Can Sticky Quantities Explain Export Insensitivity to Exchange Rates?

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November 2023

[1] The views expressed here are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

Introduction

- Expenditure-switching in response to exchange rates is modest
- Why don't firms adjust exports when exchange rates move?
- Literature focus: sticky nominal prices, pricing-to-market

Our contribution: Shift attention from pricing to sticky quantities

1. Firm-level evidence
   - Conditional on markups, quantities unresponsive to RER, but responsive to tariffs
2. Quantitative analysis
   - Calibrate firm problem with sticky quantities & prices to match post-entry export dynamics, export price stickiness
   - Simulate responses to VAR in RER & foreign demand; tariffs
   - Rationalize different responses to RER & tariffs, can't fully explain export insensitivity to RER

Micro data

- Customs data on exports for Ireland, 1996-2009
  - Quantity (tonnes) and price (unit value)
  - Observation: firm-product-market-year
  - Focus on 30 major export markets: >94% of export value
- Macro data for export markets:
  - Annual average nominal exchange rate, CPI, aggregate demand
- Ad valorem tariffs at market-6-digit HS level from WTO
  - Variation due to phasing in of Uruguay Round tariff reductions

Estimating equation

$$w_t^{ijk} = c_t^{ij} + \gamma^{jk} + \alpha' \mathbf{h}_t^{ijk} + \beta' \mathbf{z}_t^k * low_t^{ijk} + \phi' \mathbf{z}_t^k * high_t^{ijk} + \eta_t^{ijk}$$

- i: firm, j: product, k: market
- w_t^{ijk}: log revenue, quantity or price (in home currency)
- c_t^{ij}: firm-product-year fixed effects - costs
- γ^{jk}: product-market fixed effects
- $\mathbf{h}_t^{ijk}$: export history controls
- $\mathbf{z}_t^k$: $\left\{ \ln\left(E_t^k P_t^{k*}\right), \ln\left(Q_t^{k*}\right), \ln\left(1 + \tau_t^{jk}\right) \right\}$ - aggregate shocks
- Selection: low_t^{ijk} low exit probability given export history

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- $\mathbf{z}_t^k$: $\left\{ rer_t^k, dem_t^k, tariff_t^{jk} \right\}$ - aggregate shocks
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Results

$$w_t^{ijk} = c_t^{ij} + \gamma^{jk} + \alpha' \mathbf{h}_t^{ijk} + \beta' \mathbf{z}_t^k * low_t^{ijk} + \phi' \mathbf{z}_t^k * high_t^{ijk} + \eta_t^{ijk}$$

	Revenue		Quantity		Price	
β	coeff	s.e.	coeff	s.e.	coeff	s.e.
rer_t^k	0.50	(0.08)**	0.32	(0.09)**	0.18	(0.04)**
$tariff_t^{jk}$	-3.13	(0.65)**	-3.10	(0.67)**	-0.02	(0.35)

Price elasticity of demand and estimated elasticities

- Demand for firm i in market k:

$$Q_t^{ik} = Q_t^{k*} d\left(\frac{P_t^{ik*}}{P_t^{k*}}\right)\Phi_t^{ik} = Q_t^{k*} d\left(\frac{(1+\tau_t^{ik})\mu_t^{ik} C_t^i}{E_t^k P_t^{k*}}\right)\Phi_t^{ik}$$

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- Holding Q_t^{k*}, C_t^i, Φ_t^{ik} fixed

$$\theta_t^{ik} = -\frac{\partial \ln Q_t^{ik}}{\partial \ln P_t^{ik*}} = \frac{\frac{\partial \ln Q_t^{ik}}{\partial \ln E_t^k P_t^{k*}}}{1 - \frac{\partial \ln \mu_t^{ik}}{\partial \ln E_t^k P_t^{k*}}} = \frac{-\frac{\partial \ln Q_t^{ik}}{\partial \ln \left(1+\tau_t^{ik}\right)}}{1 + \frac{\partial \ln \mu_t^{ik}}{\partial \ln \left(1+\tau_t^{ik}\right)}}$$

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- What do firm-level elasticities say about θ_t^{ik}?

$$\theta_{RER} = \frac{\beta_{rer}^Q}{1-\beta_{rer}^P} = \frac{0.32}{1-0.18} = 0.39 < 1$$

$$\theta_{tariff} = \frac{-\beta_{tariff}^Q}{1+\beta_{tariff}^P} = \frac{3.10}{1-0.02} = 3.16 > 1$$

Delta

Potential resolution

- Demand:

$$Q_t^{ik} = Q_t^{k*} d\left(\frac{\left(1+\tau_t^{ik}\right)\mu_t^{ik} C_t^i}{E_t^k P_t^{k*}}\right)\Phi_t^{ik}$$

- What if not just μ_t^{ik} but also Φ_t^{ik} depends on $E_t^k P_t^k$, τ_t^{ik}?

$$\theta_t^{ik} = \frac{\frac{\partial \ln Q_t^{ik}}{\partial \ln E_t^k P_t^{k*}} - \frac{\partial \ln \Phi_t^{ik}}{\partial \ln E_t^k P_t^{k*}}}{1 - \frac{\partial \ln \mu_t^{ik}}{\partial \ln E_t^k P_t^{k*}}} = \frac{-\frac{\partial \ln Q_t^{ik}}{\partial \ln\left(1+\tau_t^{ik}\right)} + \frac{\partial \ln \Phi_t^{ik}}{\partial \ln\left(1+\tau_t^{ik}\right)}}{1 + \frac{\partial \ln \mu_t^{ik}}{\partial \ln\left(1+\tau_t^{ik}\right)}}$$

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- Idea: Φ_t^{ik} depends on accumulable customer base
- Forward-looking, subject to adjustment costs
- What if investment cost is in foreign currency?

Quantitative model: Customer base

- Partial equilibrium model of firm decision
- Demand faced by firm i in market k at time t is:

$$Q_t^{ik} = Q_t^{k*} \underbrace{\left(\frac{1+\tau_t^{ik}}{E_t^k P_t^{k*}} P_t^{ik}\right)^{-\theta}}_{d(\cdot)} \underbrace{\left(D_t^{ik}\right)^{\alpha} \exp\left(\varepsilon_t^{ik}\right)}_{\Phi_t^{ik}}$$

- ε_t^{ik}: exogenous idiosyncratic demand
- D_t^{ik}: customer base, depends on D_{t-1}^{ik}, investment A_t^{ik}

$$D_t^{ik} = (1-\delta)\, D_{t-1}^{ik} + A_t^{ik}$$

- Expenditure on investment in customer base:

$$INV_t^{ik} = P_t^{\gamma_D} \left(E_t P_t^{k*}\right)^{1-\gamma_D} \left(A_t^{ik} + \phi \frac{\left(A_t^{ik}\right)^2}{D_t^{ik}}\right)$$

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Quantitative model: Cost and prices

- Marginal cost of production for firm i: W_t/ω^i
- Flexible prices:

$$P_t^{ik} = \frac{\theta}{\theta - 1}\frac{W_t}{\omega^i}$$

- Sticky prices: Rotemberg (1982) quadratic cost of adjustment
- Domestic currency stickiness:

$$cost = P_t^{\gamma_P}\left(E_t P_t^{k*}\right)^{1-\gamma_P}\chi\left(\frac{P_t^{ik} - P_{t-1}^{ik}}{P_{t-1}^{ik}}\right)^2$$

- Foreign currency stickiness:

$$cost = P_t^{\gamma_P}\left(E_t P_t^{k*}\right)^{1-\gamma_P}\chi\left(\frac{P_t^{ik*} - P_{t-1}^{ik*}}{P_{t-1}^{ik*}}\right)^2$$

Model parameters & simulation

- Fitzgerald, Haller & Yedid-Levi (2023) fix β, estimate α, δ, ϕ, to match match post-entry export dynamics
- Set θ consistent with a long-run trade elasticity of 3
- Fitzgerald and Haller (2014) report monthly freq of price adj for domestic- and foreign-invoiced export prices ▸ Parameters

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- Set θ consistent with a long-run trade elasticity of 3
- Fitzgerald and Haller (2014) report monthly freq of price adj for domestic- and foreign-invoiced export prices ▸ Parameters
- Use quarterly data to estimate VAR in nominal xrate, CPI, demand for Ireland & 12 major export markets
- Simulate 60-quarter time series for each market, calculate firm responses
- Aggregate to annual frequency, pool across 12 markets, estimate similar regression to micro data

$$w_t^k = \gamma^k + \beta_{rer} rer_t^k + \beta_q q_t^k + \varepsilon_t^k$$

- Repeat 50 times, calculate median $\{\beta_{rer}, \beta_q\}$

Simulated firm-level responses to RER

Baseline parameter values*

	Revenue	Quantity	Price	$\partial \ln \Phi / \partial \ln RER$	θ
	Data				
	0.50	0.32	0.18	n.a.	n.a.
Invoice currency	Investment in foreign currency				
Foreign	1.77	1.22	0.55	0.42	1.77
Domestic	2.20	2.20	0.00	0.43	1.77
Invoice currency	Investment in home currency				
Foreign	2.47	1.92	0.55	1.12	1.77
Domestic	2.90	2.90	0.00	1.13	1.77

$^*\phi = 0.73,\ \rho_f = 0.295$

Simulated firm-level responses to RER

Stickier quantities, Stickier prices*

	Revenue	Quantity	Price	$\partial \ln \Phi / \partial \ln RER$	θ
	Data				
	0.50	0.32	0.18	n.a.	n.a.
Invoice currency	Investment in foreign currency				
Foreign	1.63	0.93	0.69	0.38	1.77
Domestic	2.18	2.18	0.00	0.41	1.77
Invoice currency	Investment in home currency				
Foreign	2.28	1.59	0.69	1.04	1.77
Domestic	2.82	2.82	0.00	1.05	1.77

$^*\phi = 3,\ \rho_f = 0.1$

Simulation: tariff shocks

- Surprise announcement of deterministic tariff reduction over 14 years, tariffs expected to remain fixed forever after reduction
- Calculate firm responses to 12 tariff reduction paths drawn randomly from data on tariff paths
- Pool 12 paths, estimate similar regression to micro data

$$w_t^k = \gamma^k + \beta_\tau \tau_t^k + \varepsilon_t^k$$

- Repeat 50 times, calculate median β_τ

Baseline parameter values

Revenue	Quantity	Price	$\partial \ln \Phi / \partial \ln \mathit{tariff}$	θ
Data				
-3.13	-3.10	-0.02	n.a.	n.a.
Model				
-3.00	-3.00	0.00	-1.23	1.77

Conclusion

Empirical contribution

- Sticky prices/ PTM insufficient to account for firm-level export insensitivity to real exchange rates
- Conditional on markups, quantities are insensitive
- This is not true for tariffs

Quantitative analysis of specific sticky quantity story

- Firms compete through marketing as well as price
- Adjustment costs slow down response of investment
- Home depreciations make marketing & advertising more costly

- Generates wedge between responses to RER & tariffs
- Can't fully explain quantity stickiness wrt RER

Delta method ▸ Back

$corr\left(\frac{\partial \ln Q_t^{ik}}{\partial \ln Z_t^{ik}}, \frac{\partial \ln \mu_t^{ik}}{\partial \ln Z_t^{ik}}\right)$	-1	0	1
	$Z_t^{ik} = rer_t^k$		
$\mu\left(\theta_t^{ik}\right)$	-0.39	-0.39	-0.40
$\sigma\left(\theta_t^{ik}\right)$	0.09	0.11	0.13
Variation	$Z_t^{ik} = \tau_t^{jk}$		
$\mu\left(\theta_t^{ik}\right)$	-3.62	-3.39	-3.17
$\sigma\left(\theta_t^{ik}\right)$	1.70	1.23	0.39

Model parameters

Parameter values

β	α	δ	ϕ	θ	ρ_d	ρ_f
$1.05^{-0.25}$	0.41	0.38	0.73	$3(1-\alpha)$	0.407	0.295

- Use approach of Keen and Wang (2007) to obtain χ from frequency of price adjustment

Back