Exchange-Rate Regimes and the Behavior of Exporters

14th EIEF-UNIBO-IGIER Bocconi Workshop on Industrial Organization — Rome, December 2025

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Motivation: Two Puzzles

1. The Mussa Puzzle (1986)

When economies switch from Fixed to Floating exchange-rate regimes:

- **Nominal** exchange rate volatility increases
- **Real** exchange rate volatility matches 1:1

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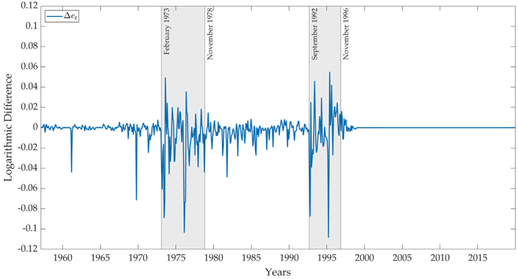
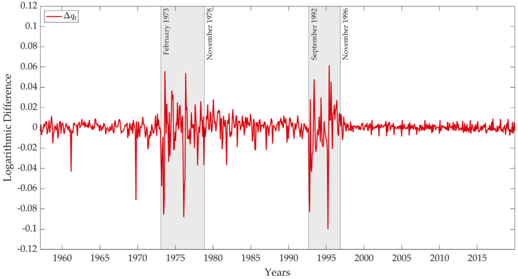
2. The Exchange Rate Disconnect

Despite the explosion in relative price volatility:

- Real macro aggregates (consumption, output) remain **stable**
- We can think of the **real** exchange rate as relative price $\rightarrow$ consumption should move



(a) Nominal exchange rate



(b) Real exchange rate

Figure 1: Bilateral exchange rates for Italy vs. Germany (log changes)

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The Literature's Focus:

- Recent work on *segmented financial markets* (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021)
- Limited evidence on the **micro-level transmission mechanism**

This Paper

Research Question

- How do multi-product exporters adjust their optimal pricing in response to **breaks** in exchange-rate regimes?

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- **Empirics**: structural estimation of demand and supply system to measure product-level **markup changes around regime breaks**

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- **Empirics**: structural estimation of demand and supply system to measure product-level **markup changes around regime breaks**
- **Model**: Two-country Real Business Cycle model rationalise the disconnect through strategic complementarity (PtM)

Literature

- **Exchange-rate regimes in international macro-finance**
  Cavallo et al. (2014), Gabaix and Maggiori (2015), Itskhoki and Mukhin (2021), Petracchi (2025)
- **Real rigidities and pricing-to-market**
  Goldberg and Verboven (2001), Atkeson and Burstein (2008), Fitzgerald and Haller (2015), Aruoba et al. (2024)
- **Structural IO and the Car Industry**
  Berry, Levinsohn, and Pakes (1995), Brenkers and Verboven (2006), Reynaert and Verboven (2014), Coşar et al. (2018), Gandhi and Houde (2019)
- **Large devaluations and firm response**
  Blaum (2024), Fukui et al. (2025), Ottonello et al. (2025)

Preview of Results

1. Empirical Evidence (Micro)
   - **Drop in Markups:** Floating regimes cause an immediate decline in average markups and an increase in markup dispersion
   - **Transient:** Markups recover over $\approx$ 3 years
   - **Systematic:** Holds across all origin-destinations (not idiosyncratic)

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2. Structural Mechanism (Macro)
   - We discipline a two-country RBC model using these markup estimates
   - **Strategic Complementarity:** Identified as the key ”shock absorber”
   - **Insulation:** Endogenous markup readjustment dampens the effect of foreign shocks on the real economy (disconnect)

Setting and Data

Why the Car Industry?

- Highly tradable sector: import penetration ranges from 27% to 45%
- Oligopolistic structure with large multiproduct firms
- **Rich Data:** Detailed product-level data on prices, sales, and characteristics for 30 years (1970–1999).
- **No Financial Hedging:** Capital controls in Europe until the early 90s prevented financial hedging, forcing operational adjustments
- **Cost Structure:** Production is concentrated in the origin country, meaning marginal costs depend primarily on domestic factors
    - *Implication:* Exchange rate shocks primarily affect revenues, not costs, simplifying identification

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- **Additional Information**:
  - Production location and brand ownership
  - Household income distribution and factor prices

Summary Statistics

	France	Germany	Italy	U.K.	All
Average price (ECU)	17,894.4	16,116.1	18,536.5	18,489.3	17,745.1
	(22,312.7)	(19,364.2)	(22,454.0)	(21,426.8)	(21,421.8)
Foreign market share (%)	32.9	26.8	43.9	39.6	35.8
	(15.7)	(5.4)	(15.3)	(11.9)	(14.2)
Horsepower (HP)	75.2	75.4	79.6	77.3	76.8
	(49.1)	(48.5)	(53.4)	(48.7)	(49.9)
Weight (kg)	1,052.7	1,058.9	1,066.3	1,061.4	1,059.7
	(275.0)	(276.7)	(284.6)	(271.8)	(276.9)
Observations	3,078	3,091	2,835	3,133	12,137

Notes: Summary statistics for the European car market (1970–1999). Standard deviations in parentheses.

Exchange-rates regimes

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France

- January 1974 (*Snake* exit)
- May 1975 (*Snake* re-accession)
- March 1976 (*Snake* exit)
- November 1978 (ERM agreement)

Italy

- February 1973 (*Snake* exit)
- November 1978 (ERM agreement)
- September 1992 (ERM exit)
- November 1996 (ERM re-accession)

United Kingdom

- June 1972 (*Snake* exit)
- October 1990 (ERM accession)
- September 1992 (ERM exit)

Stylised facts

Law of One Price Does Not Hold

Definition:

$$RER_{jmt} = \frac{P_{jt}^{m}}{P_{jt}^{DE}} \mathcal{E}_{mt}$$

Notes:
Conditional means of real exchange rates between market *m* (IT, FR, UK) and Germany.
Standard errors in parentheses.

	Exchange-rate Regime		
Segment	All	Peg	Floating
Mini (A)	1.028	0.993	1.084
	(0.010)	(0.012)	(0.015)
Small (B)	1.013	0.963	1.050
	(0.027)	(0.010)	(0.013)
Medium (C)	1.056	1.009	1.134
	(0.008)	(0.010)	(0.014)
Large (D)	1.050	1.001	1.131
	(0.008)	(0.010)	(0.017)
Executive (E)	1.076	1.026	1.160
	(0.010)	(0.012)	(0.016)
Luxury (F) & Sports (S)	1.124	1.105	1.155
	(0.012)	(0.012)	(0.019)
All	1.072	1.033	1.135
	(0.007)	(0.007)	(0.012)
Observations	10,278	6,390	3,888

How Prices and Quantities Move

$$\tilde{p}_{it}^{m} = \alpha + \beta \cdot \varepsilon_{mt} + \gamma_t + \delta_{im} + \eta_{imt}$$

where $\tilde{p}_{jt}^{m} \equiv \ln(P_{jt}^{m} / P_{jt}^{DE})$

Table 1: Relative prices and quantities

	A. Ln prices ($\tilde{p}_{jt}^{m}$)			B. Ln sales		
	All sample	Peg regimes	Floating regimes	All sample	Peg regimes	Floating regimes
Nominal exch. rate	-0.882 (0.036)	-1.115 (0.0375)	-0.830 (0.053)	-0.405 (0.280)	-0.535 (0.338)	-0.501 (0.593)
Obs.	7,482	4,606	2,783	9,126	5,686	3,336
N. clusters	332	249	196	356	280	206

Notes:OLS regression of relative prices in local currency ($\tilde{p}_{it}$, Panel A) or sales (Panel B) on the nominal exchange rates. All regressions include year fixed effects and the interaction between destination market and car model fixed effects. Robust standard error in parentheses.

Structural Model

Demand: Bi-Level RCNL

$$U_{ijm} = \underbrace{-\alpha_i \, p_{jm}}_{\substack{\text{price sensitivity} \\ \text{(heterogeneous)}}} + x_{jm}\beta + \xi_{jm} + \nu_{ijm} + \varepsilon_{ijm}$$

Random Coefficients: $\alpha_i = \bar{\alpha} + \Sigma\nu_i$ (Unobserved heterogeneity in price sensitivity)

Structural Model

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$$U_{ijm} = -\alpha_i p_{jm} + \underbrace{x_{jm}}_{\text{obs. prod.}} \beta + \xi_{jm} + \nu_{ijm} + \varepsilon_{ijm}$$

Observable Characteristics (x_{jm}): Horsepower, weight, dimensions (length/width/height), fuel efficiency, and engine displacement.

Demand: Bi-Level RCNL

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Structural Model

Demand: Bi-Level RCNL

$$U_{ijm} = -\alpha_i p_{jm} + x_{jm}\beta + \xi_{jm} + \underbrace{\nu_{ijm}(\sigma)}_{\substack{\text{bi-level nests} \\ \text{(seg, orig)}}} + \varepsilon_{ijm}$$

Bi-Level Nesting: $\nu_{ijm} = \zeta_{ig} + \zeta_{ih}$ (Correlation within Segment g and Origin h)

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$$U_{ijm} = -\alpha_i \, p_{jm} + x_{jm} \, \beta + \xi_{jm} + \nu_{ijm} + \underbrace{\varepsilon_{ijm}}_{\substack{\text{iid shock} \\ \text{(T1EV)}}}$$

Structural Model

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$$U_{ijm} = -\alpha_i\, p_{jm} + x_{jm}\beta + \xi_{jm} + \nu_{ijm}(\sigma) + \varepsilon_{ijm}$$

Supply: Multiproduct Oligopoly

$$\max_{\{p_{jm}\}} \Pi_f = \sum_{m=1}^{M} R_{f,m} - \sum_{j \in J_{f,m}} C_j(q_{j,1}(\mathbf{p}_1); \ldots ; q_{j,M}(\mathbf{p}_M))$$

where

$$R_{f,m} \equiv \mathcal{E}_m \sum_{j \in J_{f,m}} p_{j,m}\, q_{j,m}(\mathbf{p}_m)$$

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Market clearing

$$q^d_{j,m}(\cdot) = q^s_{j,m}(\cdot) = q_{j,m}(\cdot)$$

Empirical framework

Identification: Gandhi & Houde (2019) Instruments

- Standard instruments (sums of rival characteristics) can lose power when products become close substitutes
- We use Gandhi & Houde (2019) instruments, which exploit the *distribution* of characteristic differences between rivals
- For characteristic k (e.g., horsepower, size), the instrument for product j is:

$$Z_{jmt}^{GH} = \sum_{r \neq j \in \mathcal{J}_{mt}} d_k(x_{jmt}, x_{rmt})$$

  - **Logic:** Measures isolation in characteristic space. Products with few close rivals have higher markups (identifies α) and different substitution patterns (identifies σ)
  - We use quadratic differences $d_k(\cdot) = (x_j - x_r)^2$ as the specific functional form

Firm Problem

- Define revenues for firm f in market m as $R_{f,m} \equiv \mathcal{E}_m \sum_{j \in J_{f,m}} p_{j,m} \, q_{j,m}(\mathbf{p}_m)$. The firm problem can be stated as:

$$\Pi_f = \sum_{m=1}^{M} R_{f,m} - \sum_{j \in J_{f,m}} C_j(q_{j,1}(\mathbf{p}_1); \ldots; q_{j,M}(\mathbf{p}_M)) \tag{1}$$

Supply Estimation

- Assume Bertrand-Nash competition
- FOC: main moment restriction (holds period by period):

$$\frac{\partial}{\partial p_{j,m}} \Pi_f = \left(q_{j,m}(\mathbf{p}_m) + \sum_{k \in F_{f,m}} \mathcal{E}_m p_{j,m} \cdot \frac{\partial q_{k,m}}{\partial p_{j,m}}(\mathbf{p}_m) \right)$$

$$- \sum_{k \in F_{f,m}} \left(\frac{\partial C_j(\cdot)}{\partial q_{k,m}} \cdot \frac{\partial q_{k,m}}{\partial p^w_{j,m}} \right) = 0$$

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- Data + demand estimation = moment condition

GMM

- The FOC can then be rewritten and be used to estimate the marginal cost

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- If we assume a Cobb-Douglas production function then:

$$\ln\left(\Delta_j^{-1}A\right) = z_j\gamma_s + \delta \ln\left(W_s/F_s\right) + \zeta \ln Q_j + \omega_s + \omega_f \quad (2)$$

- where A is the term in the first row in the previous slide, ω_s country of origin fixed effects, ω_f firm fixed effects, z_j product characteristics, W_s and F_s respectively wage and capital costs, Q_j total European production, Δ_j own and cross price elasticities

Results

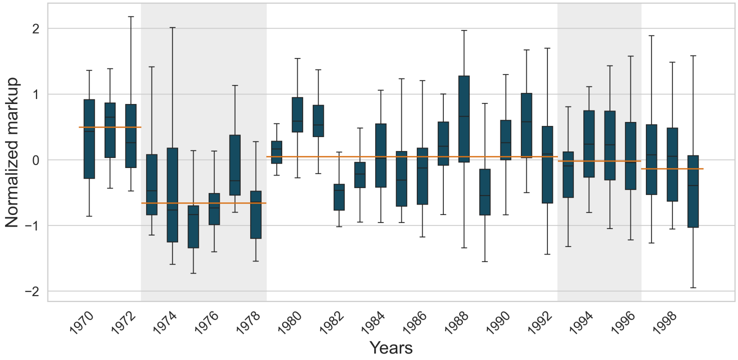

Figure 2: Markup **German** cars sold in **Italy**

Note: Box plot of product-level markups for all German cars sold in Italy. Shaded area represent floating exchange-rate regimes identified in Petracchi (2022)

Event Study

We pool all ”Peg-to-Float” transitions to trace markup dynamics.

Specification:

$$\mu_{jmt} = \sum_{\tau=-5,\tau\neq-1}^{5} \beta_\tau D_{t-\tau} + \gamma_{jm} + \delta_t + \varepsilon_{jmt}$$

where:

- μ_{jmt} is the estimated markup for car model j in market m at time t
- $D_{t-\tau}$ is an indicator variable for being τ years away from a regime break
- γ_{jm} are car model-by-market fixed effects controlling for time-invariant unobservables
- δ_t are year fixed effects to control for common global shocks
- Coefficients normalized relative to $\tau = -1$ (year prior to break)

Results – Event Study

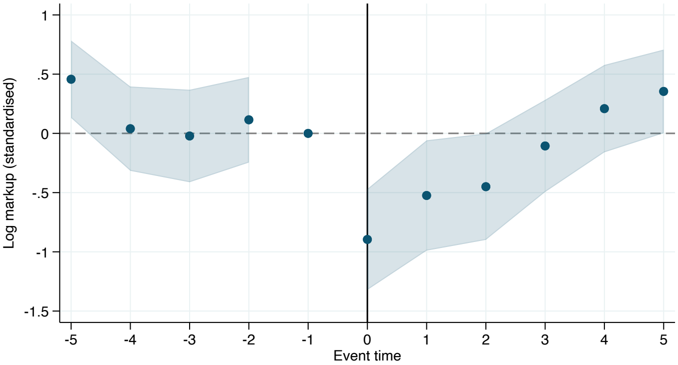

Figure 3: Event study of markups

Note: Event study plot of markups (z-scores) around all regime breaks from pegged to floating (all countries). Pre-break year (t=-1) normalised to zero. Shaded area report 95% confidence intervals.

General Equilibrium Model

General Equilibrium Framework

Backbone: Two-country RBC model (Germany vs. Italy) driven by productivity (a_t) and financial (ψ_t) shocks

Three Key Frictions:

1. **Imperfect Financial Markets** (Gabaix & Maggiori, 2015)
   - Financiers have limited risk-bearing capacity (Γ_t)
   - Deviations from UIP $\rightarrow$ Source of exchange rate volatility (e_t)
2. **Variable Markups & Pricing-to-Market** (Kimball, 1995)
   - Demand side characterized by a **Kimball Aggregator**
   - Generates endogenous price stickiness (*Real Rigidities*)
3. **Exporter-Importer Firms** (Petracchi, 2025)
   - Firms export output but import intermediate inputs
   - *Natural Hedge*: Costs and Revenues move together

Disciplining the Model with Micro-Estimates

From Micro to Macro: We calibrate the degree of strategic complementarity (α) using our structural estimates around the 1973 break

The Pricing Equation (Log-linearized)

$$p^*_{Ht}(j) = (1-\alpha)mc_{Et} + \alpha p^*_t$$

Solving for α using the observed markup adjustment ($\hat{\theta}_t$):

$$\alpha = \frac{1}{\hat{\mu}_t}\left(p^*_t - mc_{Et} - \varepsilon_t\right)$$

Calibration Input:

- Est. Markup Drop ($\hat{\mu}$): -8.7%
- Cost/Exchange Rate Gap: $24.2\% - 5.7\% - 23.6\%$

Result

$$\hat{\alpha} \approx 0.59$$

Interpretation: Firms place $\approx 60\%$ weight on local competitor prices (p^*) and only 40% on their own marginal costs.

Results: Matching the Twin Puzzles

Key Finding: The model replicates the ”Mussa Puzzle” and the ”Disconnect” **without** requiring nominal rigidities (Sticky Prices).

Table 2: Model Performance: Flex vs. Sticky Prices (Germany)

Moment	Data	Model (Flex)	Model (Sticky)
1. Mussa Puzzle			
$Corr(\Delta e, \Delta q)$	0.91	**0.93**	0.99
2. The Disconnect			
$\sigma(\Delta e)/\sigma(\Delta GDP)$	2.82	**1.90**	1.32
$\sigma(\Delta e)/\sigma(\Delta C)$	2.82	**2.36**	2.83

Note: Flex-price model uses $\alpha \approx 0.59$.

Interpretation: Why it Works

Why does the Flex-Price model work?

- Real Rigidity as a Substitute for Nominal Rigidity
  - High strategic complementarity ($\alpha \approx 0.59$) means exporters ”peg” to local prices even if their costs move.
  - This generates volatility in the Real Exchange Rate without needing sticky prices
- The Insulation Mechanism (Disconnect)
  - Exporters act as ”shock absorbers”
  - By absorbing exchange rate shocks into markups, they prevent volatility from spilling over into consumer prices and quantities (GDP, C)

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1. We estimate a structural demand and supply model for differentiated goods sold by large exporters, exposed to exchange-rate regime breaks
2. Results show a sharp change in markup levels and dispersion corresponding to these episodes, with large heterogeneity across markets, firms and segments
3. Structural estimates reveal that variable markups act as a shock absorber ($\alpha \approx 0.59$), generating the disconnect without nominal rigidities

Appendix

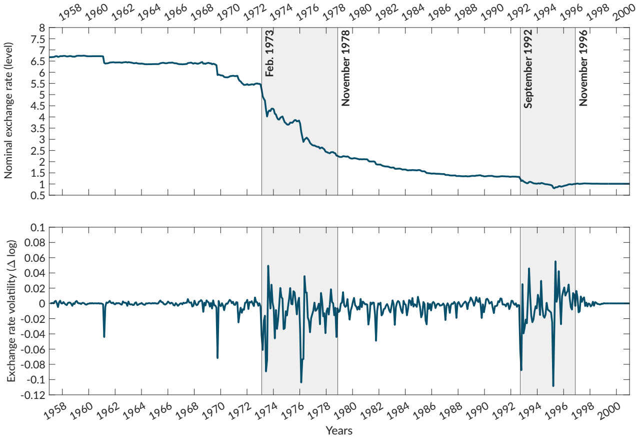

Figure 4: Depreciation