ECO862 - International Trade
Lecture 7: Short-run trade dynamics, trade policy and inventories

Standard trade models

$$M_t^q = \left(\frac{P_t^m}{P_t}\right)^{-\sigma} Q_t$$

- Standard trade frameworks model consumption/usage of traded goods (M^q)
  Not the goods crossing the border or purchases of traded goods (M)
- In the short-run, consumption/usage and purchases of traded goods can differ significantly
- Missing link: inventories

$$M_t = M_t^q + I_t - I_{t-1}$$

- Useful in understanding trade response to policy + business cycle changes

Trade during business cycles

- Aggregate trade moves more than output during business cycles

TABLE 1—TRADE DYNAMICS

	Peak-to-trough elasticity		Relative volatility
	2009:II	Median	
Imports			
GDP	5.3	4.7	3.8
IP	1.6	1.6	1.6
Demand	1.7	2.4	1.8
Exports			
GDP	5.2	3.3	3.4
IP	1.5	1.5	1.5

Inventories, trade and business cycles

- Explore role of inventories in aggregate trade fluctuations
- Measure deviation between data and standard theory
- Begin with:

$$M_t = M_t^q + I_t - I_{t-1}$$
$$\frac{M_t - \overline{M}}{\overline{M}} = \frac{M_t^q - \overline{M}^q}{\overline{M}^q} + \frac{\overline{I}}{\overline{M}^q}\frac{I_t - I_{t-1}}{\overline{I}}$$

- Plug import demand equation

$$m_t^{theory} = -\sigma p_t + q_t + \frac{\overline{I}}{\overline{M}^q}(i_t - i_{t-1})$$

lowercase denote percent dev from SS

Trade Wedges

- Define wedge as the difference between theory-implied and actual variable
- Wedge w/ inventory adjustment

$$m_t^{theory} = -\sigma p_t + q_t + \frac{\overline{I}}{\overline{M}^q}(i_t - i_{t-1})$$
$$\omega_t^T = m_t^{data} - m_t^{theory}$$

- Wedge w/o inventories (standard trade models)

$$m_t^q = -\sigma p_t + q_t$$
$$\omega_t^q = m_t^{data} - m_t^q$$

Trade wedge during business cycles

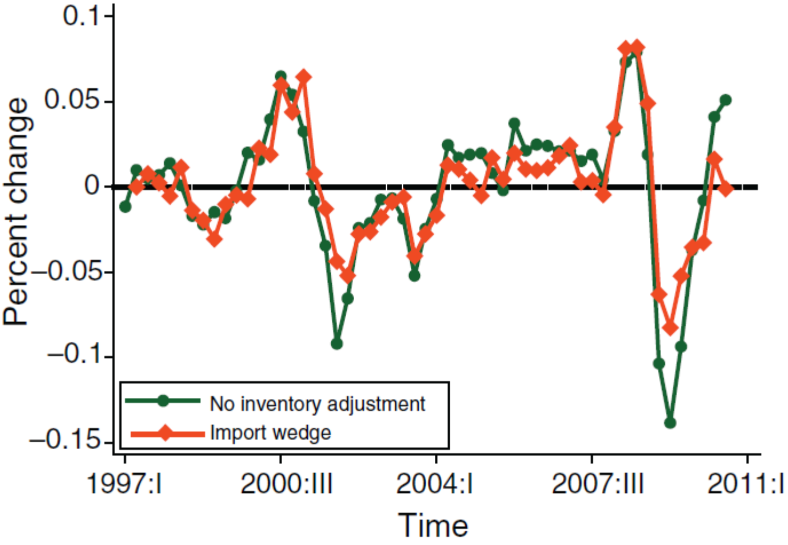


FIGURE 3. WEDGES

Inventories and trade

- Even aggregate inventories explain sizeable BC deviations from standard theory
- Aim: study models of SR dynamics to capture the role of inventories
- Consider firm-level inventory facts next

Next two lectures

Consider the role of inventories in international trade during:

1. Large devaluations
   Alessandria, Kaboski and Midrigan - “Inventories, Lumpy Trade, and Large Devaluations” (AER 2010)
2. Trade liberalization episodes
   Khan and Khederlarian - “How Does Trade Responds to Anticipated Tariff Changes?” (JIE 2021)
3. Trade policy uncertainty
   Alessandria, Khan and Khederlarian - “Taking Stock of Trade Policy Uncertainty: Evidence from Chian’s WTO Accession” (JIE 2024)

\+ A primer on solving inventory models

Inventories, Lumpy Trade, and Large Devaluations

George Alessandria, Joseph Kaboski, and Virgiliu Midrigan

American Economic Review, 2010

Inventory behavior

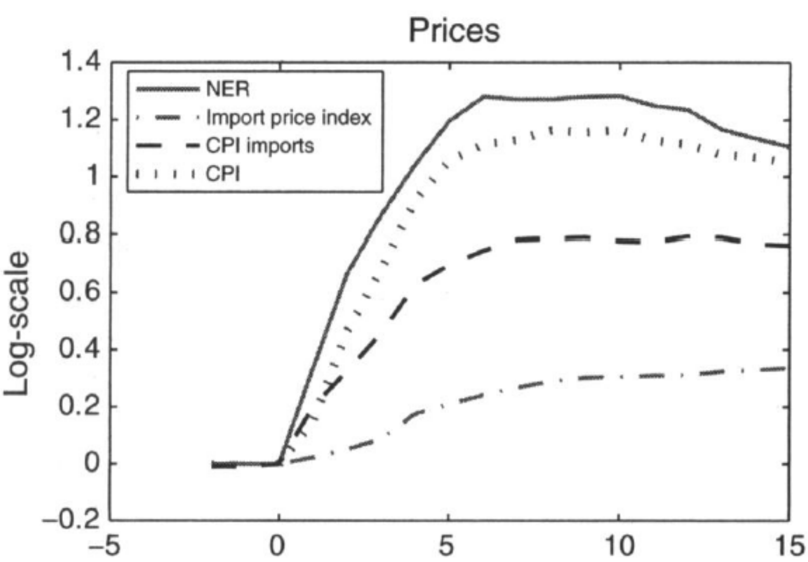
- Firms hold 2-5 months of sales in inventories
  - Higher for developing countries (why?)
- Inventories higher for trading firms
- Trade in large infrequent shipments i.e. lumpy trade
- Helps rationalize gap between small observed trade costs and large inferred trade costs (Anderson and Van Wincoop 2003)

Key trade dynamics in devaluations

Devaluation: large increase in relative price of imports at dock
Understand key Δs in imports and prices after large devaluations

1. Slow increase in import prices at retail level

Argentina 2002



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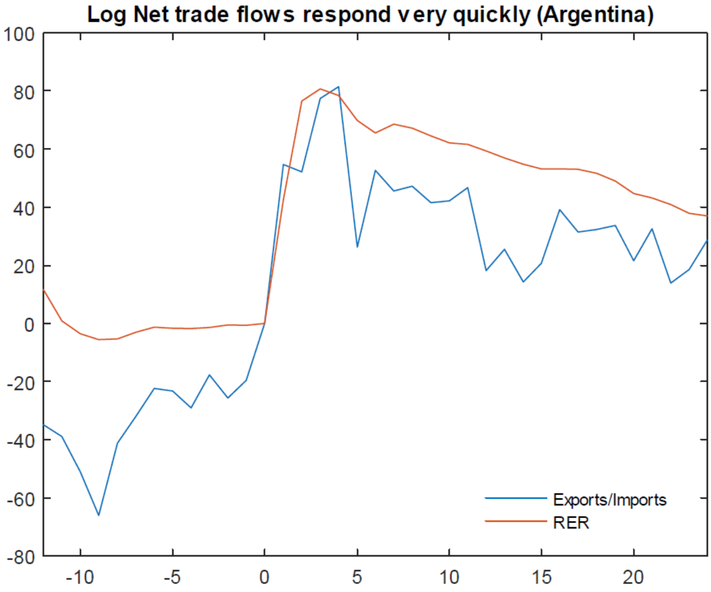

Key trade dynamics in devaluations

Devaluation: large increase in relative price of imports at dock
Understand key Δs in imports and prices after large devaluations

1. Slow increase in import prices at retail level
2. Large NX reversals accounted for by drop in imports (no J curve)
3. Large drop in extensive margin of trade: # of varieties imported

Argentina 2002

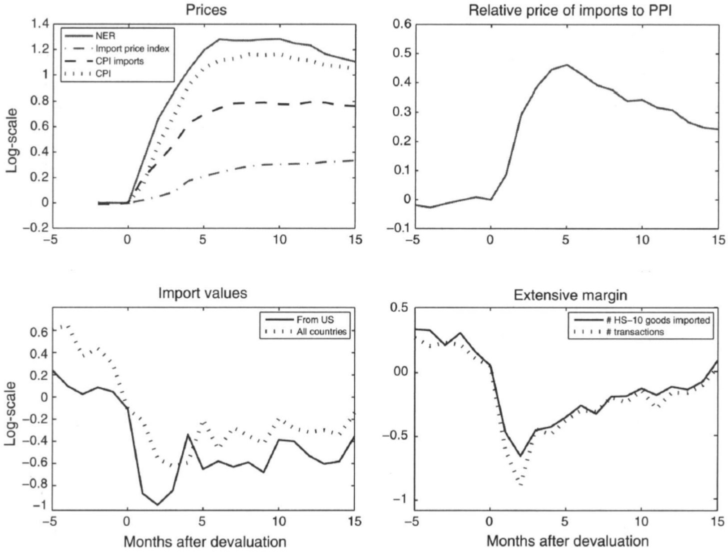

FIGURE 1. DEVALUATION IN ARGENTINA, 2002

Form of trade friction matters

1. Iceberg trade cost
2. Fixed order costs
3. Sunk export costs
4. Lags between order and delivery

Particular form matters at micro and macro levels

Key trade dynamics in devaluations

Devaluation: large increase in relative price of imports at dock
Understand key Δs in imports and prices after large devaluations

1. Slow increase in import prices at retail level
2. Large NX reversals accounted for by drop in imports (no J curve)
3. Large drop in extensive margin of trade: # of varieties imported

Common to: Argentina, Brazil, Mexico, Korea, Thailand, Russia

Story here

Large devaluations cause excess inventories $\implies$

1. Stop importing
2. Lower ratio of retail price to replacement cost

Fact 1: Trade friction: fixed transaction costs

Lags between order and delivery: 6-8 weeks

- Shipping lags (Hummels 1999)
  - 2-6 weeks by vessel, 1 day by air
  - most trade with developing countries by vessel: 70%
- Customs/paperwork (World Bank surveys)
  - Adds 2-5 weeks

[Check World Bank logistical surveys]

Fact 1: Trade friction: fixed transaction costs

	Argentina	Russia	Mexico
Documents preparation	\$750	\$437	\$206
Customs clearance & technical control	\$150	\$500	\$224
Port & terminal handling	\$600	...	\$165
U.S. export costs	\$625	\$625	\$625
Fraction of mean shipment	0.04	0.02	0.01
Fraction of median shipment	0.17	0.07	0.11

Fact 2: Inventory problems bigger for traders

- Consider cross-country analysis using firm-level data (Nadais 2017)

Table 1.1: Summary Statistics

	Chile	**Colombia**	**India**	**Peru**
Time Period	1995 - 2007	1981 - 1991	1990 - 2014	2003 - 2010
Number of Firms/year	5,336	6,856	3,041	1,429
$\frac{\text{inv}}{\text{purch}}$	0.24	0.34	0.26	0.42
$\frac{\text{importers}}{\text{Number of Firms}}$	0.21	0.19	0.65	0.46
$\frac{\text{imports}}{\text{purchases}}$ if importer	0.36	0.38	0.21	0.44

Fact 2: Inventory problems bigger for traders

Table 1.2: Relation between inventories, firm's size and trade

Dependent Variable: $\ln(s_{ijt})$				
	Chile	**Colombia**	**India**	**Peru**
$\ln(z_{ijt})$	0.91	0.87	0.80	0.80
	(0.00)	(0.00)	(0.00)	(0.01)
d_{ijt}	0.52	0.57	0.32	0.57
	(0.02)	(0.02)	(0.01)	(0.04)
MM_{ijt}	0.43	0.27	0.81	0.46
	(0.04)	(0.04)	(0.02)	(0.06)
β_0	-1.80	-1.38	0.53	0.73
	(0.04)	(0.04)	(0.03)	(0.14)
Year FE	✓	✓	✓	✓
Industry FE	✓	✓	✓	
R^2	0.67	0.71	0.80	0.59
N	59,774	61,308	76,033	8,423

All values are statistically significant at 1% significance level.

Standard errors are reported in brackets.

Nadais (2017)

Fact 2: Inventory problems bigger for traders

- Strong correlation between size and inventories (elasticity 0.8-0.91)
- Importers hold more inventories
- 100% imports $\Longrightarrow$ 2.6x (Chile) to 3x (India) more inventories than non-importers
- Similar results for US (but levels higher for EMEs)
- Unanswered question: how do inventory costs influence measures of plant-level TFP? (attempt: Khan and Khederlarian 2024)

Fact 3: International transactions are lumpy

- Goods are traded in infrequent large shipments
- Handy tool: Herfindahl-Hirschman index (HHI)

$$HHI = \sum_{m=1}^{12} s_m^2$$

where s_m is the share of annual trade in month m

$HHI \in [1/12, 1]$

$1/HHI$ is effective number of trading months i.e. HHI = 0.5 $\implies$ 2 months of trade

Fact 3: International transactions are lumpy

- U.S. export data, monthly, 1990-2005
- Good: HS10 x port of exit

	Argentina	**Russia**	**Mexico**
Frac of months exporters	0.47	0.43	0.90
HHI	0.40	0.45	0.21
Frac of annual trade in top mon	0.50	0.53	0.27
Frac of annual trade in top 3 mons	0.83	0.85	0.53

- Data likely to understate lumpiness (aggregation bias)

Fact 3: International transactions are lumpy

Pervasive across goods:

	Food	Int	Cap	Auto/ Parts	Cons
mos. export (%)	0.33	0.45	0.36	0.68	0.45
HH index	0.53	0.40	0.52	0.35	0.41
Top mo.	0.59	0.49	0.61	0.42	0.51
Top 3 mos.	0.89	0.83	0.90	0.74	0.84
Share US Exports	0.02	0.42	0.13	0.06	0.07

Similar facts in:

- French transactions level export data: Bekes et al (2014)
- Swiss customs data: Kropf and Saure (2013)
- Spanish data (freely available): Hornok and Koren (2015)

Most standard inventory model

- Let us begin by studying the canonical inventory model
  $\rightarrow$ Economic Order Quantity (EOQ) model
- Simplest version of ordering behavior $\Rightarrow$ closed form of input cost.
- Firm faces constant demand Q
- On top of unit cost (ω), additional sourcing costs:
  1. Fixed ordering costs, f.
  2. Inventory holding costs, δ.
- Trade-off size of order (Z) and level of inventories (S).
- Later: Validate our approach in extended version.

EOQ details

- Firms minimize total costs given by (abstract from variable purchase cost)

$$TC(Q) = \min_{Z} \quad \underbrace{f \frac{Q}{Z}}_{\text{order cost}} + \underbrace{\delta \frac{Z}{2}}_{\text{holding cost}}$$

- Take FOC to arrive at

$$Z^* = \sqrt{\frac{2\ f\ Q}{\delta}} \qquad\qquad \frac{Q}{Z^*} = \sqrt{\frac{\delta\ Q}{2\ f}}$$

Intuition:

- $f \uparrow \implies$ place large infrequent orders (opposite if $\delta \uparrow$)
- additional volume evenly divided among size and frequency of order
- Clear results from a simple framework

Revisit firm level evidence

- Coefficient on inventories (i.e. order size) > 0.5
- Volume loads more on size than frequency
- Need more reasons for holding inventories than just the fixed cost of ordering

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Model

- Extend EOQ with more frictions
- Partial equilibrium model of monopolistic importer
- Goods depreciate at rate δ
- Fixed cost f to import if $z > 0$, MC $= \omega$
- 1 period delivery lag
- Consumer demand: $q(p) = e^{\nu} p^{-\sigma}$
  where ν is the taste shock

Importer's problem

- State variables: s stock, ν taste shock
- Firms sell $q = min\{e^{\nu} p^{-\sigma}, s\}$
- Static gross profit

$$\pi = \begin{cases} pq & z = 0 \\ pq - \omega z - f & z > 0 \end{cases}$$

- Law of motion for states
  - $s' = (1 - \delta)(s - q + z)$
  - $\nu \sim_{iid} N(0, \sigma_{\nu}^2)$

Model discrete choice

- Importer Decides between Importing or not importing

$$V(s,\nu) = \max[V^a(s,\nu), V^n(s,\nu)]$$

$$\text{If order: } V^a(s,\nu) = \max_{p,z>0} q(p,s,\nu)p - \omega z - f + \beta EV(s',\nu')$$

$$\text{No order: } V^n(s,\nu) = \max_{p>0} q(p,s,\nu)p + \beta EV(s',\nu')$$

subject to

$$q(p,s,\nu) = min(e^{\nu}p^{-\sigma}, s)$$

$$s' = \begin{cases} (1-\delta)[s - q(p,s,\nu) + z] & \text{if import} \\ (1-\delta)[s - q(p,s,\nu)] & \text{o/w} \end{cases}$$

FOCs

- Plug in next period stock: $EV(s', \nu') = EV((1-\delta)(s+z-q), \nu')$
- FOC w.r.t. z:

$$\omega = \frac{\beta \partial EV(s', \nu')}{\partial z} = \beta(1-\delta)\frac{\partial EV(s', \nu')}{\partial s'}$$

- Euler equation:

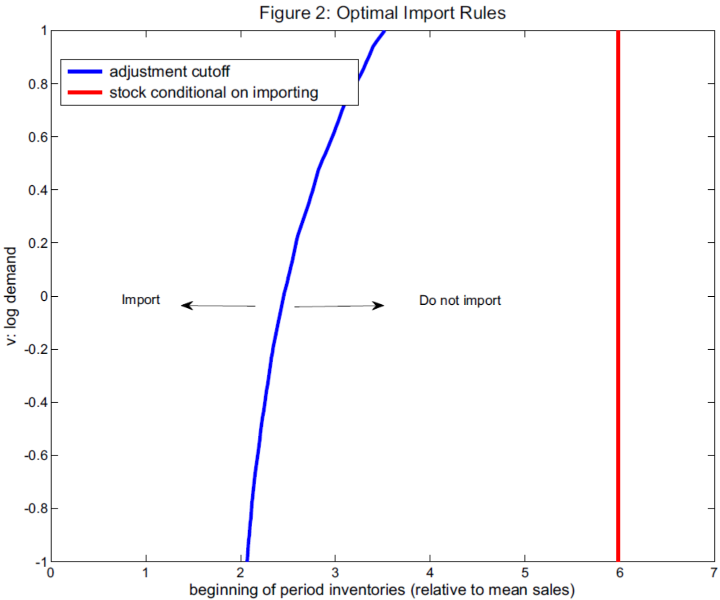
$$\frac{\partial EV(s, \nu)}{\partial s} = \beta(1-\delta)\frac{\partial EV(s', \nu')}{\partial s'}$$

- FOC w.r.t. price:

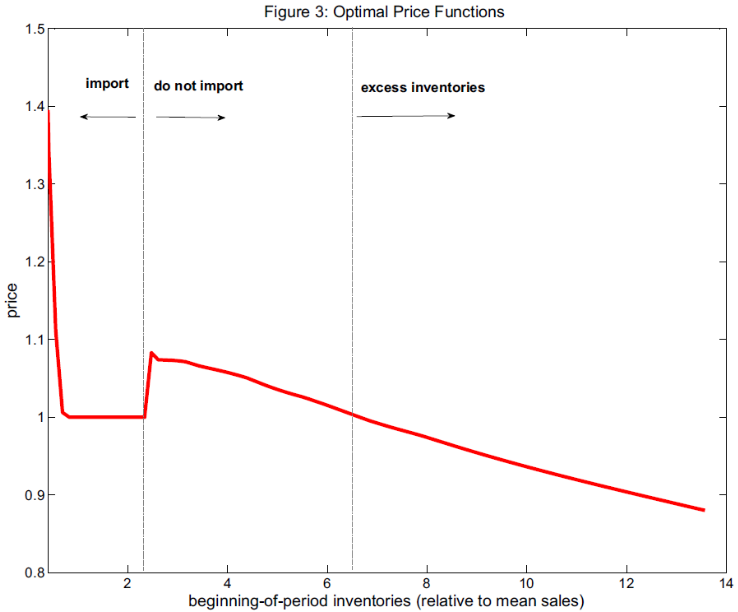
$$p = \frac{\sigma}{\sigma-1}\beta(1-\delta)\frac{\partial EV(s', \nu')}{\partial s'}$$

  constant markup over inventory replacement value
- When order: $p = \frac{\sigma}{\sigma-1}\omega$

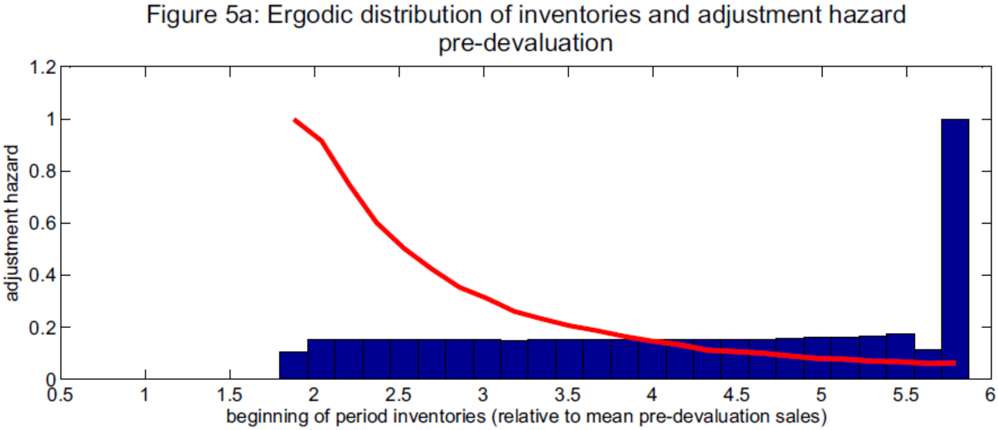
Optimal Policy - (s,S) Ordering



Optimal Policy - Prices



Inventory distribution in steady state



Main Question

- Can model account for trade pattern after devaluations?
- Aggregate importer decision rules
  - according to ergodic SS distribution of (s, ν)

Calibration - assigned

Period		1 month	length of delivery delay
Demand elasticity	σ	1.5	armington elasticity
Discount factor	β	$0.94^{1/12}$	6% annual interest rate
Depreciation	δ	0.025	Richardson (1995)

Calibration - targets

Choose (f, σ_ν) to match trade lumpiness and Chilean inventories

Targets		
Lumpiness of trade (HHI)		0.44
Inventory/annual purchases		0.36
Parameters		
Fixed cost (share of med rev)	f	0.095
Std dev of demand	σ_ν	1.15

Additional implications

	Data	Model
Fraction of months good imported	0.47	0.21
Fraction of annual trade by top month	0.53	0.48
Fraction of annual trade by top 3 months	0.85	0.98
Fraction of annual trade by top 5 months	0.95	1.00
Fixed cost per avg. shipment (%)	3-11	3.6
Tariff equivalent	-	20

Decoding tariff equivalent

Estimate using:

$$V^f(\tau) = max_{p_t} E_0 \sum_{t=0}^{\infty} (p_t - (1+\tau)\omega) e^{\nu_t} p_t^{-\sigma}$$

$$V^f(\tau) = EV(0, \nu)$$

- Tariff equivalent of 20pp (5.5x estimated fixed cost)
- Inventories 36% of annual purchase ($\approx$ 4 months of purchase)
- Tariff equivalent $\approx$ depreciation + interest + delay + fixed cost
  - depreciation + interest: 36% annual, 13% of purchase cost
  - delay (additional month of holding costs): 3% of average order
  - fixed cost: 3.6% of average order

How does model economy respond in devaluations?

- Devaluation:
  1. **1.** permanent increase in wholesale import price: $\omega : 1 \rightarrow 1.5$
  2. **2.** increase in interest rates β : 6% $\rightarrow$ 30%
  3. **3.** reduction in demand $\nu : N(0, \sigma_\nu^2) \rightarrow N(-0.15, \sigma_\nu^2)$
- Assume local content of 25% so that marginal cost of supplying imported goods does not increase 1-for-1 with the import price : $y = m^{1-\alpha} l^{\alpha}$, $\alpha = 0.25$
- Compare decision rules in pre and post-crisis state and then work out transition (more on solution method in next class)

Figure 5a: Ergodic distribution of inventories and adjustment hazard
pre-devaluation

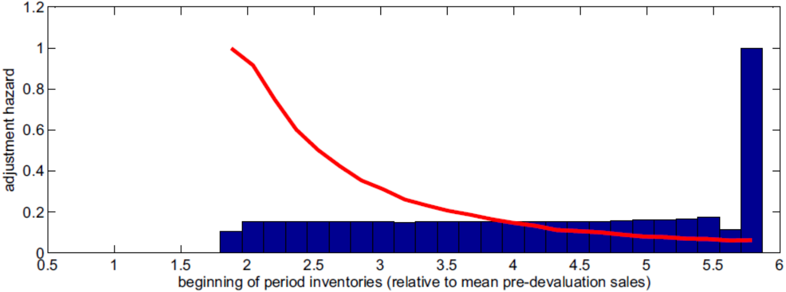


Figure 5b: post-devaluation

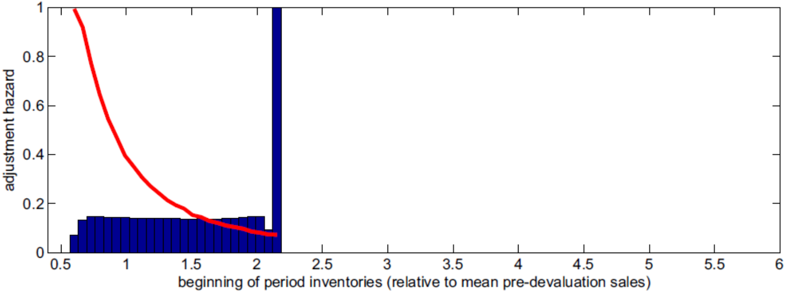
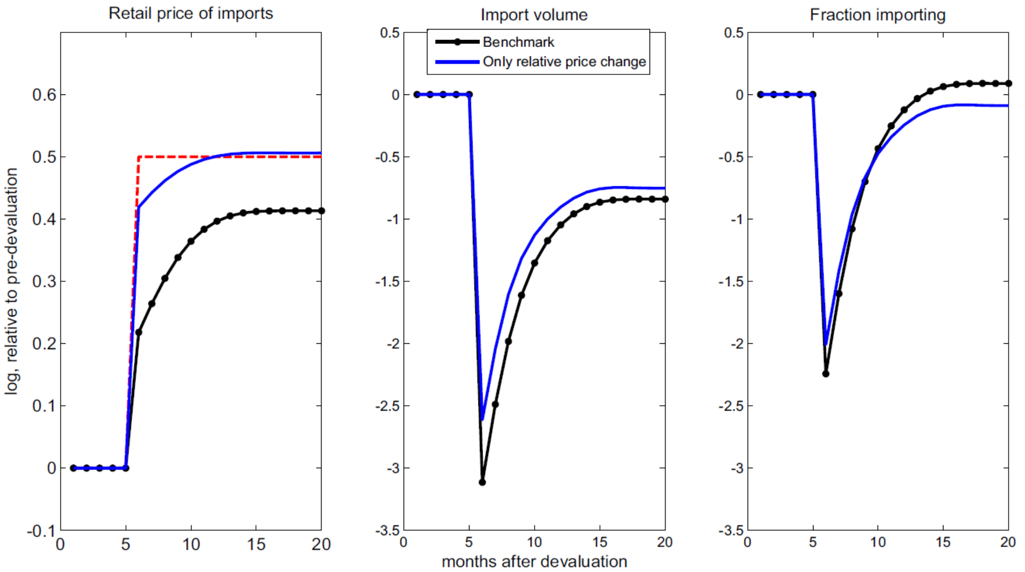
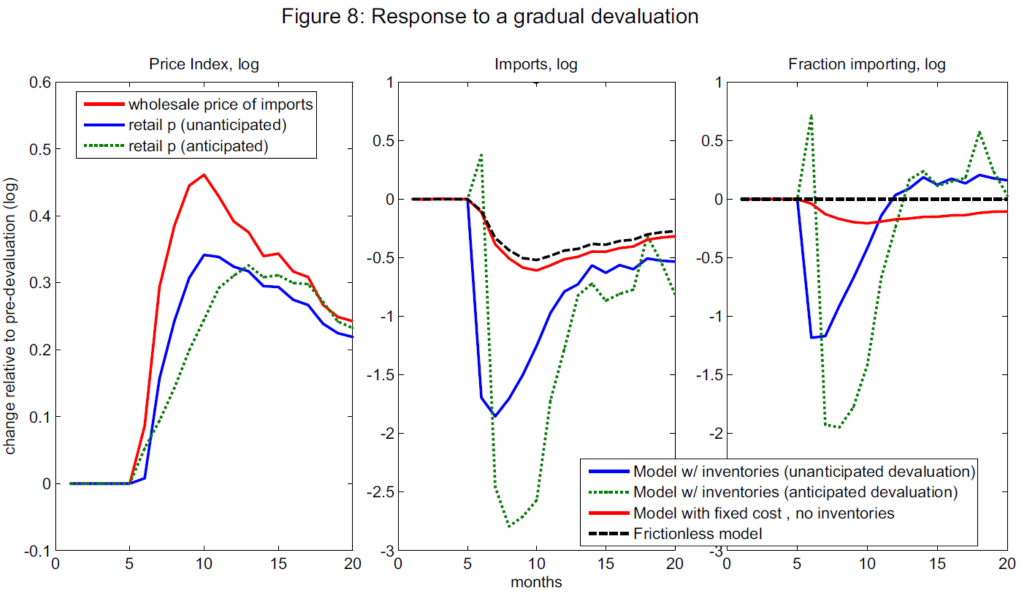


Figure 6: Response of model economy to devaluation



Gradual devaluation



Sensitivity

TABLE 5—MOMENTS AND PARAMETERS

	Data	Benchmark	Domestic	No fixed cost	No lag	High depreciation
Panel A. Moments						
Used for calibration						
Herfindhal-Hirschmann ratio	0.44	0.44	0.23	0.14	0.32	0.33
Inventory to annual purchases ratio	0.36	0.36	0.21	0.29	0.12	0.25
Additional implications						
Tariff equivalent of frictions	—	0.20	0.09	0.13	0.08	0.32
f (relative to mean shipment)		0.036	0.017	0	0.050	0.047
Panel B. Parameters						
Calibrated						
f (fixed cost, rel. median revenue)		0.095	0.025	0	0.095	0.095
Standard deviation of demand, σ		1.15	1.15	1.15	1.15	1.15
Assigned						
Period length		1 month	½ month	1 month	1 month	1 month
Shipping lag		1 month	½ month	1 month	0 months	1 month
Elasticity of demand for imports, θ		1.5	1.5	1.5	1.5	1.5
Elasticity of subs. across imported goods		—	—	—	—	—
Monthly discount factor, β		0.995	0.995	0.995	0.995	0.995
Monthly depreciation rate, δ		0.025	0.025	0.025	0.025	0.05
Parameters characterizing devaluation	Change in wholesale import price: $\Delta\log\omega = 0.50$ Interest rate change: $\beta = 0.70$ (annually) Change in consumption: $\Delta\log C = -0.15$ Local labor share: 25 percent					

Testing the inventory mechanism

After devaluation

- Large drop in quantities, particularly for firms with relatively large inventory
- High pass-through for low inventory & low carrying cost goods

Research idea: would be useful to test these more rigorously around COVID and shipping crisis

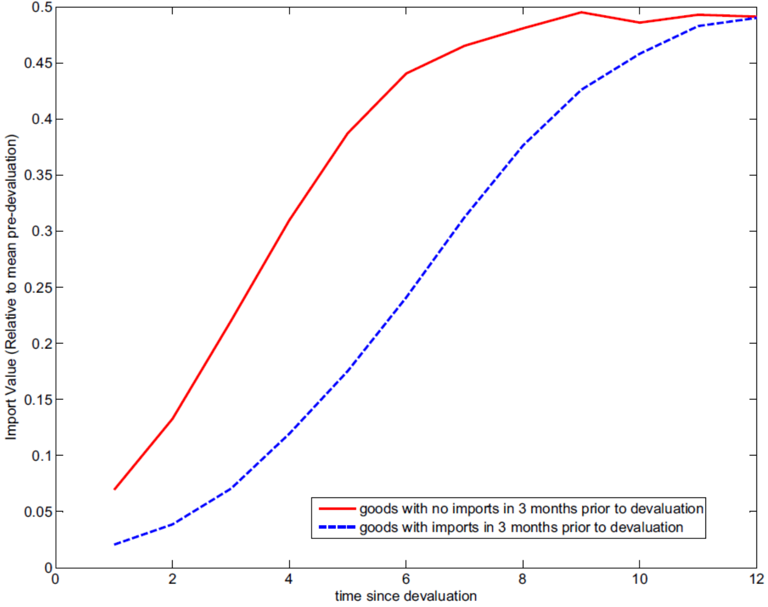
Testing the inventory mechanism: quantities

Large drop in quantities, particularly for firms with large inventory

Divide firms in 2 groups:

1. Recent importers (within last 3 months)
2. Distant importers (not in last 3 months)

Figure 9: Imports vs. Date of Last pre-devaluation Import



Testing the inventory mechanism: quantities

Using data on US exports, regress

$$M_{ijt} = c_{it} + \rho M_{ij,t-1} + \alpha REC_{ijt} + \beta(I_t \times REC_{ijt}) + i_{ijt}$$

- M_{ijt}: imports of HS10 good i from port j in period t
- REC_{ijt}: indicator denoting a shipment in 3 months prior to beginning of year
- I_t: indicator for crisis year
- c_{it}: good-year fixed effect

Table 7: Effect of Recent Shipments on Value Traded in the Crisis Years

	Country					
Regressors	**Argentina**	**Brazil**	**Korea**	**Mexico**	**Russia**	**Thailand**
Recent Shipment	2.46 (20.7)	0.79 (9.3)	2.55 (16.9)	2.14 (21.4)	5.66 (15.1)	1.91 (11.5)
Recent Shipment before Crisis	**-1.51** **(-6.1)**	**-0.91** **(-5.3)**	**-2.34** **(-8.2)**	**-0.60** **(-3.0)**	**-6.17** **(-8.9)**	**-0.67** **(-2.1)**
Lagged Imports	0.535 (196.6)	0.969 (511.5)	0.718 (293.5)	0.730 (365)	0.393 (100.1)	0.763 (327.1)
R-squared	0.41	0.55	0.51	0.42	0.28	0.75

Notes: T-stats in parentheses. The dependent variable is value imported$_{ijt}$, where i=commodity, j=exit port, t=year relative to devaluation. Here we annualize the data for value of trade and positive shipments (constructing years around the crisis date rather than calendar years). Using five years of data, we regress value traded on the amount of trade in the last three months of the year (i.e., preceding the crisis) interacted with the year. We control for commodity-year fixed effects, and therefore use variation in port to identify the effect. We also control for the value traded in the previous year (to control for differential levels and trends among ports). The omitted year is the year before the crisis; the interaction effect in year three is the impact in the 12 months following the devaluation.

Testing the inventory mechanism: prices

High passthrough for low inventory & low carrying cost goods

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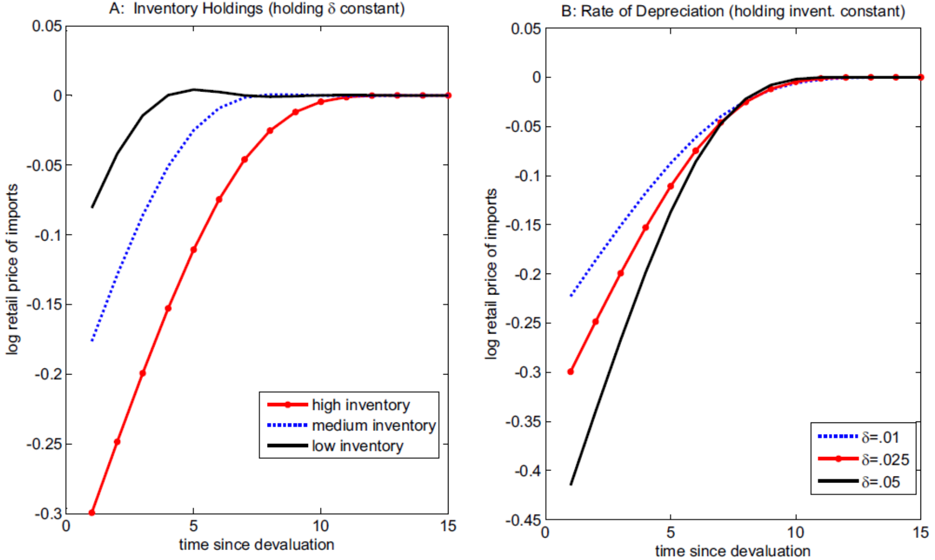
Figure 10: Effect of Depreciation and Inventory Holdings on Pass-through.
Benchmark Setup.



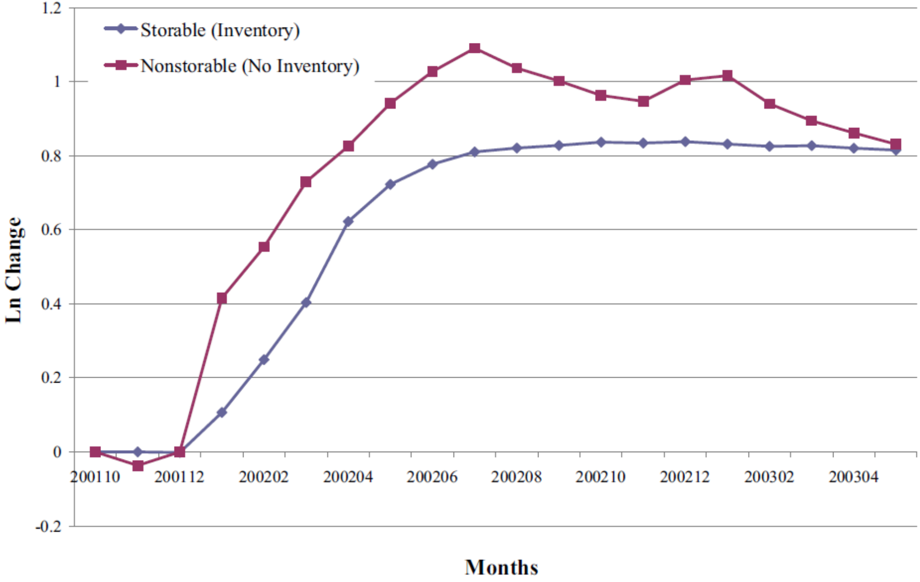
Price dynamics in data

Use micro prices from Argentine CPI

Split 64 imported goods into

1. With inventories
   - 52 goods: air conditioners, automobiles,...
2. Without
   - 12 goods: pineapples, bananas, cruises, airline tickets,...

Figure 11: Argentine Price Dynamics by Inventory: Storable and Nonstorable Goods



Price dynamics in data: low inventory cost goods

Use micro prices from Argentine CPI for 538 storable goods

$$\frac{\Delta p_{it}}{\Delta p_{i,15}} = c_{jt} + \alpha_0 \ln DEP_i + \alpha_1 \ln INV_i + \alpha_2 \ln HHI_i + u_{it}$$

- c_{jt}: indicator for goods "tradedness" classification
- DEP_i: depreciation rate for good (proxy for inventory costs) $\in [0.2, 25]$
  - based on useful life (i.e. men's winter cost: 48 months: 2%)
- INV_i: inventory sales ratio of NAICS retail sector goods i
- HHI_i: lumpiness of 4-digit HS good in previous 5 years

Table 8: Short-run Pass-through
On Depreciation, Lumpiness, and Inventories

	Months after crisis		
	3 months	**6 months**	**9 months**
Depreciation	-0.047	-0.031	-0.011
	(-3.6)	(-1.8)	(-0.8)
Lumpiness (*HH*)	-0.146	-0.068	-0.001
	(-4.2)	(-1.5)	(-0.0)
Inventory	-0.091	-0.005	0.013
	(-3.0)	(-0.1)	(-0.4)
Constant	-0.014	0.714	0.962
	(0.2)	(-6.4)	(-10.5)
# obs.	538	538	538
R^2	0.247	0.14	0.009

Notes: T-stats in parentheses. All regressions include dummies for tradability (imported, with some import share, exportable etc.), coefficients are not reported. All variables are in logs. The dependent variable is the change in log price over t (=3, 6, or 9) months from the devaluation over the long-run (15-month) price change.

Conclusions

- Key transaction costs i) lags and ii) economies of scale, particularly important for trade
- Develop model w/ lumpy trade
  - inventories economize on international trade costs
  - rationalizes low measures of trade costs yet low trade flows
- Trade cost/inventories matter for aggregate dynamics
  - Dynamics very different from iceberg & sunk cost models
  - Sudden quantity response and slow price response in devaluations
  - Consistent with trade/price dynamics after devaluations

How Does Trade Respond to Anticipated Tariff Changes?

Evidence from NAFTA

Shafaat Yar Khan and Armen Khederlarian

Journal of International Economics 2021

Motivation

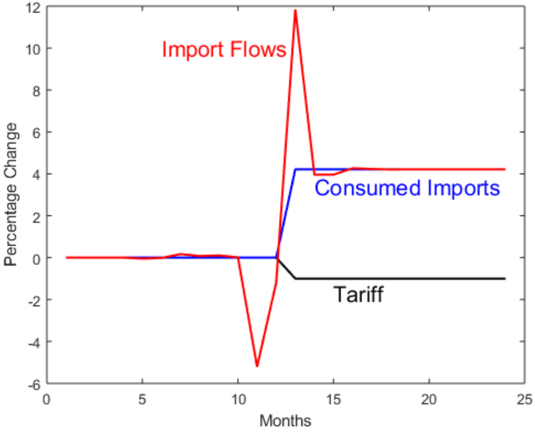
- Elasticity of substitution (**EoS**) key parameter for policy and welfare analysis.
- Standard approach identifies using Free Trade Agreements (FTA)
- FTAs **phase-out** tariffs
- Incentivize **delaying** purchases

$\Longrightarrow$ **Overestimation** of consumption response to tariff changes

Displaying the Bias in Elasticity

- Elasticity of Substitution dictates consumption response
- Standard assumption: import flows = consumption

  Anticipation $\implies$ trade elasticity $>$ elasticity of substitution



What This Paper Does

Application: NAFTA - 96% of the tariff changes known 1+ year in advance.

1. Is there evidence of anticipatory behavior?

   Result 1: Significant anticipatory decline and subsequent spike

2. Does anticipatory behavior bias the Elasticity of Substitution (EoS)?

   Build a model of short-run anticipation to tariff reductions

   Result 2: Anticipatory effects $\implies$ trade response $>$ consumption response

What This Paper Does

3 Can we estimate EoS in presence of anticipation?

Result 3: Estimate EoS using consumption of imports

Problem: Lack of data on product-source level import consumption

4 Use detailed trade data to construct measure of consumption

5 Our consumption measure estimates EoS in model simulations

5a whether the shock is anticipated or not

5b whether the good is storable or not

Biases in EoS Estimates

Compare response with import flows to consumption

Result 4a: Short-run elasticity 68% $\searrow$

Result 4b: Long-run elasticity $\sim$ no effect

4a & 4b $\Longrightarrow$ Gradual response 75% $\nearrow$

Result 5: Average elasticity (static-models) 16% $\searrow$

Biases are driven by the storable goods that experienced **phaseouts**

How Elasticity of Substitution Matters

Elasticity of substitution between domestic and foreign goods is important for:

- Quantification of response to policy changes
- Measures of welfare gains

  Direclty maps changes in trade openness into consumption gains

$$\text{Static Models: } \Delta C = -\frac{1}{\sigma}\Delta\lambda$$

$$\text{Dynamic Models: } \Delta C \approx -\frac{\sigma^{LR}}{\sigma^{SR}}\Delta\lambda$$

Today: Removing biases in EoS estimate

Literature

1. **Elasticity Estimation**

   Gallaway, McDaniel and Rivera (2003), Romalis (2007), Head & Ries (2001), Simonovska & Waugh (2011), Hilberry & Hummels (2012), Caliendo & Parro (2014), Broda & Weinstein (2006), Feenestra et al. (2014), Yilmazkuday (2019)

   Contribution:

   1. Document overestimation in standard approach
   2. Eliminate bias using consumption of imports

2. **Anticipation to Policy Changes**

   Agarwal, Marwell & McGranahan (2017), Coglianese et al. (2017), Baker, Keung & Johnson (2018), Alessandria, Khan & Khederlarian (2019)

   New: Evidence of anticipation of FTA's phaseouts

3. **Inventories & Trade**

   Alessandria, Kaboski & Midrigan (2010, 2011), Kropf & Saure (2013), Bekes et al. (2017), Blum et al. (2017), Charnavoki (2017)

   New: Inventories dynamics account for anticipated changes.

Double Difference Approach

- Demand equation in value:

$$v_{zijt} = p_{zjt}(1+\tau_{zijt})^{-\sigma}\left(\frac{p_{zjt}}{P^M_{zit}}\right)^{-\sigma}\left(\frac{P^M_{zit}}{P_{it}}\right)^{-\theta}\alpha_{zit}C_{it}$$

- 1st difference: reference exporter j' - importer i FEs.
- 2nd difference: reference importer i' - exporter j FEs.

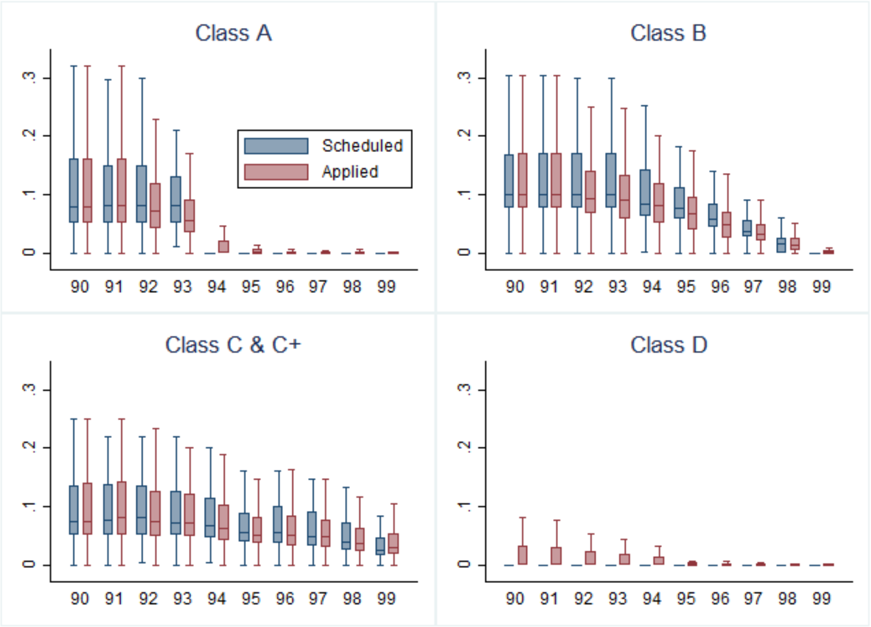
$$\underbrace{\ln\left(\frac{v_{zijt}}{v_{zij't}}\Big/\frac{v_{zi'jt}}{v_{zi'j't}}\right)}_{y^{DD}_{z,t}} = -\sigma\underbrace{\ln\left(\frac{1+\tau_{zijt}}{1+\tau_{zij't}}\right)}_{\tau^{DD}_{z,t}} + \delta_z + \delta_t + u_{zt} \quad (1)$$

Data

- HS6-month imports from Mexico to US, 1990 - 1999.
- Reference importer: 12 European countries
- Reference exporter: Aggregate of 137 countries.
- $\tau_{z,t}^{DD} \equiv \tau_{z,US,MEX,t} - \tau_{z,US,RoW,t}$, applied duties.
- Classify goods into phaseout categories:
  - Phaseouts: 5, 10, 15 years
  - Others: Immediate reduction and zero pre-NAFTA

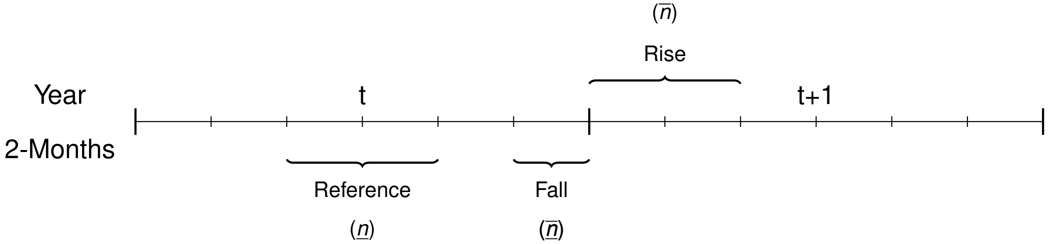
Phaseout Classification

Stages	Number of Goods	1993 Number of Cuts	Class Share	Mexico Share
0	3,012	0	66%	11%
1	241	241	17%	11%
5	462	2,310	12%	16%
10	323	3,230	4%	6%
15	21	315	1%	10%
Total	4,727	6096	100%	11%



Class A
Scheduled
Applied
.3
.2
.1
0
90
91
92
93
94
95
96
97
98
99
Class B
Class C & C+
Class D

Time Horizons



Estimation Equation

- Recall:

$$y_{z,t}^{DD} = -\sigma\, \tau_{z,t}^{DD} + \delta_z + \delta_t + u_{zt}$$

- Estimate anticipatory effects

$$\text{Decline:} \qquad \Delta_{\overline{n}-\underline{n}} y_{z,t}^{DD} = \sigma^D \Delta \tau_{z,t+1}^{DD} + \delta_z + u_{z,t}$$

$$\text{Rise:} \qquad \Delta_{\overline{n}-\underline{n}} y_{z,t}^{DD} = \sigma^R \Delta \tau_{z,t}^{DD} + \delta_z + \delta_t + u_{z,t}$$

- Seasonality concerns:
  1. Product- or country- specific controlled by double difference
  2. Further pair-specific controlled by product FE

Anticipation: Decline and Spike

Dep. Var.: $\Delta_{\underline{n}:\overline{n}} m^{DD}_{zt}$	Slump	Bump
$\overline{n}$ (months)	11:12	1:4
$\underline{n}$ (months)	4:8	11:12
$\mathbf{1}\{\text{Phased}\}\Delta\tau^{DD}_z$	6.1***	-11.7**
	(2.10)	(4.67)
$\mathbf{1}\{\text{Other}\}\Delta\tau^{DD}_z$	-1.6	-2.7
	(2.76)	(2.77)
HS6 FE	✓	✓
N	6023	7014
Adj R2	0.075	0.266

Storability

- Proxy storability through lumpiness in trade
- Measured using HH concentration index of monthly imports.

$$HH_g = \sum_{m=1}^{12} \left(\frac{v(g,m)}{\sum_m^{12} v(g,m)} \right)^2$$

- Consider disaggregate g, then take median to obtain HH_z

Anticipation & Storability

Dep. Var.: $\Delta_{\underline{n}:\overline{n}} m_{zt}^{DD}$	Slump	Bump	Slump	Bump
$\overline{n}$ (months)	11:12	11:12	1:4	1:4
$\underline{n}$ (months)	4:8	4:8	11:12	11:12
$\mathbf{1}\{Phased\}\Delta\tau_z^{DD}$	6.1**	-11.7***		
	(2.10)	(4.67)		
$\mathbf{1}\{HH_z > med(HH_z)\}\mathbf{1}\{Phased\}\Delta\tau_z^{DD}$			7.07**	-17.0**
			(2.75)	(7.46)
$\mathbf{1}\{Others\}\Delta\tau_z^{DD}$	-1.6	-2.7	-0.8	-2.5
	(2.76)	(2.77)	(1.94)	(2.89)
HS6 FE	✓	✓	✓	✓
N	6023	7014	6285	7014
Adj R2	0.075	0.266	0.075	0.103

Extensive Margin Effect

- $\mathbf{1}\{V_{us,mex,z,n>0}\}$: Logit with storability interaction
- Result: $\Delta\tau = -1pp \implies 8\% \downarrow Pr(\mathbf{1}\{V_{us,mex,z,n} > 0\} = 1)$
- Similar result with triple difference extensive margin index

Takeaway

- Significant evidence of
  1. Anticipatory decline (intensive and extensive margin)

  2. Sharp rebound of imports afterwards

- Driven by storable goods that experienced phaseouts

Motivation

- Questions:
  1. Anticipatory effects bias measured EoS (σ)?
  2. If yes, then how to estimate σ?
- Use model to:
  1. Reproduce observed dynamics.
  2. Simulate the model to answer these questions.

Model

- Standard (s,S) inventory model
- Monopolistically competitive retail foreign good.
- Fixed cost of ordering, demand uncertainty and delivery lag.

$\Longrightarrow$ This leads to a (s,S) ordering policy

- Demand faced by firms

$$q_{j,t} = e^{\nu_{j,t}} p_{j,t}^{-\sigma}$$

Model

- Importer Decides between Importing or not importing

$$V(s,\nu) = \max[V^a(s,\nu), V^n(s,\nu)]$$

$$\begin{aligned}
\text{If order: } V^a(s,\nu) &= \max_{p,m>0} q(p,s,\nu)p - \omega m - f + \beta EV(s',\nu') \\
\text{No order: } V^n(s,\nu) &= \max_{p>0} q(p,s,\nu)p + \beta EV(s',\nu')
\end{aligned}$$

subject to

$$q(p,s,\nu) = min(e^{\nu} p^{-\sigma}, s)$$

$$s' = \begin{cases} (1-\delta)[s - q(p,s,\nu) + m] & \text{if import} \\ (1-\delta)[s - q(p,s,\nu)] & \text{o/w} \end{cases}$$

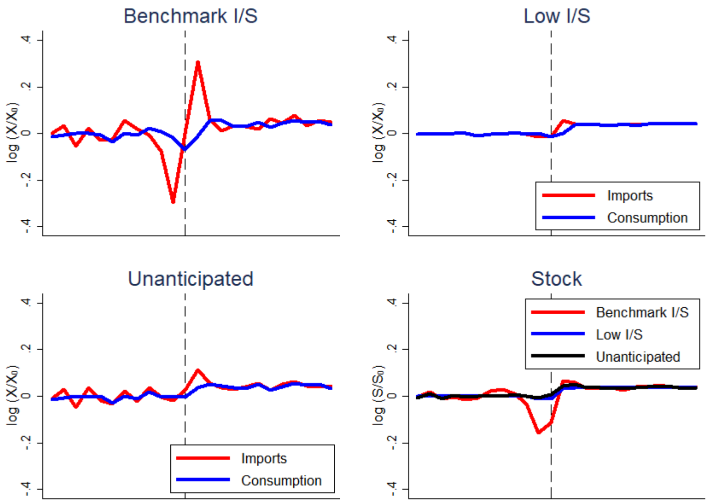
Simulation Exercise

- Set $\sigma = 4$
- Recover EoS from 3 types of simulations:
  1. Anticipated change to high storable good (benchmark)
  2. Anticipated change to less storable good
  3. Unanticipated change to high storable good

Parameters and Moments of the Simulation

Assigned	**Parameters**	High I/S	Low I/S
σ	Elasticity of Substitution	4	4
β	Monthly Interest Rate	$0.96^{(1/12)}$	$0.96^{(1/12)}$
σ_ν	Variance of Taste Shocks	0.6^2	0.6^2
Matched	**Parameters**		
δ	Monthly Depreciation Rate	2.50%	10%
f	Fixed Cost Ordering	0.05	0.005
Moments			
I/S Ratio	Storability (monthly)	2.54	1.35
HH Index	Lumpiness	0.21	0.09
	Fixed Cost over Mean Revenues	3.60%	0.37%

Simulation Results



Elasticities in Simulations

Dep. Var.:	Import Flows m_t	Consumed Imports q_t
$1\{\text{Benchmark}\} \times \omega_t$	-6.08	-4.34
$1\{\text{Low I/S}\} \times \omega_t$	-4.14	-3.97
$1\{\text{Unanticipated}\} \times \omega_t$	-4.20	-4.04
N	60000	60000

Lessons from Simulation

- Simulate anticipated tariff reduction high I/S ratio and low I/S ratio goods
- Finding: Elasticity biased in case of more storable good
- Fix: use consumption of imports instead of import flows

Using Insights from the Model

- Product-source specific consumption of imports is unavailable
  - For e.g. sales of ‘plastic tableware’ produced in Mexico

- Construct consumption measure by assuming
  1. Initial inventories
  2. Inventory-Sales Ratio

- Validate our measure in the simulations

- Apply the measure to the data

Measuring Consumption of Imports

- Measure using:

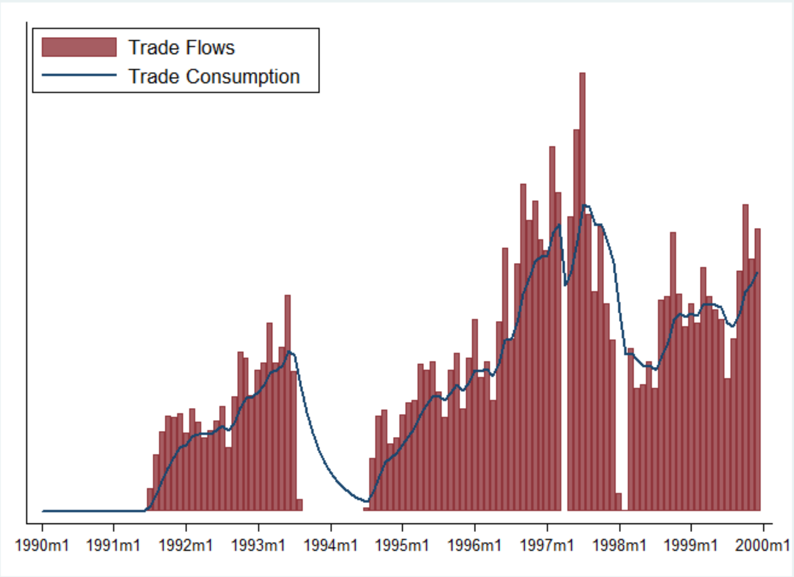
$$\tilde{s}_{i,j,z,n} = \tilde{s}_{i,j,z,n-1} + \underbrace{m_{i,j,z,n}}_{\text{observed}} - \tilde{q}_{i,j,z,n}$$

- Assume $\tilde{q}_{i,j,z,n}$ is constant fraction $1/k$ of inventory holdings:

$$\tilde{q}_{i,j,z,n} = \frac{(\tilde{s}_{i,j,z,n-1} + m_{i,j,z,n})}{\tilde{k}_{j,z}}$$

- $\tilde{k}_{j,z}$ is proportional to inventory sales ratio ($\propto$ lumpiness)
- Use concentration of monthly imports to calculate $\tilde{k}_{i,j,z} = HH_{US,j,z} * 12$

Example of the Measure



Consumption Measure in Simulations

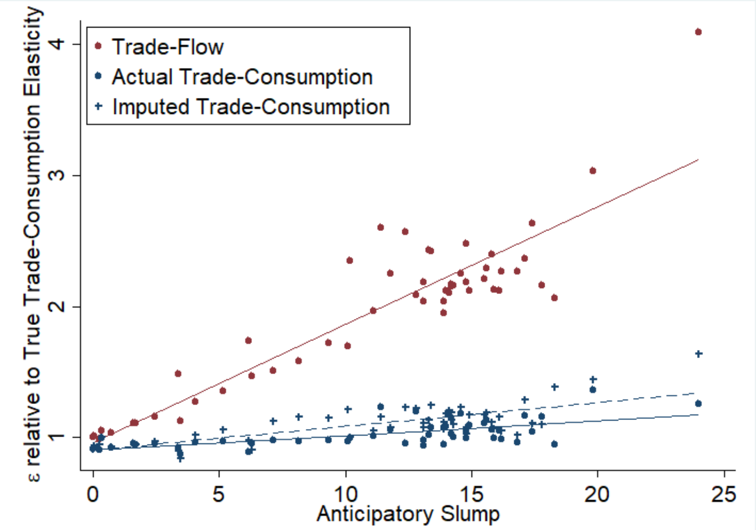
- Check how measure performs relative to actual consumption

Dep. Var. :	Imports m_t	Actual q_t	Imputed $\tilde{q}_t$
$1\{\text{Benchmark}\} \times \omega_t$	-6.08	-4.34	-4.39
$1\{\text{Low I/S}\} \times \omega_t$	-4.14	-3.97	-3.97
$1\{\text{Unanticipated}\} \times \omega_t$	-4.20	-4.04	-3.91
N	60000	60000	60000

Robustness to calibration

- Shown: Bias correction does not contaminate unaffected goods
- Investigate robustness of bias correction:
  1. Degree of anticipatory effects
  2. Calibrations to get I/S ratio
- Simulate a sparse grid of fixed cost, depreciation, demand uncertainty and interest rate

Bias Correction with different I/S



I/S ratios

Static Elasticity Estimation

- Recall:

$$y_{z,t}^{DD} = -\sigma\ \tau_{z,t}^{DD} + \delta_z + \delta_t + u_{zt}$$

- Use:
  1. $y_{zt}^{DD} = m_{zt}^{DD}$ for trade elasticity,
  2. $y_{zt}^{DD} = \tilde{q}_{zt}^{DD}$ for elasticity of substitution.

Static Elasticity

	(1)	(2)	(3)	(4)	
Dep. Var. :	$m^{DD}_{z,t}$	$\tilde{q}^{DD}_{z,t}$	$m^{DD}_{z,t}$	$\tilde{q}^{DD}_{z,t}$	Bias
$\tau^{DD}_{z,t}$	-8.9***	-7.7***			16%
	(1.89)	(1.97)			
$1\{Phased\} \times \tau^{DD}_{z,t}$			-13.2***	-10.9***	21%
			(1.43)	(1.64)	
$1\{Others\} \times \tau^{DD}_{z,t}$			-6.6***	-6.0**	10%
			(2.21)	(2.51)	
N	15135	15135	15135	15135	
adj. R^2	0.607	0.684	0.608	0.685	

Note: Standard errors, in parentheses, are clustered at HS-6 level,

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Static Elasticity - Goods type

US Imports Mexico Dep. Var. :	(1) $m_{z,t}^{DD}$	(2) $\tilde{q}_{z,t}^{DD}$	Bias
$1\{$ Non-Consumer Goods $\} \times \tau_{US,z,t}^{Mex,RoW}$	-10.4***	-8.2***	28%
	(1.60)	(1.59)	
$1\{$ Consumer Goods $\} \times \tau_{US,z,t}^{Mex,RoW}$	-7.9***	-7.4***	6%
	(1.41)	(1.36)	
Year FE	✓	✓	
HS6 FE	✓	✓	
N	15800	15800	

Note: Standard errors, in parentheses, are clustered at HS-6 level,

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Robustness of Consumption Measure

1. Allow time to market

$$\tilde{q}_{i,j,z,n} = \frac{\tilde{s}_{i,j,z,n-1}}{\tilde{k}_{i,j,z}}$$

2. Use common I/S across exporters k_z

3. Add demand shock

$$\hat{q}_{icz,n} = \underbrace{\frac{\tilde{s}_{icz,n} + m_{icz,n}}{k_{icz}}}_{\text{expected}} + \underbrace{\frac{m_{icz,n+1}}{k_{icz}} - \mathbb{E}_n(m_{icz,n+1})}_{\text{shock}}$$

$$\tilde{q}_{icz,n} = \min\left[\hat{q}_{icz,n}\ ,\ \tilde{s}_{icz,n-1} + m_{icz,n}\right]$$

Results

Measure's Example

Removing Sample Selection

- Double diff w/ import flows requires all 4 directions of trade flows
- Observe large number of zero trade flows (average 63% products)
- Our consumption measure overcomes this

Without Sample Restrictions

	(1)	(2)	(3)	(4)	(5)
	$m_{z,t}^{DD}$	$\tilde{q}_{z,t}^{DD}$	$\tilde{q}_{z,t}^{DD}$	$\tilde{q}_{z,t}^{DD}$	$\tilde{q}_{z,t}^{DD}$
$\tau_{z,t}^{DD}$	-8.9***	-7.7***	-5.7***	-5.7***	-5.7***
	(1.10)	(1.05)	(1.27)	(1.24)	(1.27)
Sample restriction	All	All	US-Mex	US-Mex US-RoW	US-Mex EU-RoW
N	15135	15135	21423	21309	21421
adj. R^2	0.607	0.684	0.625	0.625	0.625

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dynamic Elasticities

1. Error-Correction Mechanism (ECM) model

$$\Delta y_{zt}^{DD} = \sigma^{S}\,\Delta\tau_{z,t}^{DD} + \sigma^{L}\,\tau_{z,t-1}^{DD} + \alpha\, y_{z,t-1}^{DD} + \delta_t + \delta_z + u_{zt}$$

Where

1. σ^{S} : Short-run elasticity

2. $-\sigma^{L}/\alpha$: Long-run elasticity

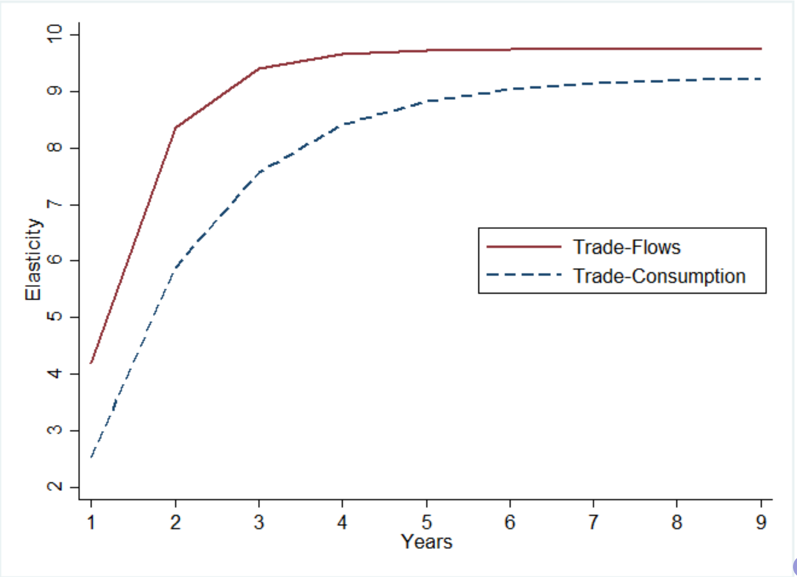
2. h-horizon changes

$$\Delta_h y_{zt}^{DD} = \sigma^{h}\,\Delta_h\tau_{z,t}^{DD} + u_{zt}$$

Dynamic Elasticities - ECM

	All Goods			Phased Goods		
Dep. Var. :	$m_{z,t}^{DD}$	$\tilde{q}_{z,t}^{DD}$	Bias	$m_{z,t}^{DD}$	$\tilde{q}_{z,t}^{DD}$	Bias
Short-run (σ^S)	-4.2***	-2.5***	68%	-7.1***	-2.9**	145%
	(1.25)	(0.89)		(1.98)	(1.37)	
Long-run (σ^L)	-9.7***	-9.2***	5%	-14.0***	-12.0***	17%
	(1.52)	(1.62)		(2.18)	(2.28)	
Year FE	✓	✓		✓	✓	
HS6 FE	✓	✓		✓	✓	
N	11290	11290		11290	11290	
adj. R^2	0.345	0.314		0.345	0.314	

Dynamic Elasticity - Aggregate



Phased Goods

Dynamic Elasticity - H horizon differences

Table 4
Trade-flow vs. trade-consumption elasticities over time.

Dep. var.	1-year		3-year		5-year		7-year	
	$\Delta_1 m^{DD}_{z,t}$	$\Delta_1 \tilde{q}^{DD}_{z,t}$	$\Delta_3 m^{DD}_{z,t}$	$\Delta_3 \tilde{q}^{DD}_{z,t}$	$\Delta_5 m^{DD}_{z,t}$	$\Delta_5 \tilde{q}^{DD}_{z,t}$	$\Delta_7 m^{DD}_{z,t}$	$\Delta_7 \tilde{q}^{DD}_{z,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: All goods								
$\Delta_h \tau^{DD}_{z,t}$	-4.2^{***}	-2.7^{***}	-7.5^{***}	-6.7^{***}	-9.2^{***}	-8.0^{***}	-9.8^{***}	-9.1^{***}
	(1.2)	(0.8)	(1.2)	(1.1)	(1.3)	(1.3)	(1.5)	(1.5)
Difference		56%		12%		15%		8%
Panel B: Phaseout categories								
$1\{\text{Phased}\} \times \Delta_h \tau^{DD}_{z,t}$	-7.4^{***}	-2.9^{**}	-10.4^{***}	-9.2^{***}	-12.2^{***}	-10.0^{***}	-12.6^{***}	-10.5^{***}
	(2.1)	(1.3)	(1.8)	(1.6)	(1.8)	(1.7)	(2.2)	(2.1)
Difference		154%		13%		22%		20%
$1\{\text{Others}\} \times \Delta_h \tau^{DD}_{z,t}$	-3.2^{**}	-2.6^{***}	-6.3^{***}	-5.7^{***}	-7.7^{***}	-7.0^{***}	-8.2^{***}	-8.2^{***}
	(1.3)	(0.9)	(1.4)	(1.3)	(1.7)	(1.7)	(1.9)	(2.0)
Difference		19%		11%		10%		0%
N	11,693	11,693	8402	8402	5550	5550	3155	3155
Adjusted R^2	0.002	0.001	0.009	0.010	0.018	0.017	0.026	0.025

Note: All estimates are obtained using (4). Odd columns use trade flows as dependent variable (m); and even columns use imputed consumed imports as dependent variable ($\tilde{q}$). The subscript h in the dependent variable, $\Delta_h \tau^{DD}_{zt}$, is 1 in columns 1 and 2 (1-year change), 3 in column 3 and 4 (3-year change) and so on. Estimates in Panel B separate between the effect of $\Delta_h \tau^{DD}_{zt}$ for good's whose tariffs were phased-out (class B,C,C+) and the rest. The difference is calculated as the difference between the estimate using m and $\tilde{q}$ over the estimate with $\tilde{q}$. Standard errors, in parentheses, are clustered at HS-6 level.

Sketch of a Dynamic Model

- Model with persistent habits to generate gradual consumption reponse

$$y_{j,t} = e^{\nu_{j,t}} \, p_{j,t}^{-\sigma} \, h_{j,t-1}^{\theta}$$

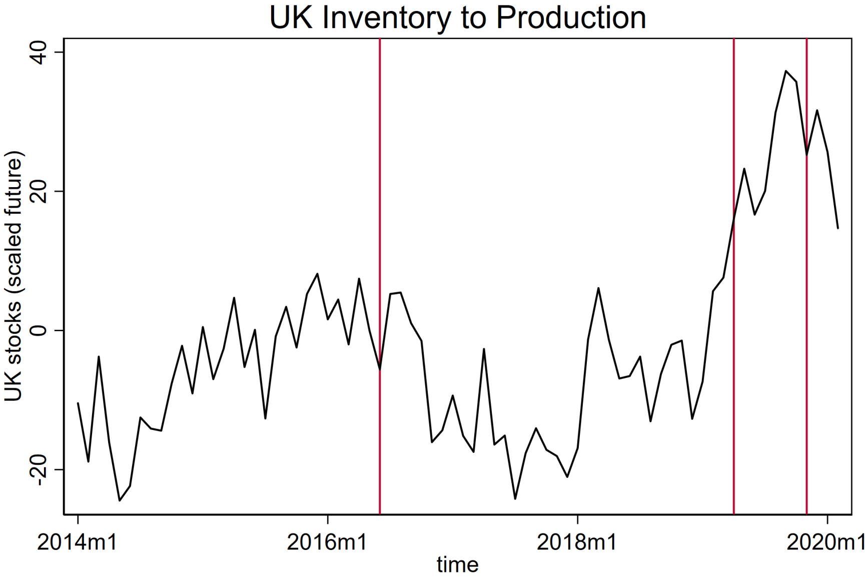
$$h_{j,t} = \rho h_{j,t-1} \; + \; (1-\rho) q_{j,t}$$

Where $q_{j,t} = \min(y_{j,t}, s_{j,t})$

Summary

- Evidence of anticipation during NAFTA's phaseouts.
- Anticipation matters for elasticity of substitution.
- Propose theoretically-founded and easily implementable consumption measure.

Anticipation at Work



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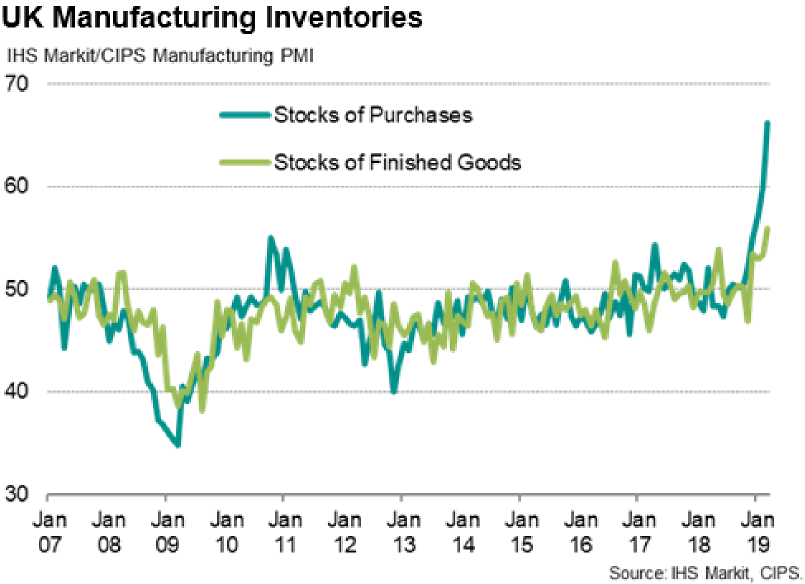
Anticipation at Work



More literature on this

1. Pattern of micro trade - frequency vs size of shipment
   Hornok and Koren 2011, Kropf and Suare 2013
2. Idiosyncratic uncertainty and trade
   Evans and harrigan (2007), Hummers and Schaur (2011), Clark, Kozlova and Schaur (2015)
3. Aggregate uncertainty and trade
   Novy and Taylor (2014), Bekes et al (2014)
4. GE effects of inventories: Do inventories magnify shocks? (old but unanswered question)
   Ramey and West (1999), Bils and Kahn (2000), Khan and Thomas (2007), Wang, Wen and Xu (2014) More recently: Ferrari (2023), Chengyuan He (2023)