Understanding International Prices: Customers as Capital

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- 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

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    - 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

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  - 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

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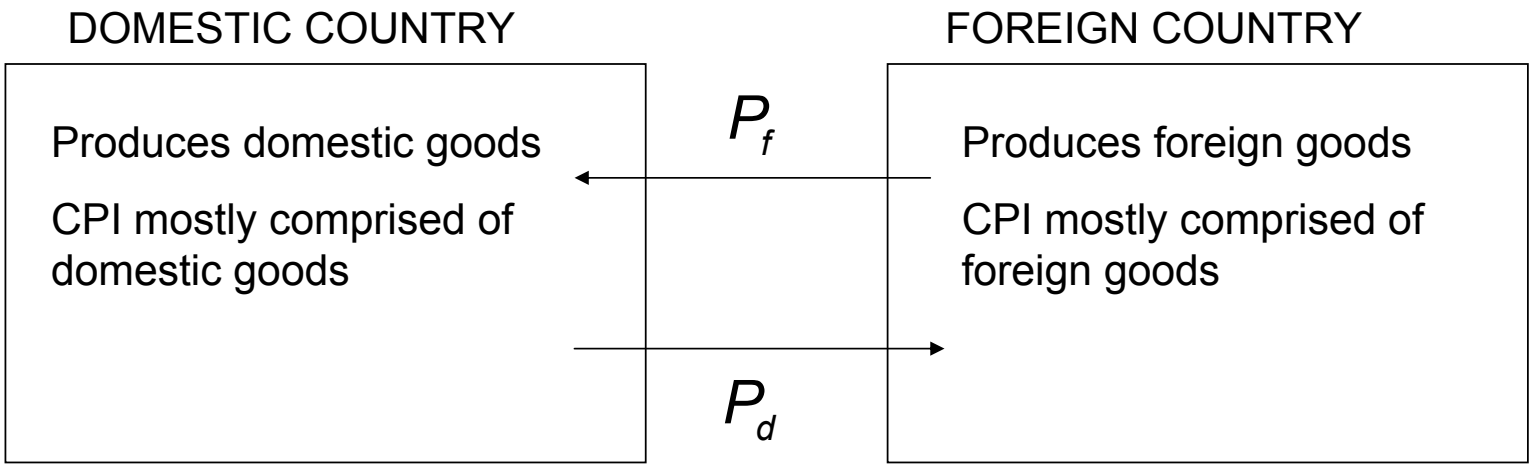

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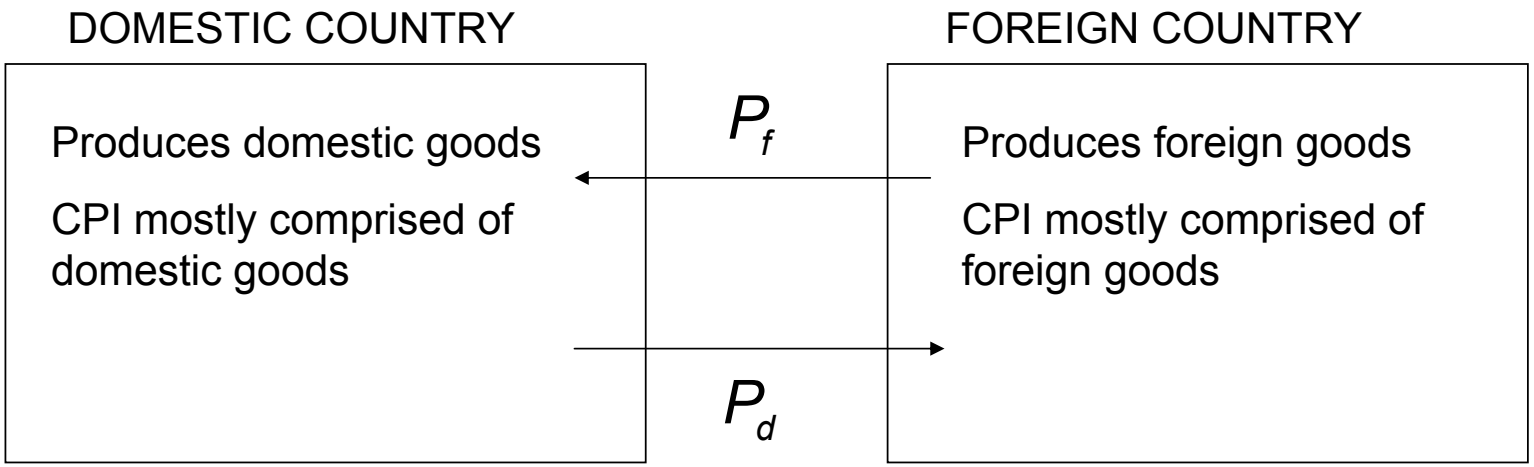

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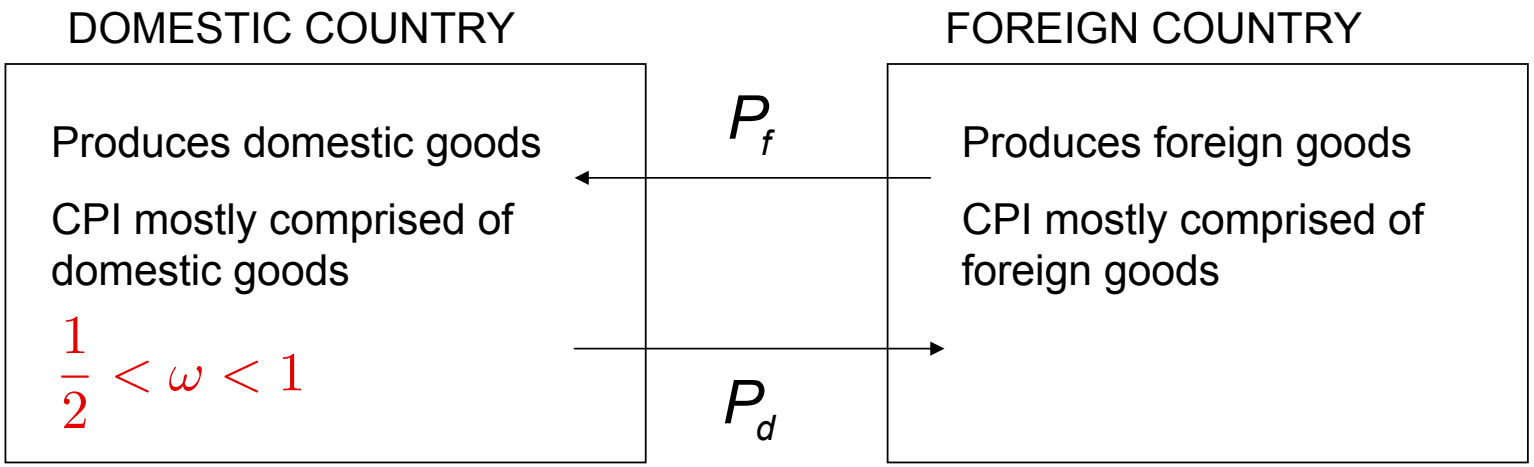

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$$x \equiv \frac{CPI^*}{CPI} = \frac{(P_f)^{\omega}(P_d)^{1-\omega}}{(P_d)^{\omega}(P_f)^{1-\omega}} = (\frac{P_f}{P_d})^{2\omega-1}$$

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

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

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  - Conveniently tabulated data (domestically-produced & sold goods)

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- 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...

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    - 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

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

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- **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*

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- Contribution

  - formalize this idea into a micro-founded GE model

    - model *marketing frictions* in search and matching environment

    - make relations with customers valuable

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  - different S-R and L-R price elasticity of trade flows

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- Show promising in accounting for price data

Related Literature

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  - Sluggish market shares: Froot & Klemperer (1989), Alessandria (2004)
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  - 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*
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  - domestic country: $c + i = G(d, f)$
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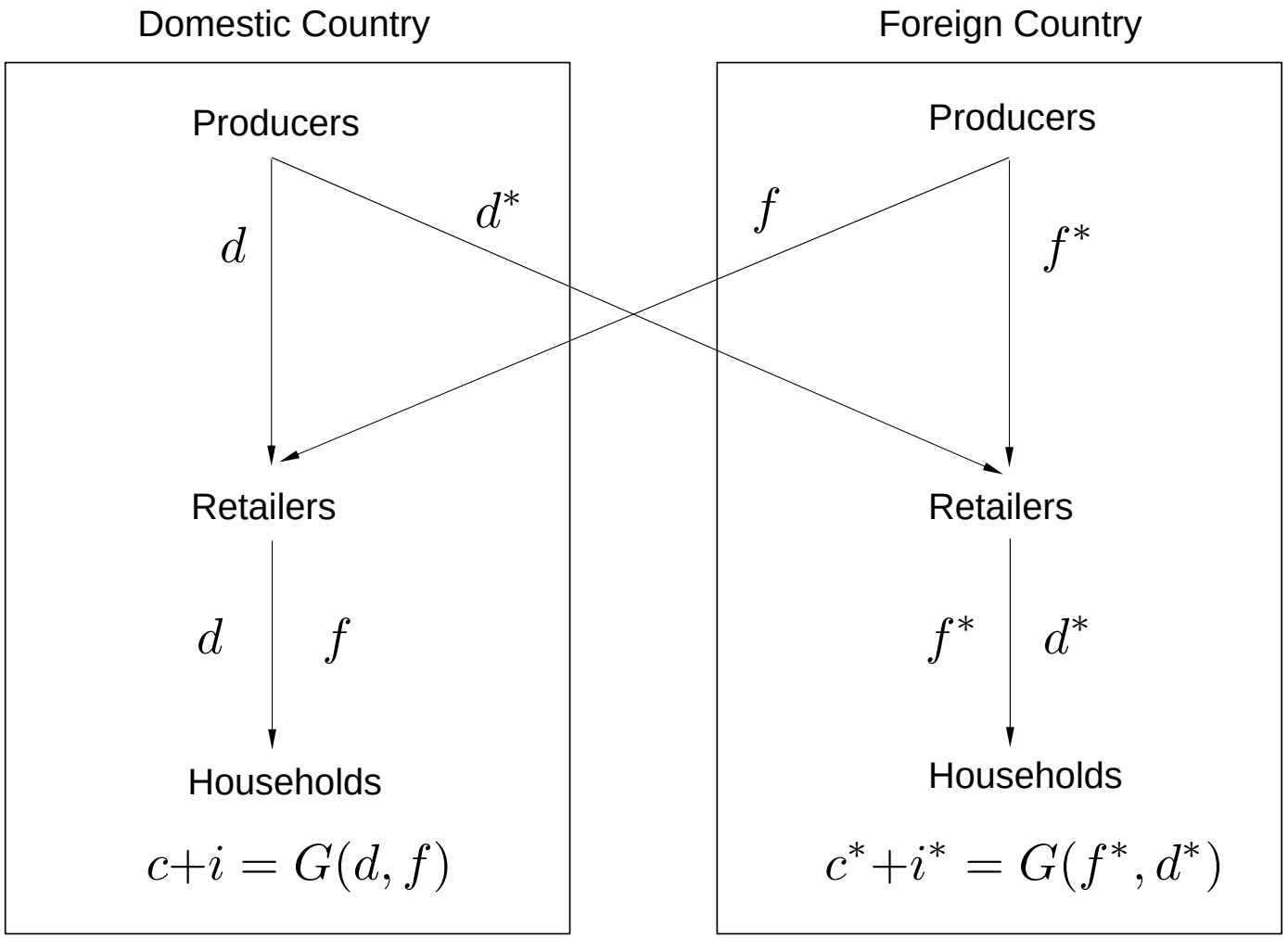
- d and f the only tradable goods
- Physical capital and labor immobile across countries

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



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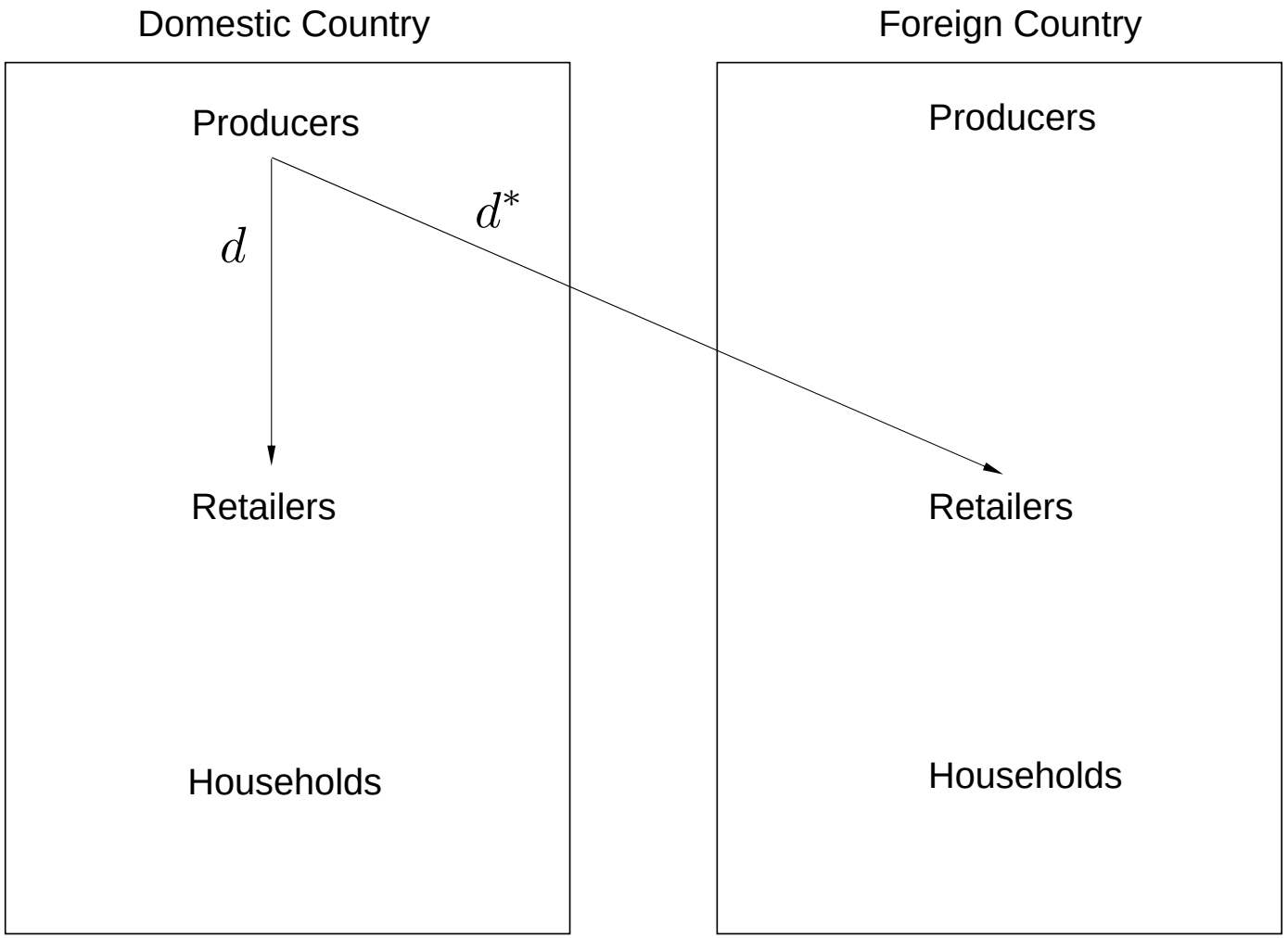

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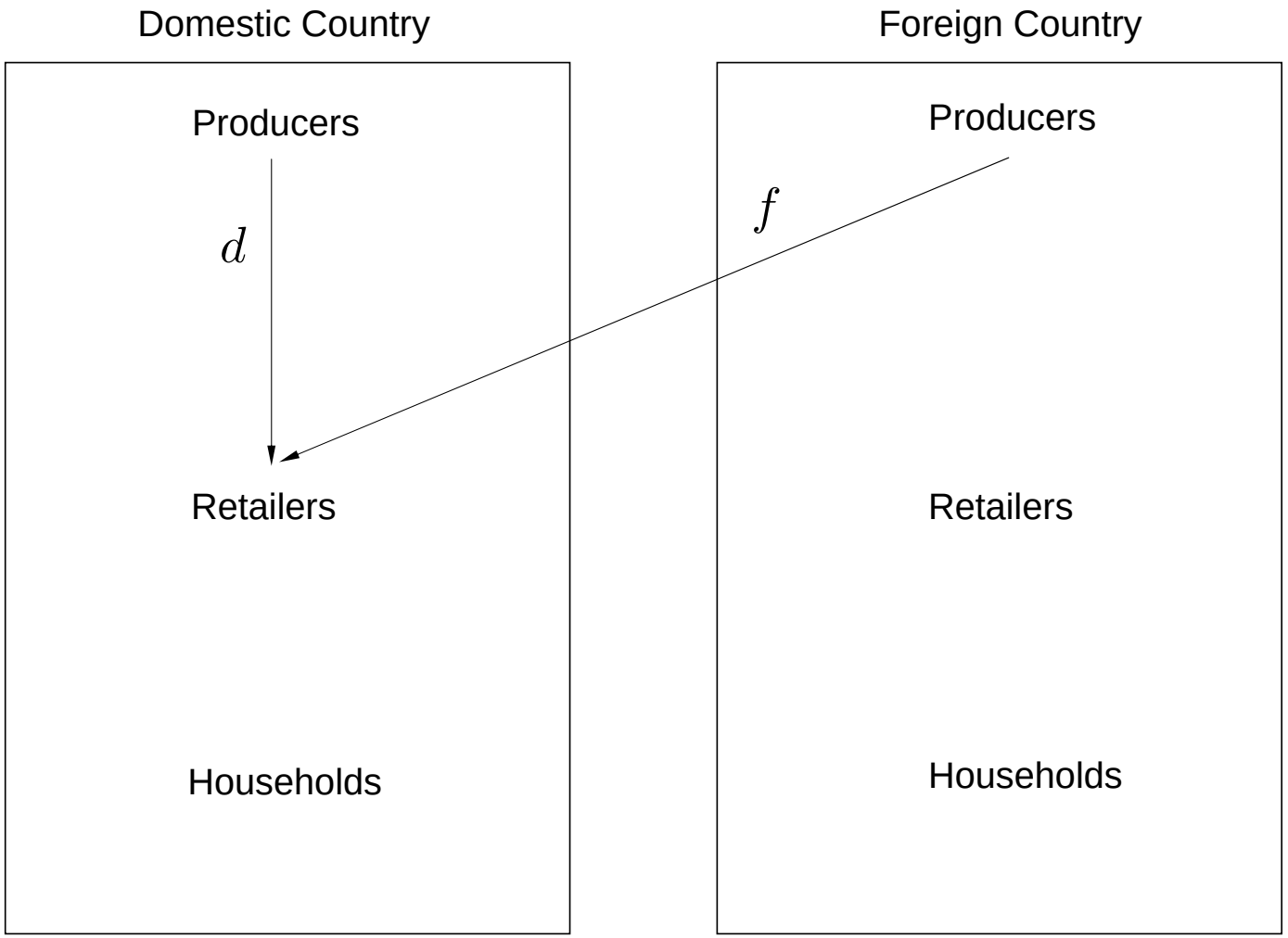

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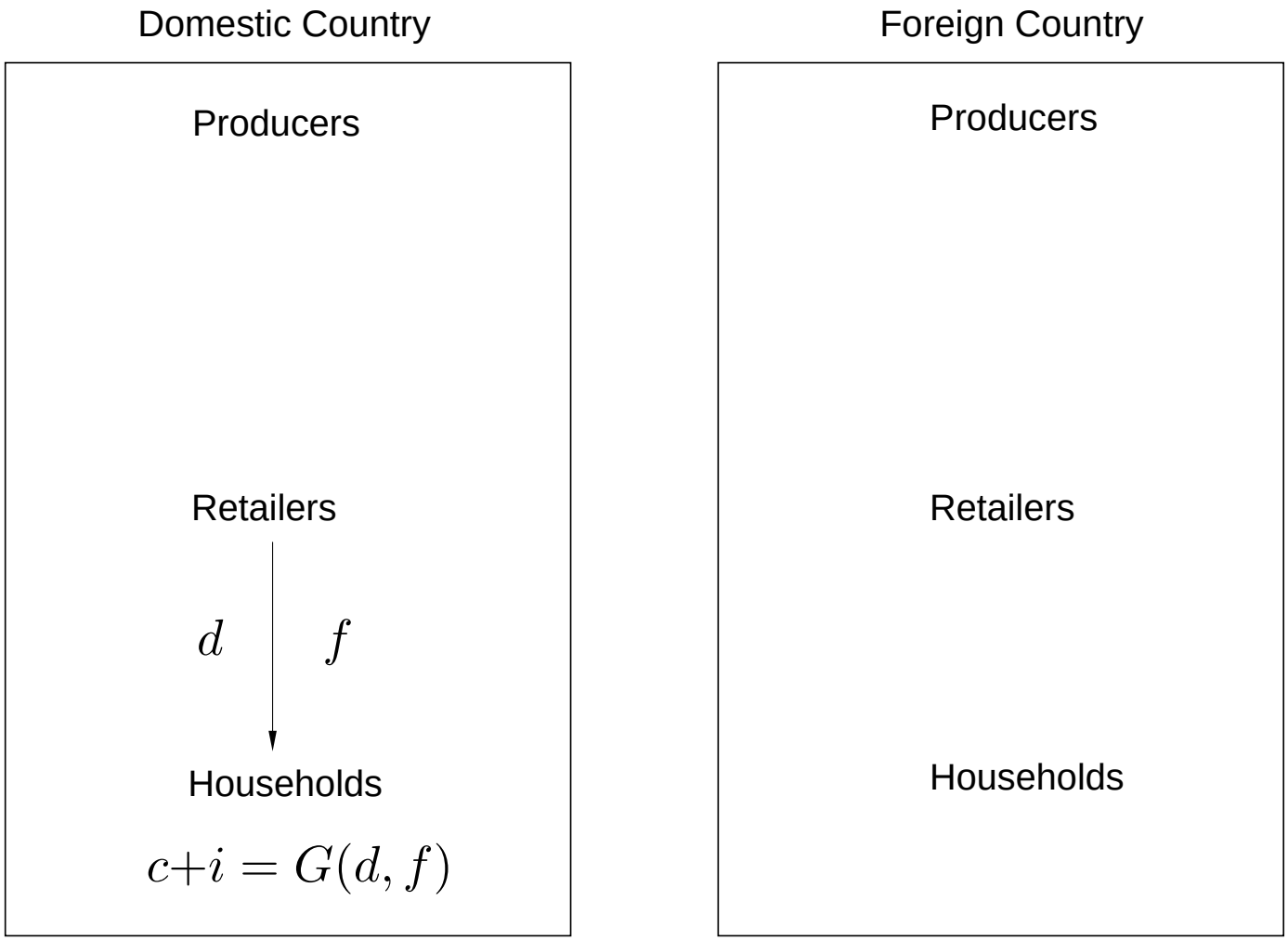
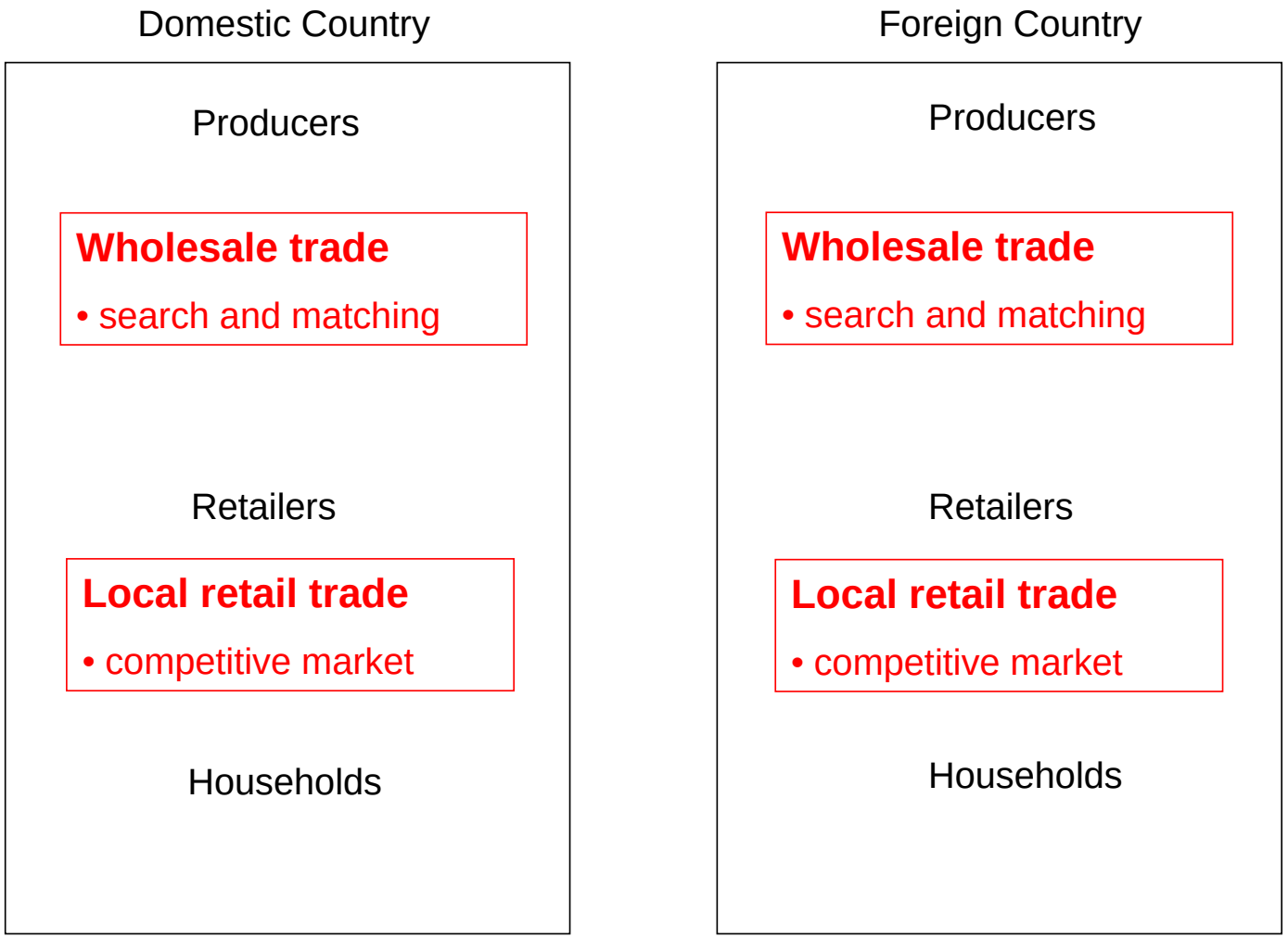
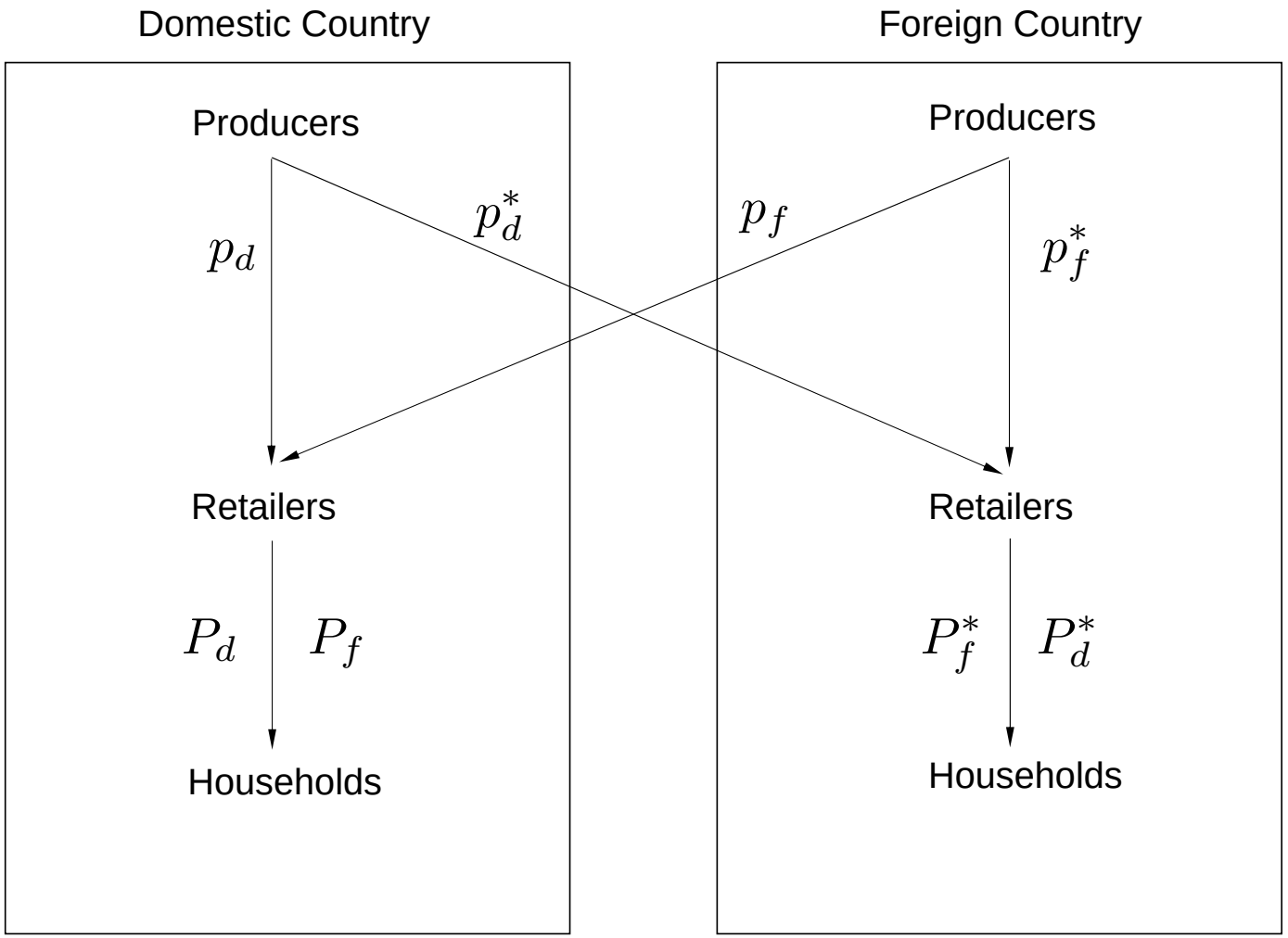


Two Levels of Trade



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

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

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- 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)
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  h – searching retailers (*potential new* customers)

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

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

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

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  - 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

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

- value from the match for the producer

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

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

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

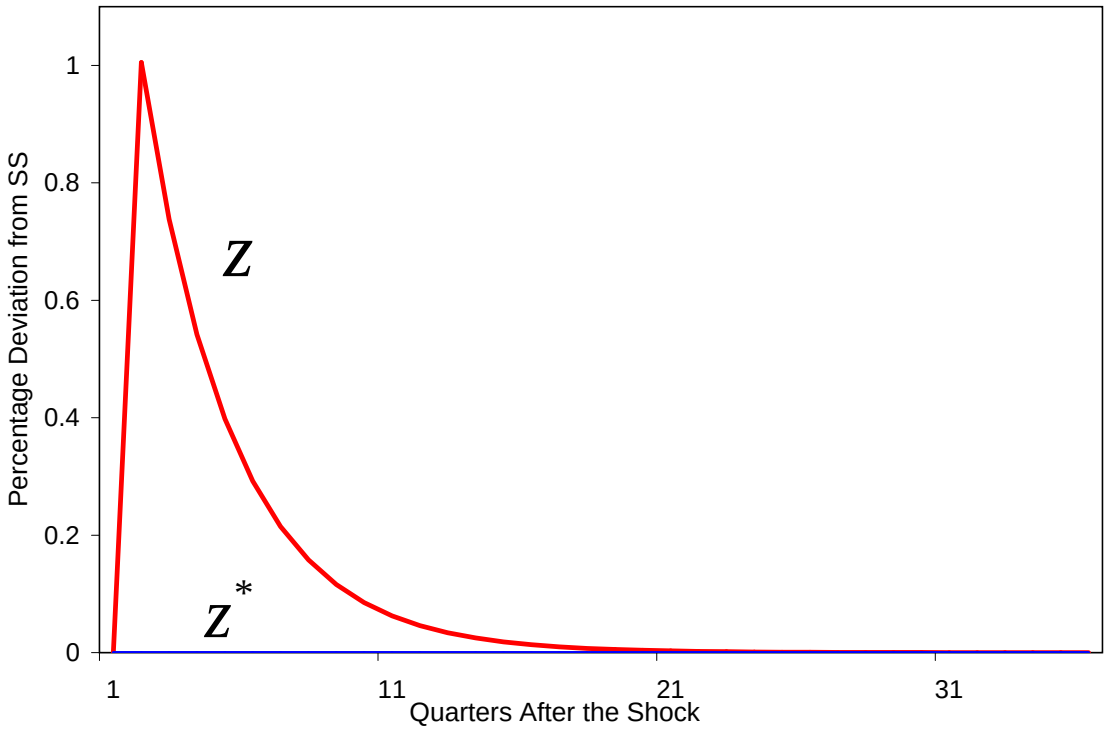
- Definition of equilibrium is standard

Intuition and Qualitative Features

Parameterization: Qualitative Features

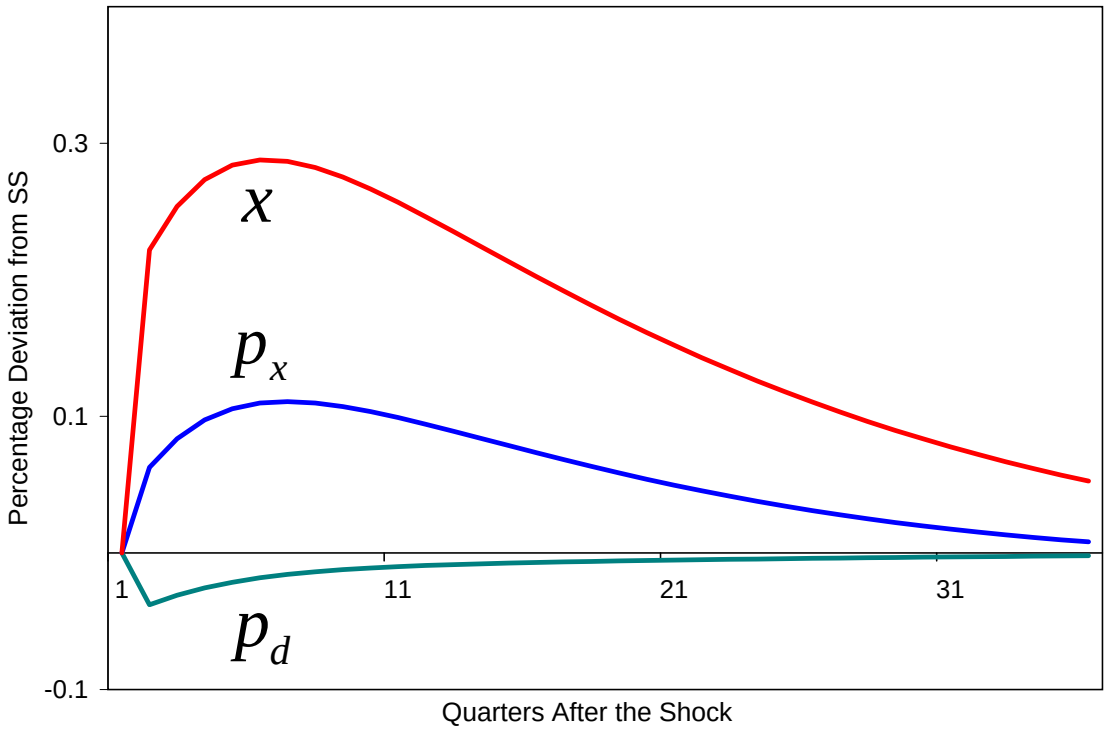
- Model parameters are such that
  - domestic and foreign goods close substitutes
  - market shares are sluggish in the short-run
- Justified quantitatively by:
  - estimates of low short-run and high long-run price elasticity of trade flows
    - trade *responsive* to trade liberalizations
    - trade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

Primitive Shock



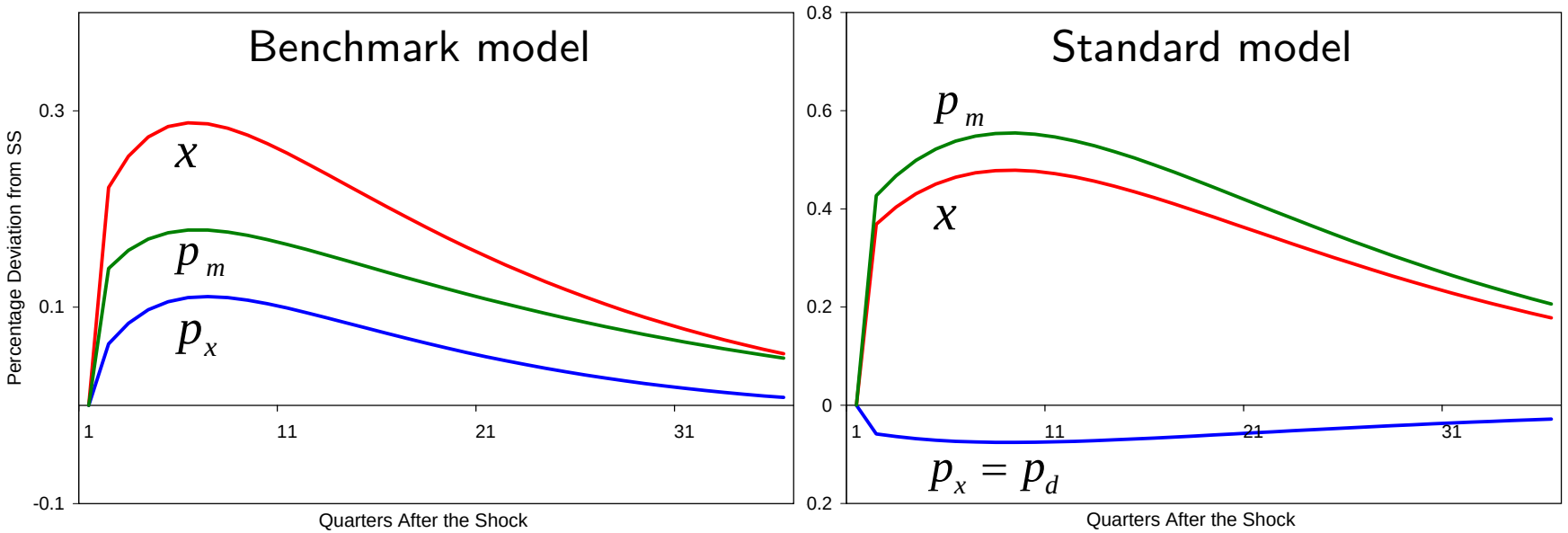
Positive productivity shock in the domestic country

Key Feature: Producers Price To Market



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

Comovement of Prices in the Models



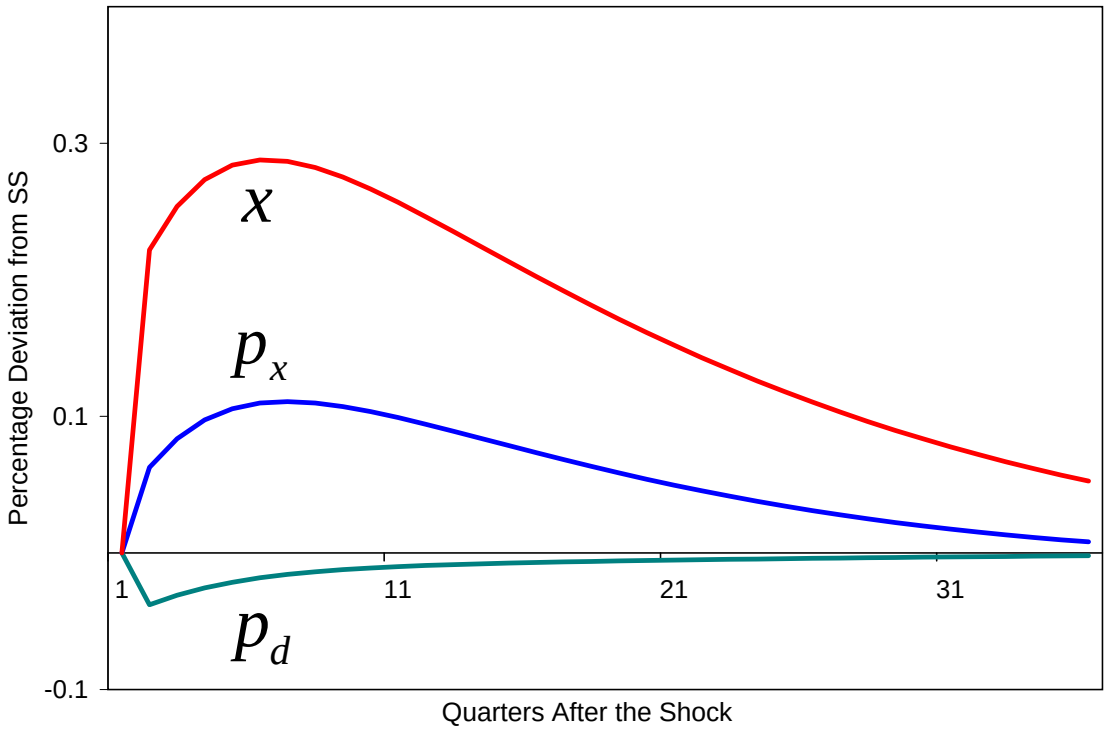
$corr(p_x, p_m) = +1$

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

$corr(p_x, p_m) = -1$

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

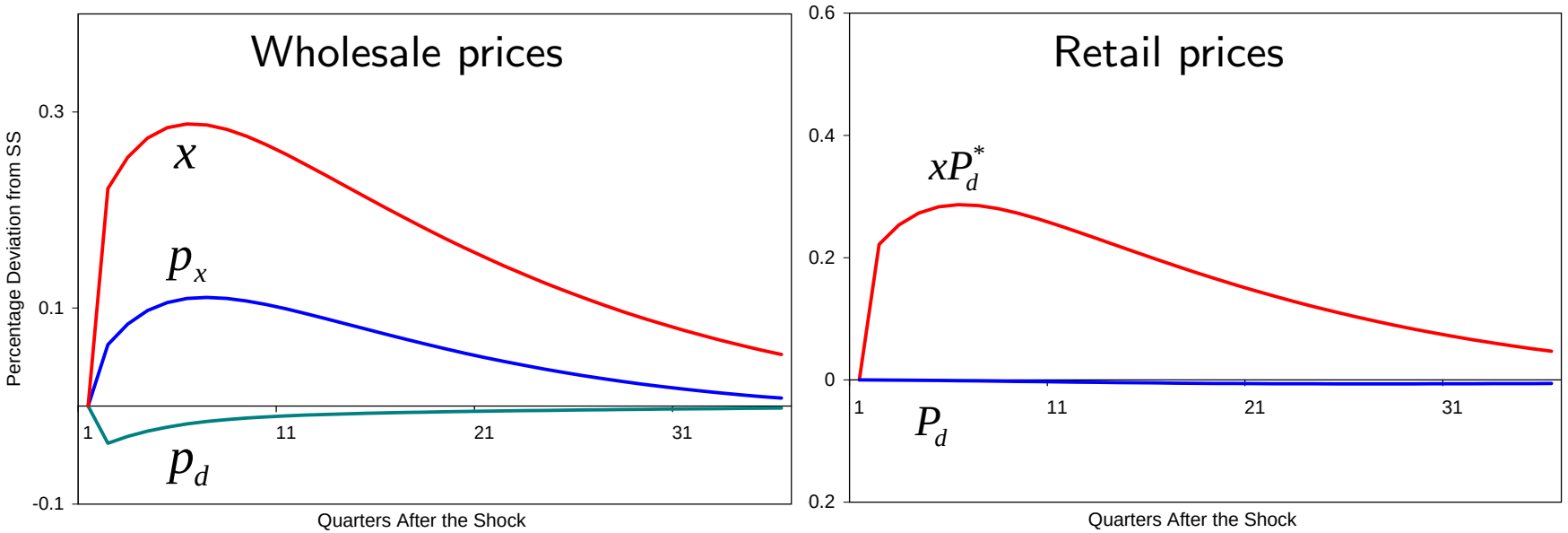
Why Do Producers Price To Market?



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

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

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

- Real exchange rate $=$ *price of foreign consumption basket*

  in terms of the domestic consumption consumption basket

Why xP_d^* rises relatively to P_d?
B. Real Exchange Rate Depreciates

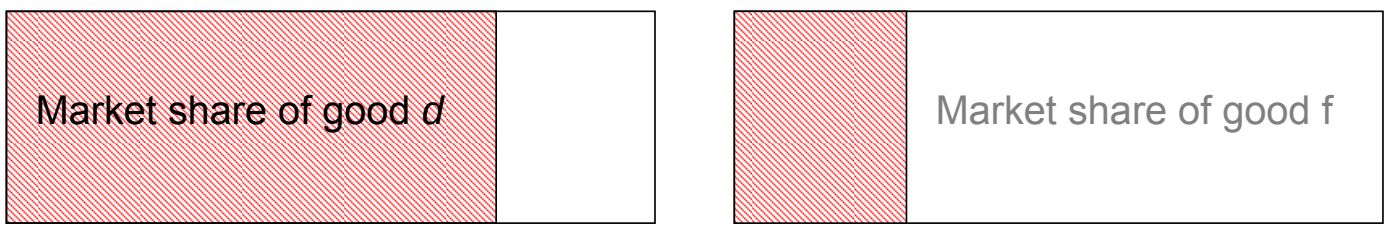
- Real exchange rate $=$ *price of foreign consumption basket*

  in terms of the domestic consumption consumption basket

- Following the shock, delivering consumption at home

  costs *less* than delivering consumption abroad

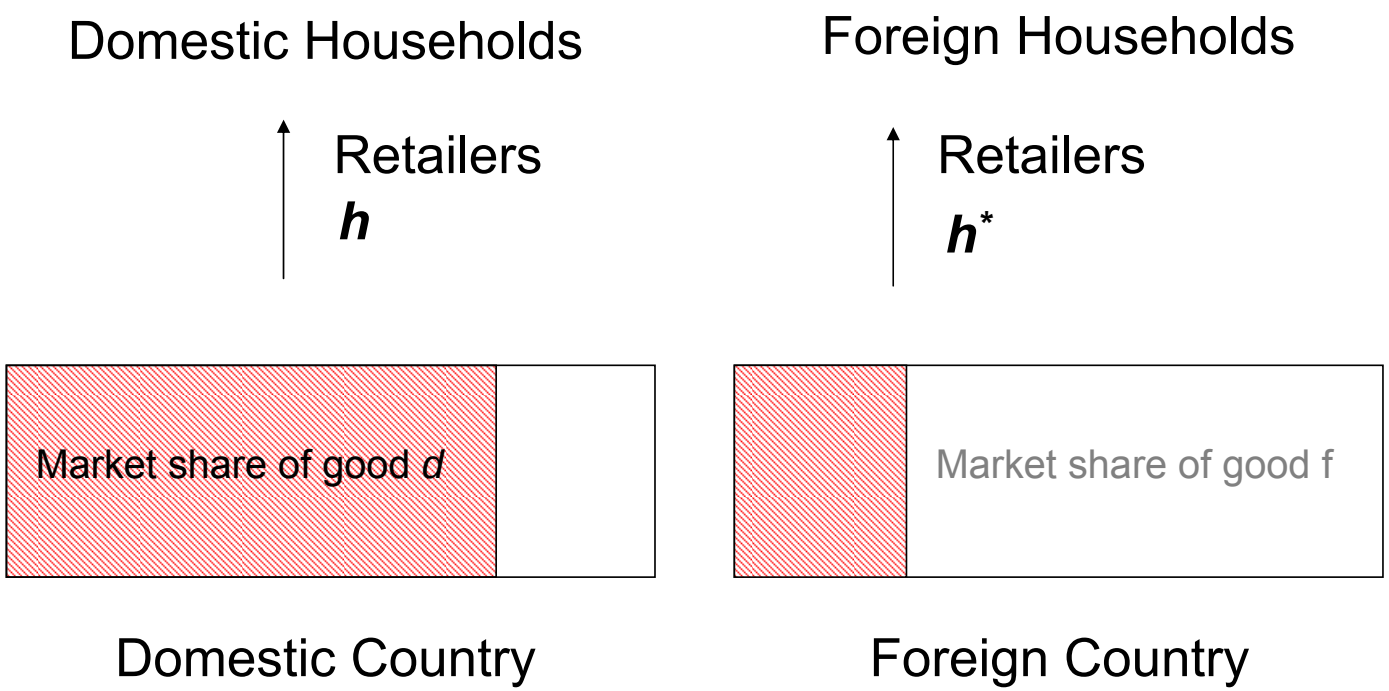
Real Exchange Rate Depreciates



Domestic Country

Foreign Country

Real Exchange Rate Depreciates



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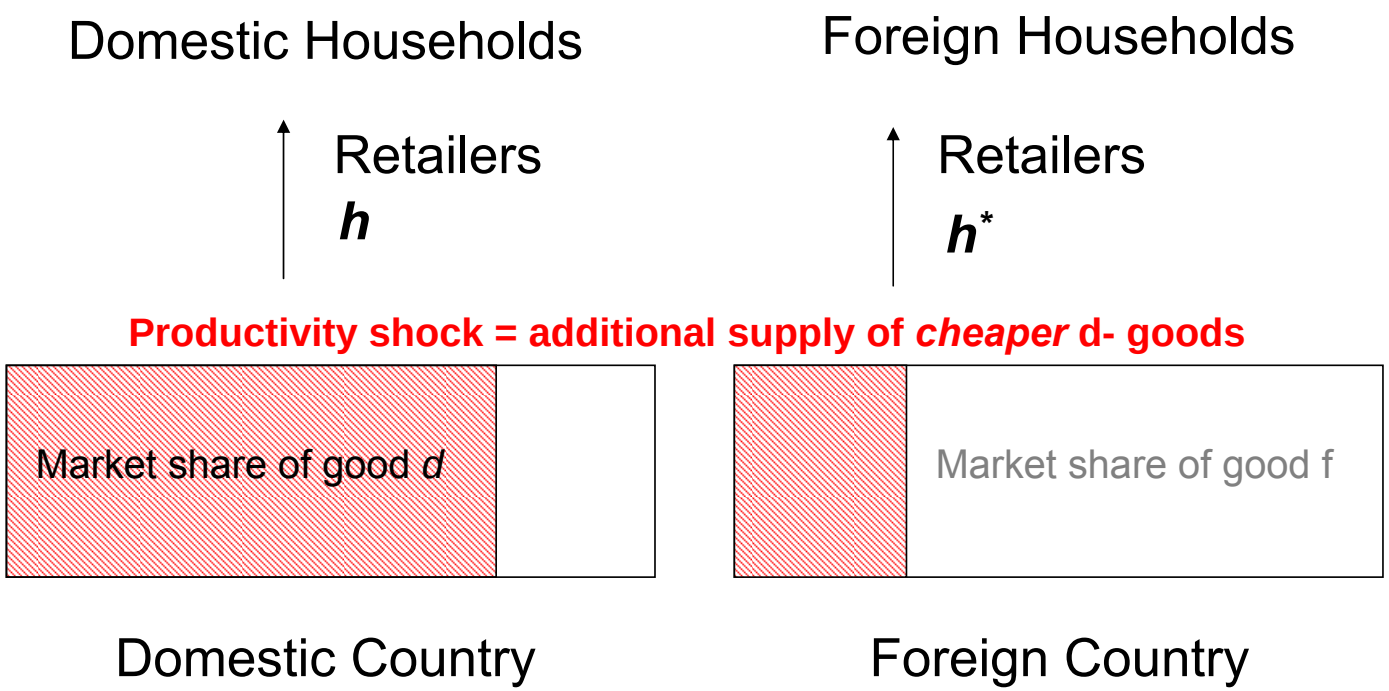

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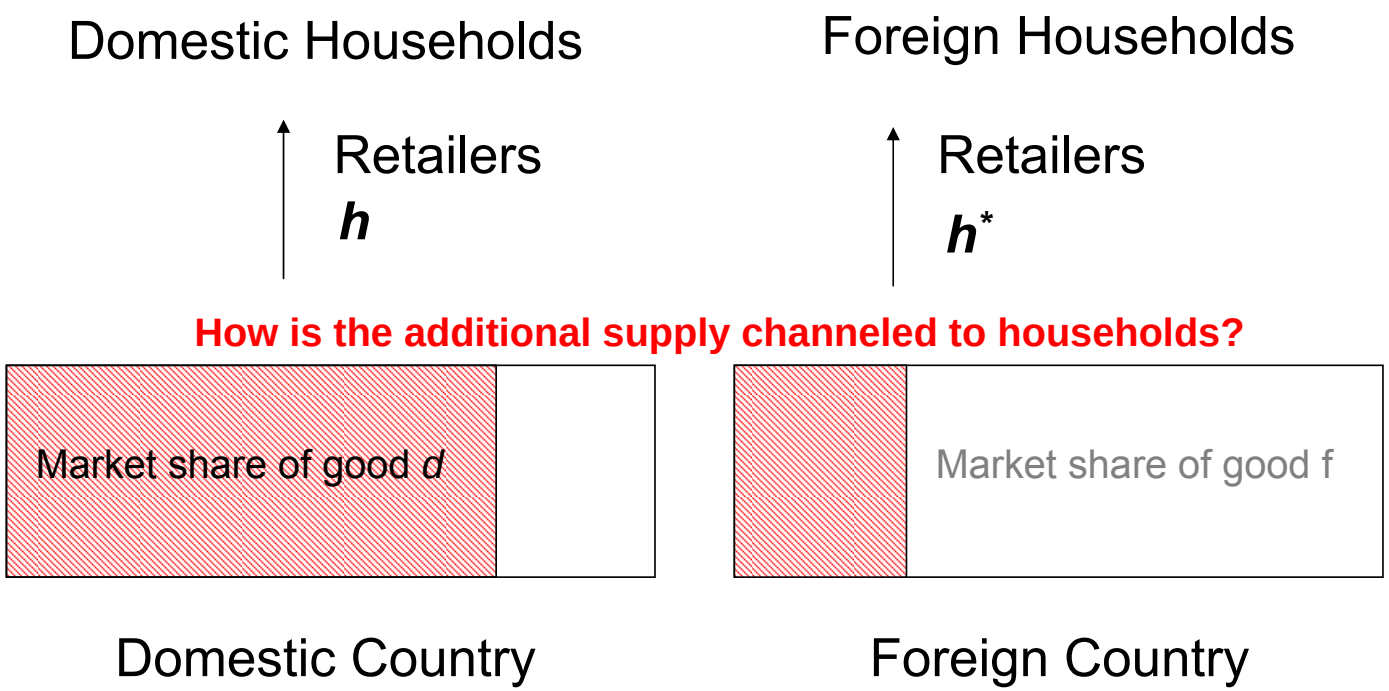

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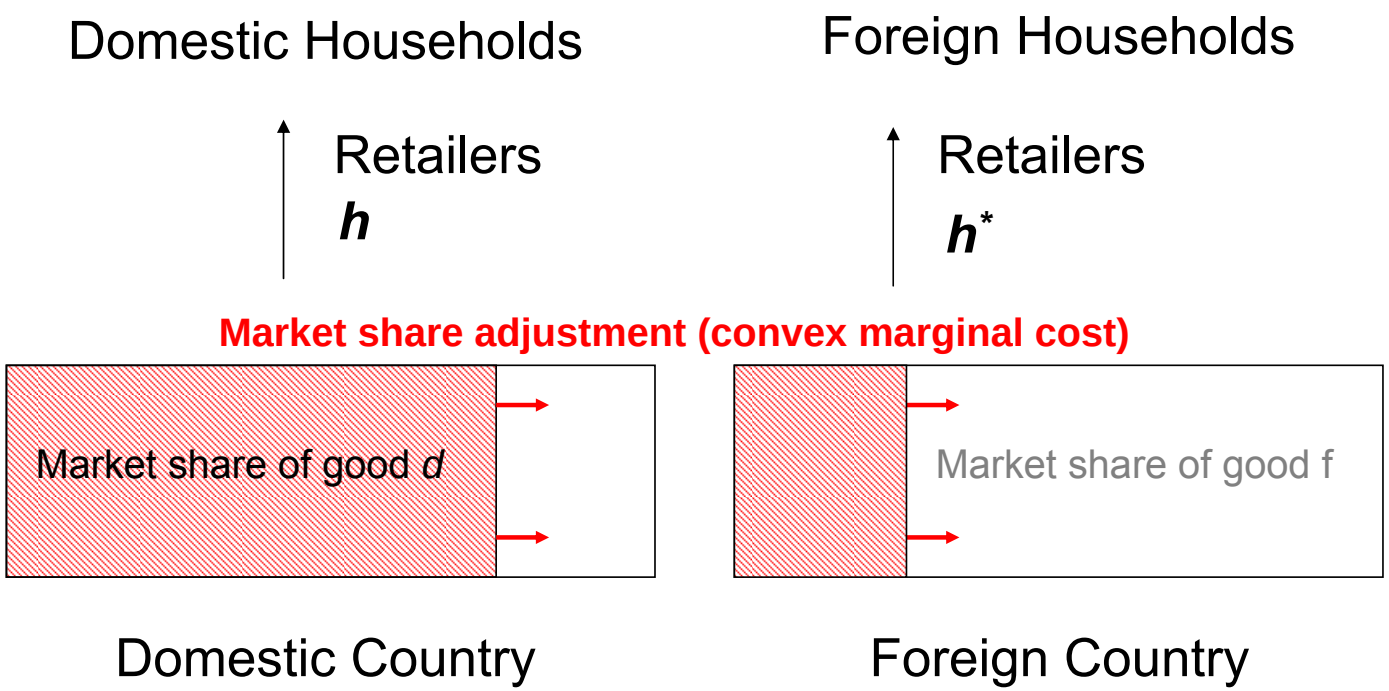

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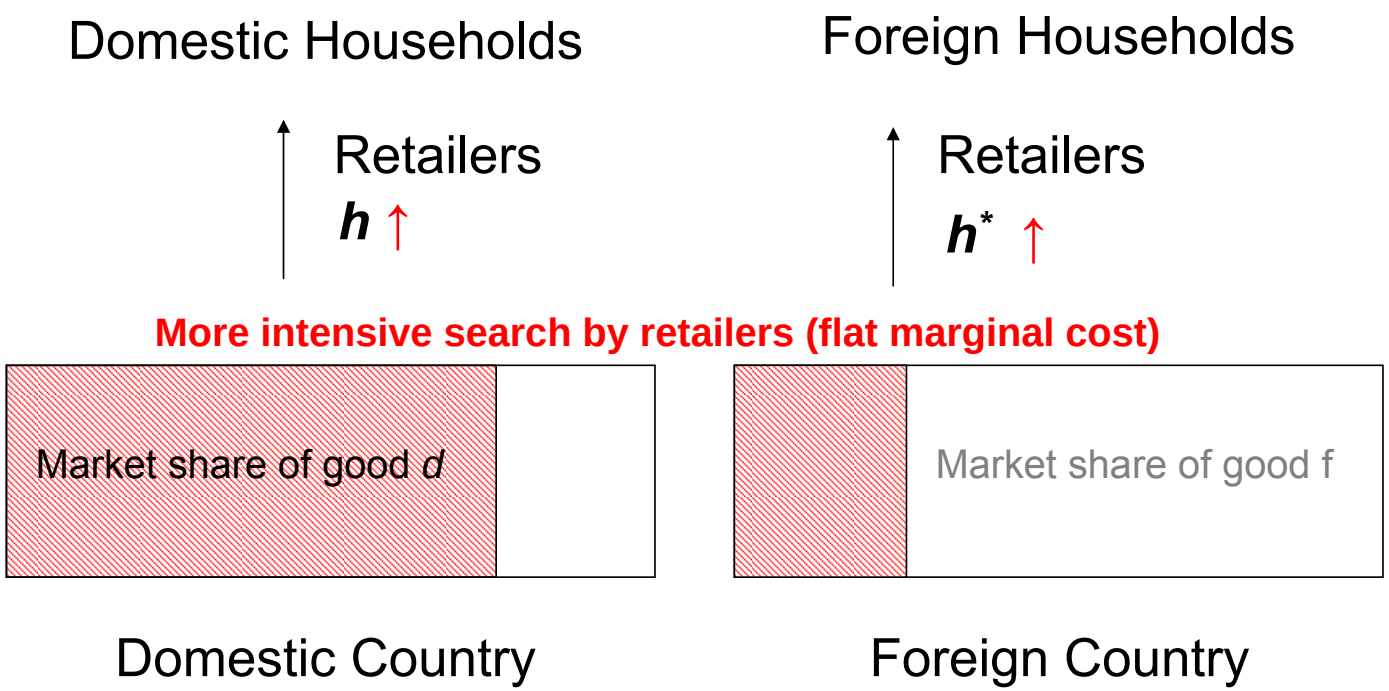

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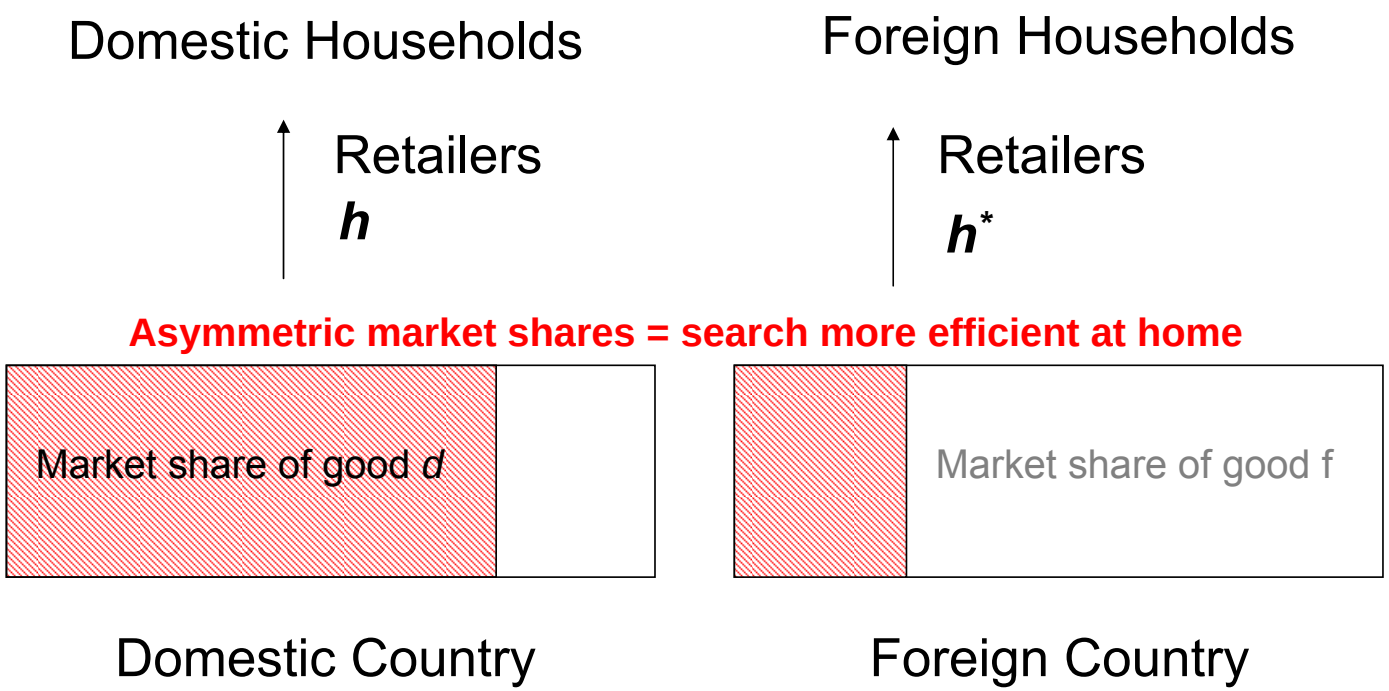

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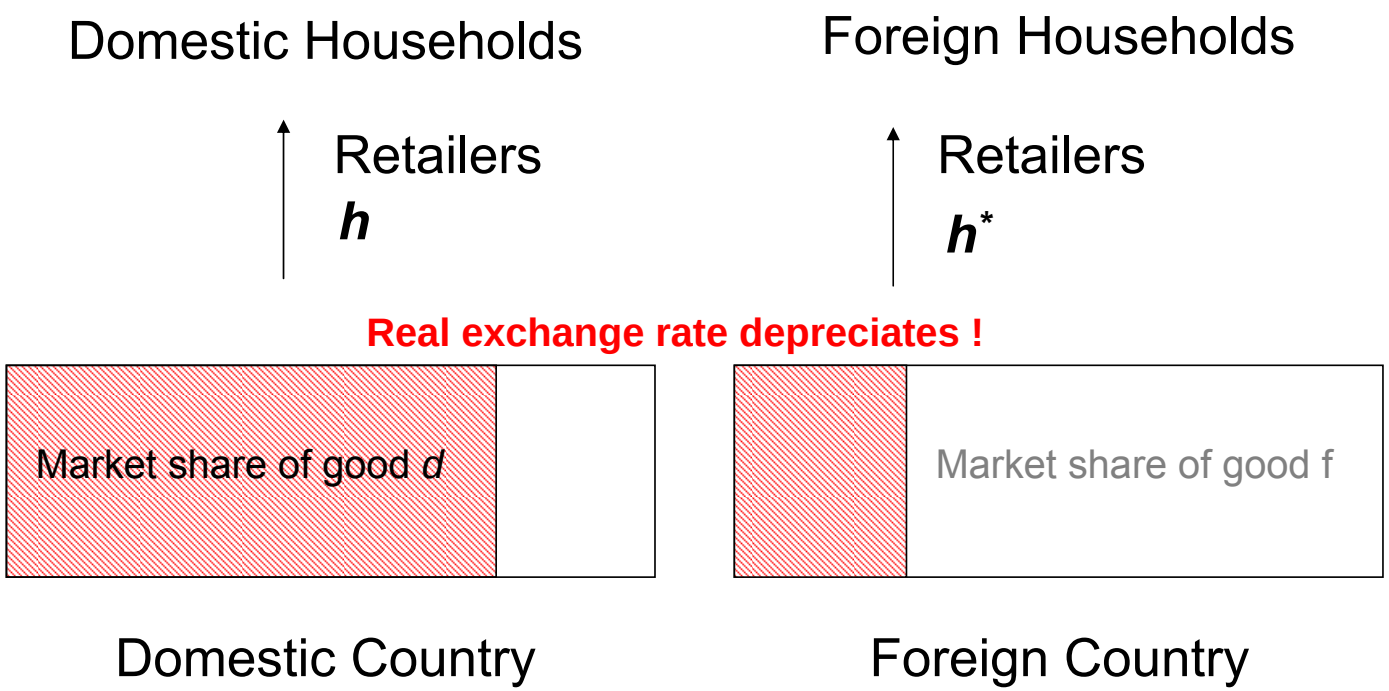

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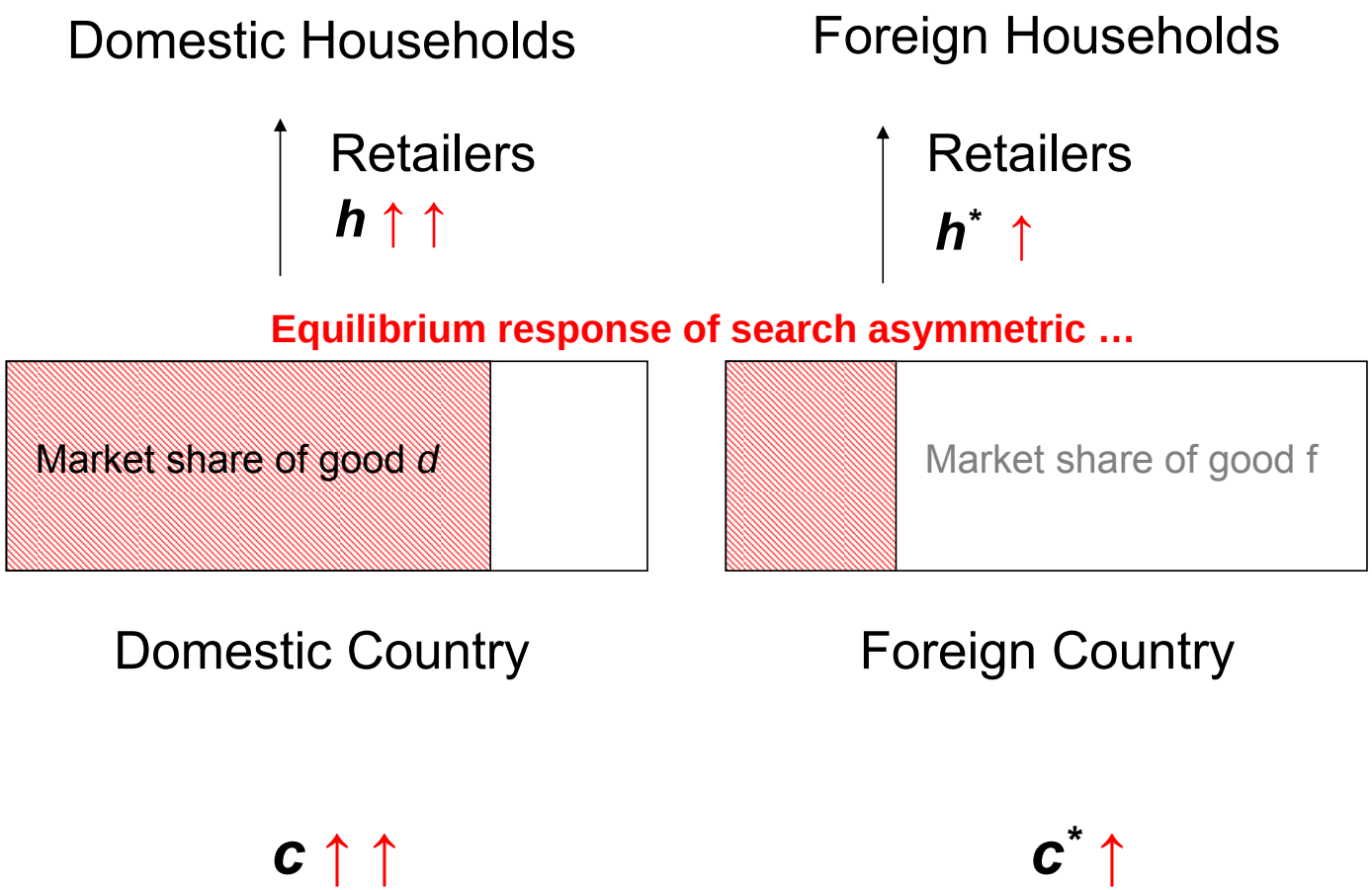

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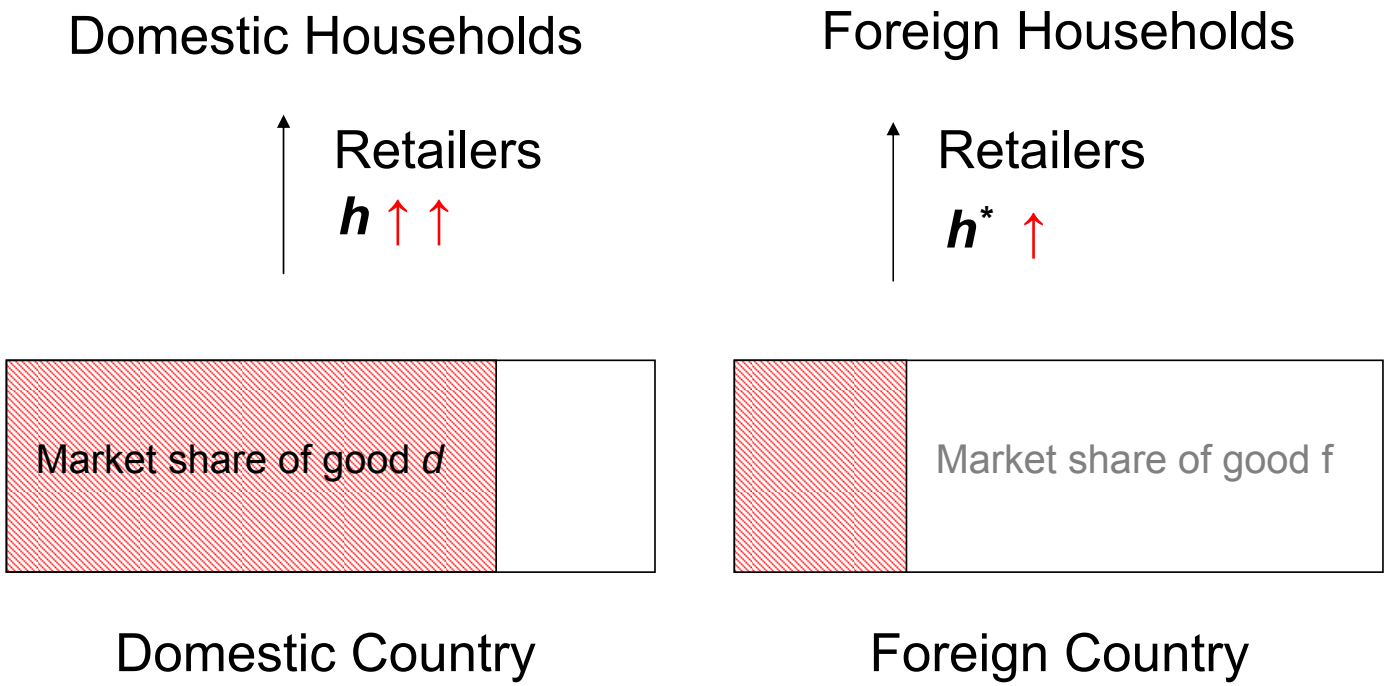
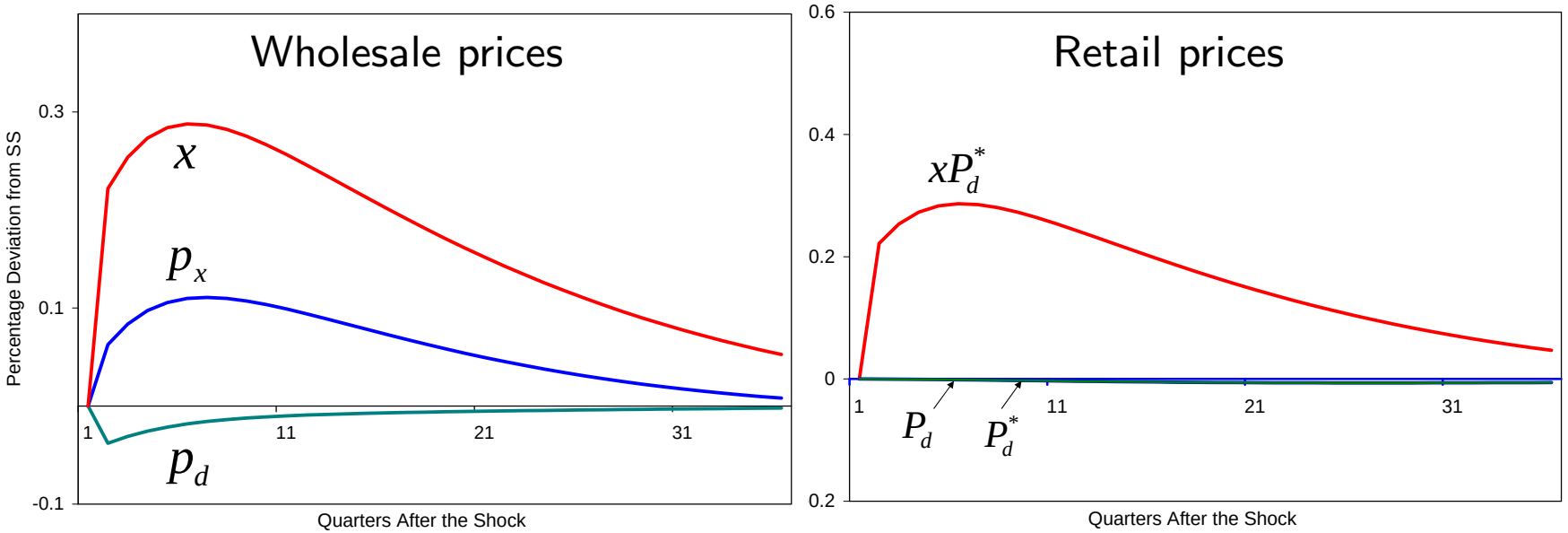


Under complete markets "MRS" equalized with depreciating real exchange rate:

$$\boldsymbol{c} \uparrow \uparrow \qquad \uparrow x = \frac{u'(c^*)}{u'(c)} \qquad \boldsymbol{c^*} \uparrow$$

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

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    - 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

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C. Volatility of Real Exchange Rate			
$std(x)$	3.60	0.43	0.49

Quantitative Results: International Prices

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p_m	0.61	0.62	1.16	0.63
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C. Volatility of Real Exchange Rate				
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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$= -1.00$

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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'*

Backup Slides

Volatility Ratio in the Standard Model

- Standard model adopts Armington '69 model of trade

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

d– domestic good, f– foreign good, γ– Armington elasticity

- Step 1: demand relations: $p_d = G_d(d,f)$, $p_f = G_f(d,f)$
- Step 2: derive from demand relations

$$\log(\frac{f}{d}) = \gamma \log(\frac{p_d}{p_f}) + \gamma \log(\frac{\omega_t}{1-\omega_t})$$

- Step 3: independent ω shocks + standard deviation of both sides

$$\sigma[\log(\frac{f}{d})] \geq \gamma \sigma[\log(\frac{p_d}{p_f})]$$

Details: Market Expansion Friction ϕ

- Logged quarterly data 1980-2000

	Volatility Ratio	
Country	HP-1600	HP-10^6
US	1.23	1.02
Canada	1.27	0.64
Japan	0.60	0.43
UK	0.65	0.61
...	...	...
12 OECD median	0.71	0.73
Standard Model	$= \gamma$	$= \gamma$

Robustness

	Price index used to construct p_x, p_m, x							
	CPI all-items		CPI tradables		WPI or PPI		None (nominal)	
Country	p_x, x	p_m, x	p_x, x	p_m, x	p_x, x	p_m, x	p_x, e	p_m, e
Belgium	0.72	0.74	0.50	0.54	0.60	0.41	0.77	0.76
Canada	0.50	0.92	0.53	0.91	0.52	0.90	0.20	0.71
France	0.61	0.66	0.46	0.53	0.57	0.69	0.71	0.72
Germany	0.50	0.85	0.06	0.76	-0.05	0.88	0.63	0.80
Italy	0.68	0.72	0.61	0.63	0.59	0.73	0.62	0.72
Japan	0.92	0.85	0.92	0.87	0.92	0.87	0.88	0.76
Netherlands	0.76	0.80	0.72	0.78	0.80	0.82	0.72	0.76
Switzerland	0.51	0.83	0.48	0.82	0.44	0.88	0.59	0.80
US	0.46	0.69	0.47	0.70	0.45	0.79	0.13	0.44
Australia	0.45	0.95	n.a	n.a	0.50	0.93	0.35	0.91
Sweden	0.60	0.74	n.a	n.a	0.28	0.28	0.54	0.67
UK	0.61	0.79	n.a	n.a	0.41	0.65	0.34	0.61
Median	0.61	0.80	0.47	0.66	0.51	0.80	0.60	0.74