


- ▶ Cash share **drops** in anticipation and **rises** for over two weeks

# Hurricane: Debit and credit share at stores



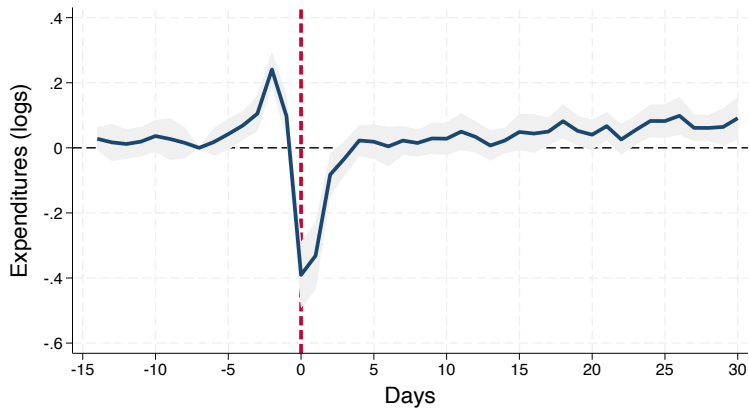
(a) Share Credit



(b) Share Debit

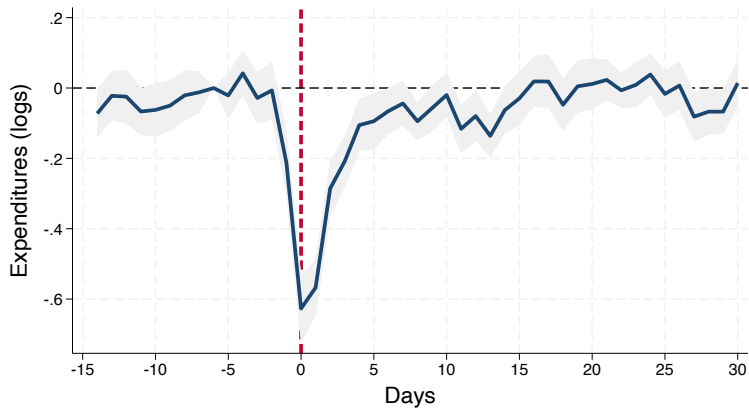
- ▶ Consistent with the survey, **stockpiling purchases are made with credit**
- ▶ Both share of **credit and debit drop** after hurricanes

## Hurricane: Expenditures using credit card data



- Confirms data from stores and survey

## Hurricane: "Challenger" (debit) card expenditure



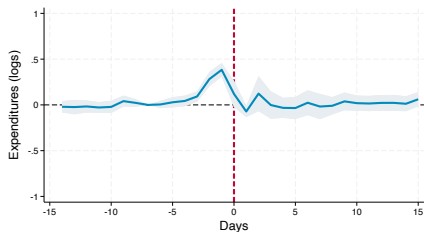
- Confirms data from stores on debit cards

# Mechanisms

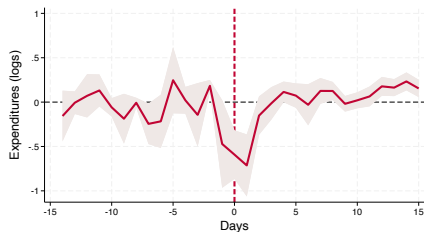
- ▶ Natural disasters on their own do not alter choice of means of payment
- ▶ Power outages: electronic payments not available
- ▶ Precautionary motive + Cash burns
  1. Increase in cash holding for precautionary reasons
  2. Household more likely to use cash when they have it available

# Hurricane: Expenditures and outages (neighbor)

$$Y_{it} = \alpha + \sum_{k=-\infty}^{\infty} \gamma_k \mathbb{1}\{K_{it} = k\} + \sum_{k=-\infty}^{\infty} \delta_k \mathbb{1}\{K_{it} = k\} \times \text{Outage}_{it} + \beta \text{Outage}_{it} + \theta_i + \lambda_t + \varepsilon_{it}$$



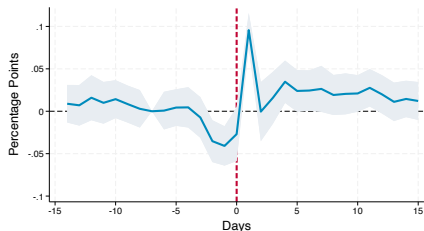
(a) No Outage (before and after  $\gamma_k$ )



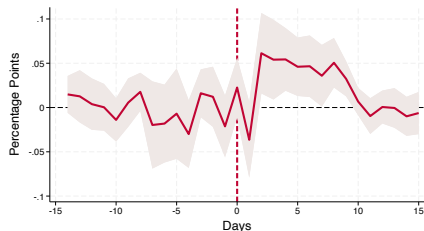
(b) Outage (before and after  $\beta + \delta_k$ )

- ▶ **No outage:** only precautionary effect (i.e. stockpiling paying with cards)
- ▶ **Outage:** large drop in expenditures (e.g. digital payments not available)

# Hurricane: Cash share (neighbor)



(a) No Outage (before and after  $\gamma_k$ )



(b) Outage (before and after  $\beta + \delta_k$ )

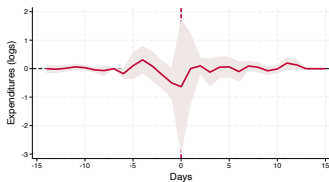
- ▶ **No outage:** precautionary effect + cash burns
- ▶ **Outage:** shift from digital payments to cash

# Does cash holdings help “weather the storm”?

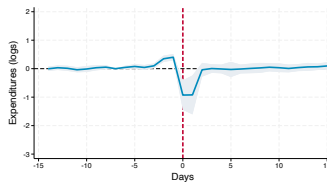
- ▶ Shifter of cash holdings before severe weather events
  1. Households report holding more cash first week of month ▶ Survey
  2. Impute cash holdings in NielsenIQ based on diary (DCPC) and surveys
    - ▶ Age, hh size, marital status, race, income, location, spending, year effects
  3. Randomized information treatment to half of Nielsen HMS panel
  
- ▶ Measure effect of cash holdings on cash share
  - ▶ Hurricanes + tropical depressions + storm surge and floods ( $\approx$  500 events)

Cash Share(t)	PDI		HMS	
	(1)	(2)	(3)	(4)
Event(t-1)	0.009*	0.001	0.002	-0.195
	(0.005)	(0.005)	(0.011)	(0.126)
Outage(t)	0.013	0.006	-0.002	-0.267***
	(0.009)	(0.008)	(0.011)	(0.093)
Outage(t) × Event(t-1)	0.126***	0.130***	0.107*	0.102*
	(0.047)	(0.047)	(0.061)	(0.058)
Outage(t) × First Week		0.031*		
		(0.018)		
Event(t-1) × First Week		0.047***		
		(0.018)		
Imp. Cash				0.027***
				(0.003)
Outage(t) × Imp. Cash				0.058***
				(0.020)
Event(t-1) × Imp. Cash				0.043
				(0.027)
Observations	3,849,639	3,849,639	3,527,204	2,931,085
R-squared	0.096	0.096	0.123	0.126
Storm Event	Y	Y	Y	Y
County	Y	Y	Y	Y
Time	Y	Y	Y	Y

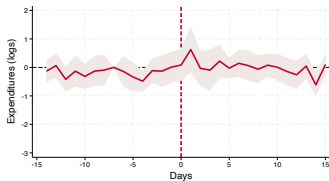
# Hurricanes: Total expenditures by cash-holdings



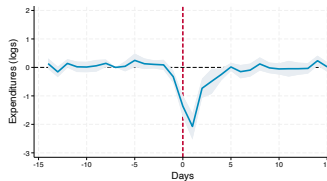
(a) First Week (More Cash)



(b) Non-First Week (Less Cash)



(a) High Cash Counties



(b) Low Cash Counties

- Suggestive evidence cash helps to sustain expenditures

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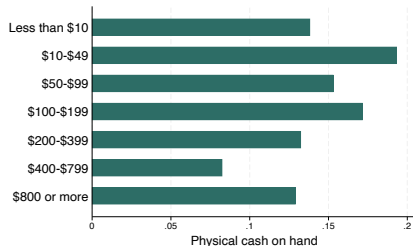
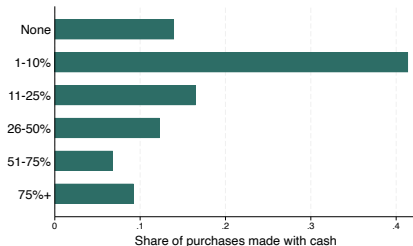
**Surveys: US, Spain, Sweden**

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## US: Cash use is moderate



- ▶ 14% of purchases paid in cash (21% in consumer goods)
- ▶ 52% hold more than 100 USD in cash

# Cash use during digital payment failures

	(1)
Complete Payment with Cash	Natural Disaster + Outage US
Log Cash Holdings	0.0362*** (0.005)
Observations	3,461
R-squared	0.054
Controls	Y
Region	Y

Controls: race, age, gender, education, employment, marital status, income, education, region

- ▶ Recall: 47% complete purchase with cash when digital payments fail
- ▶ 20% increase in cash holdings raises prob. of **completing a cash purchase during an outage** by about .72 p.p.

	(1)	(2)
Increasing Cash Reserves		US
Natural Disaster + Outage	0.0685*** (0.015)	
Cash During Outage		0.1579*** (0.017)
Blackout		
Cash During Blackout		
Disruption		
Cash During Disruption		
Log Cash Holdings	-0.0045 (0.005)	-0.0113* (0.006)
Observations	6,000	3,461
R-squared	0.041	0.085
Controls	Y	Y
Region	Y	Y

Controls: race, age, gender, education, employment, marital status, income, education, region

- ▶ 68% plan to **increase cash reserves** in preparation natural disaster
- ▶ Being able to use cash during the outage increases the likelihood of **planning to hold more cash by 15 p.p.**

## Outage Iberian Peninsula



**Luis Garicano**   

@lugaricano



Back online (still no light here). Lessons from Spain after a really weird day (no electricity, no 4G, no WiFi) for the world

1. Go out and buy a pocket battery-power radio. It was really disconcerting to have no way to know what is going on.
2. Buy a battery powered torche . There were none left in shops.
3. Keep cash. I had none.
4. Keep spare batteries.

3:09 PM · Apr 28, 2025 · **989.1K** Views

## Outage Iberian Peninsula



A screenshot of a tweet from Luis Garicano (@lugaricano) on a dark background. The tweet text is white. It includes a profile picture of a man in a suit, the name 'Luis Garicano' with flags for Spain and a verified badge, and the handle '@lugaricano'. The tweet content describes a power outage in Spain and lists four survival tips. At the bottom, it shows the time '3:09 PM', the date 'Apr 28, 2025', and '989.1K Views'.

**Luis Garicano**    
@lugaricano

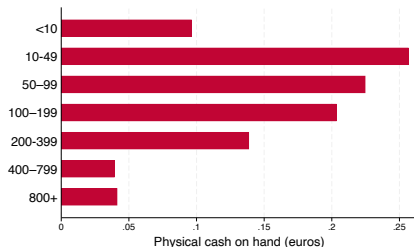
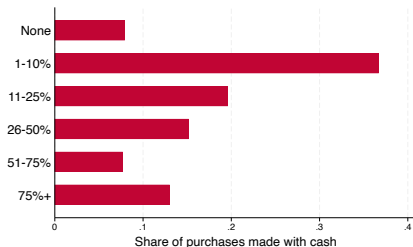
Back online (still no light here). Lessons from Spain after a really weird day (no electricity, no 4G, no WiFi) for the world

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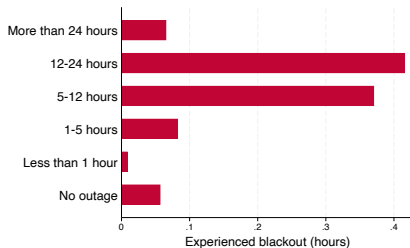
- ▶ We run a representative survey using YouGov in Spain ( $N = 1000$ )
- ▶ Cash holdings, demographics, and payments during outage

## Spain: Cash remains very popular



- ▶  $\approx$  30% of purchases paid in cash
- ▶ 42% hold more than 100 euros in cash

## Spain: Outages of digital payments



- ▶ Digital payments unavailable during blackout: **cash as fallback**
- ▶ 57% able to complete a payment with cash when **digital payments failed**

# Cash use during digital payment failures

Complete Payment with Cash	(1) Natural Disaster + Outage US	(2) Blackout Spain
Log Cash Holdings	0.0362*** (0.005)	0.0456*** (0.008)
Observations	3,461	1,000
R-squared	0.054	0.051
Controls	Y	Y
Region	Y	Y

Controls: race, age, gender, education, employment, marital status, income, education, region

- ▶ 20% increase in cash holdings raises prob. of **completing a cash purchase during an outage** by about 0.9 p.p.

	(1)	(2)	(3)	(4)
Increasing Cash Reserves	US		Spain	
Natural Disaster + Outage	0.0685*** (0.015)			
Cash During Outage		0.1579*** (0.017)		
Blackout			0.1123* (0.058)	
Cash During Blackout				0.1403** (0.054)
Disruption				
Cash During Disruption				
Log Cash Holdings	-0.0045 (0.005)	-0.0113* (0.006)	-0.0250* (0.011)	-0.0315** (0.013)
Observations	6,000	3,461	1,000	1,000
R-squared	0.041	0.085	0.067	0.081
Controls	Y	Y	Y	Y
Region	Y	Y	Y	Y

Controls: race, age, gender, education, employment, marital status, income, education, region

- ▶ 57% plan to **increase cash reserves** ( $\approx$  100 euros on avg.)
- ▶ Being able to use cash during the outage increases the likelihood of **planning to hold more cash by 14 p.p.**

# Sweden: In Case of Crisis of War



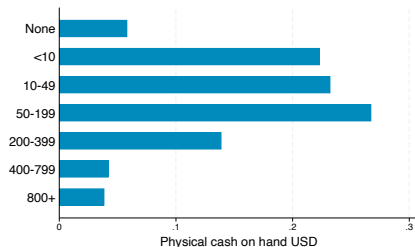
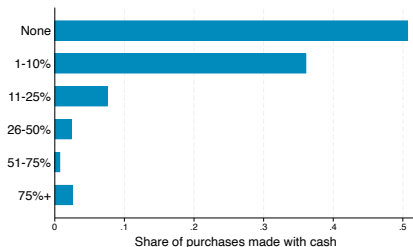
## Currency

The ability to make payments in various ways increases your emergency preparedness. You should use cash occasionally. Good to have:

- Enough cash for at least one week, preferably in different denominations.
- Other payment options – for example, debit or credit cards and digital services.

- ▶ We run a representative survey using YouGov in Sweden ( $N = 800$ )
- ▶ Cash holdings, payment during outages, self-reported effect of brochure

## Sweden: Cash use is low



- ▶ 87% of people pay less than 10% of purchases in cash
- ▶ CB pushing for mandatory cash acceptance in essential services due to security and resilience concerns

## Sweden: Brochure and planned reserves

- ▶ More than 70% of people read the brochure “In Crisis or War Comes”
  - ▶ In our survey, we inform those who have not read the brochure about it
- ▶ 32% of people plan to increase cash reserves
- ▶ 22% of people plan to increase cash use
- ▶ Cash enabled payments for 24% during digital payment disruptions

# Cash use during digital payment failures

Complete Payment with Cash	(1) Natural Disaster + Outage US	(2) Blackout Spain	(3) Payments Disruption Sweden
Log Cash Holdings	0.0362*** (0.005)	0.0456*** (0.008)	0.0496*** (0.010)
Observations	3,461	1,000	745
R-squared	0.054	0.051	0.121
Controls	Y	Y	Y
Region	Y	Y	Y

Controls: race, age, gender, education, employment, marital status, income, education, region

- ▶ 20% increase in cash holdings raises prob. of **completing a cash purchase during an outage** by about 1 p.p.

	(1)	(2)	(3)	(4)	(5)	(6)
Increasing Cash Reserves	US		Spain		Sweden	
Natural Disaster + Outage	0.0685*** (0.015)					
Cash During Outage		0.1579*** (0.017)				
Blackout			0.1123* (0.058)			
Cash During Blackout				0.1403** (0.054)		
Disruption					0.1341*** (0.025)	
Cash During Disruption						0.0893 (0.071)
Log Cash Holdings	-0.0045 (0.005)	-0.0113* (0.006)	-0.0250* (0.011)	-0.0315** (0.013)	0.0445*** (0.008)	0.0444** (0.011)
Observations	6,000	3,461	1,000	1,000	745	745
R-squared	0.041	0.085	0.067	0.081	0.110	0.095
Controls	Y	Y	Y	Y	Y	Y
Region	Y	Y	Y	Y	Y	Y

Controls: race, age, gender, education, employment, marital status, income, education, region

- ▶ Positive but insignificant effect of cash payment during digital disruption
- ▶ Those with less cash are less likely to increase reserves

# Outline

Motivation

Facts about Payments During Natural Disasters

Event Studies

Surveys: US, Spain, Sweden

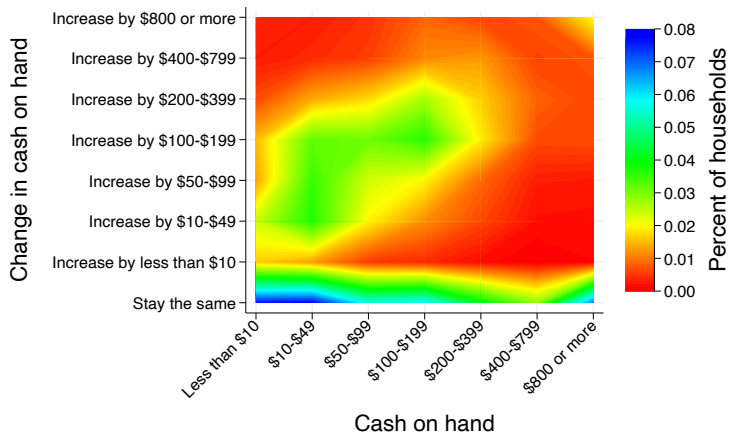
**Experiment**

Conclusions

Appendix

# Survey and information treatment

- ▶ Advice from Department of Homeland Security (DHS)
  - ▶ Hold cash for emergencies, such as severe weather events.
- ▶ Provide DHS advice to 1/2 of NielsenIQ panel ( $\approx$  21K) in May-June 2024
- ▶ Use 2024 natural disasters to compare spending (treatment vs control)
- ▶ Response to treatment and expenditures will be available in 2026
- ▶ Asked households in HMS if they plan to increase cash after that
  - ▶ Responses coincide with YouGov survey



- ▶ Information treatment of DHS advised **increased** desired cash holdings

# Outline

Motivation

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Experiment

**Conclusions**

Appendix

# Summary and conclusions

- ▶ Availability of cash helps mitigate disruptions in digital payments
  - ▶ Outages + precautionary motives + cash burns
- ▶ Evidence consistent across several data sets and surveys
- ▶ Information treatment + new data  $\implies$  sharper estimates
- ▶ In line w/ dynamic models of cash mgmt. & choice of payment method
- ▶ Implications for the design of offline-capable CBDCs

# Outline

Motivation

Facts about Payments During Natural Disasters

Event Studies

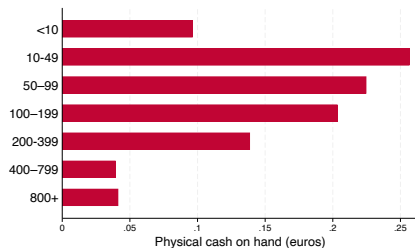
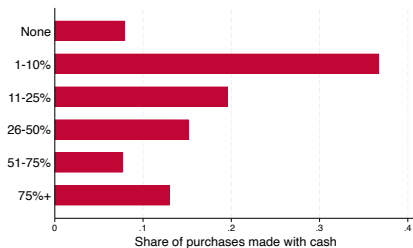
Surveys: US, Spain, Sweden

Experiment

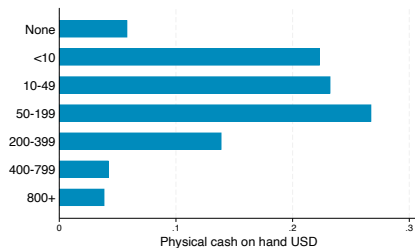
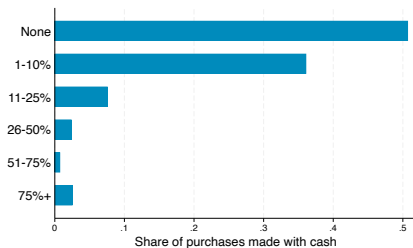
Conclusions

Appendix

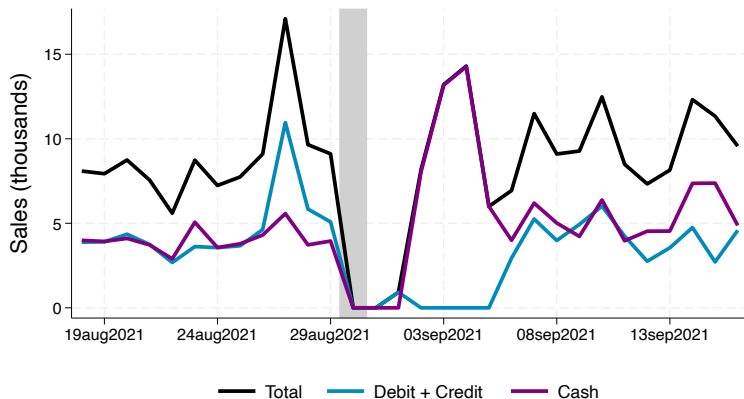
# Spain: Cash Use and Holdings



# Sweden: Cash Use and Holdings



# Hurricane: Case Study of One Store



## Diary of Consumer Payment Choice (DCPC)

- ▶ Use DCPC + demographics to predict cash holdings
- ▶ DCPC is run by the Federal Reserve Bank of Atlanta and USC's Understanding America Study (UAS)
- ▶ Survey: participants record all their transactions over a three days
- ▶ Includes information about payment choices as well as cash holdings
- ▶ Demographic data including age, income, and location, etc.
- ▶ Information from 2015-2023

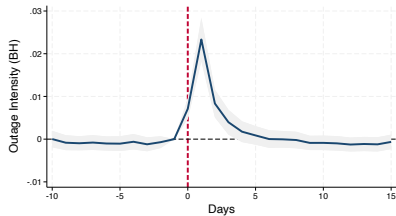
## Cash Response

- ▶ Considering this advice from the Department of Homeland Security regarding financial preparedness during natural disasters, would you consider increasing the typical amount of physical cash your household has on hand or at home (including cash for emergency purchases) in anticipation of such events? (Select one)
  1. Yes, I will increase my cash reserves by less than \$10
  2. Yes, I will increase my cash reserves by \$10-\$49
  3. Yes, I will increase my cash reserves by \$50-\$99
  4. Yes, I will increase my cash reserves by \$100-\$199
  5. Yes, I will increase my cash reserves by \$200-\$399
  6. Yes, I will increase my cash reserves by \$400-\$799
  7. Yes, I will increase my cash reserves by \$800 or more
  8. No, I will not increase my cash reserves

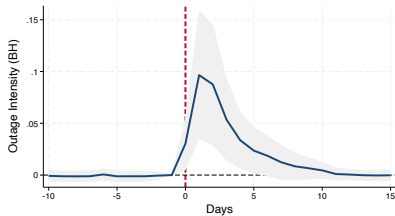
# Predicting Cash Holdings

- ▶ We use demographic information that coincide in both DCPC and HMS
- ▶ Use survey waves from 2015-2022
- ▶ Demographics: age, household size, marital status, race, income, location
- ▶ Include controls form expenditures, share of cash, and year effects
- ▶ Used coefficients to predict cash holdings in the Nielsen HMS

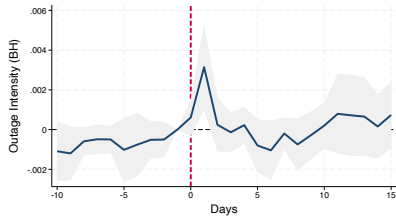
# Outages: other natural disasters



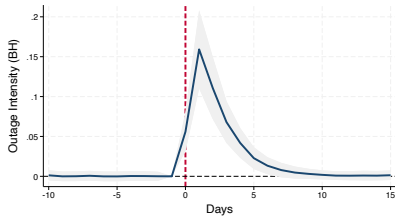
(a) Tornado



(b) Storm Surge/Tide

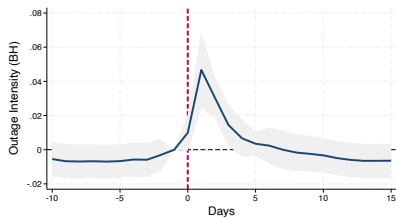


(c) Lightning

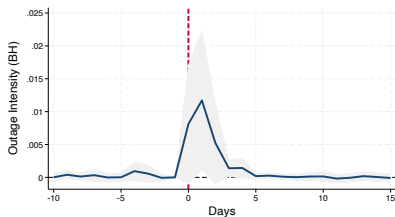


(d) Tropical Storm

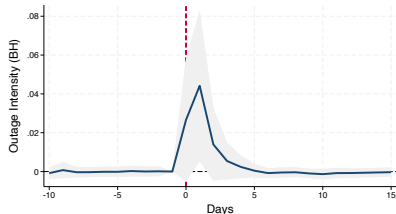
# Outages: other natural disasters



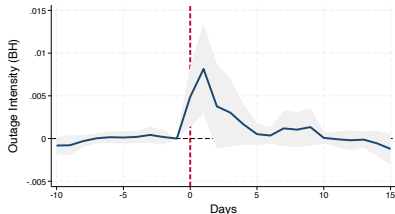
(a) Ice Storm



(b) Coastal Flood

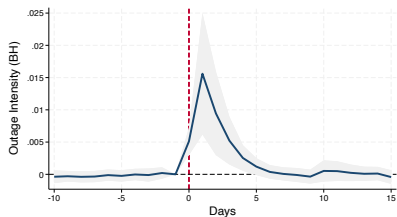


(c) Tropical Depression

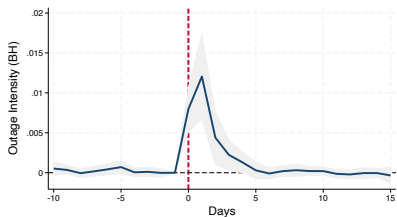


(d) Blizzard

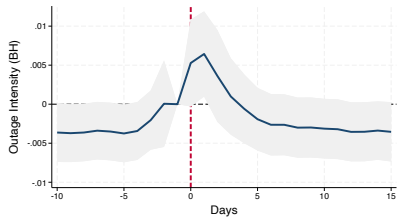
# Outages: other natural disasters



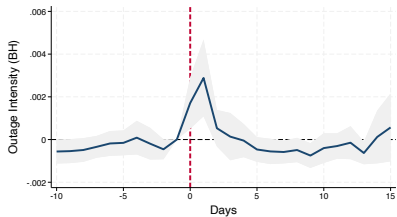
(a) Flash Flood



(b) Strong Wind

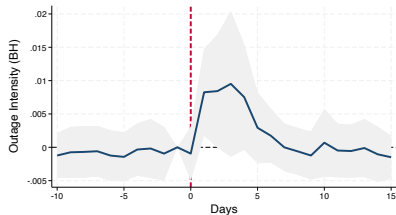


(c) Flood

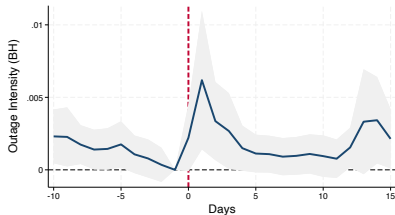


(d) Heavy Rain

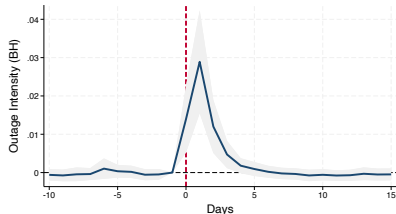
# Outages: other natural disasters



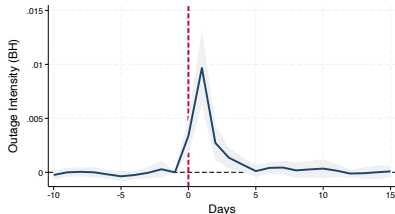
(a) Winter Storm



(b) Heavy Snow

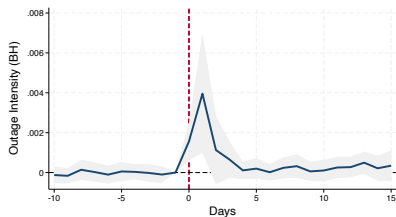


(a) High Wind

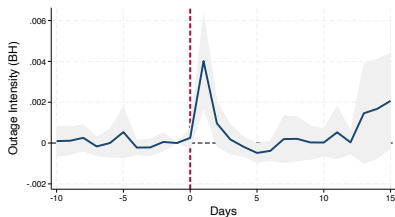


(b) Thunderstorm Wind

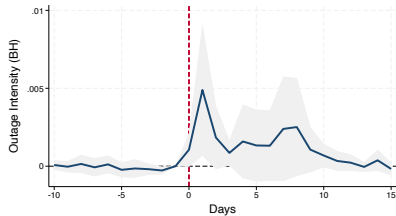
# Outages: other natural disasters



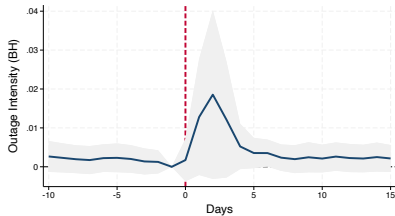
(a) Hail



(b) Funnel Cloud

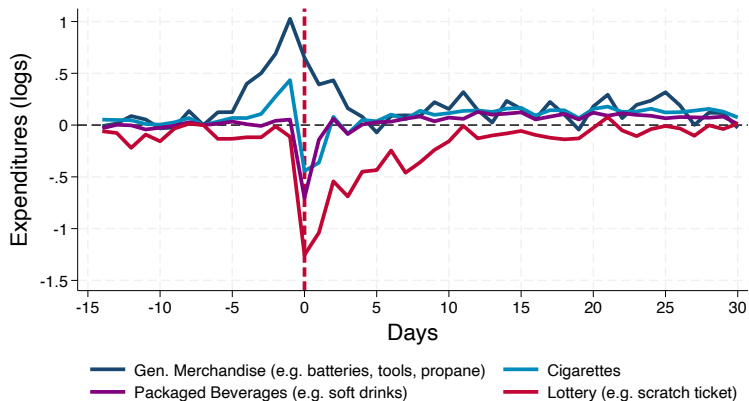


(c) Wildfire

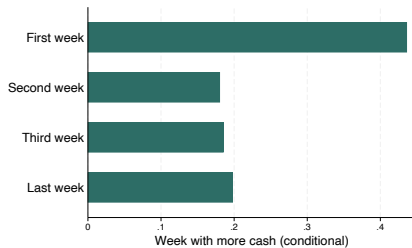


(d) Cold/Wind Chill

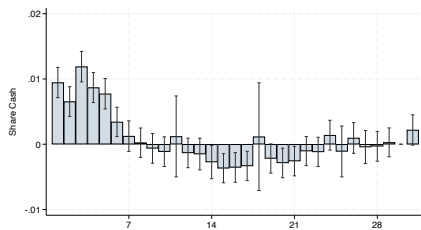
# Hurricane: expenditures at stores by Category

[▶ Back](#)

# Week of month with more cash [▶ Back](#)



(a) YouGov survey



(b) Store cash share sales