The Mutable Geography of Firms' International Trade: Evidence and Macroeconomic Implications

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Introduction

- International trade is dominated by firms selling to multiple destinations
  - → e.g., multi-destination exporters account for 75% transactions and 95% trade values of China's exports.
- Conventional wisdom: the set of destination markets is stable over time
  - → i.e., once a firm starts exporting a market, it keeps selling there
- Set of destinations changes frequently for a multi-destination exporter:

Trade Pattern of a Chinese Exporter (ID 3107930188)
Selling T-shirts (HS 61091000)

2003	Australia	South Korea	Japan		
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2005	Australia		Japan	Germany	
2006	Australia			Germany	Belgium Canada

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Questions

- Are these market changes quantitatively important?
- What drives these market changes?
- How do market changes affect international transmission of shocks?

This Paper

1. Documents **new facts** on firm (and firm-product) level market changes based on two customs databases (China 2000-2006 and UK 2010-2016). These market changes:
   - (i) involve large values relative to a firm's total export value
   - (ii) are endogenous to changes in local market conditions
   - (iii) involve distinct pricing in continuing v.s. changed markets

2. Investigates the **sources** of these market changes by building a multi-country general equilibrium model:
   - → competition among firms from multiple countries
   - → productivity, preference, and trade cost shocks

3. Quantifies the **importance** of these market changes by studying a bilateral trade war scenario.
   - → I find big impacts on welfare of the third country

New Micro Evidence

Firm (and Firm-product) Level Market Changes

1. Involve large values and substantial switching
   - $\rightarrow$ $\frac{\text{Value of Add \& Drop from } t-1 \text{ to } t}{\text{Total Exports at } t} \approx$ 1-3 (median)
   - $\rightarrow$ 30-40% market changes involve simultaneously adding **and** dropping markets
2. Endogenous to local market conditions
   - $\rightarrow$ more likely to continue selling to markets whose currencies appreciate
   - $\rightarrow$ exchange rates and local CPIs explain 20% of variation
3. Conditional on a market change, firms dropping more markets
   - $\rightarrow$ raise average price (across all markets) and suffer large drops in total quantity exported
   - $\rightarrow$ have little price change in continuing markets but suffer large drops in quantities sold in these markets

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A Multi-Country Model

Featuring Variable Markups and Variable Markets

- Elements of the model and their effects on market changes
  - $(-)$ Oligopolistic competition among firms (Atkeson and Burstein 2008)
  - $(-)$ Local cost component (Corsetti and Dedola 2005)
  - $(+)$ Competition among firms from different countries (multilateral competition)

- Multilateral competition makes firms' residual demand more volatile
  - $\rightarrow$ The entry cost for foreign firms is higher than that for domestic firms
  - $\rightarrow$ Foreign firms' market share is larger than domestics'
  - $\rightarrow$ Shocks that induce entry/exit by foreign firms have a big effect on others' residual demand

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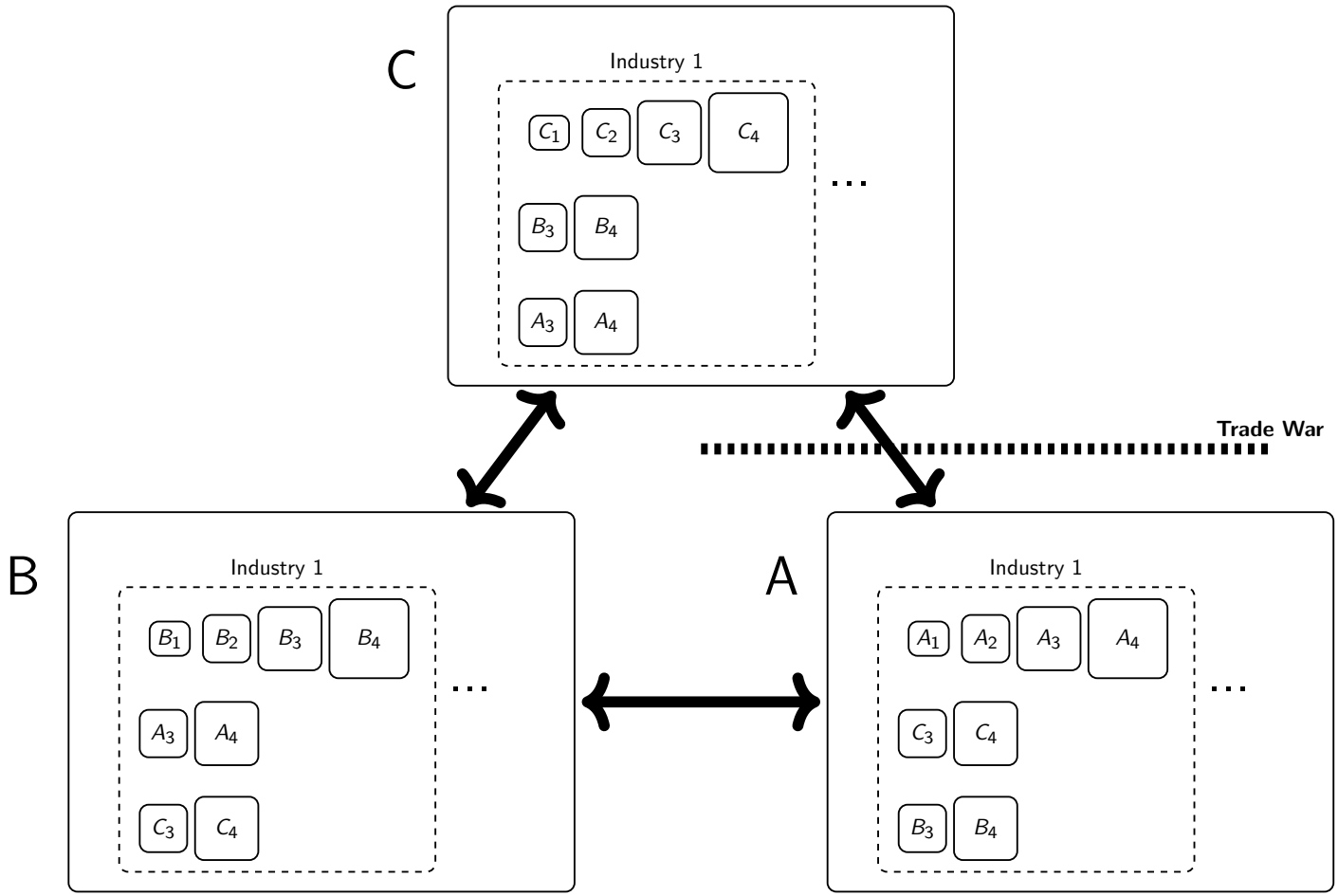
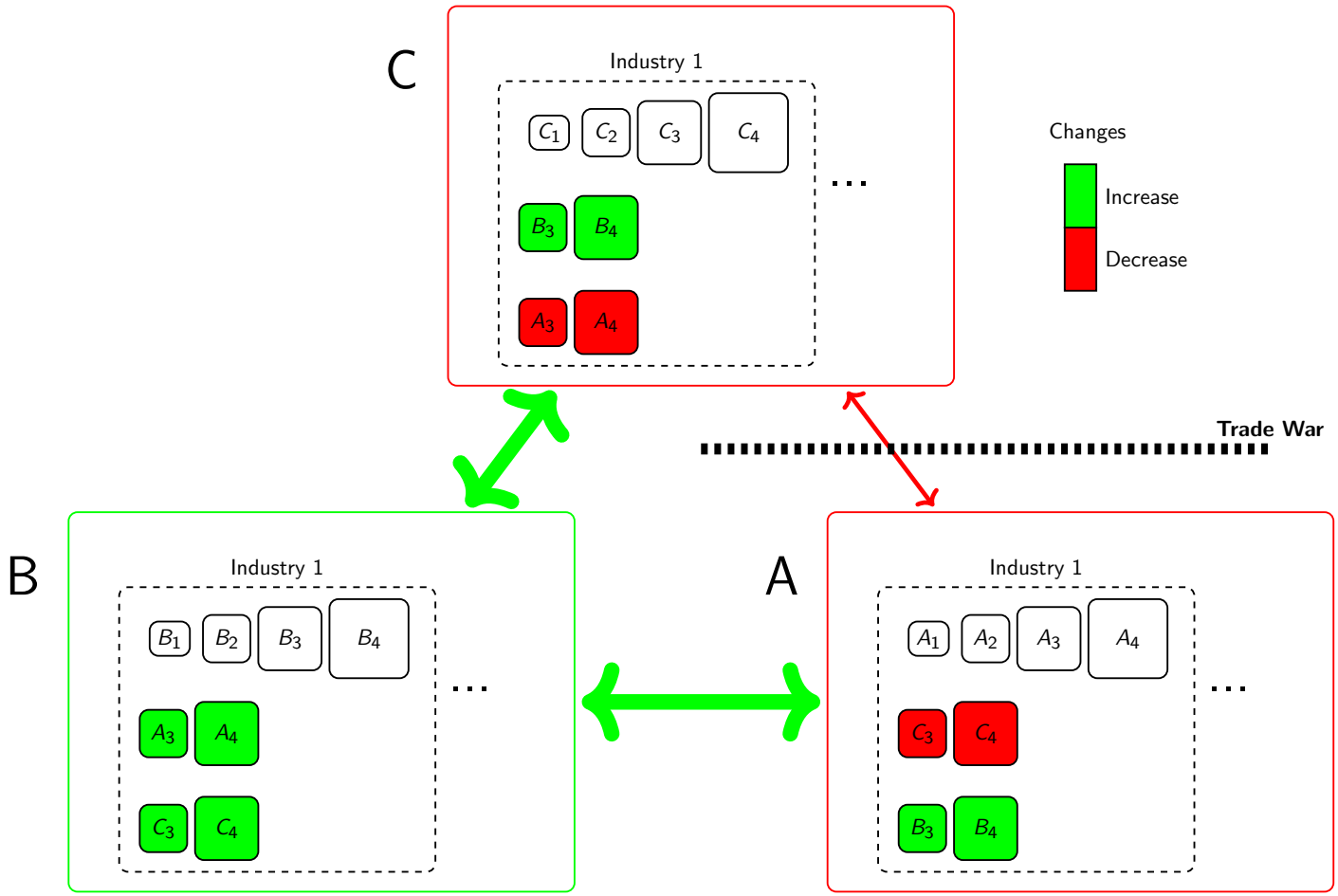
Application: Bilateral Trade War (C-A)



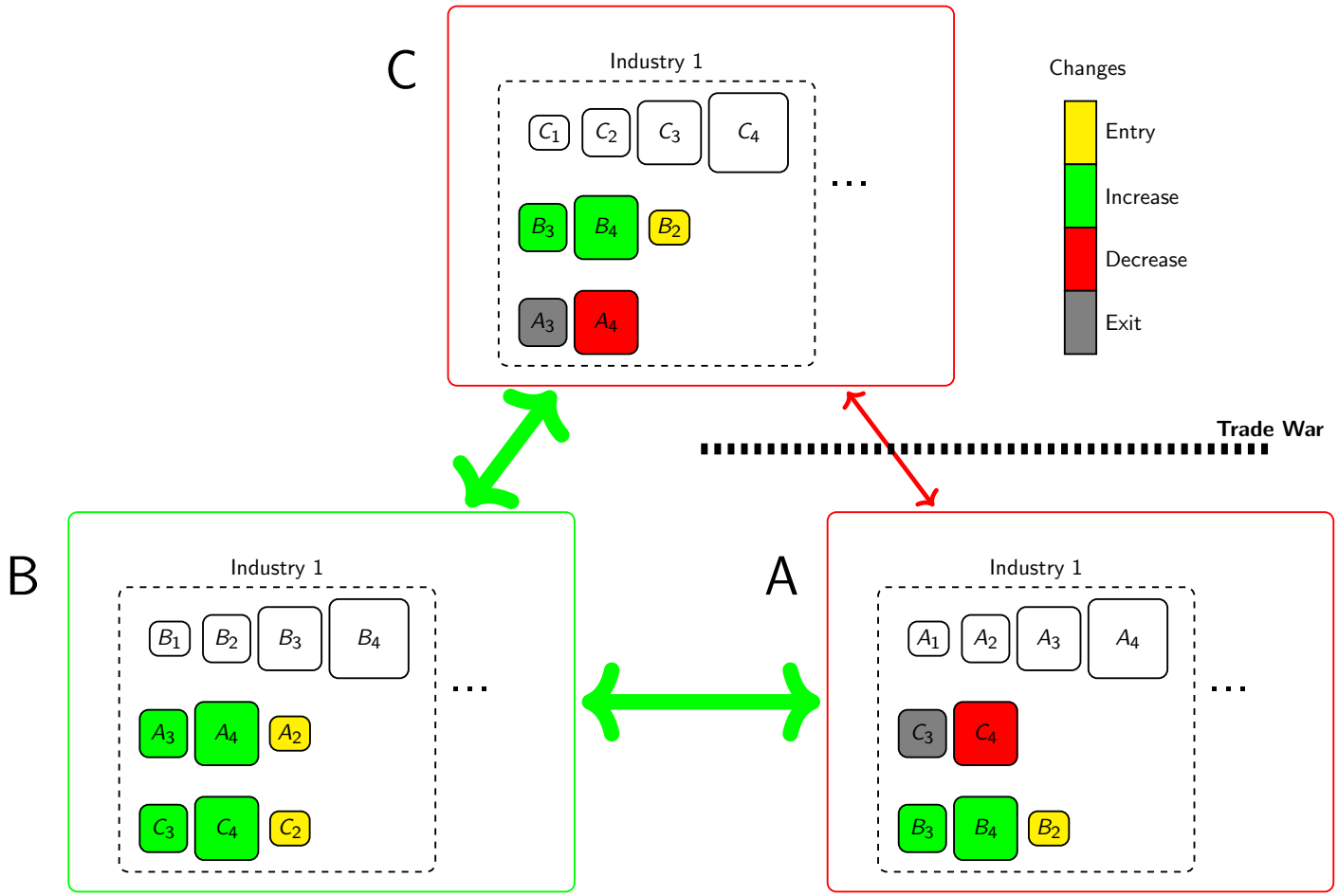
- Three countries (A, B, and C); a continuum of industries in each country
- Within each industry, there is a limited number of domestic and foreign firms competing with each other

Application: Bilateral Trade War (C-A)



- the aggregate productivities of A and C fall
- the aggregate productivity of the third country (B) increases

Application: Bilateral Trade War (C-A)



The effects of market changes:

(i) average markups of exporters from C to A: much smaller adjustments

(ii) aggregate productivity: little impact on A and C; but a big increase for B

Relative to the Literature

1. **Pricing-to-market and international shock transmissions:**

   e.g., Dornbush (1987); Corsetti and Dedola (2005); Atkeson and Burstein (2008); Amiti, Itskhoki and Konings (2012, 2018), Chatterjee, Dix-Carneiro and Vichyanond (2013); Fitzgerald and Haller (2014, 2018); Auer and Schoenle (2016); Caselli, Chatterjee, and Woodland (2017); Corsetti, Crowley, Han and Song (WP2018);

   This paper → firms actively adjust their set of destination markets due to large fluctuations in destination-specific residual demand

2. **Margins of trade and export dynamics:**

   e.g., Dunne, Roborts and Samuelson (1989); Eaton, Kortum and Kramarz (2004); Chaney (2008, 2014); Bernard, Redding and Schott (2010); Albornoz, Pardo, Corcos, and Ornelas (2012); Fitzgerald, Haller and Yedid-Levi (2017); Ruhl and Willis (2018); Li (2018)

   → **new measures to quantify within-firm market changes:**
   (i) endogenous to local market conditions;
   (ii) closely related to firms' prices and quantities in all markets

3. **Trade, Markups and Welfare:**

   e.g., Edmond, Midrigan and Xu (2015); Feenstra and Weinstein (2017); Arkolakis, Costinot, Donaldson and Rodriguez-Clare (2018)

   → **study the effect of market changes on competition and welfare in a multi-country framework**

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Roadmap

1. Empirical Results
   → New measures of changes in trade patterns
2. Multi-country General Equilibrium Model
   → Featuring variable markups and variable markets
3. Aggregate Implications
   → Application: bilateral "trade war"
4. Conclusions

Measures of Variable Markets

Consider a firm selling a product to four countries, A, B, C, D over 4 time periods:

					Trade Pattern	Activity	M. Changes/ Markets	Drops/ Changes
$t = 1$	A	B			A-B	–	–	–
$t = 2$	A		C		A-C	Churn	2/2	1/2
$t = 3$	A		C	D	A-C-D	Add	1/3	0/1
$t = 4$	A		C		A-C	Drop	1/2	1/1

Note: Add $\Leftrightarrow$ drops/changes $= 0$; Churn $\Leftrightarrow 0 <$ drops/change < 1; Drop $\Leftrightarrow$ drops/change $= 1$

Corresponding value measures:

$$\text{Market Changes/Markets in period 2} = \frac{V_{B,1} + V_{C,2}}{V_{A,2} + V_{C,2}}$$

$$\text{Drops/Changes in period 2} = \frac{V_{B,1}}{V_{B,1} + V_{C,2}}$$

e.g. $V_{B,1}$ refers to the trade value at firm-product level to country B in period 1.

Statistics from Firm-product Level Trade Patterns (Median)

	All Firms	Large Firms
Chinese Exporters, 2000-2006		
Markets Changes/ Markets	0.67	0.64
Markets Changes/ Markets (Trade Value)	3.27	**2.21**
British Exporters, 2010-2016		
Markets Changes/ Markets	0.50	0.50
Markets Changes/ Markets (Trade Value)	2.10	**1.45**

Note: statistics on Chinese exporters are calculated using Chinese Customs Database, 2000-2006. Statistics on British exporters are calculated using HMRC administrative datasets, 2010-2016.

Data Breakdown by Firm and Product Types Alternative Measures

Statistics from Firm Level Trade Patterns (Median)

	All Firms	Large Firms
Chinese Exporters, 2000-2006		
Markets Changes/ Markets	0.57	0.50
Markets Changes/ Markets (Trade Value)	1.40	**0.79**
British Exporters, 2010-2016		
Markets Changes/ Markets	0.60	0.37
Markets Changes/ Markets (Trade Value)	4.49	**0.47**

Note: statistics on Chinese exporters are calculated using Chinese Customs Database, 2000-2006. Statistics on British exporters are calculated using HMRC administrative datasets, 2010-2016.

Data Breakdown by Firm and Product Types

Statistics from Firm-product Level Trade Patterns (Median)

	All Firms	Large Firms
Chinese Exporters, 2000-2006		
Markets Drop/ Market Changes	0.50	0.50
Markets Drop/ Market Changes (Trade Value)	0.41	0.35
Probability of Churn	0.26	0.33
British Exporters, 2010-2016		
Markets Drop/ Market Changes	0.50	0.50
Markets Drop/ Market Changes (Trade Value)	0.48	0.46
Probability of Churn	0.32	0.45

Note: statistics on Chinese exporters are calculated using Chinese Customs Database, 2000-2006. Statistics on British exporters are calculated using HMRC administrative datasets, 2010-2016.

- Drop-to-change (DC) ratio provides a directional measure of market changes.

  $\rightarrow$ Market adds and drops can be analysed jointly.

Next

- To what extent, do market changes respond to changes in local market conditions?
  - → Drop-to-Change (DC) ratio and local market conditions
- What happens to prices and quantities in all markets when a firm adjusts its trade patterns?
  - → Drop-to-Change (DC) ratio, prices and quantities

Market Changes and Local Market Conditions

Constructing firm-product level measures of changes in local market conditions (focusing on those markets changed)

					Continuing Markets	Markets Changed	Changes in Relative Exchange Rates
$t=1$	A	(B)	[C]		–	–	–
$t=2$	A	[B]	(C)	[D]	A	B, C	$log(e_{C,2}/e_{C,1}) - log(e_{B,2}/e_{B,1})$
$t=3$	A		C	(D)	A, C	D	$log(e_{D,3}/e_{D,2})$
$t=4$	A		C	[D]	A, C	D	$-log(e_{D,4}/e_{D,3})$

Note: Dashed circles indicate auxiliary cells with no transaction observed. Circled cells mark the variation used to construct the augmented exchange rates.

Regressing drop-to-change (DC) ratio on the constructed measures

$$DC_{f,i,t} = \beta_e \widetilde{e}_{f,i,t} + \beta_P \widetilde{P}_{f,i,t} + \delta_{f,i} + \delta_t + \epsilon_{f,i,t}$$

where $DC_{f,i,t}$ is drop-to-change ratio; $\widetilde{e}_{f,i,t}$ is relative exchange rates; $\widetilde{P}_{f,i,t}$ is relative local CPI rate; $\delta_{f,i}$ and δ_t are firm-product and time fixed effects respectively. f, i, t = firm, product, time.

Market Changes and Local Market Conditions

Regressing drop-to-change (DC) ratio on changes in local market conditions (results from Chinese Exporters, 2000-2006)

	Exchange Rate	Destination CPI	Within R^2	Observations
Count Measure				
Firm-product (8-digit) level	-0.22***	-0.81***	0.23	1,791,353
Firm-industry (2-digit) level	-0.14***	-0.59***	0.21	875,096
Firm level	-0.12***	-0.45***	0.20	301,455
Trade Value Measure				
Firm-product (8-digit) level	-0.21***	-0.83***	0.17	1,791,353
Firm-industry (2-digit) level	-0.14***	-0.61***	0.16	875,095
Firm level	-0.11***	-0.46***	0.16	301,455

Data source: Chinese Customs Database, 2000-2006

Note: The statistical significance is calculated based on robust standard errors with ***, **, * representing statistical significance at 1%, 5%, 10% respectively. Firm-product and year fixed effects are added for firm-product and firm-industry specifications. Firm and year fixed effects are added for firm level specifications.

UK Results

Market Changes, Prices and Quantities

Conditional on the same firm selling the same product, how do its prices and quantities change

- if the firm has added more markets v.s. dropped more markets
- in all markets v.s. in continuing markets

					Changes in Unit Value	**Drops/Changes**
$t=1$	A	B			$-$	$-$
$t=2$	A		C		$p_{AC,2} - p_{AB,1}$	$1/2$
$t=3$	A		C	D	$p_{ACD,3} - p_{AC,2}$	$0/1$
$t=4$	A		C		$p_{AC,4} - p_{ACD,3}$	$1/1$

Illustration of the Estimation Equation

Market Changes, Prices and Quantities

Price and Quantity Elasticities to Drop-Change Ratio
(Summary of Key Estimates, China Results)

	Unit Value	Mean Quantity	Total Quantity	Observations
Firm-product level	0.08***	-0.52***	-2.49***	1,788,094
Firm-industry level	0.15***	-0.57***	-2.49***	873,994
Firm level	0.16***	-0.06***	-1.82***	314,537

Each cell represent an estimate from a separate estimation equation. UK Results

Conditional on a market change,

1. the price is higher if more markets are dropped;
2. less units being sold per market if more markets are dropped

Continuing Markets

					Changes in the Unit Value of Continuing Markets
$t = 1$	A	B			$-$
$t = 2$	A		C		$p_{A,2} - p_{A,1}$
$t = 3$	A		C	D	$p_{AC,3} - p_{AC,2}$
$t = 4$	A		C		$p_{AC,4} - p_{AC,3}$

Construction of Measures of Continuing Markets

Continuing Markets

Price and Quantity Elasticities to Drop-Change Ratio for Continuing Markets
(Summary of Key Estimates, Chinese Exporters, 2000-2006)

	Unit Value	Mean Quantity	Observations
Firm-product level	0.01***†	-0.65***	1,244,580
Firm-industry level	0.03***†	-0.73***	731,199
Firm level	0.05***†	-0.73***	281,564

† indicates the estimate is sensitive to alternative samples and measurements.

UK Results

- little change in price but large drop in quantity
- this evidence suggests that firms are dropping some markets and reducing sales in others because of large negative demand shocks.

Roadmap

- How can we develop a model to account for these facts?
  - ⋆ a multi-country general equilibrium model
  - ⋆ possible sources of demand fluctuations
  - ⋆ multi-lateral competition is important
- What are the implications of these market changes?
  - ⋆ a bilateral trade war scenario
  - ⋆ interdependence of markup adjustments and market changes
  - ⋆ aggregate implications on imports and welfare

A Multi-country General Equilibrium Model with Variable Markups and Variable Markets

Key Elements:

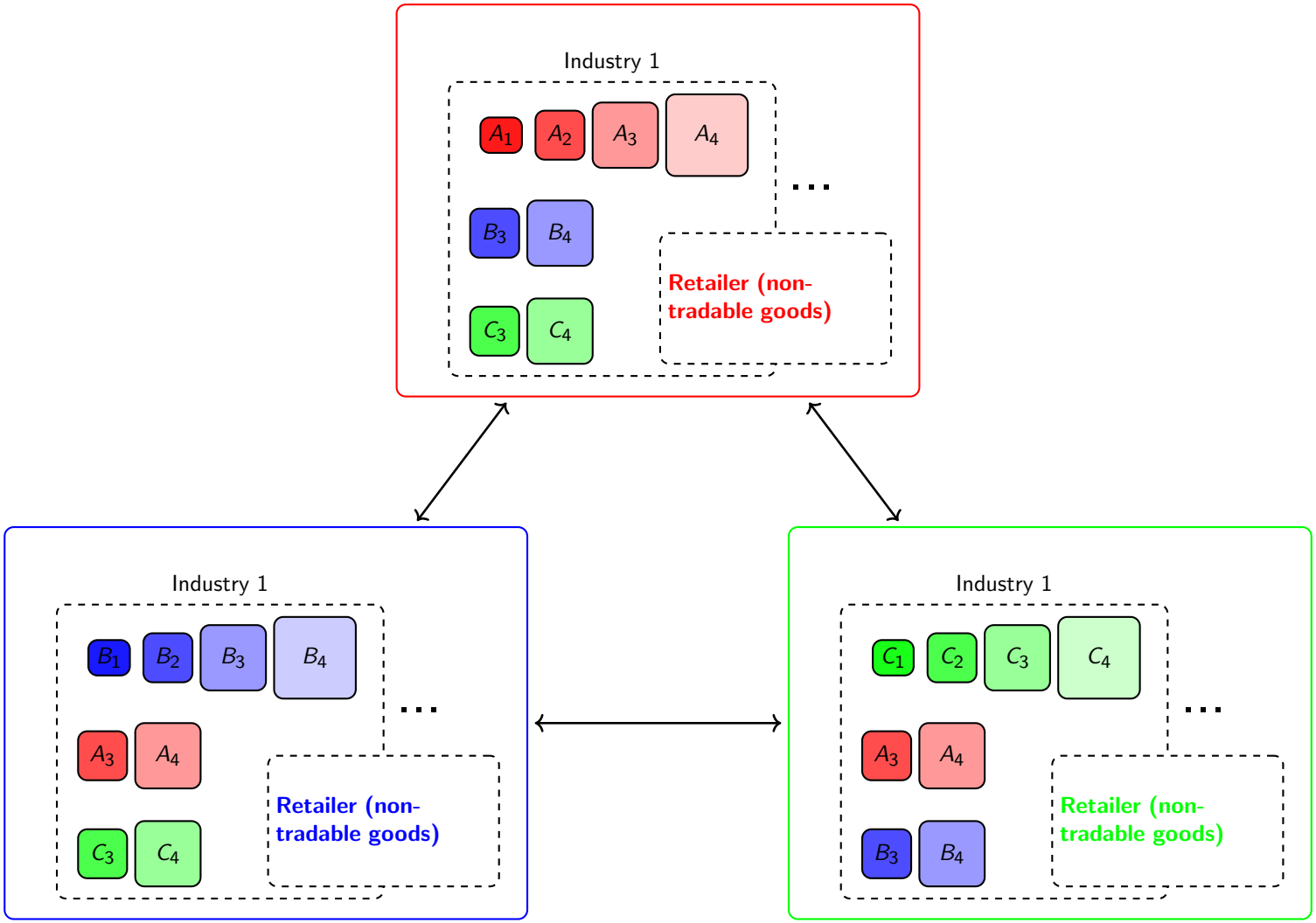
1. **Variable Markets**
   - $H > 2$ countries in the world
   - Firms making entry decisions for each country separately in each period

2. **Variable Markups**†
   (i) demand competition by local and international producers of substitutable goods (Atkeson and Burstein 2008)
   (ii) additive local cost component e.g., the need for retail distribution (Corsetti and Dedola 2005)

$$\Rightarrow (ABCD)^H$$

†: drawing on my ongoing project Corsetti, Crowley and Han (2018).

Structure



blue: country B; red: country A; green: country C
lighter colour: lower price
price = retail cost + markup + marginal cost

Production of Final and Intermediate Goods

Final consumption and the price of final good are:

$$C_{d,t} \equiv \left[\int_0^1 \left(C_{i,d,t}\right)^{\frac{\eta-1}{\eta}} di\right]^{\frac{\eta}{\eta-1}}, \quad P_{d,t} \equiv \left[\int_0^1 \left(P_{i,d,t}\right)^{1-\eta} di\right]^{\frac{1}{1-\eta}}$$

Industry level consumption and the price of intermediate good are:

$$C_{i,d,t} = \left[\sum_f \sum_o \left(\alpha_{f,i,o,d,t}\right)^{\frac{1}{\rho}} \left(q_{f,i,o,d,t}\right)^{\frac{\rho-1}{\rho}} \phi_{f,i,o,d,t}\right]^{\frac{\rho}{\rho-1}},$$

$$P_{i,d,t} = \left[\sum_f \sum_o \alpha_{f,i,o,d,t} \left(p_{f,i,o,d,t}\right)^{1-\rho} \phi_{f,i,o,d,t}\right]^{\frac{1}{1-\rho}}$$

- subscripts: f firm, i industry, o origin, d destination, t time
- $1 < \eta$ (cross-industry elasticity of substitution) $< \rho$ (within-industry elasticity of substitution)
- α preference shifter
- q and p are firm-level price and quantity respectively
- $\phi_{f,i,o,d,t} \in \{0, 1\}$ indicates whether firm f in industry i from origin o sells to destination d at t
- all prices denominated in the destination currency

Two sources of variable markups

(i) Demand Competition among Firms

Demand competition by local and international producers of substitutable goods (Atkeson and Burstein AB 2008)

The demand for firm f in industry i from origin o at time period t is

$$q_{f,i,o,d,t} = \alpha_{f,i,o,d,t} \left(\frac{p_{f,i,o,d,t}}{P_{i,d,t}} \right)^{-\rho} \left(\frac{P_{i,d,t}}{P_{d,t}} \right)^{-\eta} C_{d,t}$$

Price elasticity of demand:

$$\varepsilon_{f,i,o,d,t} = \rho(1 - ms_{f,i,o,d,t}) + \eta ms_{f,i,o,d,t}$$

ms market share

ρ (within-industry elasticity of substitution) $> \eta$ (cross-industry elasticity of substitution)

Two sources of variable markups

(ii) Additive local cost component

- Distribution cost (Corsetti and Dedola CD 2005)
- Alternatives: consumer search (Alessandria 2009); consumer list (Drozd and Nosal 2012)

$$
\begin{aligned}
p_{f,i,o,d,t} &= p^{border}_{f,i,o,d,t} + \chi_{f,i,o,d,t} \\
dm_{f,i,o,d,t} &\equiv \frac{\chi_{f,i,o,d,t}}{p^{border}_{f,i,o,d,t} + \chi_{f,i,o,d,t}} \\
\varepsilon^{b}_{f,i,o,d,t} &= \rho\left(1 - dm_{f,i,o,d,t}\right)
\end{aligned}
$$

p consumer price

dm distribution margin

ρ within-industry elasticity of substitution

ε^b demand elasticity with respect to border price

Price and Export Decisions

Firms compete by simultaneously choosing:

1. whether to enter a market, indicated by $\phi_{f,i,o,d,t}$
2. and if enter, the price $p_{f,i,o,d,t}$ internalizing
   - (i) impact on the industry level price index $P_{i,d,t}$ and
   - (ii) the wedge $\chi_{f,i,o,d,t}$ between producer and consumer prices

$$\pi_{f,i,o,d,t} = \max_{p_{f,i,o,d,t}, \phi_{f,i,o,d,t}} \left[q_{f,i,o,d,t}(\mu^b_{f,i,o,d,t} - 1) mc_{f,i,o,t} - W_{o,t} F_x \right] \phi_{f,i,o,d,t}$$

subject to

$$q_{f,i,o,d,t} = \alpha_{f,i,o,d,t} \left(\frac{p_{f,i,o,d,t}}{P_{i,d,t}} \right)^{-\rho} \left(\frac{P_{i,d,t}}{P_{d,t}} \right)^{-\eta} C_{d,t}$$

$$\mu^b_{f,i,o,d,t} = \frac{(p_{f,i,o,d,t} - \chi_{f,i,o,d,t}) e_{o,d,t}}{\tau_{o,d} mc_{f,i,o,t}}$$

μ^b denotes producer's markup denominated in home currency

$mc_{f,i,o,t}$ marginal cost of firm f from industry i and origin o at time t

$e_{o,d,t}$ bilateral exchange rate; defined as units of currency o per unit of currency d at time t

$\tau_{o,d}$ bilateral trade cost (including tariff)

F_x fixed cost of export; $W_{o,t}$ nominal wage in origin o at time t

Variable Markets and Profit Heterogeneity

Probability of Market Change

$$= Pr(\pi_{k,i,o,d,t+1} < 0 \bigcap \pi_{k,i,o,d,t} > 0) + Pr(\pi_{k,i,o,d,t+1} > 0 \bigcap \pi_{k,i,o,d,t} < 0)$$

where

$$\begin{aligned} & Pr(\pi_{k,i,o,d,t+1} < 0 \bigcap \pi_{k,i,o,d,t} > 0) \\ =& Pr((1 + \widehat{\pi}_{k,i,o,d,t})\pi_{k,i,o,d,t} < 0 | \pi_{k,i,o,d,t} > 0) Pr(\pi_{k,i,o,d,t} > 0) \end{aligned}$$

Drop to Change Ratio

$$= \frac{Pr(\pi_{k,i,o,d,t+1} < 0 \bigcap \pi_{k,i,o,d,t} > 0)}{Pr(\pi_{k,i,o,d,t+1} < 0 \bigcap \pi_{k,i,o,d,t} > 0) + Pr(\pi_{k,i,o,d,t+1} > 0 \bigcap \pi_{k,i,o,d,t} < 0)}$$

Variable Markets and Profit Heterogeneity

Probability of Market Change

$$= Pr(\pi_{k,i,o,d,t+1} < 0 \bigcap \pi_{k,i,o,d,t} > 0) + Pr(\pi_{k,i,o,d,t+1} > 0 \bigcap \pi_{k,i,o,d,t} < 0)$$

where

$$\begin{aligned} & Pr(\pi_{k,i,o,d,t+1} < 0 \bigcap \pi_{k,i,o,d,t} > 0) \\ =& Pr((1 + \widehat{\pi}_{k,i,o,d,t})\pi_{k,i,o,d,t} < 0 | \pi_{k,i,o,d,t} > 0) Pr(\pi_{k,i,o,d,t} > 0) \end{aligned}$$

Drop to Change Ratio

$$= \frac{Pr(\pi_{k,i,o,d,t+1} < 0 \bigcap \pi_{k,i,o,d,t} > 0)}{Pr(\pi_{k,i,o,d,t+1} < 0 \bigcap \pi_{k,i,o,d,t} > 0) + Pr(\pi_{k,i,o,d,t+1} > 0 \bigcap \pi_{k,i,o,d,t} < 0)}$$

Variable Markets and Profit Heterogeneity II

Changes in potential profit $\widehat{\pi}^*_{k,i,o,d,t}$ is given by:

$$\begin{aligned}\widehat{\pi}^*_{k,i,o,d,t} \propto\ & \underbrace{\widehat{\alpha}_{k,i,o,d,t}}_{\text{taste}} - \left[\varepsilon_{k,i,o,d,t}(1-dm_{k,i,o,d,t})-1\right]\underbrace{\widehat{mc}_{k,i,o,t}}_{\text{marginal cost}} \\ & - \varepsilon_{k,i,o,d,t}\, dm_{k,i,o,d,t}\,\underbrace{\widehat{\chi}_{k,i,o,d,t}}_{\text{retail cost}} \\ & - \frac{\rho-\eta}{\rho-1}\underbrace{\widehat{CE}_{k,i,o,d,t}}_{\text{competitors' effect}} \\ & + \underbrace{\varepsilon_{k,i,o,d,t}(1-dm_{k,i,o,d,t})\widehat{e}_{o,d,t}+\eta\widehat{P}_{d,t}+\widehat{C}_{d,t}}_{\text{local market conditions}}\end{aligned}$$

(AB) $\varepsilon_{f,i,o,d,t} = \rho(1-ms_{f,i,o,d,t}) + \eta\, ms_{f,i,o,d,t}$

(CD) $dm_{f,i,o,d,t} = \frac{\chi_{f,i,o,d,t}}{p^{border}_{f,i,o,d,t}+\chi_{f,i,o,d,t}}$

Competitors' Effect

$$\widehat{CE}_{k,i,o,d,t} \approx \underbrace{\sum_{o'} \sum_{f \neq k} \phi_{f,i,o',d,t+1} \phi_{f,i,o',d,t} ms_{f,i,o',d,t} (1-\rho) \widehat{p}_{f,i,o',d,t}}_{\text{impact of continuing firms}}$$
$$+ \underbrace{\sum_{o'} \sum_{f \neq k} \phi_{f,i,o',d,t+1} (1 - \phi_{f,i,o',d,t}) ms_{f,i,o',d,t+1}}_{\text{impact of entrants}}$$
$$- \underbrace{\sum_{o'} \sum_{f \neq k} (1 - \phi_{f,i,o',d,t+1}) \phi_{f,i,o',d,t} ms_{f,i,o',d,t}}_{\text{impact of exitors}}$$

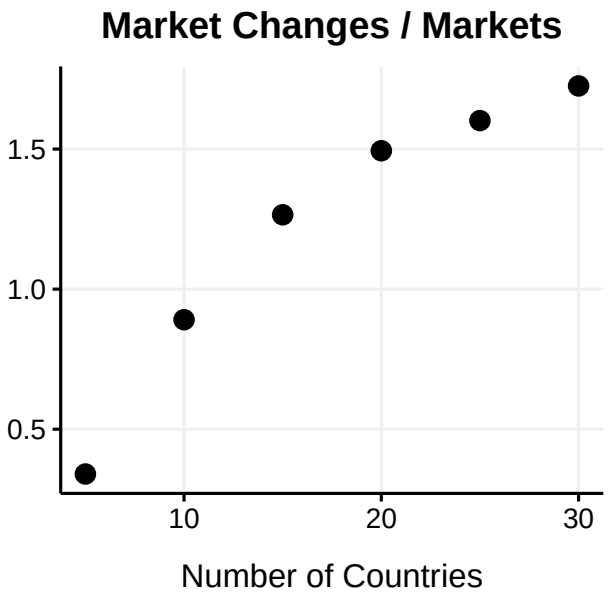
where

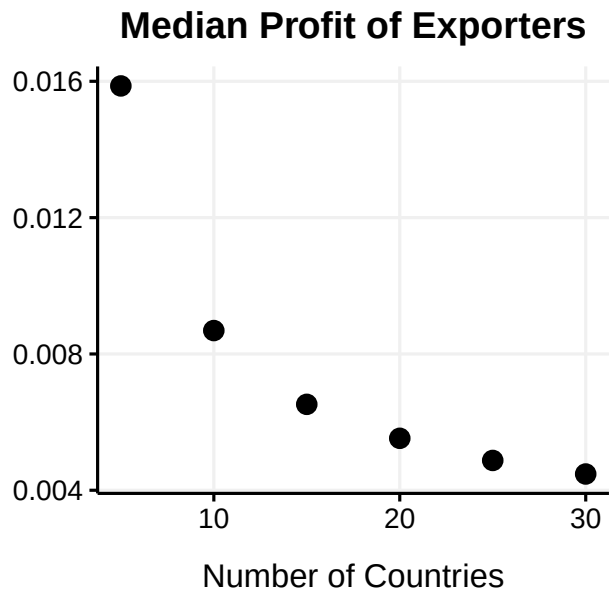
$$\widehat{p}_{f,i,o',d,t} = (1 - \omega_{f,i,o',d,t})(\widehat{mc}_{f,i,o',t} - \widehat{e}_{o',d,t}) + \omega_{f,i,o',d,t} \widehat{\chi}_{f,i,o',d,t} + \kappa_{f,i,o',d,t} \widehat{ms}_{f,i,o',d,t}$$

$\omega(mc, \chi, e)$: cost share of local component

$\kappa(ms, \eta, \rho)$: price elasticity w.r.t. market share

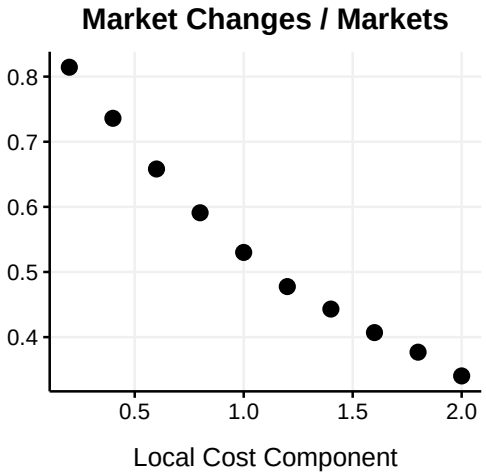
Multilateral Competition Effect

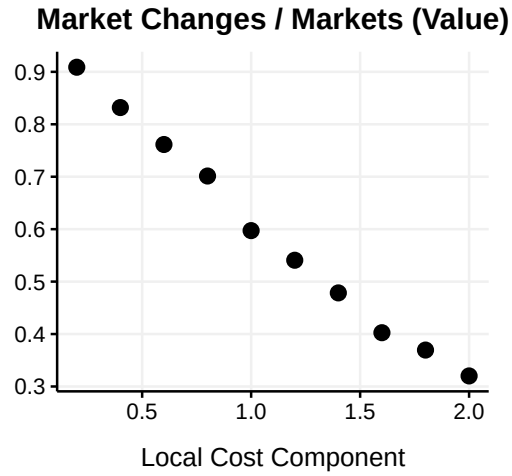


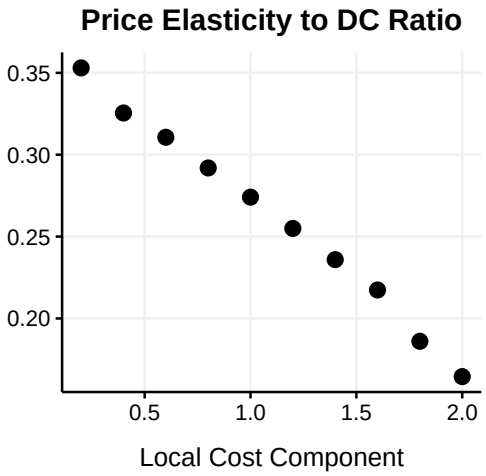


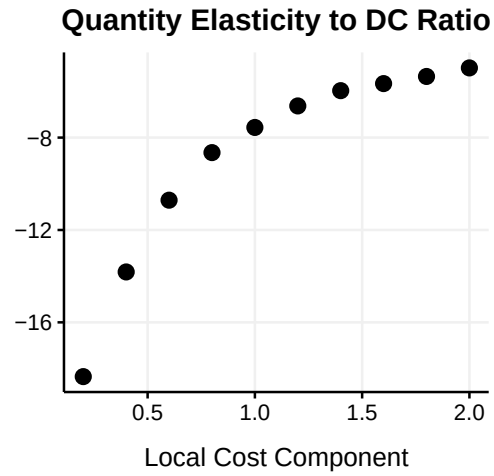
- Multilateral competition flattens the distribution of profits, making exporters more sensitive to shocks
- Entry and exit of foreign firms have a larger impact on others' residual demand

Increasing in Local Cost Component









- The existence of local cost component reduces the magnitude of market changes but improves the fits of price and quantity elasticities

Equilibrium

Production:

$$mc_{f,i,o,t} = \frac{W_{o,t}}{\Omega_{f,i,o,t}}, \quad mc_{N,d,t} = \frac{W_{d,t}}{\Omega_{N,d,t}}$$

Goods market clearing:

$$C_{d,t} = Y_{d,t}$$

$$\sum_d q_{f,i,o,d,t} = \Omega_{f,i,o,t} l_{f,i,o,t}$$

$$q_{N,d,t} = \sum_i \sum_o \sum_f \chi_{f,i,o,d,t} q_{f,i,o,d,t} = \Omega_{N,d,t} L_{N,d,t}$$

Labor market clearing:

$$\sum_i \sum_f l_{f,i,o,t} + L_{N,o,t} + \sum_i \sum_{d \neq o} \sum_f \phi_{f,i,o,d,t} F_x + \sum_i \sum_f \phi_{f,i,o,o,t} F_h = L_{o,t} = 1$$

Balance of trade determines the bilateral exchange rates; for $o \neq d$,

$$\sum_i \sum_f (p_{f,i,d,o,t} - \chi_i P_{N,d,t}) q_{f,i,d,o,t} = \sum_i \sum_f (p_{f,i,d,o,t} - \chi_i P_{N,o,t}) q_{f,i,o,d,t} * e_{o,d,t}$$

Calibration

Parameter	Value
Varies to match moments	
Cross-industry elasticity of substitution, η	1.3
Within-industry elasticity of substitution, ρ	7.5
Fixed cost of export operations	0.2
Measure of local component, χ	2.0
Size of taste shocks μ_α ($\widehat{\alpha} \sim lognormal(-\mu_\alpha, 2\mu_\alpha)$)	0.5
Size of productivity shocks μ_Ω ($\widehat{\Omega} \sim lognormal(-\mu_\Omega, 2\mu_\Omega)$)	0.1
Fixed: taken from Edmond, Midrigan and Xu (2015) to match firm and sector distributions	
Pareto shape parameter, idiosyncratic productivity	4.58
Pareto shape parameter, sector productivity	0.51
Kendall correlation for Gumbel copula	0.94
Fixed cost of domestic operations	0.004
Tariff rate	0.129

Moments

Work in Progress

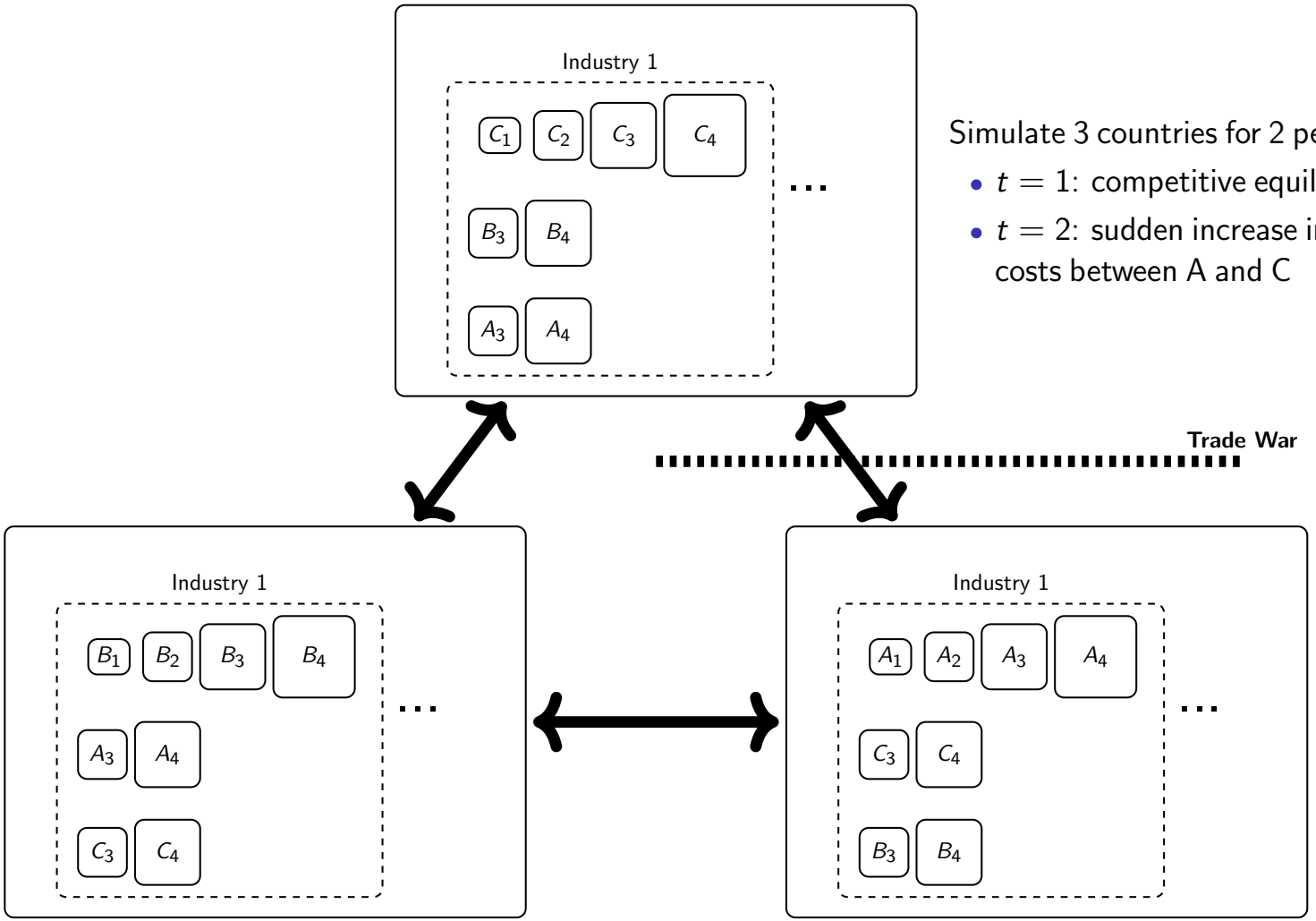
	Data	Model
Markets Changes / Markets (median)	1.40	0.94
Drop-to-Change Ratio (median)	0.50	0.50
Price Elasticity to DC ratio	0.20	0.19
Quantity Elasticity to DC ratio	-2.49	-2.95
Destination Specific Markup Elasticity†	0.07	0.14
Cross Market Supply Elasticity†	4.09	1.67

† Based on the estimates of Corsetti, Crowley, Han, and Song (2018)

Additional Model Moments CD Chanel Intensive Margins

An alternative way to calibrate: "Firm Level Pass Through: A Machine Learning Approach" (work in progress)

Application: Bilateral Trade War

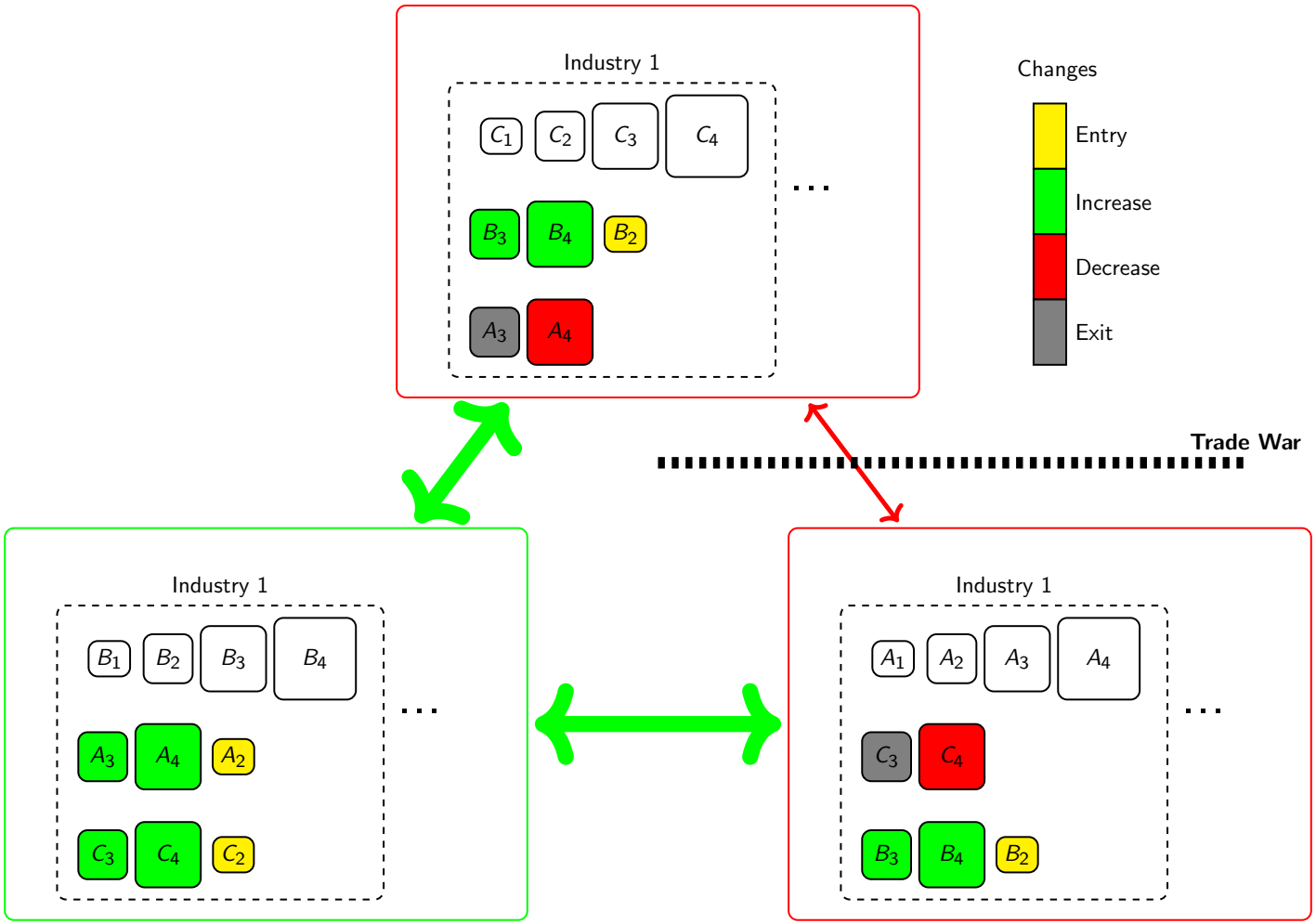


Simulate 3 countries for 2 periods:

- $t = 1$: competitive equilibrium
- $t = 2$: sudden increase in bilateral trade costs between A and C

Study percentage changes of variables from period 1 to 2, i.e., $\widehat{x} = \frac{x_2 - x_1}{x_1} * 100$

Overview: Bilateral Trade War A-C



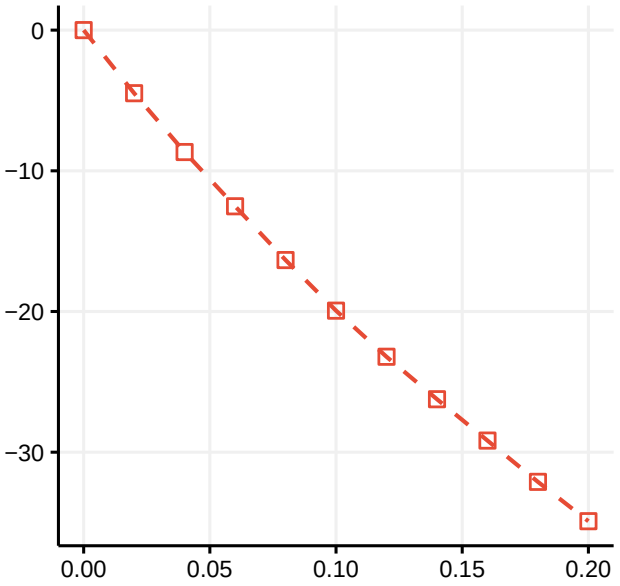
Next:

- The effects of oligopolistic competition and local cost component on market changes.
- The effects of market changes on the distribution of markups, imports and aggregate productivity.

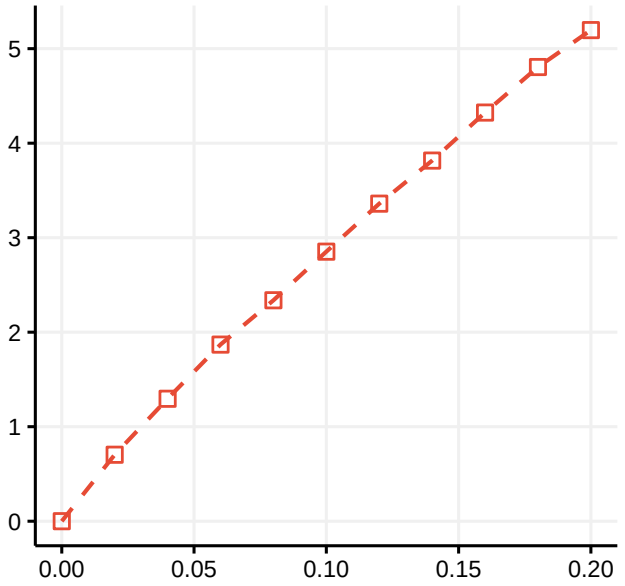
Trade War A-C: Extensive Margin

Trade destruction: Number of exporters from C to A decreases
Trade deflection: Number of exporters from C to B increases

Number of Exporters C to A



Number of Exporters C to B

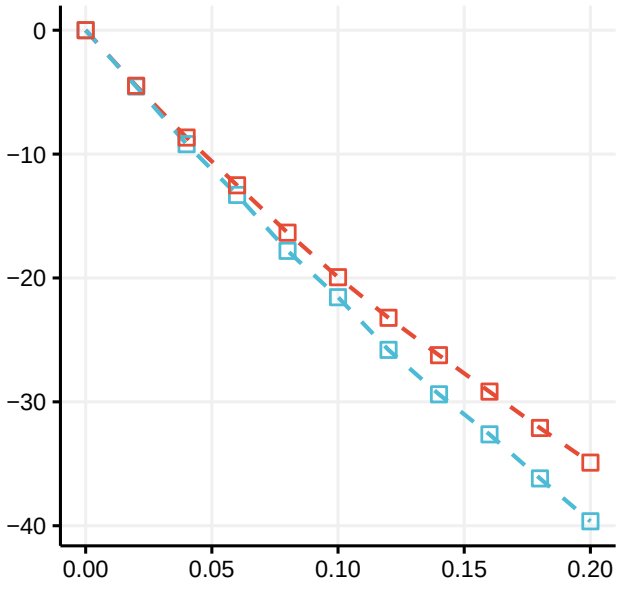


Exchange Rate

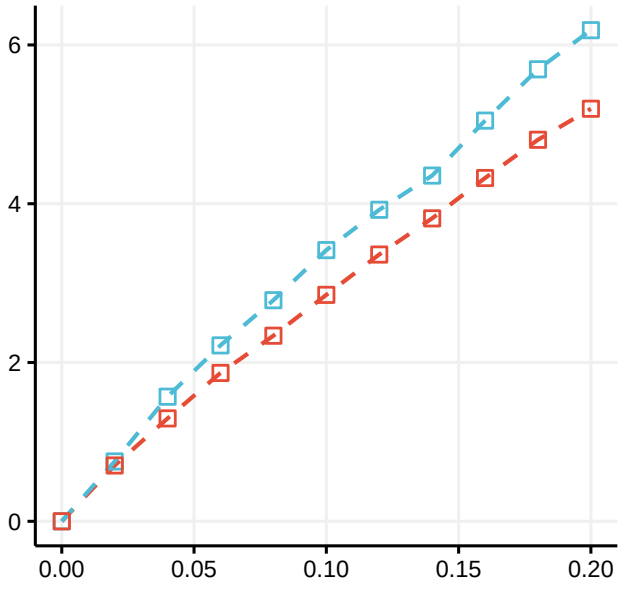
Trade War A-C: Extensive Margin

Local Cost Component Reduces Extensive Margin Responses

Number of Exporters C to A



Number of Exporters C to B

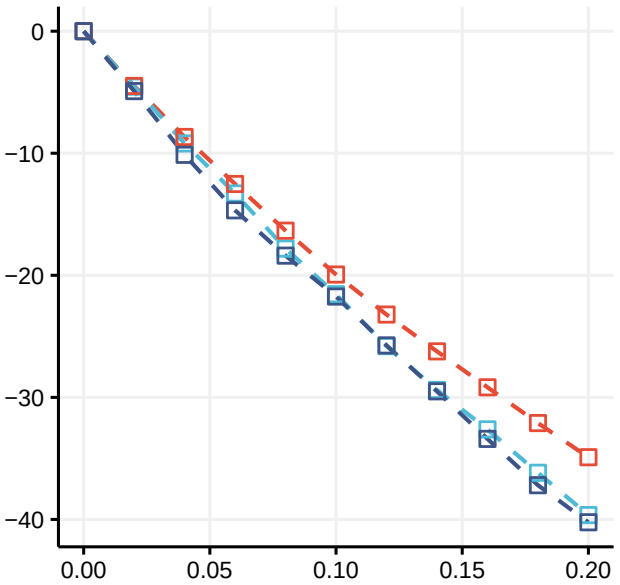


Red: Variable Markups (Oligopolistic Competition + Local Cost Component)
Cyan: Variable Markups (Oligopolistic Competition Only)

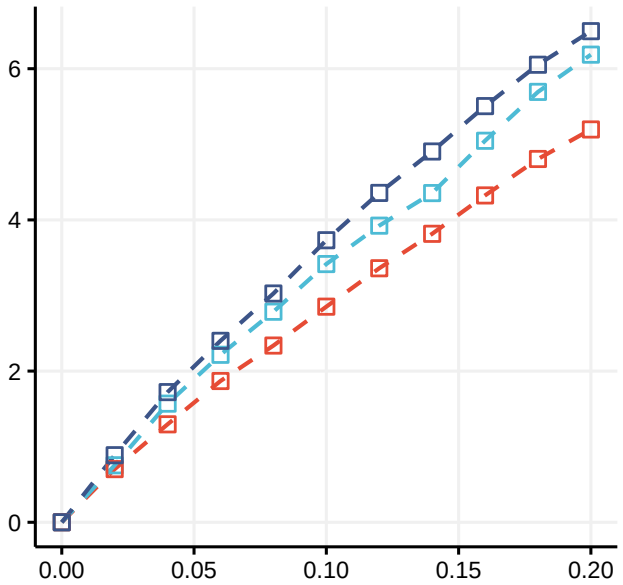
Trade War A-C: Extensive Margin

Comparing to the model with constant markups, incorporating oligopolistic competition slightly reduces the magnitude of extensive margin adjustments.

Number of Exporters C to A



Number of Exporters C to B

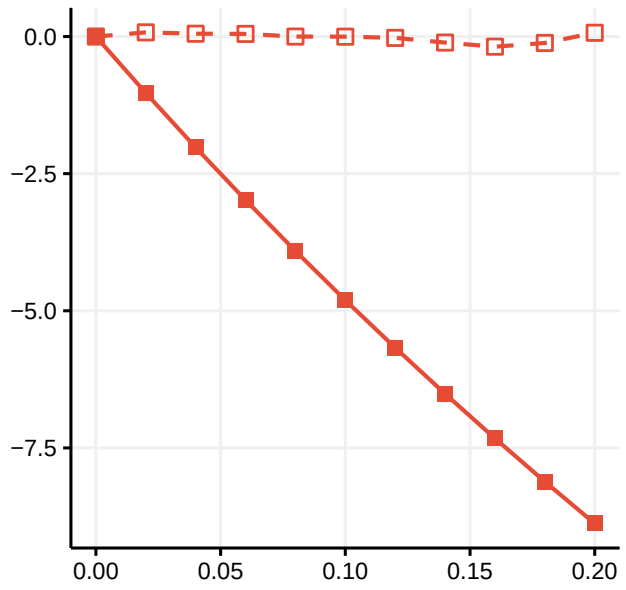


Red: Variable Markups (Oligopolistic Competition + Local Cost Component)
Cyan: Variable Markups (Oligopolistic Competition Only)
Dark Blue: Constant Markups

Trade War A-C: Markups

The Effect of Market Changes on Markup Distribution

Mean Markups of Exporters from Country C to A



Allowing firms to reallocate brings in two additional effects:

(i) selection effect: only very productive firms exports to A
(these firms are larger and charge higher markups)

(ii) competition effect: different markup adjustments as

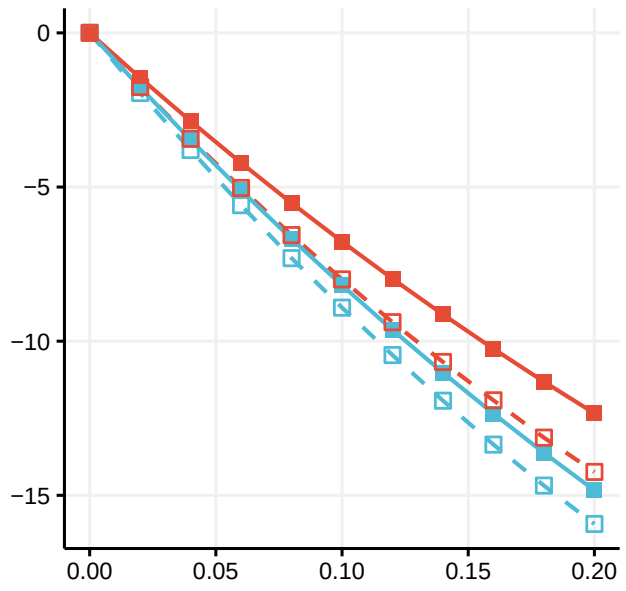
- (a) less competition due to exits of less productive exporters from C to A
- (b) more competition due to entrants of exporters from B to A

Empty Square: Variable Markets;
Solid Square: Fixed Markets (same set of firms in each market in both periods)
Red: Variable Markups (Oligopolistic Competition + Local Cost Component)

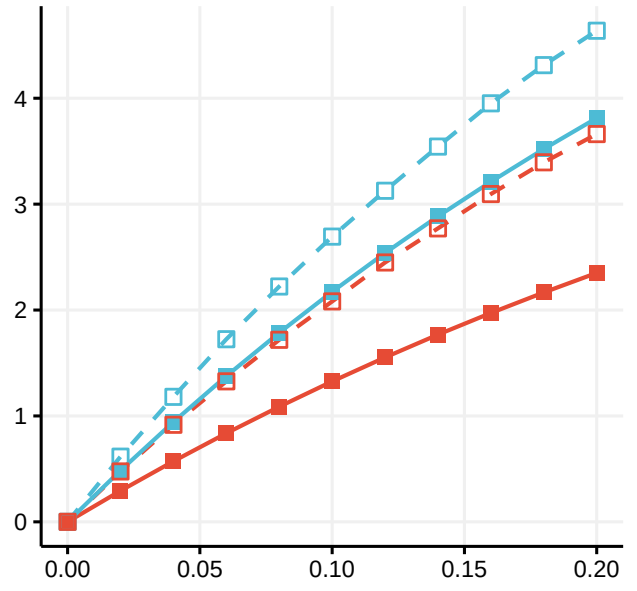
Trade War A-C: Imports

The Two Warring Countries Import Less; The Third Country (B) Imports More

Country C (or A): Changes in Import Share



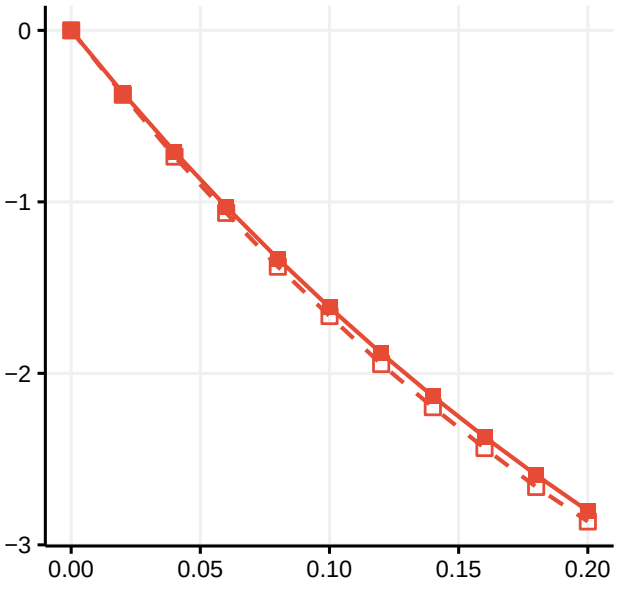
Country B: Changes in Import Share



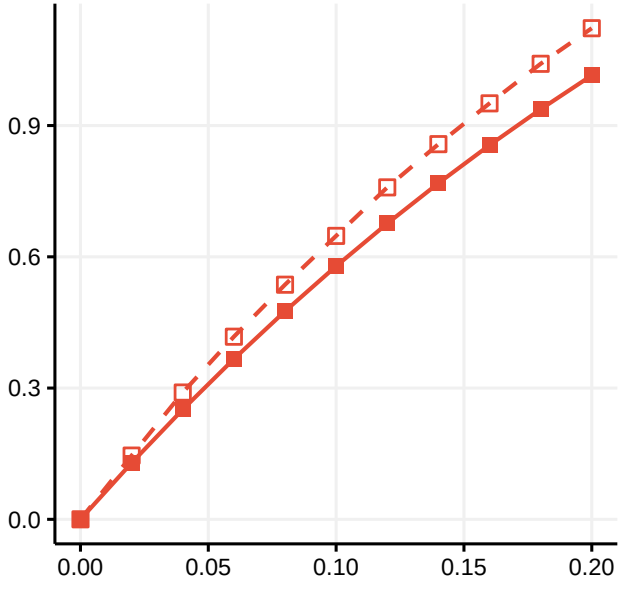
Empty Square: Variable Markets; **Solid Square: Fixed Markets**
Red: Variable Markups (Oligopolistic Competition + Local Cost Component)
Cyan: Variable Markups (Oligopolistic Competition Only)

Trade War A-C: Aggregate Productivity

Two Warring Countries C (or A)



The Third Country B



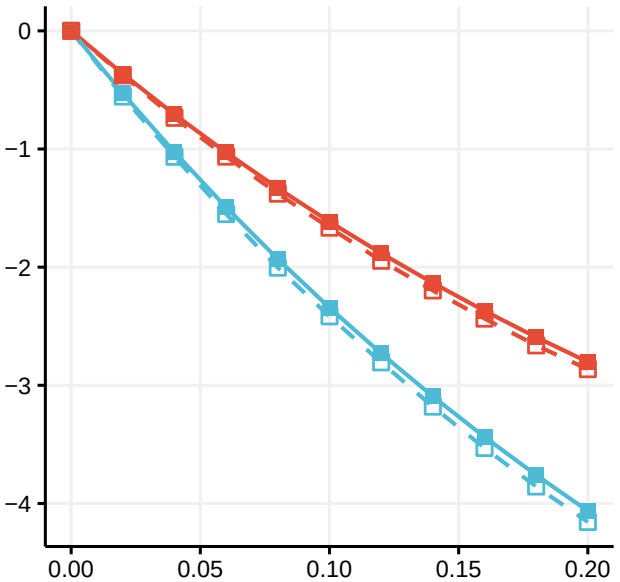
Percentage Differences in Responses between Fixed Markets and Variable Markets

Model	Aggregate Productivity C (or A)	Aggregate Productivity B
Benchmark	1-2%	10-13%

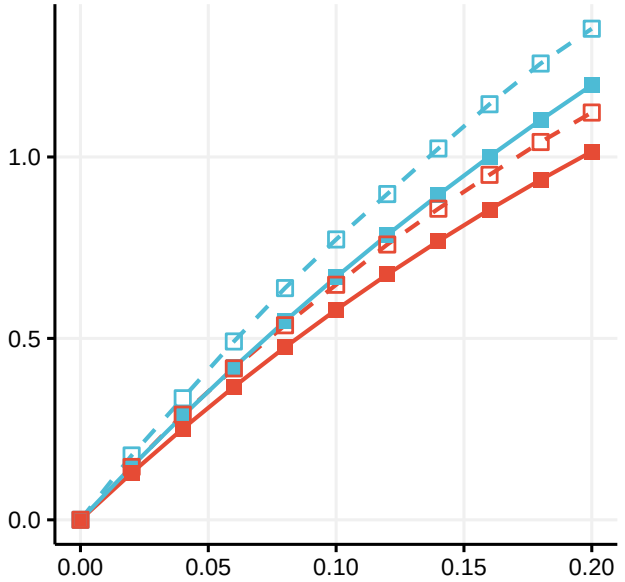
Empty Square: Variable Markets; **Solid Square: Fixed Markets**
Red: Variable Markups (Oligopolistic Competition + Local Cost Component)

Trade War A-C: Aggregate Productivity

Two Warring Countries C (or A)



The Third Country B



Percentage Differences in Responses between Fixed Markets and Variable Markets

Model	Aggregate Productivity C (or A)	Aggregate Productivity B
Benchmark	1-2%	10-13%
No Local Cost	2-3%	5-9%

Empty Square: Variable Markets; **Solid Square: Fixed Markets**
Red: Variable Markups (Oligopolistic Competition + Local Cost Component)
Cyan: Variable Markups (Oligopolistic Competition Only)

Conclusions

This paper studies changes in trade patterns of multi-destination exporters:

- Empirically, I document three new stylized facts
  - (i) involve large trade value;
  - (ii) are endogenous to local market conditions; and
  - (iii) involve distinct pricing in continuing v.s. changed markets

- Theoretically, I build a multi-country GE model $ABCD^H$
  - $\rightarrow$ interdependence of variable markups and variable markets
  - $\rightarrow$ the third country effect is important

$\Rightarrow$ a step towards building a realistic multi-country framework that captures key features of intensive and extensive adjustments across markets.

Data

1. Chinese Customs Data, 2000-2006

	Products	Exporters	Obs.	Value (billions US$)
2000	6,712	62,746	1,953,638	249
2006	7,171	171,169	6,312,897	967

2. UK Customs Data, 2010-2016 (HMRC administrative datasets)

	Products	Exporters	Obs.	Value (billions £)
All	10,457	165,798	16,357,110	1,987
Non-EU	10,032	159,328	6,772,946	990
EU	10,249	35,751	9,584,164	997

Note: Chinese customs data are aggregated at firm-8 digit HS-commerce mode-destination-year level. UK customs data are aggregated at firm-8 digit CN-destination-year level. UK-EU trade flows are available for firms whose trade value exceeds £250,000 in a given calendar year; these firms account for 96-98% of total trade values.

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Statistics from Firm-product Level Trade Patterns (Median)

	All Firms	Large Firms
British Exporters, non-EU destinations, 2010-2016		
Markets Changes/ Markets	0.86	0.71
Markets Changes/ Markets (Trade Value)	13.72	9.09
Markets Drop/ Market Changes	0.50	0.50
Markets Drop/ Market Changes (Trade Value)	0.49	0.48
Probability of Churn	0.35	0.48

Note: Statistics on British exporters are calculated using HMRC administrative datasets, 2010-2016.

Breakdown by Firm and Product Types (Median, China Results)

	Market Changes / Markets	
	Count Measure	Value Measure
By Form of Commerce		
— General Trade	0.79	4.84
— Processing Trade	0.40	0.22
— Mixture	0.00	0.00
By Rauch Classification		
— Differentiated Products	0.71	3.98
— Reference Priced	0.50	1.01
— Organised Exchange	0.40	0.19
By Firm Ownership		
— Private Enterprises	0.75	4.10
— State-owned Enterprises	0.88	5.98
— Foreign Invested Enterprises	0.33	0.18

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Dispersion in markups is distortionary

Quantity-weighted aggregate productivity can be written as:

$$A_{o,t} = \left(\sum_d \sum_i \sum_f (1+\tau_{o,d}) \frac{1}{\Omega_{f,i,o,t}} \frac{q_{f,i,o,d,t}}{Y_{o,t}} \right)^{-1}$$

where $\Omega_{f,i,o,t}$ denotes productivity of firm f in industry i from origin o. Following Edmond, Midrigan and Xu (2015), this quantity-weighted aggregate productivity A_o can be rewritten in terms of relative markups:

$$A_{o,t} = \left(\sum_i \left(\frac{\mu_{i,o,t}}{M_{o,t}} \right)^{-\eta} \Omega_{i,o,t}^{\eta-1} \right)^{-1}$$

where $M_{o,t} = \left(\sum_d \sum_i \sum_f \frac{1}{\mu_{f,i,o,d}} \frac{p_{f,i,o,d,t} q_{f,i,o,d,t}}{P_{o,t} Y_{o,t}} \right)^{-1}$ and industry-level productivity $\Omega_{i,o,t}$ is:

$$\Omega_{i,o,t} = \left[\sum_d \left(e_{o,d,t} (1+\tau_{o,d,t})^{1-\rho} \sum_f \phi_{f,i,o,d,t} \left(\frac{\mu_{f,i,o,d,t}}{\mu_{i,o,t}} \right)^{-\rho} \Omega_{f,i,o,t}^{\rho-1} \right) \right]^{\frac{1}{\rho-1}}$$

Efficient allocation is achieved when $\frac{\mu_{f,i,o,d,t}}{\mu_{i,o,t}} = 1$ and $\frac{\mu_{i,o,t}}{M_{o,t}} = 1$.

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Deviation from the Common Trade Pattern (CTP)
(Based on UK to Non-EU exports)

			Distribution (Percentile)				
	Mean	Median	1st	25th	75th	99th	Obs.
8-digit level deviation from							
product-time CTP	1.34	1.50	0.00	0.67	2.00	2.00	2,118,190
firm-product CTP	0.70	0.00	0.00	0.00	1.25	4.00	2,118,190
2-digit level deviation from							
product-time CTP	1.28	1.33	0.00	0.80	2.00	2.00	795,062
firm-product CTP	0.67	0.24	0.00	0.00	1.00	4.00	795,062

Note: This table presents measures of deviations from the common trade pattern. Two deviation measures are constructed, the deviation from the product-time common trade pattern and the deviation from the firm-product common trade pattern. Note that the deviation is normalized by the number of markets traded to facilitate the comparison across firms. Statistics are calculated based on non-EU exports of British firms during 2010-2016. Source: Calculations based on HMRC administrative datasets.

China Results

Elasticity of Prices and Quantities to DC Ratio
(Summary of Key Estimates, Based on UK to Non-EU exports)

	Unit Value	Mean Quantity	Total Quantity	Observations
Firm-product (8-digit) level	0.24***	-0.44***	-2.28***	793,046
Firm-sector (2-digit) level	0.25***	-0.30***	-1.98***	401,386
Firm level	0.34***	-0.24***	-1.86***	257,471

Note: This table summarizes the key estimates characterizing the relationship between switching and pricing. The first column indicates the level of disaggregation at which the trade pattern measures are constructed. The header of the second to fourth columns indicates the dependent variable of the corresponding estimation equation. Estimates are obtained from regressing changes of the variable described in the column header on the drop change ratio. **Each cell represents an estimate from a separate estimation equation.** Firm-product and year fixed effects are added for firm-product and firm-sector specifications. Firm and year fixed effects are added for firm level specifications. The statistical significance is calculated based on robust standard errors with ***, **, * representing statistical significance at 1%, 5%, 10% respectively. Source: Calculations based on HMRC administrative datasets, non-EU exports, 2010-2016.

China Results

Price and Quantity of Continuing Markets to DC Ratio (Summary of Key Estimates, Based on UK to Non-EU exports)

	Unit Value	Mean Quantity	Observations
Firm-product (8-digit) level	0.01**†	-0.35***	483,774
Firm-sector (2-digit) level	0.03***†	-0.27***	299,470
Firm level	0.01†	-0.21***	205,870

Note: The upper panel represents estimates from regressing unit value or mean quantity on the DC ratio after controlling the unit value or mean quantity of the continuing markets. The bottom panel represents estimates from regressing the unit value or quantities of continuing markets on the DC ratio. The first column indicates the level of disaggregation at which the trade pattern measures are constructed. The header of the second and the third columns indicates the dependent variable of the corresponding estimation equation. **Each cell represents an estimate from a separate estimation equation.** Firm-product and year fixed effects are added for firm-product and firm-sector specifications. Firm and year fixed effects are added for firm level specifications. The statistical significance is calculated based on robust standard errors with ***, **, * representing statistical significance at 1%, 5%, 10% respectively. † indicates the estimate is sensitive to alternative samples and measurements. Source: Calculations based on HMRC administrative datasets, non-EU exports, 2010-2016.

China Results

DC Ratio to Changes in Relative Market Conditions (Based on UK to Non-EU exports)

	Exchange Rate	Destination CPI	Within R^2	Observations
Count Measure				
Firm-product (8-digit) level	-0.12***	-1.06***	0.20	805,626
Firm-sector (2-digit) level	-0.11***	-0.97***	0.19	405,255
Firm-level	-0.09***	-0.92***	0.19	259,026
Trade Value Measure				
Firm-product (8-digit) level	-0.12***	-1.07***	0.15	805,626
Firm-sector (2-digit) level	-0.10***	-0.99***	0.14	405,255
Firm level	-0.09***	-0.93***	0.14	259,026

Note: This table shows estimates from regressing drop-change ratio on augmented exchange rates and destination CPI measures. The upper panel shows results using non-weighted drop-change ratio as the dependent variable and the bottom panels shows results using trade-weighted drop-change ratio as the dependent variable. The subsections of the first column indicate the level of disaggregation at which the trade pattern measures are constructed. Firm-product and year fixed effects are added for firm-product and firm-sector specifications. Firm and year fixed effects are added for firm level specifications. The statistical significance is calculated based on robust standard errors with ***, **, * representing statistical significance at 1%, 5%, 10% respectively. Source: Calculations based on HMRC administrative datasets, non-EU exports, 2010-2016.

China Results

Mean Distance to DC Ratio
(Based on UK to Non-EU exports)

	Mean Distance	Within R^2	Observations
Count Measure			
Firm-product (8-digit) level	-0.21***	0.01	805,626
Firm-sector (2-digit) level	-0.10***	0.00	405,255
Firm level	-0.20***	0.02	259,026
Trade Value Measure			
Firm-product (8-digit) level	-0.16***	0.01	805,626
Firm-sector (2-digit) level	-0.11***	0.00	405,255
Firm level	-0.15***	0.01	259,026

Note: This table shows estimates from regressing changes in average distance of trading markets on the DC ratio. The upper panel shows results using non-weighted drop-change ratio as the dependent variable and the bottom panels shows results using trade weighted drop-change ratio as the dependent variable. The subsections of the first column indicate the level of disaggregation at which the trade pattern measures are constructed. Firm-product and year fixed effects are added for firm-product and firm-sector specifications. Firm and year fixed effects are added for firm level specifications. The statistical significance is calculated based on robust standard errors with ***, **, * representing statistical significance at 1%, 5%, 10% respectively. Source: Calculations based on HMRC administrative datasets, non-EU exports, 2010-2016.

China Results

Long distance markets are more likely to be dropped

Mean Distance to Drop-Change Ratio (China Results)

	Mean Distance	Within R^2	Observations
Count Measure			
8-digit	-0.16***	0.01	1,791,353
2-digit	-0.13***	0.01	875,096
Firm-level	-0.20***	0.04	301,455
Trade Value Measure			
8-digit	-0.13***	0.01	1,791,353
2-digit	-0.13***	0.01	875,095
Firm-level	-0.15***	0.03	301,455

UK Results

Measures Based on Deviation from the **Common Trade Pattern within Firm**

					Common Trade Pattern	**Deviation**		**N. of Deviations/ Markets**
$t=1$	A	B			A-C	B	$-C$	2/2
$t=2$	A		C		A-C			0
$t=3$	A		C	D	A-C		D	1/3
$t=4$	A		C		A-C			0

Statistics Based on Chinese Exporters, 2000-2006:

			Distribution (Percentile)				
	Mean	Median	1st	25th	75th	99th	Obs.
8-digit level deviation from the CTP within firm	0.64	0.00	0.00	0.00	1.00	5.00	6,042,761
2-digit level deviation from the CTP within firm	0.71	0.00	0.00	0.00	1.00	7.00	1,927,599

UK Results | Back Firm Product Level | Back Firm Level

Measures Based on Deviation from the **Common Trade Pattern** across Firms

					Common Trade Pattern	**Deviation**	**N. of Deviations/ Markets**
$t = 1$	A	B			A	B	1/2
$t = 2$	A		C		A-C		0
$t = 3$	A		C	D	A-C	D	1/3
$t = 4$	A		C		A	C	1/2

Statistics Based on Chinese Exporters, 2000-2006:

			Distribution (Percentile)				
	Mean	Median	1st	25th	75th	99th	Obs.
8-digit level deviation from							
the CTP across firms	1.28	1.50	0.00	0.75	2.00	2.00	6,042,761
the CTP within firm	0.64	0.00	0.00	0.00	1.00	5.00	6,042,761
2-digit level deviation from							
the CTP across firms	1.23	1.25	0.00	0.83	2.00	2.00	1,927,599
the CTP within firm	0.71	0.00	0.00	0.00	1.00	7.00	1,927,599

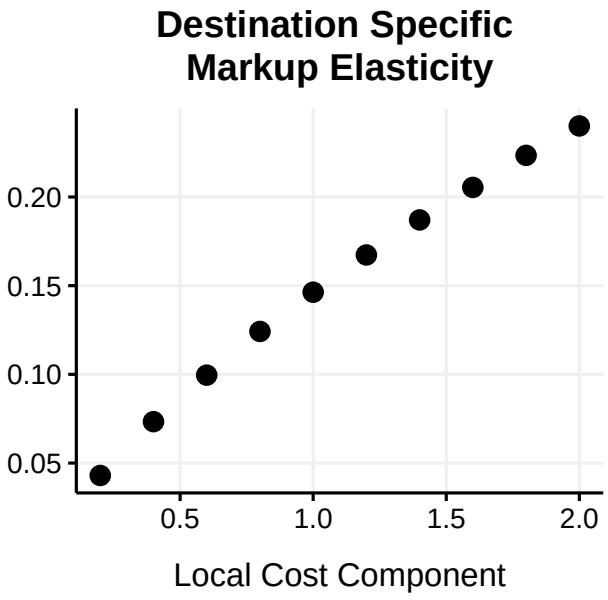
UK Results | Back Firm Product Level | Back Firm Level

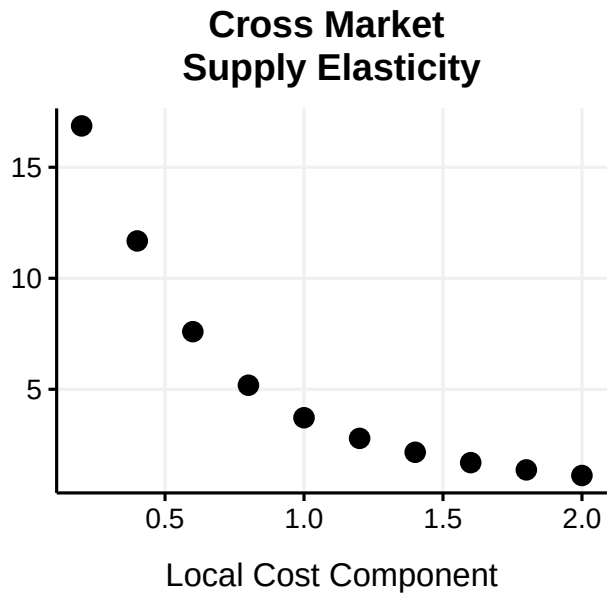
Additional Model Moments

	3 countries	2 countries	1 country
Fraction exporters (A to B)	0.169	0.194	-
Fraction exporters (A to C)	0.170	-	-
Firms of A: Home markup relative to B (median)	1.089	1.085	-
Firms of A: Home markup relative to C (median)	1.090	-	-
Exporters of A: Markup in B relative to C (median)	1.000	-	-
Firms of A: Home quantity relative to B (median)	1.289	1.355	-
Firms of A: Home quantity relative to C (median)	1.297	-	-
Exporters of A: Quantity in B relative to C (median)	1.000	-	-
Markup of domestic firms (median)	1.260	1.246	1.348
Markup of 1-country exporters (median)	2.375	2.307	-
Markup of 2-country exporters (median)	3.883	-	-
Distribution margin of domestic firms (median)	0.153	0.148	0.098
Exporters of A: Distribution margin in B (median)	0.596	0.568	-
Exporters of A: Distribution margin in C (median)	0.597	-	-

Go Back

Local Component Helps to Match Intensive Margins





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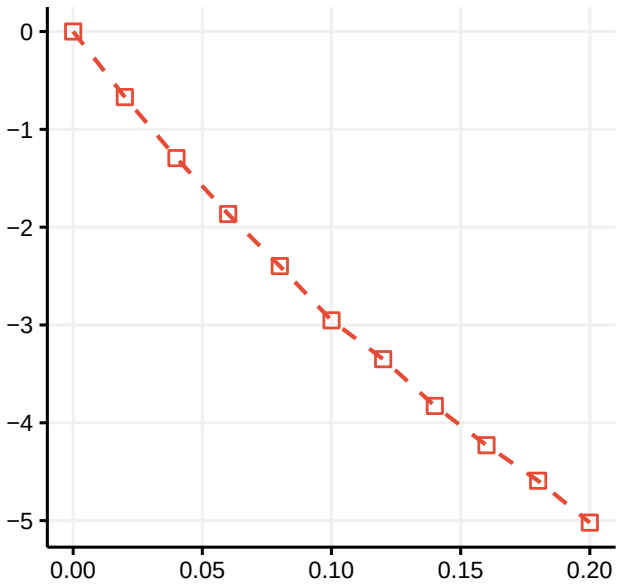
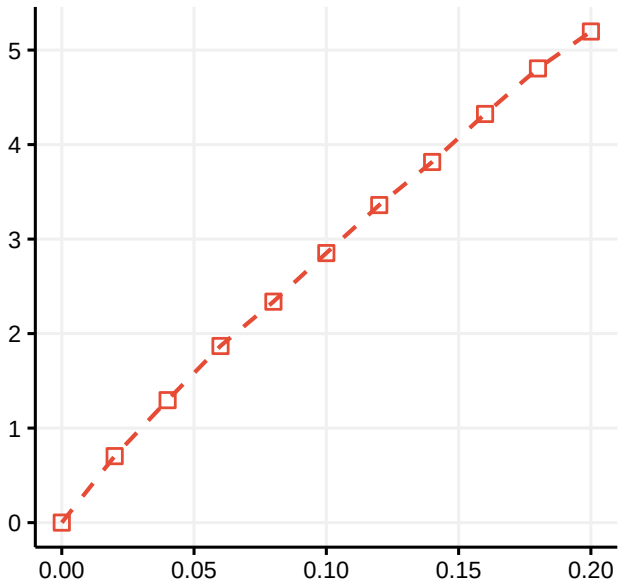
Trade War A-C: Trade Deflection

In equilibrium, country B's currency appreciate, making products from C (and A) cheaper in B.

Bilateral Exchange Rates B to C



Number of Exporters C to B



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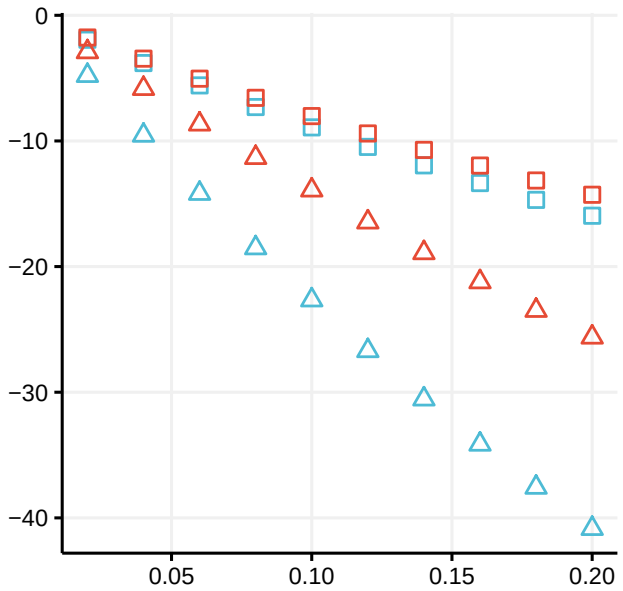
Trade War A-C: Imports

Two versus Three-Country Models

Adding the third country significantly reduce the effect of the trade war

Country C: Changes in Import Share

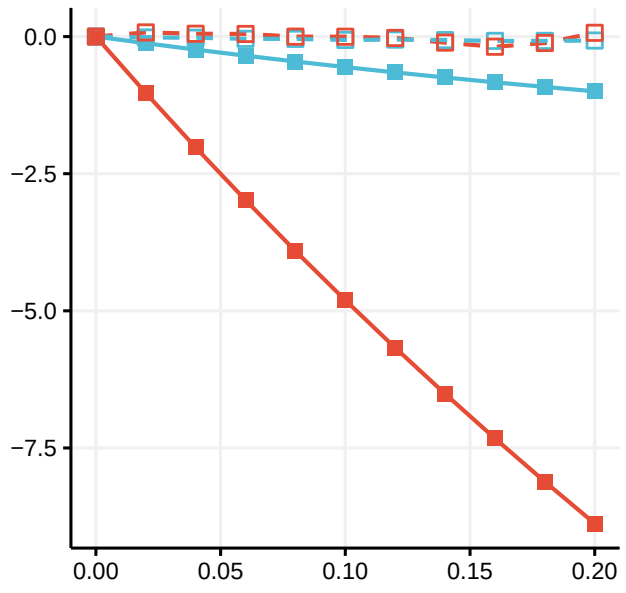


Empty Square: Three-Country Models (with Variable Markets);
Empty Triangle: Two-Country Models (with Variable Markets)
Red: Variable Markups (Oligopolistic Competition + Local Cost Component)
Cyan: Variable Markups (Oligopolistic Competition Only)

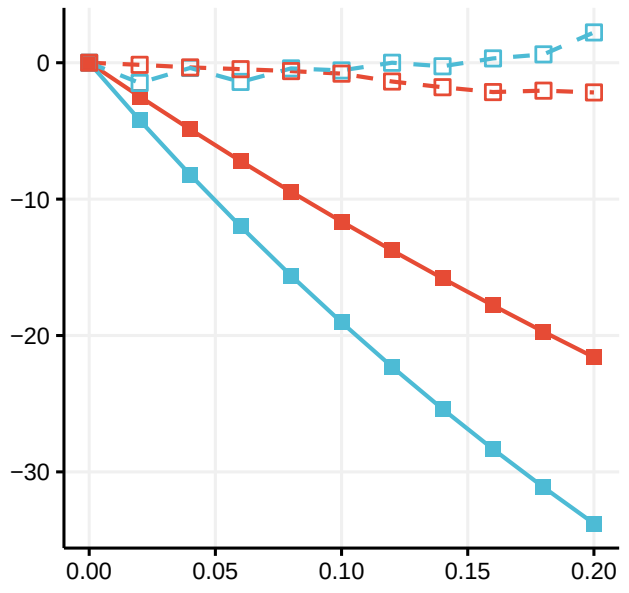
Trade War A-C: Quantity Responses

(i) Market Changes Reduce Quantity Responses
(ii) Markup Adjustments Further Dampen Quantity Responses

Markups of Exporters from Country C to A



Quantity of Exporters from Country C to A



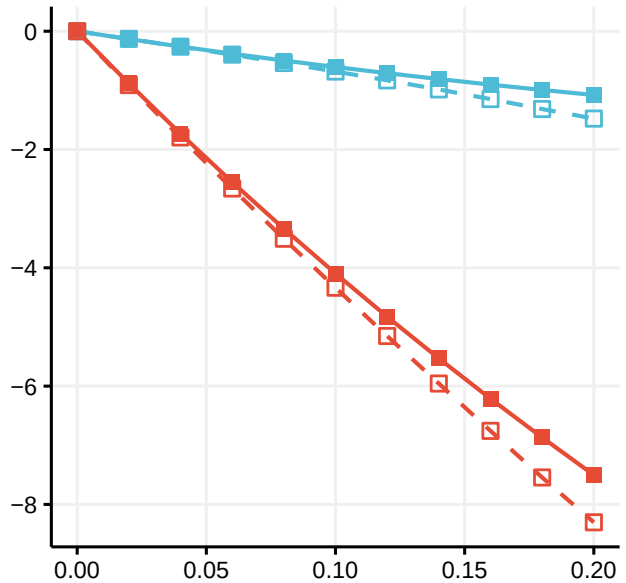
Empty Square: Variable Markets; **Solid Square: Fixed Markets**
Red: Variable Markups (Oligopolistic Competition + Local Cost Component)
Cyan: Variable Markups (Oligopolistic Competition Only)

Trade War A-C: Relative Markups and Quantities

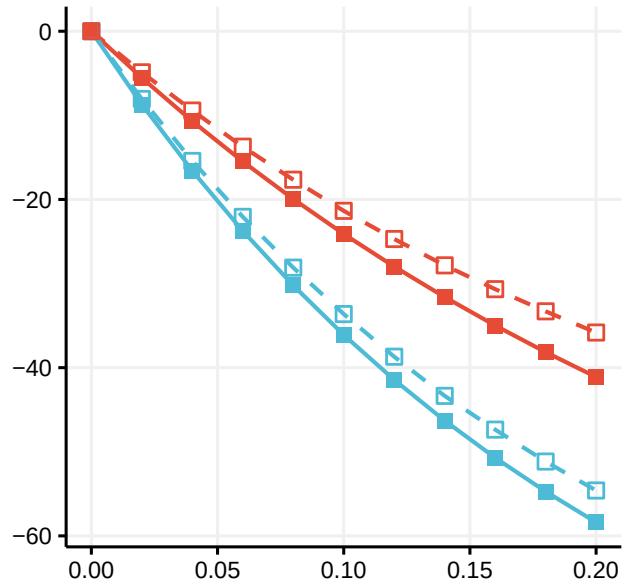
For exporters of C:

- Markup in A is relatively lower compared to B; the difference is larger with variable markets
- Relative quantity decreases in all models; the decrease is smaller with variable markups and variable markets

Exporters of C: Markup in A relative to B



Exporters of C: Quantity in A relative to B



Empty Square: Variable Markets; **Solid Square: Fixed Markets**
Red: Variable Markups (Oligopolistic Competition + Local Cost Component)
Cyan: Variable Markups (Oligopolistic Competition Only)

Markups and Quantities

$$\text{markup:} \quad \widehat{\mu}^{b*} = \frac{1}{1-dm} \left\{ \begin{array}{l} (1-\lambda)\kappa(1-ms)\widehat{\alpha} \\ -(1-\lambda)\kappa\widehat{CE} \\ +[(1-\lambda)\omega - dm]\widehat{\chi} \\ +\left[1-(1-\lambda)(1-\omega)-dm\right](\widehat{e}-\widehat{mc}) \end{array} \right\}$$

$$\text{quantity:} \quad \widehat{q} = \widehat{\alpha} - \varepsilon\widehat{p} - \frac{\rho-\eta}{\rho-1}\widehat{CE} + \eta\widehat{P} + \widehat{C}$$

Subscripts are omitted for simplicity

$\lambda(ms, \rho, \eta)$ captures the degree of competition among firms

$\kappa(ms, \eta, \rho)$: price elasticity w.r.t. market share

$\omega(mc, \chi, e)$: cost share of distribution

dm: distribution margin

ρ: within industry elasticity of substitution

η: cross industry elasticity of substitution