Environmental Shocks and Daily Consumption

Evidence from Desert Dust Storms and High-Frequency Card Transactions

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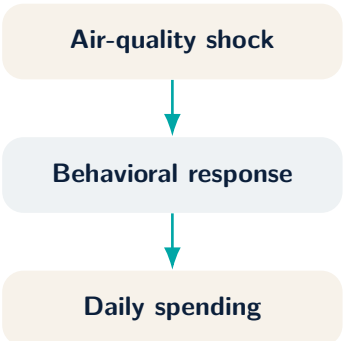
Viva Presentation – Chapter 2

Motivation and research question

Motivation: small environmental shocks can still be economically large

The central idea:

Frequent, non-catastrophic environmental shocks may alter daily consumption even without physical destruction, firm closures, or supply-side disruption.



Why consumption?

Daily spending captures immediate household adjustment: mobility avoidance, postponed errands, substitution across channels, and responses to public warnings.

Source: Literature: Dell et al. (2014); Burke et al. (2015); Hallegatte (2008, 2019); Pankratz et al. (2023).

Research question and thesis statement

Research question

How do exogenous Desert Dust Storms affect daily consumption, and through which channels?

What I study

- **Magnitude:** Effect on total consumption
- **Mechanism:** Physical exposure vs. Public information (warnings)
- **Heterogeneity:** Differences across sectors and consumers

Key Contribution

DDS episodes act as short-run demand shocks: they reduce mobility-intensive consumption, with limited substitution, highlighting the value of public information.

Contribution to the literature

1. Measurement

Near-universe daily card transactions reveal high-frequency consumption responses across 38 sectors.

2. Identification

DDS events provide exogenous variation in air quality, separated from local economic activity using rural PM_{10} data.

3. Mechanisms

The design separates realized pollution, warnings, missed warnings, channel substitution, and tourist versus resident behavior.

The chapter links environmental risk to real-time business interruption and consumption resilience.

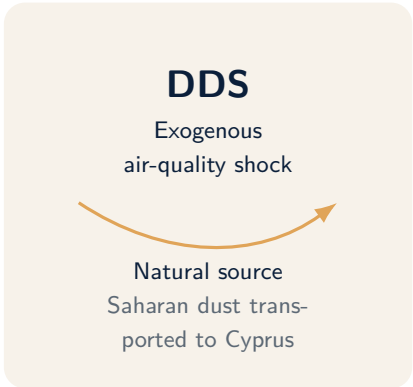
Source: Related work: Zivin and Neidell (2012); Chang et al. (2016); Jung et al. (2020); Agarwal et al. (2022); Kim et al. (2024).

Data and empirical setting

Why Desert Dust Storms are an effective setting

Identification logic

- DDS events are transboundary natural hazards originating mainly from the Sahara.
- Pollution levels are measured using the Ayia Marina rural background station.
- The station is far from anthropogenic sources, strengthening the exogeneity argument.
- Variation is high-frequency and plausibly unrelated to contemporaneous local demand shocks.



Economic relevance

DDS episodes raise PM_{10} concentrations, impacting health, mobility, and willingness to undertake discretionary errands.

Source: Event identification follows Achilleos et al. (2020) and Milidonis et al. (2024).

Data architecture

Transaction data

- Daily card transactions from JCC Payment Systems
- Cyprus, 2015–2018
- Aggregated by Merchant Category Code (MCC)
- Outcomes: transaction count and amount
- Split by channel and card origin

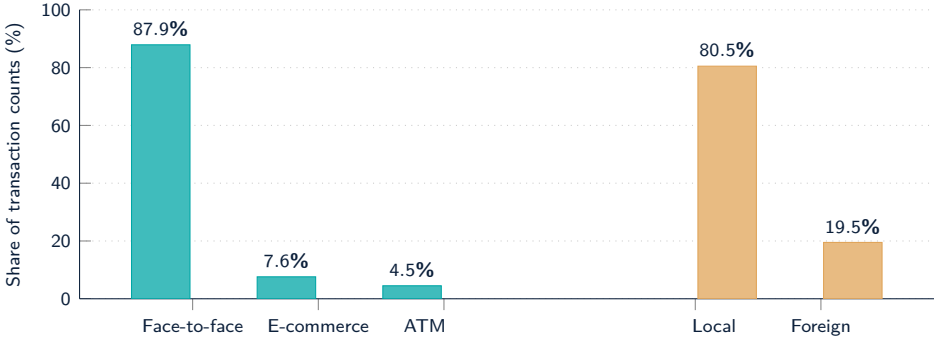
Air quality & information

- PM_{10} from Ayia Marina rural background station
- Official dust announcements from the Department of Labour Inspection

Panel overview

1,825	38	>95%
days	**MCC sectors**	**card volume**
Daily panel	Economic coverage	Processor coverage

Descriptive statistics: consumption is mainly in-person and local



Economy Composition

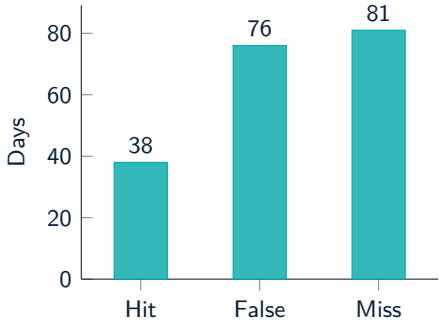
Given that most transactions are local face-to-face, DDS effects are expected to impact primarily the resident economy through in-person mobility.

Source: Chapter 2, Table 2.4.

Descriptive fact: DDS events are infrequent but extreme

PM_{10} distribution, 2015–2019

Statistic	Value
Mean	21.65 $\mu g/m^3$
Median	17.70 $\mu g/m^3$
Standard deviation	22.14
Maximum	455.78 $\mu g/m^3$
DDS events	119

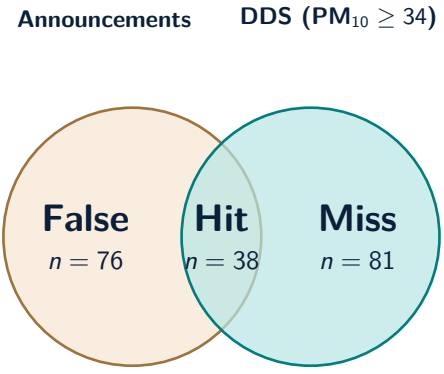


Event-warning decomposition used to separate physical exposure from public-information effects.

Source: Chapter 2, PM_{10} descriptive statistics and announcement classification.

Identification and methodology

Event classification separates exposure from information



Interpretation

Hit	DDS occurred and public warning was issued
False	Warning issued without DDS exposure
Miss	DDS occurred without public warning

Why this matters

This decomposition identifies whether consumption responds to realized pollution, precautionary information, or the absence of timely information.

Empirical design: flexible high-frequency models

Outcomes and distributions

- **Counts**: quasi-Poisson, because transaction counts are non-negative and overdispersed.
- **Amounts**: Gamma log-link, because purchase values are positive and right-skewed.
- Coefficients are converted as $\exp(\hat{\beta}) - 1$.

Controls

- Day-of-week, month, year effects.
- Holiday and calendar structure.
- Smooth terms for time and macro controls in the dynamic model.

Baseline count model

$$\ln(\mu_{it}) = \alpha_i + \beta_i DDS_t + \Gamma X_t$$

$\exp(\beta_i) - 1$ is the percentage change in expected transactions.

Dynamic cumulative effect

$$\beta^{type}_{i,[0,L_i]} = \sum_{\ell=0}^{L_i} \beta^{type}_{i\ell}$$

Captures postponed, persistent, or recovered consumption.

Main findings

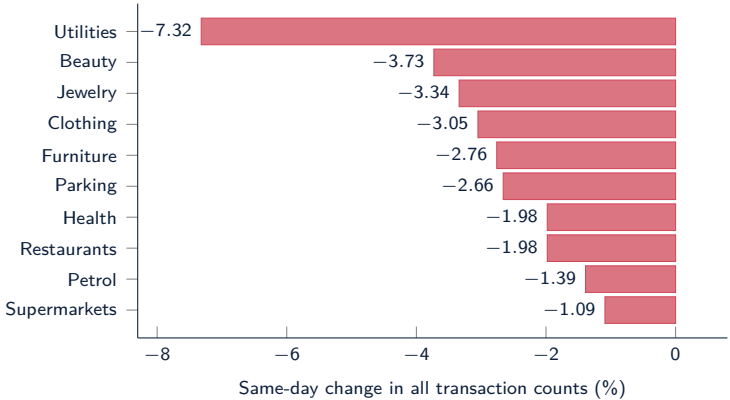
Results map: each empirical split tests one mechanism

All transactions	Face-to-face	E-commerce	Hit / False / Miss
Magnitude of the demand shock	Mobility and physical exposure	Substitution across channels	Information versus realized exposure

Interpretation

Interpretation is not isolated on table estimates. I use selected sectors to show whether behavioral patterns are consistent with coherent economic mechanisms.

Finding 1: DDS compresses daily activity in mobility and in-person sectors

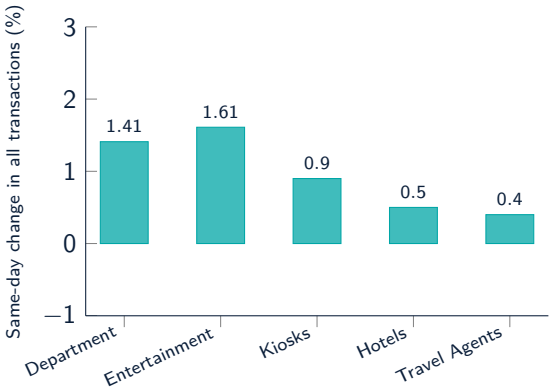


Interpretation

The strongest contractions are not random: they cluster in sectors that require movement, physical presence, or postponable discretionary errands.

Source: Table 2.5. Percent effects computed as $\exp(\hat{\beta}) - 1$.

Finding 1b: Limited pockets of positive same-day substitution



Interpretation

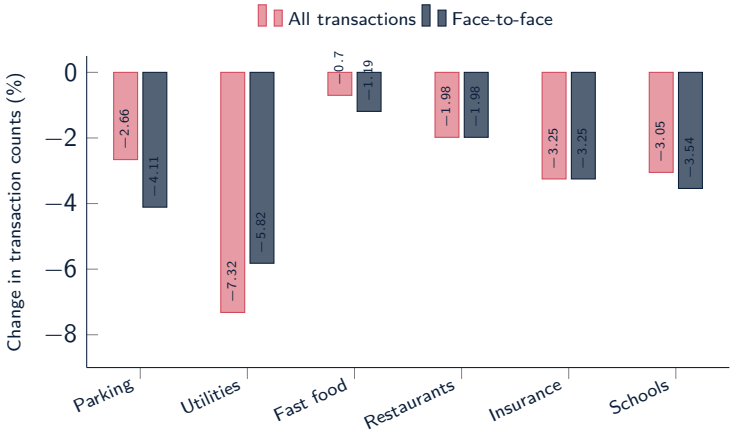
Positive sectors are narrow and economically interpretable: indoor retail, convenience purchases, or trip-related spending.

Contribution

These pockets do not overturn the main result. They show partial reallocation, not full recovery of aggregate demand.

Source: Table 2.5. Hotels and Travel Agents are statistically weaker than Department Stores, Entertainment and Kiosks.

Finding 2: face-to-face transactions reveal the mobility channel



Interpretation

The effect is concentrated where consumption requires physical presence.

Source: Tables 2.5 and 2.7. Percent effects computed as $\exp(\hat{\beta}) - 1$.

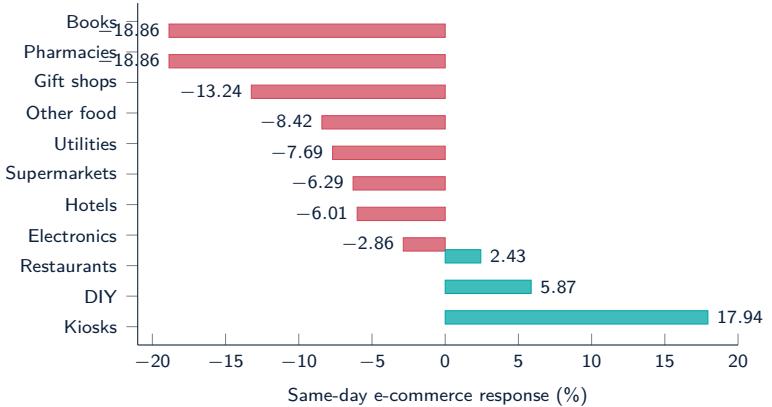
Finding 2b: local face-to-face transactions show the sharpest resident response

Source: Table 2.14, Hit_{34} lag-0 coefficients reported as percentage changes.

Interpretation

The resident, in-person margin exhibits very large same-day responses when warnings and DDS exposure are decomposed dynamically.

Finding 3: e-commerce does not fully insure consumption

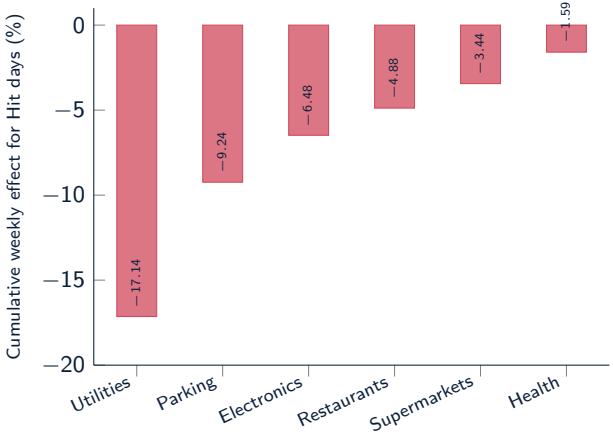


Limited Substitution

Online substitution is selective. Kiosks and DIY increase, but routine and essential categories often fall online too, implying a broader demand contraction.

Source: Table 2.8. Percent effects computed as $\exp(\hat{\beta}) - 1$. Jewelry is excluded from the chart because its unusually large positive estimate would dominate the scale.

Finding 4: information accuracy changes the economic effect

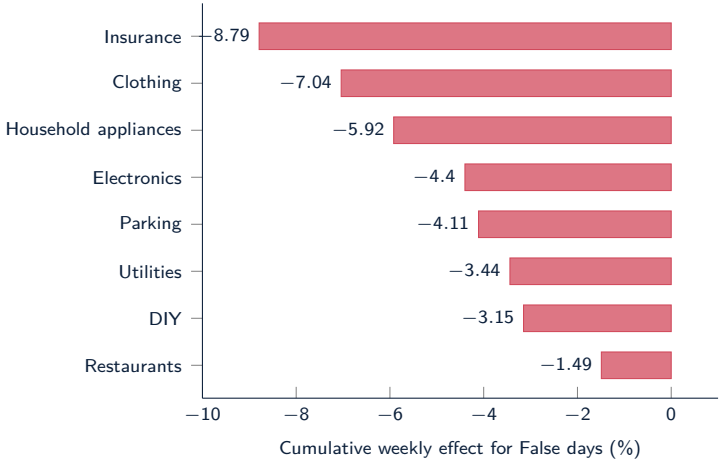


Source: Table 2.9, Hit_{34}. Percent effects computed as $\exp(\hat{\beta}) - 1$.

Interpretation

DDS events are correctly announced, several sectors record cumulative weekly contractions. Warnings may allow some adjustment, but they also induce avoidance. For services and scheduled payments, same-day reductions are not fully recovered within the week.

Finding 4b: false warnings have real economic costs

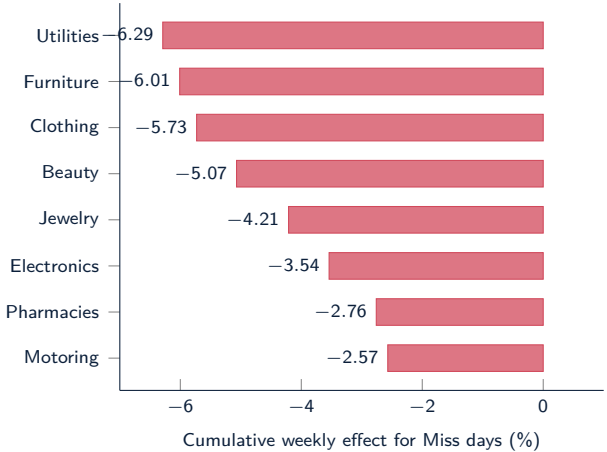


Core message

Information is not neutral: warnings can affect consumption even when realized pollution remains below the threshold.

Source: Table 2.9, False_{34}. Percent effects computed as $\exp(\hat{\beta}) - 1$.

Finding 4c: missed events generate persistent unanticipated losses



Source: Table 2.9, Miss_{34}. Percent effects computed as $\exp(\hat{\beta}) - 1$.

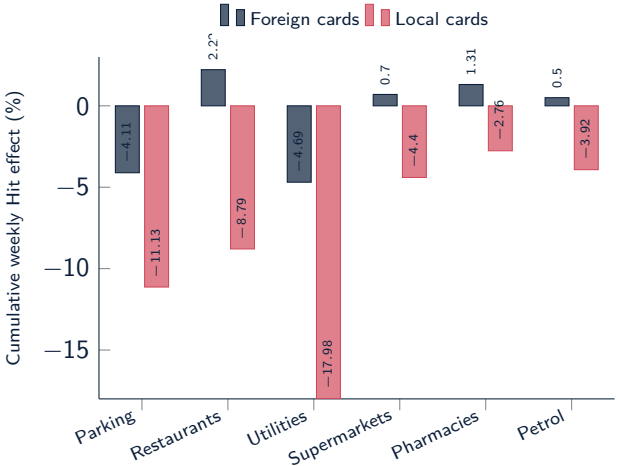
Interpretation

Missed DDS events are unanticipated pollution shocks. Households cannot adjust in advance, and losses are less likely to be recovered.

Economic lesson

The accuracy of risk communication is itself a determinant of the economic cost of environmental shocks.

Finding 5: resident consumption bears the larger burden



Source: Tables 2.10–2.11, Hit_{34}. Percent effects computed as $\exp(\hat{\beta}) - 1$.

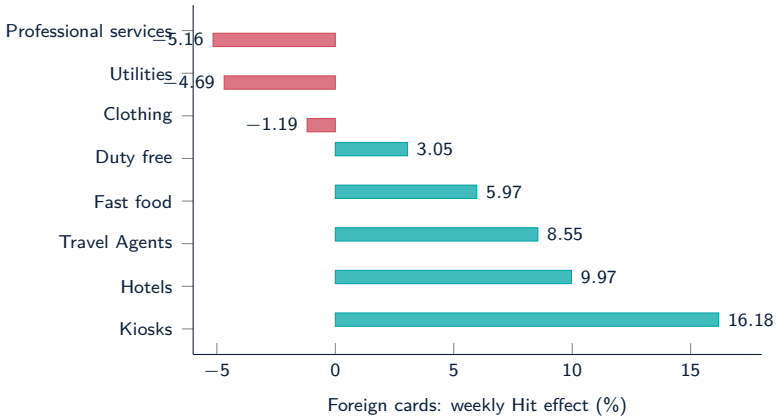
Interpretation

The resident economy responds through routine disruption: parking, restaurants, utilities, supermarkets, pharmacies and petrol all decline for local cards.

Why foreigners differ

Tourists have pre-committed itineraries and can reallocate within the trip rather than cancel consumption entirely.

Finding 5b: foreign-card activity reallocates toward trip-compatible sectors



Interpretation

Foreign-card responses are not simply smaller; they are compositionally different.

Source: Table 2.10, Hit_{34}. Percent effects computed as $\exp(\hat{\beta}) - 1$.

Business interruption insurance

From estimated elasticities to business interruption exposure

Pricing intuition

$$\widehat{\mathbb{E}}[Loss_i] = \widehat{\lambda}_{34} \cdot \max\{-(e^{\hat{\beta}_i} - 1), 0\} \cdot \overline{Q}_{i,DDS} \cdot \widehat{A}_{i,next}$$

- $\widehat{\lambda}_{34} = 23.8$: expected annual DDS trigger days.
- $\max\{-(e^{\hat{\beta}_i} - 1), 0\}$: insured proportional demand shortfall.
- $\overline{Q}_{i,DDS}$ and $\widehat{A}_{i,next}$: exposure and ticket size.

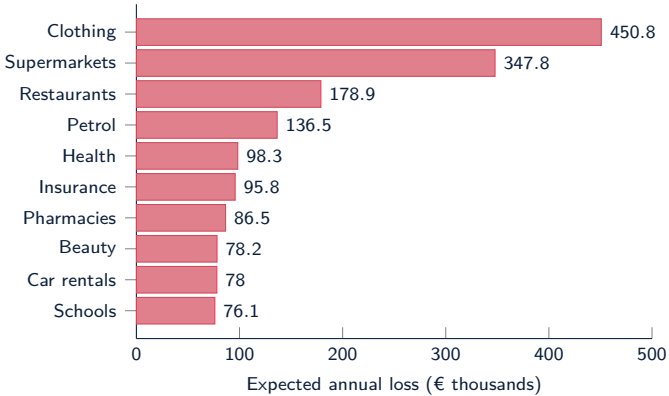
Conceptual contribution

The transaction estimates become sector-specific cash-flow sensitivities that can price parametric business interruption insurance.

Insured base

Face-to-face $\times$ local cards, approximating the resident in-person economy most exposed to DDS disruption.

Insurance result: expected annual losses are concentrated



Portfolio result

Total expected annual loss across insured industries is approximately **€2.03 million**.

Interpretation

Loss concentration reflects both elasticity and exposure: high-frequency sectors such as supermarkets matter even when percentage effects are modest.

Source: Business interruption insurance table, face-to-face × local cards.

Insurance examples: percentage shock versus exposure

Large loss because exposure is high

- **Supermarkets**: only -1.4% local face-to-face effect, but high transaction volume produces **€347,763** expected annual loss.
- **Restaurants**: -3.1% with large daily frequency gives **€178,927**.

Large loss because sensitivity is high

- **Clothing**: -3.6% economic effect and high exposure give **€450,782**, the largest sectoral loss.
- **Insurance**: -4.5% effect and higher ticket size produce **€95,848**.

Interpretation

Business interruption risk is a product of three components: event frequency, behavioral sensitivity, and insured economic exposure.

Source: Business interruption insurance table.

Interpretation and implications

Economic interpretation: what the evidence says collectively

Demand shock	Behavioral mechanism	Information mechanism
DDS reduces transaction activity across many sectors without physical capital destruction.	The largest effects occur in face-to-face, mobility-intensive, and resident-consumption categories.	False and missed warnings show that risk communication is part of the economic transmission channel.

Environmental risk is not only physical exposure; it is behavioral response, sectoral exposure, and information accuracy.

Final takeaways

1. **DDS events generate real economic costs** even without physical destruction or supply-side disruption.
2. **The primary channel is behavioral**: mobility avoidance and lower in-person activity.
3. **Substitution is incomplete**: e-commerce and delayed purchases do not fully offset lost demand.
4. **Information matters**: false warnings and missed events both create economically relevant distortions.
5. **Heterogeneity is central**: local consumers, mobility sectors, and face-to-face services carry the largest burden.

Contribution

This chapter shows that air-quality shocks propagate into the real economy through daily consumption behavior, sectoral exposure, and the accuracy of public risk communication.

Thank you.

Questions?

Backup: detailed model structure

Baseline count specification

$$Y_{it} \mid X_{it} \sim \text{Quasi-Poisson}(\mu_{it}, \phi), \qquad \ln(\mu_{it}) = \alpha_i + \beta_i DDS_t + \delta_d + \gamma_m + \eta_y.$$

Purchase amounts

$$A_{it} \mid X_{it} \sim \Gamma(\mu_{it}, \theta), \qquad \ln(\mu_{it}) = \alpha_i + \beta_i DDS_t + \lambda \ln(\text{Purchases}_{it}) + \Gamma X_t.$$

Dynamic cumulative effect

$$\beta_i^{cum} = \sum_{\ell=0}^{L_i} \beta_{i\ell}, \qquad \text{effect} = \exp(\beta_i^{cum}) - 1.$$

Backup: values used in the main charts

Slide	Values and source
Same-day contractions	Table 2.5; all-transaction betas converted using $\exp(\hat{\beta}) - 1$.
Face-to-face channel	Tables 2.5 and 2.7; all versus face-to-face transaction counts.
Local face-to-face lag 0	Table 2.14; reported values are already percentage changes.
E-commerce	Table 2.8; all-transaction e-commerce betas converted using $\exp(\hat{\beta}) - 1$.
Hit/False/Miss	Tables 2.9–2.11; cumulative coefficients converted using $\exp(\hat{\beta}) - 1$.
Insurance	Business interruption table; expected annual loss in euros, divided by 1,000 for plotting.

Backup: likely questions

Question	Core answer
Why Cyprus?	High DDS exposure, service-oriented economy, strong transaction coverage, and meaningful tourist/local split.
Why GAM?	High-frequency consumption is nonlinear, seasonal, and volatile; GAM flexibly absorbs calendar and trend structure.
Are DDS exogenous?	The pollution source is transboundary and measured at a rural background station, reducing reverse causality from local spending.
Why separate Hit/False/Miss?	It distinguishes realized exposure from risk communication and identifies information as an economic mechanism.
Can this generalize?	Most directly to service-heavy regions exposed to recurrent air-quality shocks; magnitudes may differ by payment habits and warning systems.

Backup: limitations and extensions

Limitations

- Card transactions exclude cash spending.
- Sector-level aggregation cannot observe individual household mobility directly.
- External validity depends on payment systems, tourism structure, and warning institutions.

Extensions

- Link transaction effects to firm-level cash flow.
- Combine with mobility data to validate behavioral mechanisms.
- Compare across countries with different public-warning systems.