Understanding International Prices: Customers as Capital

Lukasz A. Drozd[1] Jaromir B. Nosal[2]

[1] University of Wisconsin-Madison

[2] Columbia University

- Fundamental features of international price data
  - Aggregate data:
    - *Real* export and import prices of a country *positively* correlated
    - Both *positively* correlated with the real exchange rate
  - Disaggregated data shows evidence of pricing to market
    - export price $\neq$ domestic price for the same commodities
    - vary systematically with the real exchange rate

- Fundamental features of international price data
  - Aggregate data:
    - *Real* export and import prices of a country *positively* correlated
    - Both *positively* correlated with the real exchange rate
  - Disaggregated data shows evidence of pricing to market
    - export price $\neq$ domestic price for the same commodities
    - vary systematically with the real exchange rate
- Puzzle for a large class of models

Outline

- Illustrate why these observations are puzzling
- Document correlation of aggregate prices
- Document pricing-to-market using disaggregated data
- Propose model with customers as capital
- Show how model consistent with prices and quantities

Illustrate the Puzzle for Standard Theory

- Assumes
  - country specific tradable goods; possibly non-tradable goods
  - consumption baskets biased towards the home tradable good
  - law of one price for each tradable good

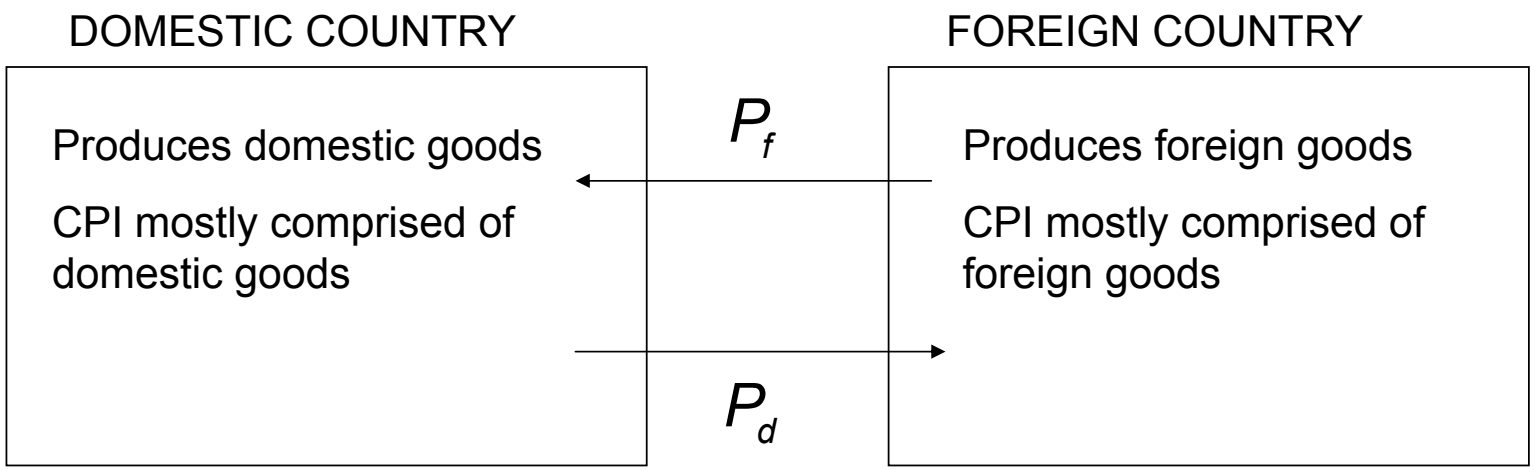
Illustrate the Puzzle for Standard Theory

- Assumes
  - country specific tradable goods; possibly non-tradable goods
  - consumption baskets biased towards the home tradable good
  - law of one price for each tradable good
    - inconsistent with pricing-to-market observations

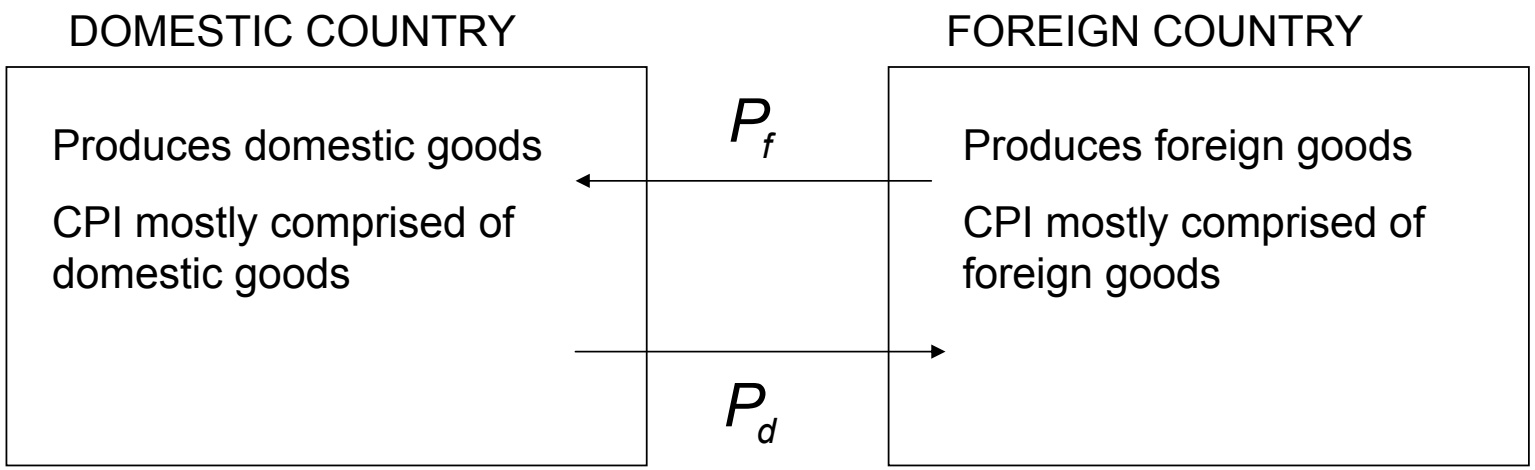
Illustrate the Puzzle for Standard Theory

- Assumes
  - country specific tradable goods; possibly non-tradable goods
  - consumption baskets biased towards the home tradable good
  - law of one price for each tradable good
    - inconsistent with pricing-to-market observations
    - show also inconsistent with aggregate data

Illustrate the Puzzle for Standard Theory



Illustrate the Puzzle for Standard Theory

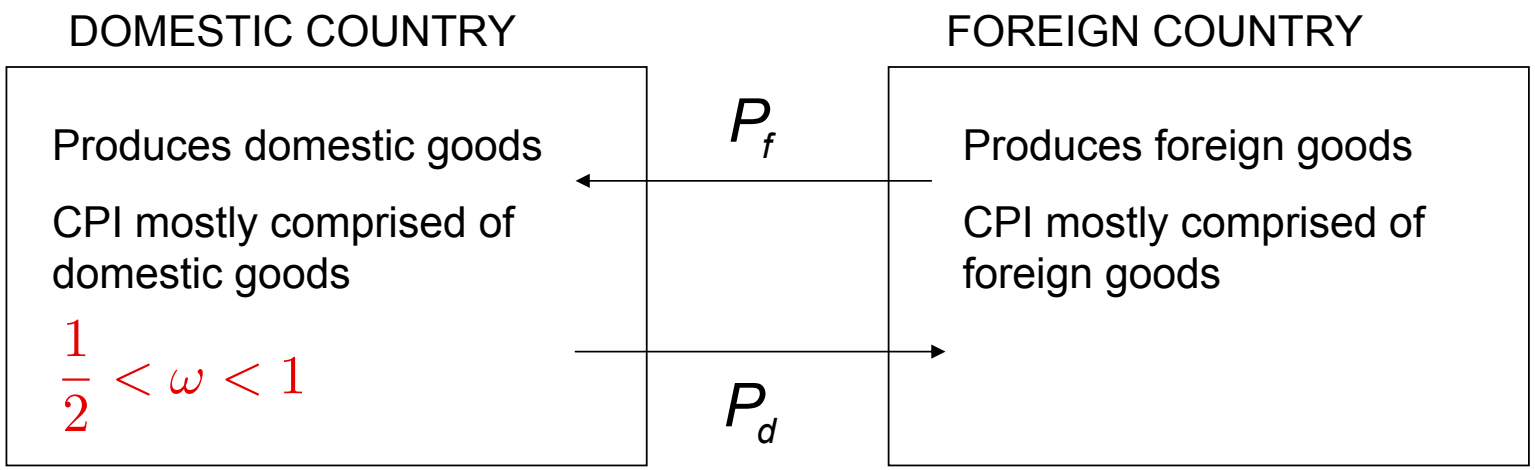


$$p_m \equiv \frac{P_f}{CPI} \equiv \frac{P_f}{(P_d)^{\omega}(P_f)^{1-\omega}} = (\frac{P_f}{P_d})^{\omega}$$

$$\Rightarrow corr(p_x, p_m) = -1$$

$$p_x \equiv \frac{P_d}{CPI} \equiv \frac{P_d}{(P_d)^{\omega}(P_f)^{1-\omega}} = (\frac{P_d}{P_f})^{1-\omega}$$

Illustrate the Puzzle for Standard Theory



$$p_m \equiv \frac{P_f}{CPI} \equiv \frac{P_f}{(P_d)^{\omega}(P_f)^{1-\omega}} = (\frac{P_f}{P_d})^{\omega}$$

$$\Rightarrow corr(p_x, p_m) = -1$$

$$p_x \equiv \frac{P_d}{CPI} \equiv \frac{P_d}{(P_d)^{\omega}(P_f)^{1-\omega}} = (\frac{P_d}{P_f})^{1-\omega}$$

$$\Rightarrow corr(p_x, x) = -1$$

$$x \equiv \frac{CPI^*}{CPI} = \frac{(P_f)^{\omega}(P_d)^{1-\omega}}{(P_d)^{\omega}(P_f)^{1-\omega}} = (\frac{P_f}{P_d})^{2\omega-1}$$

Evidence for Correlations of Aggregate Prices

12 major OECD countries

Statistics refer to detrended quarterly series, 1980-2004

	Statistic	
	$corr(p_x, p_m)$	$corr(p_x, x)$
OECD median	0.87	0.61

where

$$p_x = \frac{EPI}{CPI}, \quad p_m = \frac{IPI}{CPI} \quad x = \frac{CPI^*}{CPI}$$

$EPI =$ export price index, $IPI =$ import price index

Data has opposite signs as the standard model

Non-tradable Goods?

- With non-tradable goods, the CPI is given by

$$CPI = (v(P_d^{\omega} P_f^{1-\omega})^{\frac{\mu-1}{\mu}} + (1-v)(CPI^N)^{\frac{\mu-1}{\mu}})^{\frac{\mu}{\mu-1}},$$

where: v - share of N goods, μ - elasticity between T & N

Non-tradable Goods?

- With non-tradable goods, the CPI is given by

$$CPI = (v(P_d^{\omega} P_f^{1-\omega})^{\frac{\mu-1}{\mu}} + (1-v)(CPI^N)^{\frac{\mu-1}{\mu}})^{\frac{\mu}{\mu-1}},$$

where: v - share of N goods, μ - elasticity between T & N

- From the definition of p_x and p_m, obtain

$$p_x \equiv \frac{P_d}{CPI} \equiv \frac{P_d}{(v(P_d^{\omega} P_f^{1-\omega})^{\frac{\mu-1}{\mu}} + (1-v)(CPI^N)^{\frac{\mu-1}{\mu}})^{\frac{\mu}{\mu-1}}}$$

$$p_m \equiv \frac{P_f}{CPI} \equiv \frac{P_f}{(v(P_d^{\omega} P_f^{1-\omega})^{\frac{\mu-1}{\mu}} + (1-v)(CPI^N)^{\frac{\mu-1}{\mu}})^{\frac{\mu}{\mu-1}}}$$

Non-tradable Goods?

- With non-tradable goods, the CPI is given by

$$CPI = (v(P_d^{\omega} P_f^{1-\omega})^{\frac{\mu-1}{\mu}} + (1-v)(CPI^N)^{\frac{\mu-1}{\mu}})^{\frac{\mu}{\mu-1}},$$

where: v - share of N goods, μ - elasticity between T & N

- From the definition of p_x and p_m, obtain

$$p_x^T \equiv \left[\frac{1}{v}(\frac{P_d}{CPI})^{\frac{1-\mu}{\mu}} - \frac{(1-v)}{v}(\frac{P_d}{CPI^N})^{\frac{1-\mu}{\mu}}\right]^{\frac{\mu}{1-\mu}} = (\frac{P_d}{P_f})^{(1-\omega)}$$

$$p_m^T \equiv \left[\frac{1}{v}(\frac{P_f}{CPI})^{\frac{1-\mu}{\mu}} - \frac{(1-v)}{v}(\frac{P_f}{CPI^N})^{\frac{1-\mu}{\mu}}\right]^{\frac{\mu}{1-\mu}} = (\frac{P_f}{P_d})^{\omega}$$

$$\Rightarrow corr(p_x^T, p_m^T) = -1$$

Non-tradable Goods?

9 major OECD countries

Statistics refer to detrended quarterly series, 1980-2000

	Statistic	
	$corr(p_x^T, p_m^T)$	$corr(p_x^T, x)$
OECD median	0.84	0.60

where

$$p_x^T \equiv \left[\frac{1}{v} p_x^{\frac{1-\mu}{\mu}} - \frac{(1-v)}{v}(p_x^N)^{\frac{1-\mu}{\mu}}\right]^{\frac{\mu}{1-\mu}}$$

$$p_m^T \equiv \left[\frac{1}{v} p_m^{\frac{1-\mu}{\mu}} - \frac{(1-v)}{v}(p_m^N)^{\frac{1-\mu}{\mu}}\right]^{\frac{\mu}{1-\mu}}$$

Data has opposite signs as the standard model

Non-tradable Goods?

9 major OECD countries

Statistics refer to detrended quarterly series, 1980-2000

	Statistic	
	$corr(p_x^T, p_m^T)$	$corr(p_x^T, x)$
OECD median	0.84	0.60

where

$$p_x^T \equiv \left[\frac{1}{v} p_x^{\frac{1-\mu}{\mu}} - \frac{(1-v)}{v} (p_x)^{\frac{1-\mu}{\mu}} \right]^{\frac{\mu}{1-\mu}}$$

$$p_m^T \equiv \left[\frac{1}{v} p_m^{\frac{1-\mu}{\mu}} - \frac{(1-v)}{v} (p_m)^{\frac{1-\mu}{\mu}} \right]^{\frac{\mu}{1-\mu}}$$

Data has opposite signs as the standard model

Non-tradable Goods?

9 major OECD countries

Statistics refer to detrended quarterly series, 1980-2000

	Statistic	
	$corr(p_x^T, p_m^T)$	$corr(p_x^T, x)$
OECD median	0.84	0.60

where

$$p_x^T = p_x$$

$$p_m^T = p_m$$

Data has opposite signs as the standard model

Disaggregated Evidence For Pricing-To-Market

Disaggregated Evidence For Pricing-To-Market

- Chosen OECD country: Japan
  - Strong patterns on macro level (all correlations close to 1)
  - Conveniently tabulated data (domestically-produced & sold goods)

Disaggregated Evidence For Pricing-To-Market

- Chosen OECD country: Japan
  - Strong patterns on macro level (all correlations close to 1)
  - Conveniently tabulated data (domestically-produced & sold goods)
- Disaggregated data for Japan suggests
  - Export price movements attributable to pricing-to-market (PTM)
  - PTM may be all we need to understand aggregate prices

Disaggregated Evidence For Pricing-To-Market

- Disaggregated wholesale price data for Japan 1995-2004
- Quarterly frequency, detrended using HP-filter
  - 31 manufacturing commodities: copying machines, computers, etc...

Disaggregated Evidence For Pricing-To-Market

- Disaggregated wholesale price data for Japan 1995-2004
- Quarterly frequency, detrended using HP-filter
  - 31 manufacturing commodities: copying machines, computers, etc...
    - Domestic Price : DP^i
      - price of goods produced and sold at home
    - Export Price : EP^i
      - price of goods produced at home but sold abroad

Micro Evidence For Pricing-To-Market

- Decomposing movements in real export price of commodity i

$$p_x^i \equiv \frac{EP^i}{CPI} \equiv \underbrace{\frac{EP^i}{DP^i}}_{\text{PTM}} \underbrace{\frac{DP^i}{CPI}}_{\text{Res}}$$

PTM. Pricing-To-Market

– deviations of export price from domestic price for the same good

Res. Residual term

– deviations of domestic price of the good from CPI

Micro Evidence For Pricing-To-Market

- Decomposing movements in real export price of commodity i

$$p_x^i \equiv \frac{EP^i}{CPI} \equiv \underbrace{\frac{EP^i}{DP^i}}_{\text{PTM}} \underbrace{\frac{DP^i}{CPI}}_{\text{Res}}$$

- Decomposing volatility: $\text{var}(p_x^i)/\text{var}(x) \approx 88\%$

$$\text{PTM} = \frac{\text{var}(\frac{EP^i}{DP^i})}{\text{var}(\frac{EP^i}{DP^i}) + \text{var}(\frac{DP^i}{CPI})} \approx 93\%$$

$$\text{Res} = \frac{\text{var}(\frac{DP^i}{CPI})}{\text{var}(\frac{EP^i}{DP^i}) + \text{var}(\frac{DP^i}{CPI})} \approx 7\%$$

Micro Evidence For Pricing-To-Market

- Decomposing movements in real export price of commodity i

$$p_x^i \equiv \frac{EP^i}{CPI} \equiv \underbrace{\frac{EP^i}{DP^i}}_{\text{PTM}} \underbrace{\frac{DP^i}{CPI}}_{\text{Res}}$$

- Decomposing volatility: $\text{var}(p_x^i)/\text{var}(x) \approx 88\%$

$$\text{PTM} = \frac{\text{var}(\frac{EP^i}{DP^i})}{\text{var}(\frac{EP^i}{DP^i}) + \text{var}(\frac{DP^i}{CPI})} \approx 93\%$$

$$\text{Res} = \frac{\text{var}(\frac{DP^i}{CPI})}{\text{var}(\frac{EP^i}{DP^i}) + \text{var}(\frac{DP^i}{CPI})} \approx 7\%$$

- **Volatility attributable to pricing-to-market (PTM)**

Micro Evidence For Pricing-To-Market

- Decomposing movements in real export price of commodity i

$$p_x^i \equiv \frac{EP^i}{CPI} \equiv \underbrace{\frac{EP^i}{DP^i}}_{\text{PTM}} \underbrace{\frac{DP^i}{CPI}}_{\text{Res}}$$

- Decomposing correlation with x: $\text{corr}(\ p_x^i,\ x\ ) = \quad 0.82$

$$\text{PTM} = \text{corr}(\ \frac{EP^i}{DP^i},\ x\ ) \ = \quad 0.84$$

$$\text{Res} = \text{corr}(\ \frac{DP^i}{CPI},\ x\ ) \ = -0.15$$

Micro Evidence For Pricing-To-Market

- Decomposing movements in real export price of commodity i

$$p_x^i \equiv \frac{EP^i}{CPI} \equiv \underbrace{\frac{EP^i}{DP^i}}_{\text{PTM}} \underbrace{\frac{DP^i}{CPI}}_{\text{Res}}$$

- Decomposing correlation with x: $\text{corr}(\ p_x^i,\ x\ ) = \quad 0.82$

$$\text{PTM} = \text{corr}(\ \frac{EP^i}{DP^i},\ x\ ) \ = \quad 0.84$$

$$\text{Res} = \text{corr}(\ \frac{DP^i}{CPI},\ x\ ) \ = -0.15$$

- **Correlation attributable to pricing-to-market (PTM)**

Data - Summary

- Aggregate data
  - real export and import prices positively correlated
  - real export price positively correlated with the real exchange rates
- Disaggregated data suggests
  - export price movements can be attributed to pricing-to-market

    for more evidence see the survey by Goldberg and Knetter (1997)

This Paper

- Building market shares is costly and time consuming

  as argued by Dornbusch (1987) and Krugman (1986)

- Leads to *variable markups* and *pricing-to-market*

This Paper

- Building market shares is costly and time consuming
  as argued by Dornbusch (1987) and Krugman (1986)
- Leads to *variable markups* and *pricing-to-market*
- Contribution
  - formalize this idea into a micro-founded GE model
  - make the model quantitative using evidence on
    - different S-R and L-R price elasticity of trade flows
  - address the question how promising is this mechanism
    to account for the price data

Related Literature

- Direct Evidence
  - Hakansson (1982), Egan & Mody (1993) Turnbull & Cunnigham (1981), Ruhl & Willis (2008)

Related Literature

- Direct Evidence
  - Hakansson (1982), Egan & Mody (1993) Turnbull & Cunnigham (1981), Ruhl & Willis (2008)
- Models of Pricing-to-Market (Dornbusch 1987, Krugman 1986)
  - Sluggish market shares: Froot & Klemperer (1989), Alessandria (2004)
  - Consumer Search: Alessandria (2005)
  - Vertical Structure of Industry: Atkeson & Burstein (2008)
  - Local Nontradable Component: Dedola & Corsetti (2002, 2004)

Related Literature

- Direct Evidence
  - Hakansson (1982), Egan & Mody (1993) Turnbull & Cunnigham (1981), Ruhl & Willis (2008)
- Models of Pricing-to-Market (Dornbusch 1987, Krugman 1986)
  - Sluggish market shares: Froot & Klemperer (1989), Alessandria (2004)
  - Consumer Search: Alessandria (2005)
  - Vertical Structure of Industry: Atkeson & Burstein (2008)
  - Local Nontradable Component: Dedola & Corsetti (2002, 2004)
- Short-Run/Long-Run Elasticity Puzzle
  - Sunk Cost of Entry: Ruhl (2008)
  - Evidence: Eaton & Kortum (2002), Head & Ries (2001), Hummels (2001), Reinert & Roland-Holst (1992)
- Incomplete Pass-Through Literature
  - Goldberg & Campa (2005,06), Goldberg & Knetter (1997), Marston (1990)

Model

Basic Structure

- Symmetric world with two-countries and country-specific goods
  - d good produced in the *domestic country*
  - f good produced in the *foreign country*

Basic Structure

- Symmetric world with two-countries and country-specific goods
  - d good produced in the *domestic country*
  - f good produced in the *foreign country*
- Composite consumption and investment good
  - domestic country: $c + i = G(d, f)$
  - foreign country: $c^* + i^* = G(f^*, d^*)$

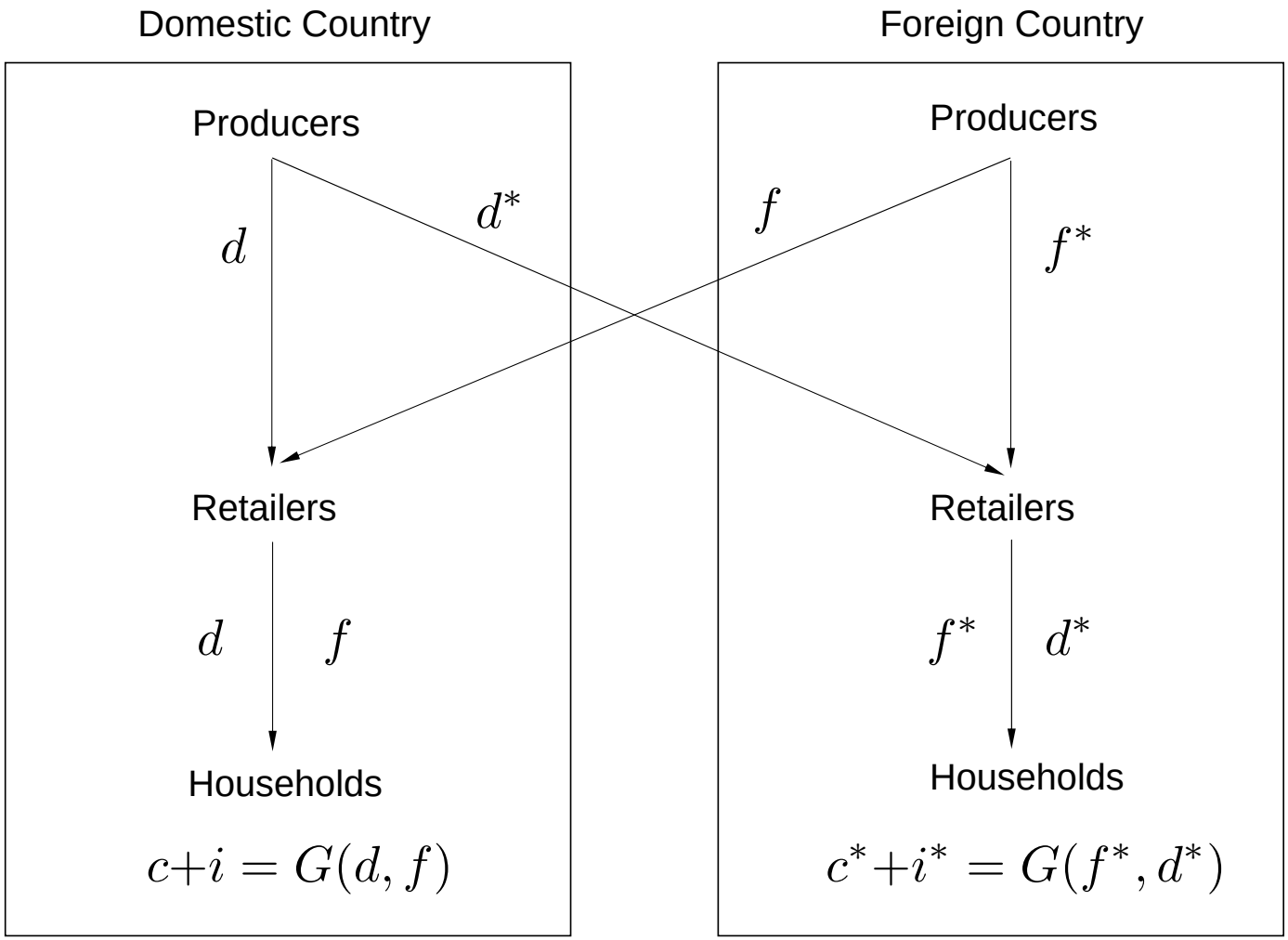
Basic Structure

- Symmetric world with two-countries and country-specific goods
  - d good produced in the *domestic country*
  - f good produced in the *foreign country*
- Composite consumption and investment good
  - domestic country: $c + i = G(d, f)$
  - foreign country: $c^* + i^* = G(f^*, d^*)$
- d and f the only tradable goods
- Physical capital and labor immobile across countries

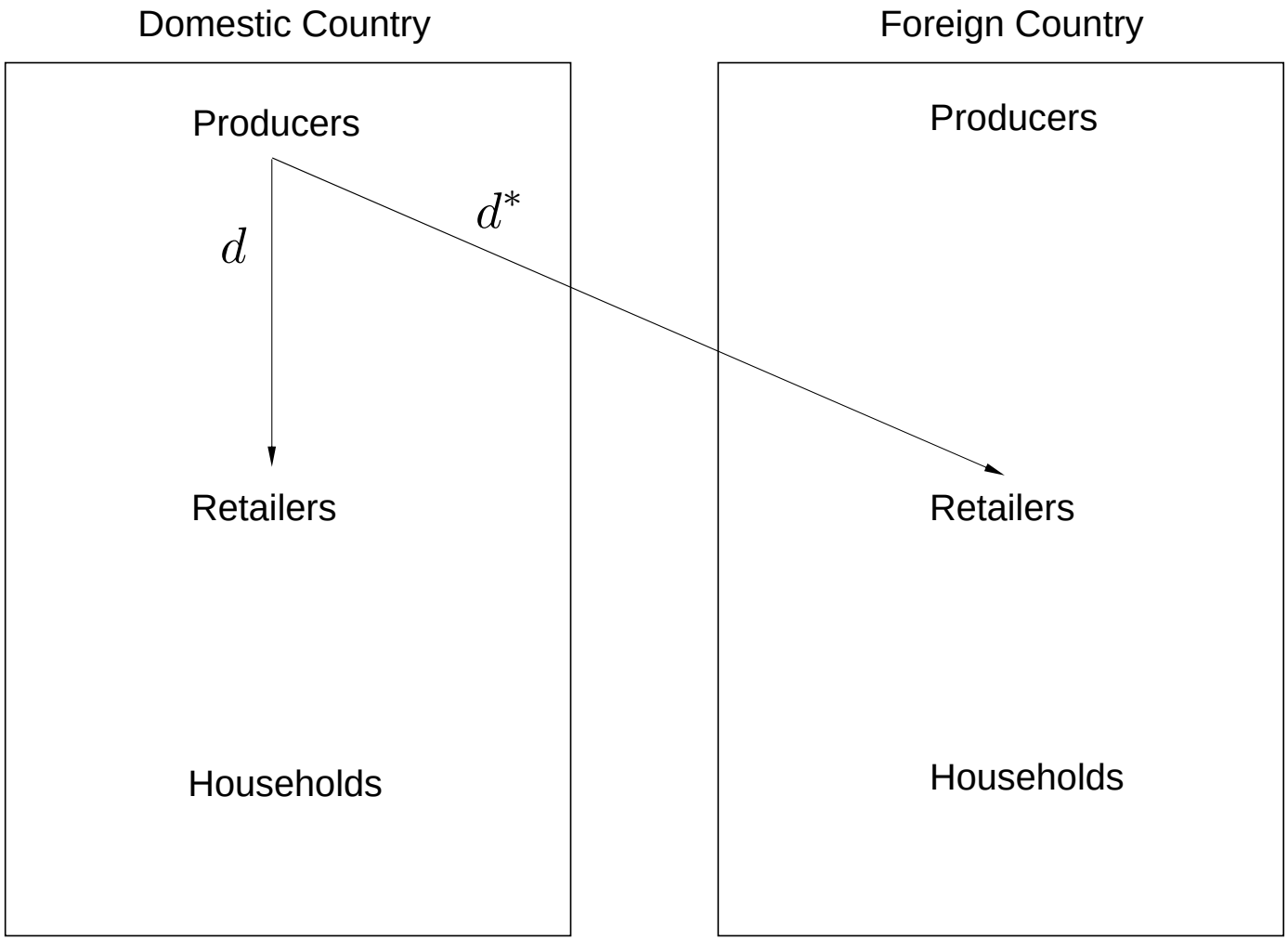
Agents

- Producers
  - Produce goods d at home (f abroad), match with retailers
- Retailers
  - Match with producers, intermediate in trade between producers and households
- Households
  - Buy goods from retailers, accumulate physical capital, supply labor and capital to producers, trade assets

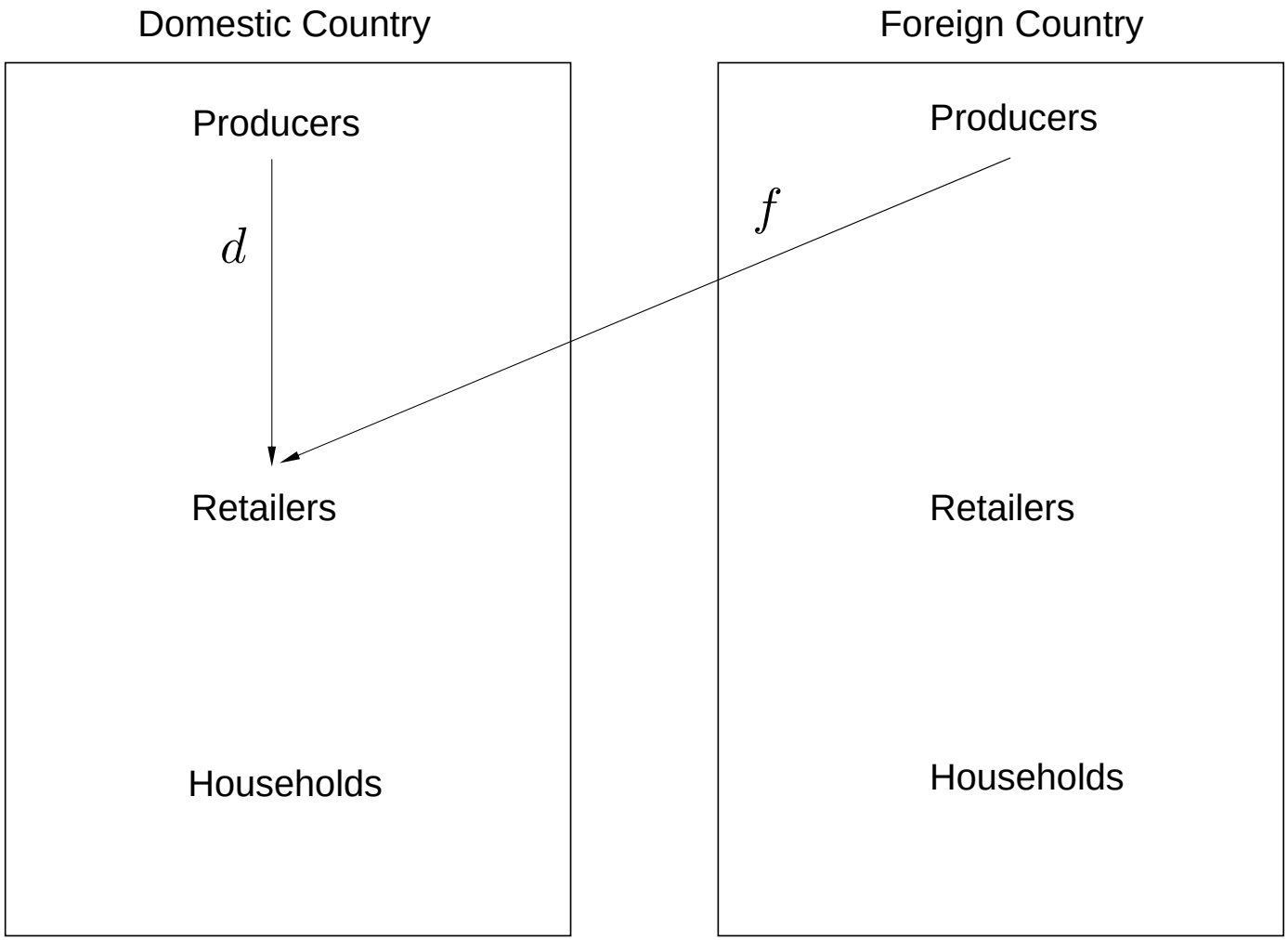
Flow of Goods



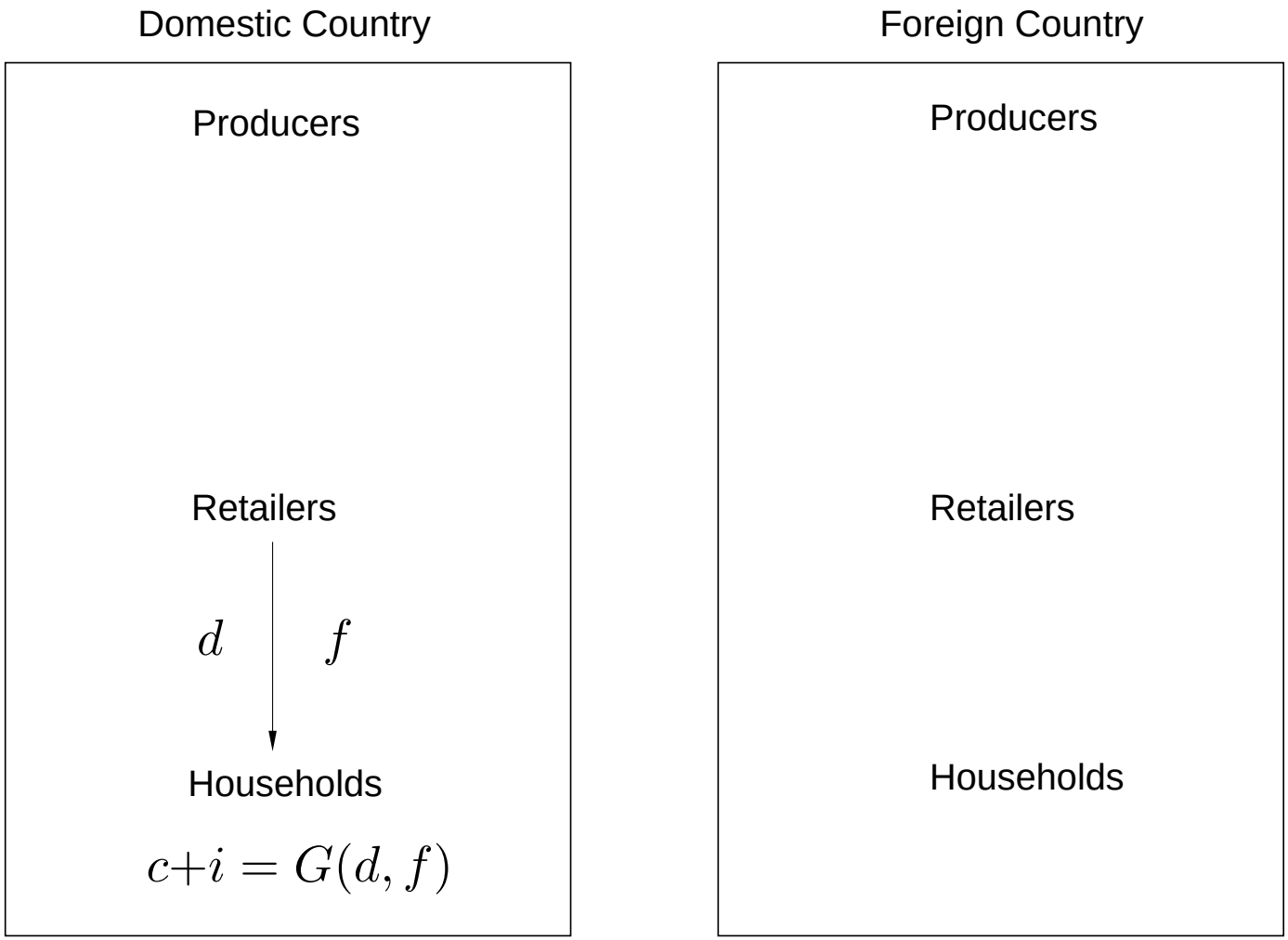
Flow of Goods



Flow of Goods



Flow of Goods



Two Levels of Trade

Domestic Country

Producers

Wholesale trade

- search and matching

Retailers

Local retail trade

- competitive market

Households

Foreign Country

Producers

Wholesale trade

- search and matching

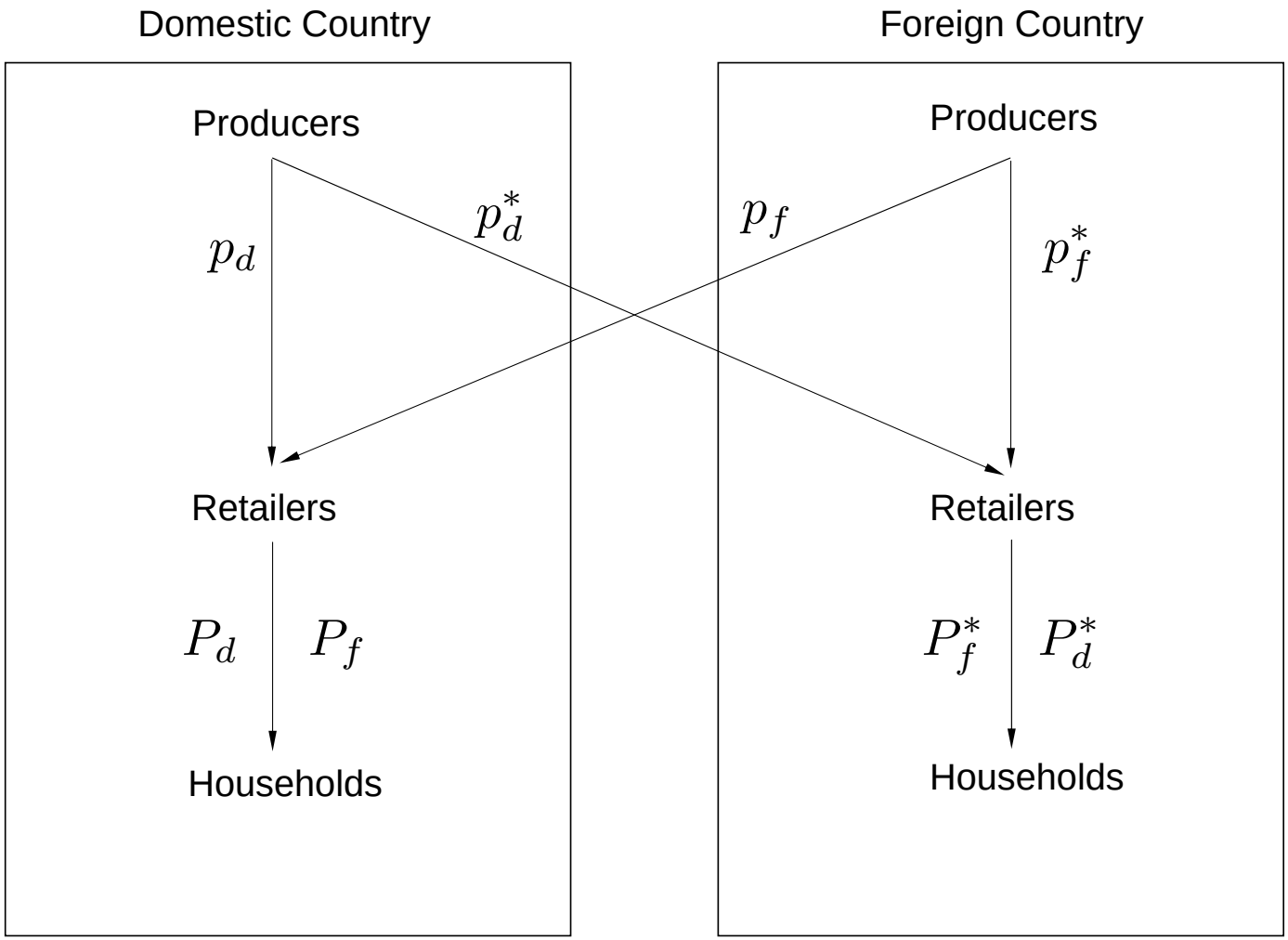
Retailers

Local retail trade

- competitive market

Households

Two Levels of Prices



Producers (domestic country perspective)

- Measure one of producers
- Produce good d according to: $zk^{\alpha}l^{1-\alpha}$
- Subject to country specific productivity shock

$$\log(z_t) = \psi \log(z_{t-1}) + \varepsilon_t \qquad \log(z_t^*) = \psi \log(z_{t-1}^*) + \varepsilon_t^*$$

Producers (domestic country perspective)

- Measure one of producers
- Produce good d according to: $zk^{\alpha}l^{1-\alpha}$
- Subject to country specific productivity shock

$$\log(z_t) = \psi \log(z_{t-1}) + \varepsilon_t \qquad \log(z_t^*) = \psi \log(z_{t-1}^*) + \varepsilon_t^*$$

- By CRS, summarize production by marginal cost v (given w and r)

$$v = \min_{k,l}\{wl + rk | zF(k,l) = 1\}$$

Producers Face Marketing Friction

- Each has a *list of customers* H_d, H_d^* and marketing capital m_d, m_d^*
- Can only sell to customers from the list (a fixed amount per period)
- Marketing capital brings new customers to the list

Producers Face Marketing Friction

- Each has a *list of customers* H_d, H_d^* and marketing capital m_d, m_d^*
- Can only sell to customers from the list (a fixed amount per period)
- Marketing capital brings new customers to the list

  h – searching retailers (*potential new* customers)

  $\frac{m_d}{\bar{m}_d+\bar{m}_f}h$ – searching retailers who become *new customers*

Producers Face Marketing Friction

- Each has a *list of customers* H_d, H_d^* and marketing capital m_d, m_d^*
- Can only sell to customers from the list (a fixed amount per period)
- Marketing capital brings new customers to the list

  h – searching retailers (*potential new* customers)

  $\frac{m_d}{\bar{m}_d+\bar{m}_f}h$ – searching retailers who become *new customers*

Producers Face Marketing Friction

- Each has a *list of customers* H_d, H_d^* and marketing capital m_d, m_d^*
- Can only sell to customers from the list (a fixed amount per period)
- Marketing capital brings new customers to the list

  h – searching retailers (*potential new* customers)

  $\frac{m_d}{\bar{m}_d+\bar{m}_f}h$ – searching retailers who become *new customers*
- Customer list evolves according to the law

$$H_d = (1-\delta_H)H_{d,-1} + \frac{m_d}{\bar{m}_d+\bar{m}_f}h$$

Producers Face Marketing Friction

- Each has a *list of customers* H_d, H_d^* and marketing capital m_d, m_d^*
- Can only sell to customers from the list (a fixed amount per period)
- Marketing capital brings new customers to the list

  h – searching retailers (*potential new* customers)

  $\frac{m_d}{\bar{m}_d+\bar{m}_f}h$ – searching retailers who become *new customers*

- Customer list evolves according to the law

$$H_d = (1-\delta_H)H_{d,-1} + \frac{m_d}{\bar{m}_d+\bar{m}_f}h$$

- Marketing capital evolves according to the law

$$m_d = (1-\delta_m)m_{d,-1} + a_d - \phi m_{d,-1}(\frac{a_d}{m_{d,-1}} - \delta_m)^2$$

Summary of Producer Problem

- Maximize expected present value of Π

$$\Pi = (p_d - v)d + (xp_d^* - v)d^* - va_d - xv^* a_d^*$$

subject to

  - sales constraints

$$d \leq H_d$$

  - laws of motion

$$H_d = (1 - \delta_H)H_{d,-1} + \frac{m_d}{\bar{m}_d + \bar{m}_f}h$$

$$m_d = (1 - \delta_m)m_{d,-1} + a_d - \phi m_{d,-1}(\frac{a_d}{m_{d,-1}} - \delta_m)^2$$

  - analogous constraints apply in the foreign market

Search by Retailers (Other Producers)

- Search to match with producers (at cost χv)
  - meet local producer with probability π
  - meet foreign producer with probability $1 - \pi$
- The match gives opportunity to trade *one* unit of output per period
- The match dissolves with per period probability δ_H

Search by Retailers (Other Producers)

- Search to match with producers (at cost χv)
  - meet local producer with probability $\pi = \frac{\bar{m}_d}{\bar{m}_d + \bar{m}_f}$
  - meet foreign producer with probability $1 - \pi = \frac{\bar{m}_f}{\bar{m}_d + \bar{m}_f}$
- The match gives opportunity to trade *one* unit of output per period
- The match dissolves with per period probability δ_H

Endogenous Measure of Searching Retailers h

- Measure of searching retailers h is endogenously determined by

$$\pi V_d + (1-\pi)V_f \leq \chi v \quad \text{with '=' whenever} \quad h > 0$$

where:

$$V_d = \max\{0, P_d - p_d\} + (1-\delta_H)E_t[QV_d']$$

$$V_f = \max\{0, P_f - p_f\} + (1-\delta_H)E_t[QV_f']$$

Determination of Wholesale Prices

- Producer & retailer bargain for the wholesale price p_d (or p_f)
- At each history s^t prices satisfy the Nash Bargaining problem

$$p_d(s^t) \in \text{argmax}_p \{J_d(s^t;p)^\theta V_d(s^t;p)^{1-\theta}\}$$

where

$$J_d(s^t;p) = \max\{0, p - v(s^t)\} + (1-\delta_H)E_t Q(s^{t+1}|s^t) J_d(s^{t+1}; p_d(s^{t+1}))$$

- value from the match for the producer

$$V_d(s^t;p) = \max\{0, P_d(s^t) - p\} + (1-\delta_H)E_t Q(s^{t+1}|s^t) V_d(s^{t+1}; p_d(s^{t+1}))$$

- value from the match for the retailer

Determination of Wholesale Prices

Proposition

The solution results in *instantaneous* surplus splitting

$$p_d = \theta P_d + (1-\theta)v$$

$$p_f = \theta P_f + (1-\theta)xv^*$$

- Intuition:
  - from tomorrow on the trade surplus split in proportion $\theta, 1-\theta$
  - from today on the trade surplus split in proportion $\theta, 1-\theta$
  - Implication: today's *instantaneous* surplus split the same way

Households

- Maximize $\quad E_t \sum_{t=0}^{\infty} \beta^t u(c, 1-l)$

  subject to

  - Armington aggregation

$$c + i = G(d, f) = (\omega d^{\frac{\gamma-1}{\gamma}} + (1-\omega) f^{\frac{\gamma-1}{\gamma}})^{\frac{\gamma}{\gamma-1}}$$

  - law of motion for physical capital

$$k(s^t) = (1-\delta) k(s^{t-1}) + i$$

  - standard budget constraint under complete markets

$$P_d d + P_f f + \int_S Q(s_{t+1}|s^t) b(s_{t+1}|s^t) \mu(ds_{t+1}) = b(s^t) + wl + rk(s^{t-1}) + \Pi$$

  - Numeraire normalization: price of final good is one

Market Clearing and Feasibility

- Meeting probability consistency condition

$$\pi = \frac{\bar{m}_d}{\bar{m}_d + \bar{m}_f}$$

- Representativeness $m_d = \bar{m}_d$, $m_f = \bar{m}_f$

- Production feasibility $d + d^* + a_d + a_f + \chi h = zF(k, l)$

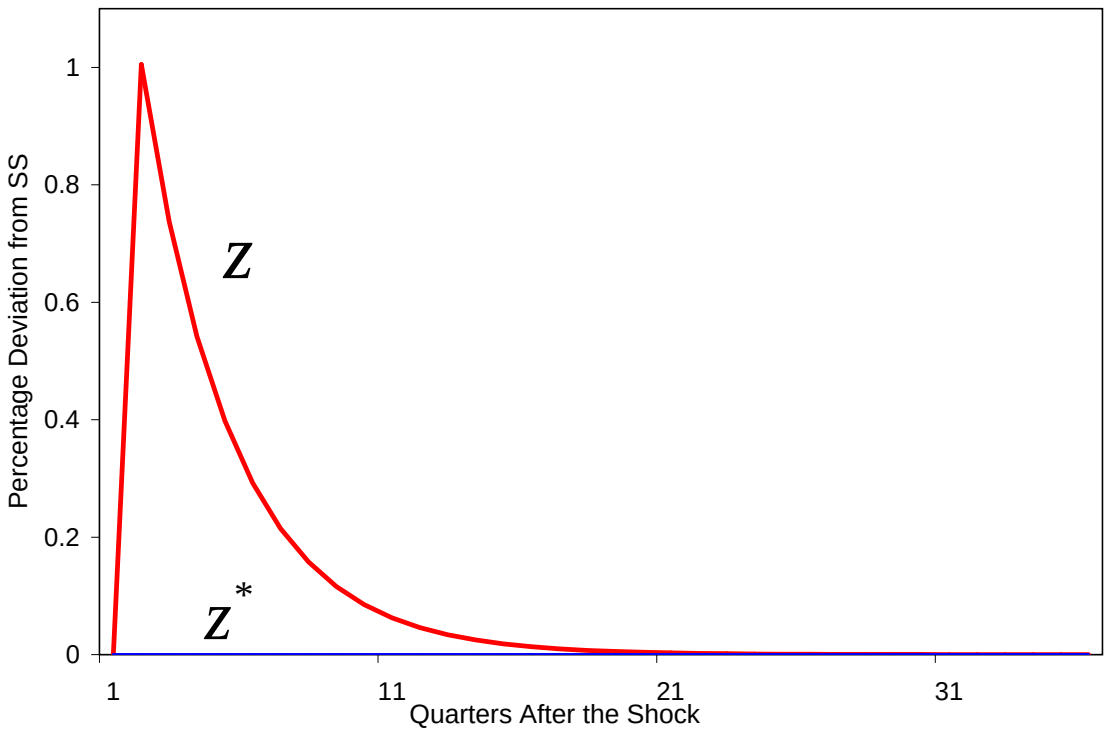
- Definition of equilibrium is standard

Intuition and Qualitative Features

Parameterization: Qualitative Features

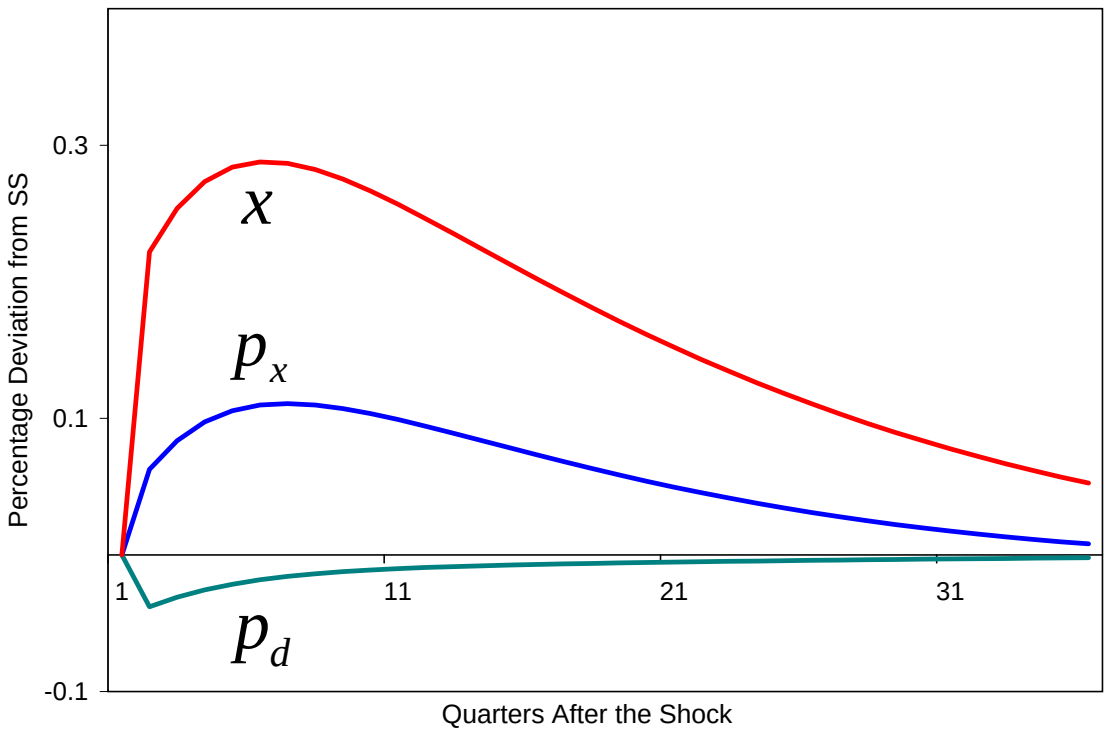
- Model parameters are such that
  - domestic and foreign goods close substitutes
  - market shares are sluggish in the short-run
- Justified quantitatively by:
  - estimates of low short-run and
    high long-run price elasticity of trade flows
    - trade *responsive* to trade liberalizations
    - trade *unresponsive* to price changes in time-series

Primitive Shock



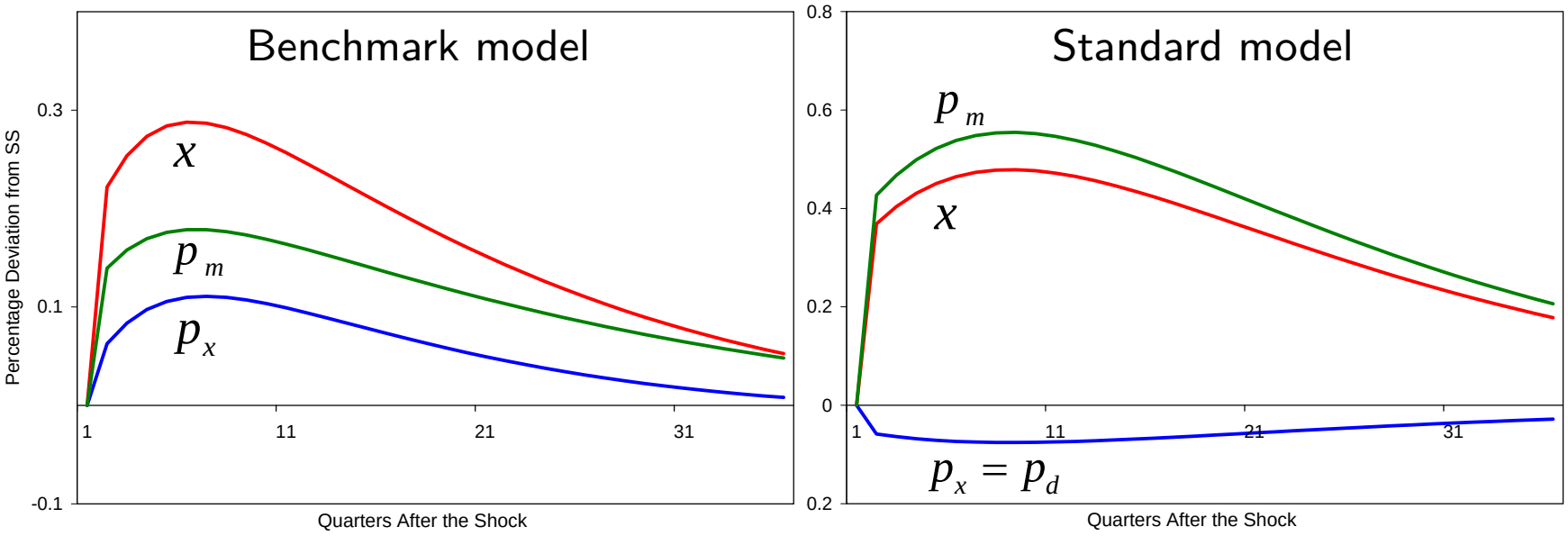
Positive productivity shock in the domestic country

Key Feature: Producers Price To Market



Markups on exported goods go up when real exchange rate depreciates!

Comovement of Prices in the Models



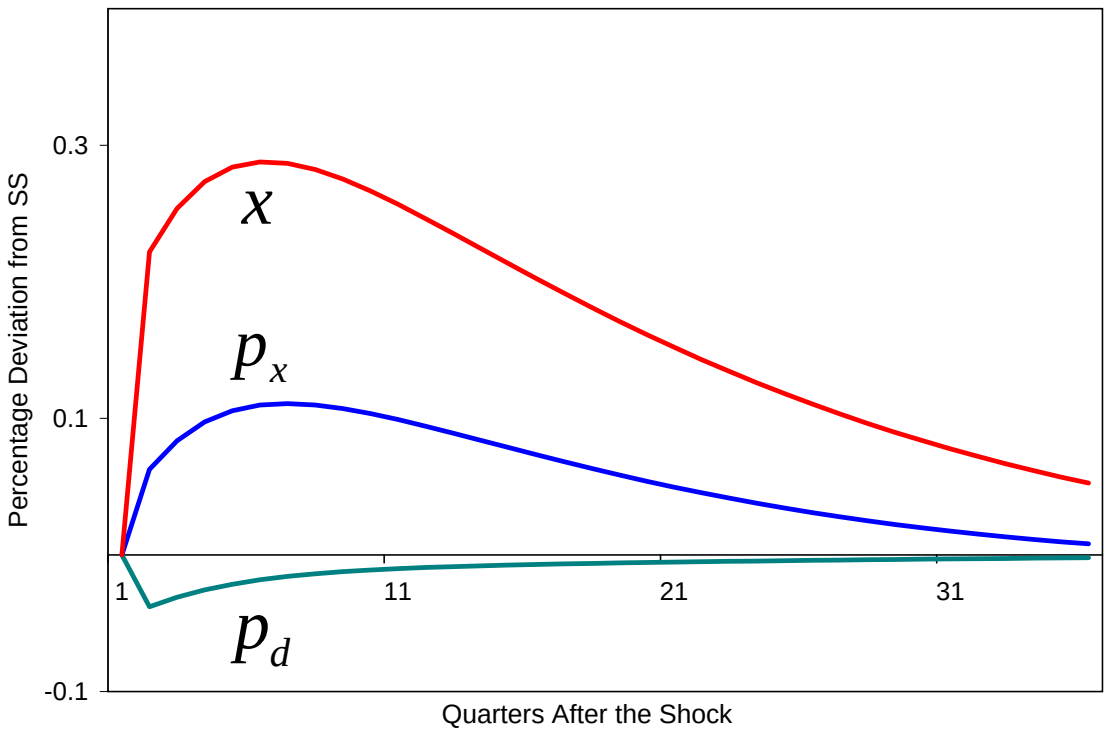
$$corr(p_x, p_m) = +1$$

$$sd(p)/sd(x) = 0.26$$

$$corr(p_x, p_m) = -1$$

$$sd(p)/sd(x) > 1$$

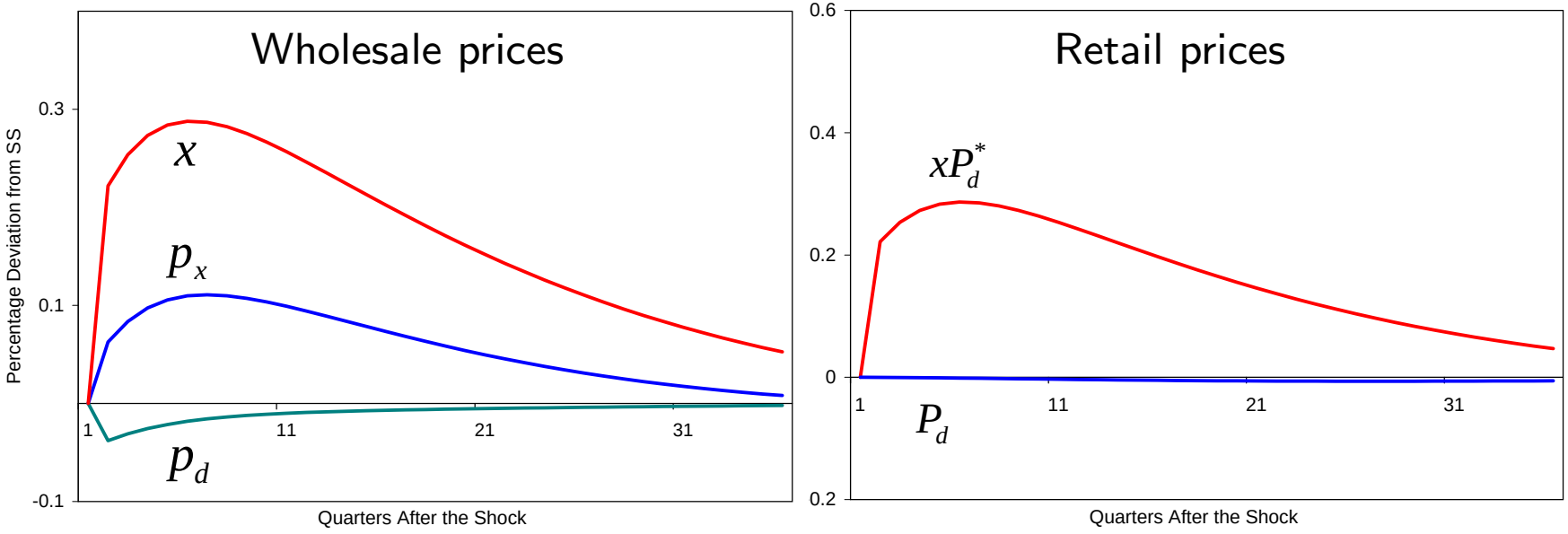
Why Do Producers Price To Market?



$$p_x = \theta x P_d^* + (1-\theta)\, v$$

$$p_d = \theta P_d + (1-\theta)\, v$$

Why Do Producers Price To Market?



$$p_x = \theta x P_d^* + (1-\theta)\, v$$

$$p_d = \theta P_d + (1-\theta)\, v$$

$$x P_d^* > P_d$$

$p_x > p_d$ – not arbitraged away due to marketing friction

Why xP_d^* rises relative to P_d?

A. Retail prices (P_d^*, P_d) change slowly and little

B. Real exchange rate x depreciates: xP_d^* goes up relative to P_d

Why xP_d^* rises relative to P_d?
A. Retail Prices Change Slowly and Little

- Retail prices depend on relative scarcity of foreign to domestic goods

$$P_d = \omega[\omega + (1-\omega)\frac{f}{d}^{\frac{\gamma-1}{\gamma}}]^{\frac{1}{\gamma-1}}$$

- Relative scarcity sluggish due to sluggish market shares in the S-R

$$\frac{f}{d} = \frac{H_f}{H_d} = \frac{(1-\delta_H)H_{f,-1} + \frac{\bar{m}_f}{\bar{m}_d+\bar{m}_f}h}{(1-\delta_H)H_{d,-1} + \frac{\bar{m}_d}{\bar{m}_d+\bar{m}_f}h}$$

- Domestic and foreign goods closely substitutable (high γ)

Why xP_d^* rises relatively to P_d?
B. Real Exchange Rate Depreciates (despite high γ)

- Real exchange rate determined by *efficient risk sharing*

$$x = \frac{u_c(c^*, 1 - l^*)}{u_c(c, 1 - l)}$$

Country consumes more iff its consumption costs less

Why xP_d^* rises relatively to P_d?
B. Real Exchange Rate Depreciates (despite high γ)

- Real exchange rate determined by *efficient risk sharing*

$$x = \frac{u_c(c^*, 1 - l^*)}{u_c(c, 1 - l)}$$

Country consumes more iff its consumption costs less

- Consumption at home costs *less* than consumption abroad because
  - Marketing frictions: market share channel severed
  - Home-bias: home retailers better at finding cheaper d-producers

Why xP_d^* rises relatively to P_d?
B. Real Exchange Rate Depreciates (despite high γ)

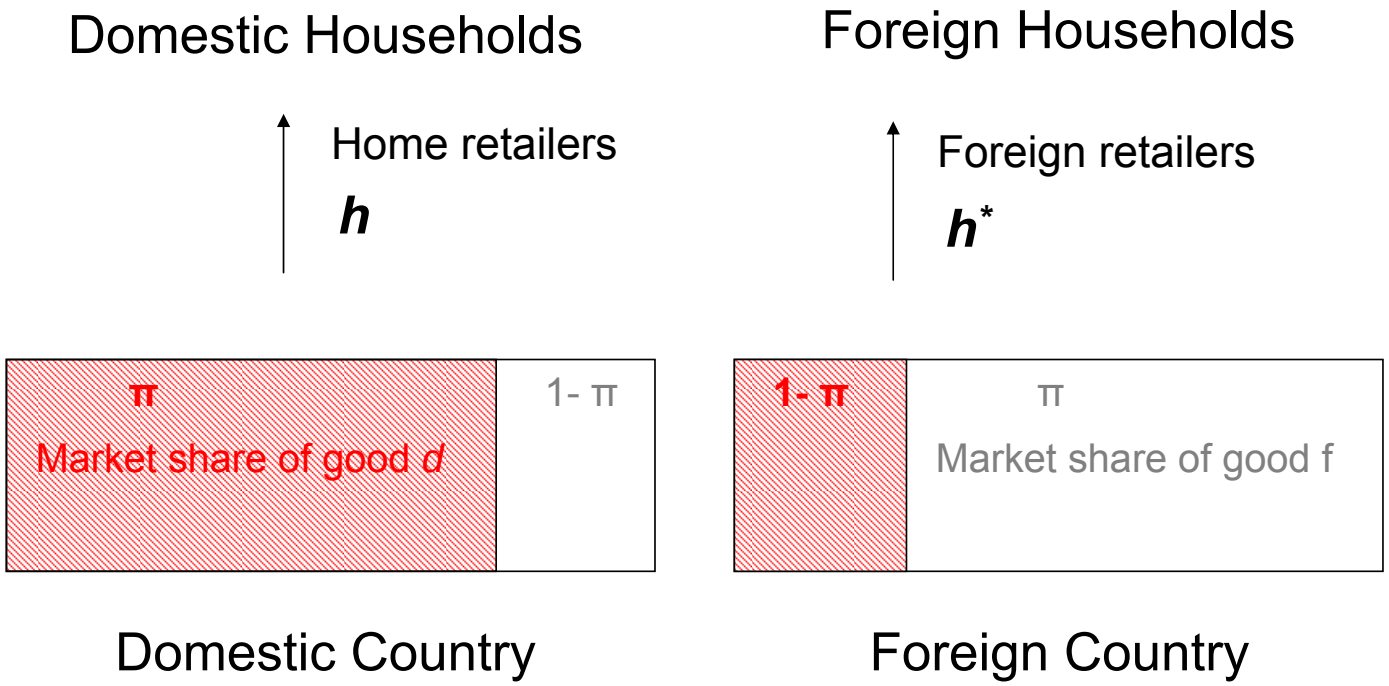
- Real exchange rate determined by *efficient risk sharing*

$$x = \frac{u_c(c^*, 1 - l^*)}{u_c(c, 1 - l)}$$

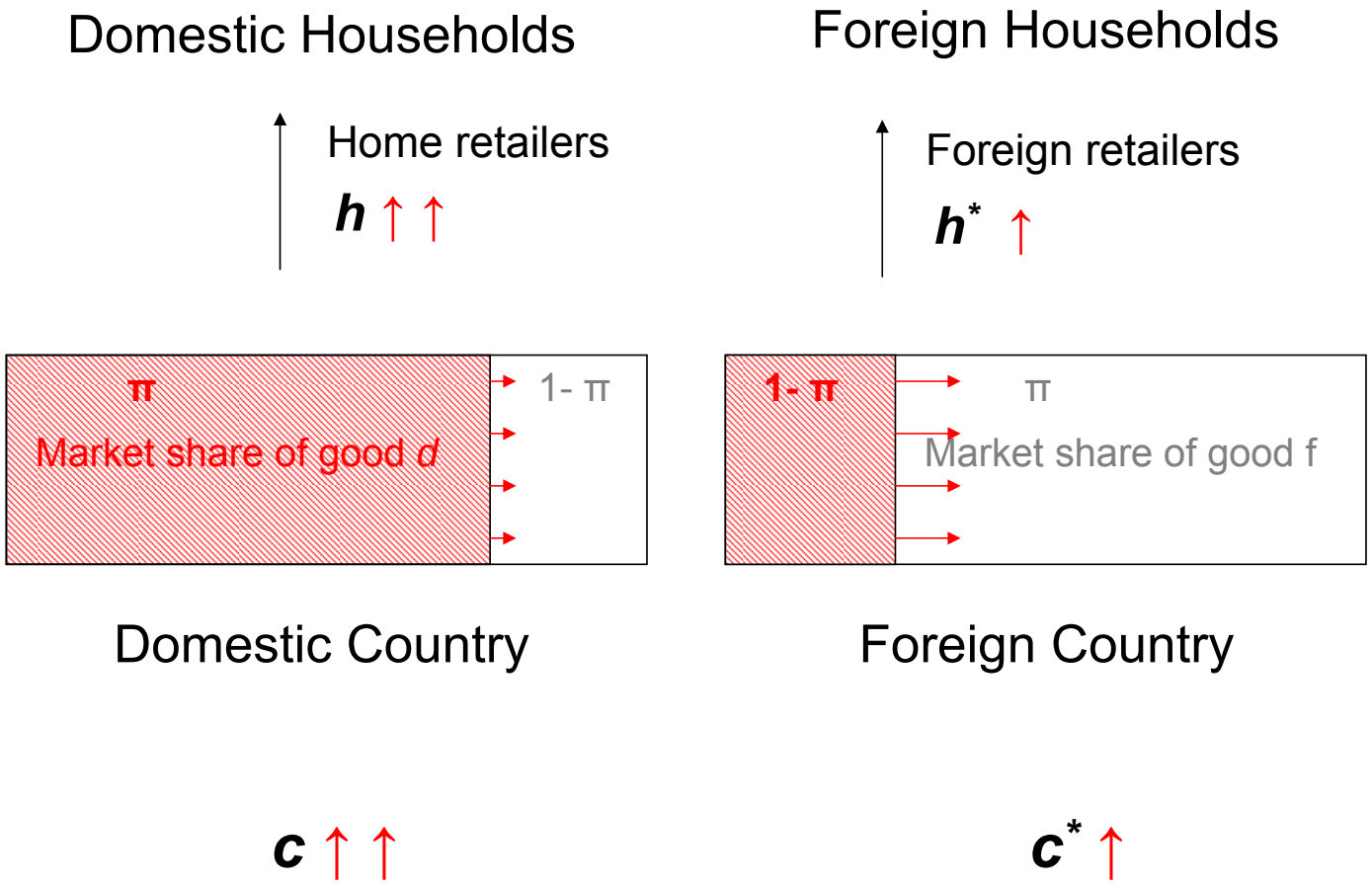
Country consumes more iff its consumption costs less

- Consumption at home costs *less* than consumption abroad because
  - Marketing frictions: market share channel severed
  - Home-bias: home retailers better at finding cheaper d-producers
    - home retailers search relatively harder
    - market shares adjust only partially (due to convex marginal cost)
    - c rises more than c^*

B. Real Exchange Rate Depreciates (despite high γ)



B. Real Exchange Rate Depreciates (despite high γ)



B. Real Exchange Rate Depreciates (despite high γ)

Domestic Households

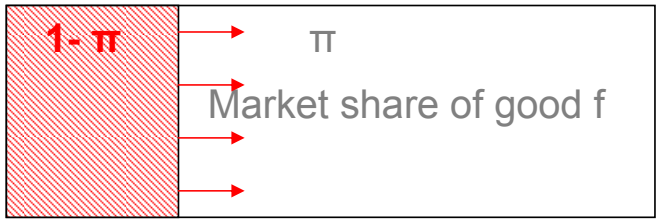
Home retailers

$h \uparrow \uparrow$

Foreign Households

Foreign retailers

$h^* \uparrow$

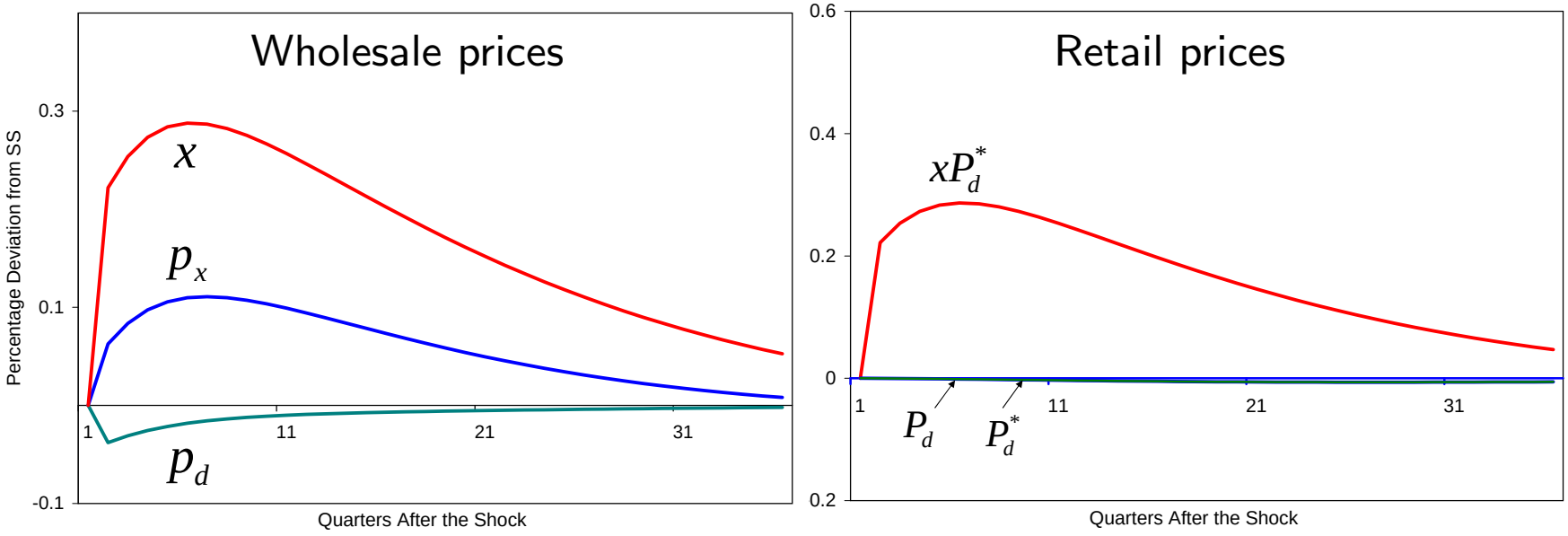


Domestic Country

Foreign Country

$c \uparrow \uparrow$ $\quad \uparrow x = \dfrac{u'(c^*)}{u'(c)} \quad$ $c^* \uparrow$

Recap



- Retail prices sluggish
- Real exchange rate depreciates: $xP_d^* > P_d$
- Bargaining leads to $p_x > p_d$
- Marketing frictions make $p_x > p_d$ sustainable in S-R

Parameterization and Quantitative Results

Key Quantitative Discipline

- Account for the short run vs. long run price elasticity puzzle
  - trade *responsive* to tariff reductions in the long run
  - trade *unresponsive* to price fluctuations in time-series

Key Quantitative Discipline

- Account for the short run vs. long run price elasticity puzzle
  - trade *responsive* to tariff reductions in the long run
    - price elasticity of trade high ≈ 8
  - trade *unresponsive* to price fluctuations in time-series
    - price elasticity of trade low ≈ 1

Key Quantitative Discipline

- Account for the short run vs. long run price elasticity puzzle
  - trade *responsive* to tariff reductions in the long run
    - price elasticity of trade high ≈ 8
  - trade *unresponsive* to price fluctuations in time-series
    - price elasticity of trade low ≈ 1
- Pins down two parameters:
  - elasticity of substitution in preferences: γ

    $$G(d,f) = (\omega d^{\frac{\gamma-1}{\gamma}} + (1-\omega) f^{\frac{\gamma-1}{\gamma}})^{\frac{\gamma}{\gamma-1}}$$

    – $\gamma = 8$ gives high 'long-run elasticity'
  - market expansion friction: ϕ

    $$m_d = (1-\delta_m) m_{d,-1} + a_d - \phi \left(\frac{a_d}{m_{d,-1}} - \delta_m \right)^2 m_{d,-1}$$

    – ϕ gives low 'short-run elasticity'

Details: Market Expansion Friction ϕ

$$m_d = (1-\delta_m)m_{d,-1} + a_d - \phi m_{d,-1}(\frac{a_d}{m_{d,-1}} - \delta_m)^2$$

- Set jointly with other parameters to match
  - our measure of 'short-run empirical elasticity of substitution'

$$\text{volatility ratio: } \sigma(\frac{DA}{f})/\sigma(\frac{p_f}{P_{DA}}) = 0.71 \text{ (12 OECD)}$$

where: DA – domestic absorption in constant prices

f – imports in constant prices

p_f – deflator price of imports

P_{DA} – deflator price of domestic absorption

- Theoretical justification: in the frictionless model volatility ratio is $\approx \gamma$

Parameterization – Overview

- Step 1: Select the following parameters independently

  $\gamma = 7.9$, $\beta = 0.99$, $\alpha = 0.36$, $\sigma = 2$, $\delta = 0.025$, $\delta_H = 0.1$ (arbitrary)

- Step 2: Select remaining parameters jointly

  $\phi = 18.4$, $\delta_m = 0.2$, $\theta = 0.4$, $\chi = 1.38$, $\eta = 0.34$, $\omega = 0.56$, shocks

  to hit the following targets from the data

Data Target	Value
1. Import to GDP	12%
2. Producer markups	10%
3. Volatility of p_x relative to x	37%
4. Volatility ratio	0.71
5. Market activities in time endowment	30%
6. Share of marketing expenditures in GDP	7.0%
7. Moments of TFP process	

Quantitative Results

Quantitative Results

- State results and contrast with standard theory
  - Benchmark ($\gamma = 7.9, \phi = 18.4$)
  - Standard model ($\gamma = 0.71$, no ϕ)
    - worse statistics for international prices
    - similar statistics for quantities

Quantitative Results: International Prices

Statistic	Data	Model Economies: Benchmark $\gamma = 7.9$ $\phi > 0$	Model Economies: Standard $\gamma = 0.7$ no ϕ
A. Correlations			
p_x, p_m	0.75	0.98	-1.00
p_x, x	0.46	0.99	-1.00
p, x	0.61	0.95	1.00
B. Volatility relative to x			
p_x	0.37	0.37	0.17
p_m	0.61	0.62	1.16
p	0.26*	0.26	1.31

Quantitative Results: International Prices

Statistic	Data	Model Economies: Benchmark $\gamma = 7.9$ $\phi > 0$	Model Economies: Standard $\gamma = 0.7$ no ϕ
A. Correlations			
p_x, p_m	0.75	0.98	-1.00
p_x, x	0.46	0.99	-1.00
p, x	0.61	0.95	1.00
B. Volatility relative to x			
p_x	0.37	0.37	0.17
p_m	0.61	0.62	1.16
p	0.26*	0.26	1.31

Quantitative Results: International Prices

Statistic	Data	Model Economies: Benchmark $\gamma = 7.9$ $\phi > 0$	Model Economies: Standard $\gamma = 0.7$ no ϕ
A. Correlations			
p_x, p_m	0.75	0.98	-1.00
p_x, x	0.46	0.99	-1.00
p, x	0.61	0.95	1.00
B. Volatility relative to x			
p_x	0.37	0.37	0.17
p_m	0.61	0.62	1.16
p	0.26*	0.26	1.31
C. Volatility of Real Exchange Rate			
$std(x)$	3.60	0.43	0.49

Quantitative Results: International Prices

Statistic	Data	Model Economies: Benchmark $\gamma = 7.9$ $\phi > 0$	Standard $\gamma = 0.7$ no ϕ	Benchmark FA $\gamma = 7.9$ $\phi > 0$
A. Correlations				
p_x, p_m	0.75	0.98	-1.00	1.00
p_x, x	0.46	0.99	-1.00	1.00
p, x	0.61	0.95	1.00	0.99
B. Volatility relative to x				
p_x	0.37	0.37	0.17	0.37
p_m	0.61	0.62	1.16	0.63
p	0.26*	0.26	1.31	0.26
C. Volatility of Real Exchange Rate				
$std(x)$	3.60	0.43	0.49	1.65

Quantitative Results: Quantities

Statistic	Data	Model Economies: Benchmark $\gamma = 7.9$ $\phi > 0$	Standard $\gamma = 0.7$ no ϕ	Benchmark FA $\gamma = 7.9$ $\phi > 0$
A. International Comovement				
Output	0.40	0.35	0.36	0.37
Consumption	0.25	0.23	0.32	0.34
Investment	0.23	0.03	0.16	0.35
Employment	0.21	0.32	0.48	0.27
B. Volatility relative to GDP				
Consumption	0.74	0.32	0.31	0.32
Investment	2.79	3.67	3.36	3.67
Employment	0.81	0.69	0.48	0.69
Net Exports	0.29	0.21	0.13	0.21

Comparison to Disaggregated Data

- Consider our previous decomposition:

$$p_x^i \equiv \frac{EP^i}{CPI} \equiv \underbrace{\frac{EP^i}{DP^i}}_{\text{PTM}} \underbrace{\frac{DP^i}{CPI}}_{\text{Res}}$$

- Volatility of p_x^i relative to x:
  - Data : 93% from PTM
  - Benchmark : 87% from PTM

- Correlation with x:
  - Data : PTM$= 0.84$ Res$= -0.15$
  - Benchmark : PTM$= 1.00$ Res$= -1.00$

Comparison to Disaggregated Data

- Consider our previous decomposition:

$$p_x^i \equiv \frac{EP^i}{CPI} \equiv \underbrace{\frac{EP^i}{DP^i}}_{\text{PTM}} \underbrace{\frac{DP^i}{CPI}}_{\text{Res}}$$

- Volatility of p_x^i relative to x:
  - Data : 93% from PTM
  - Benchmark : 87% from PTM
  - Standard : 0% from PTM

- Correlation with x:
  - Data : PTM$= 0.84$ Res$= -0.15$
  - Benchmark : PTM$= 1.00$ Res$= -1.00$
  - Standard : PTM$= 0.00$ Res$= -1.00$

Conclusions

- Model can account for prices without hurting quantities
- Same frictions account for different SR and LR elasticities of trade flows
  - Important to integrate international macro with static trade theory

Conclusions

- Model can account for prices without hurting quantities
- Same frictions account for different SR and LR elasticities of trade flows
  - Important to integrate international macro with static trade theory
- Other interesting features of the theory
  - positive relation between trade and comovement of business cycles
    'Long-Run Price Elasticity of Trade and the Trade-Comovement Puzzle'
  - positive relation between trade and volatility of real exchange rates
    'Trade Intensity and Real Exchange Rate Volatility'