Fixed costs seem better than Ricardian corner solutions for reconciling time series data on real exchange rate fluctuations with data on trade growth after liberalization experiences.

K. J. Ruhl, “Solving the Elasticity Puzzle in International Economics,” University of Texas at Austin, 2005.

The “Armington” Elasticity

- Elasticity of substitution between domestic and foreign goods
- Crucial elasticity in international economic models
- International Real Business Cycle (IRBC) models:
    - Terms of trade volatility
    - Net exports and terms of trade co-movements
- Applied General Equilibrium (AGE) Trade models:
    - Trade response to tariff changes

The Elasticity Puzzle

- Time series (Business Cycles):
    - Estimates are low
    - Relative prices volatile
    - Quantities less volatile

- Panel studies (Trade agreement):
    - Estimates are high
    - Small change in tariffs (prices)
    - Large change in quantities

Time Series Estimates: Low Elasticity (1.5)

Study	Range
Reinert and Roland Holst (1992)	$[0.1, 3.5]$
Reinert and Shiells (1993)	$[0.1, 1.5]$
Gallaway et al. (2003)	$[0.2, 4.9]$

Trade Liberalization Estimates: High Elasticity (9.0)

Study	Range
Clausing (2001)	$[8.9, 11.0]$
Head and Reis (2001)	$[7.9, 11.4]$
Romalis (2002)	$[4.0, 13.0]$

Why do the Estimates Differ?

- Time series – no liberalization:
    - Change in trade volume from goods already traded
    - Change mostly on the *intensive margin*

- Trade liberalization:
    - Change in intensive margin *plus*
    - New types of goods being traded
    - Change on the *extensive margin*

Modeling the Extensive Margin

- Model: extensive margin from export entry costs
- Empirical evidence of entry costs
  - Roberts and Tybout (1997)
  - Bernard and Wagner (2001)
  - Bernard and Jensen (2003)
  - Bernard, Jensen and Schott (2003)

The Effects of Entry Costs

- Business cycle shocks:
    - Small extensive margin effect
- Trade liberalization:
    - Big extensive margin effect
- Asymmetry creates different empirical elasticities

Model Overview

- Two countries: $\{h, f\}$, with labor L
- Infinitely lived consumers
- No international borrowing/lending
- Continuum of traded goods plants in each country
    - Differentiated goods
    - Monopolistic competitors
    - Heterogeneous productivity
- Export entry costs
    - Differs across plants: second source of heterogeneity
- Non-traded good, competitive market: A
- Tariff on traded goods (iceberg): τ

Uncertainty

- At date t, H possible events, $\eta_t = 1, ..., \mathrm{H}$
- Each event is associated with a vector of productivity shocks:

$$z_t = \left[z_h(\eta_t), z_f(\eta_t) \right]$$

- First-order Markov process with transition matrix Λ

$$\lambda_{\eta\eta'} = \mathrm{pr}\left(\eta_{t+1} = \eta' \middle| \eta_t = \eta \right)$$

Traded Good Plants

- Traded good technology:

$$y(\phi,\kappa) = z\phi l$$

- Plant heterogeneity (ϕ,κ)
  - constant, idiosyncratic productivity: ϕ
  - export entry cost: κ
  - plant of type (ϕ,κ)

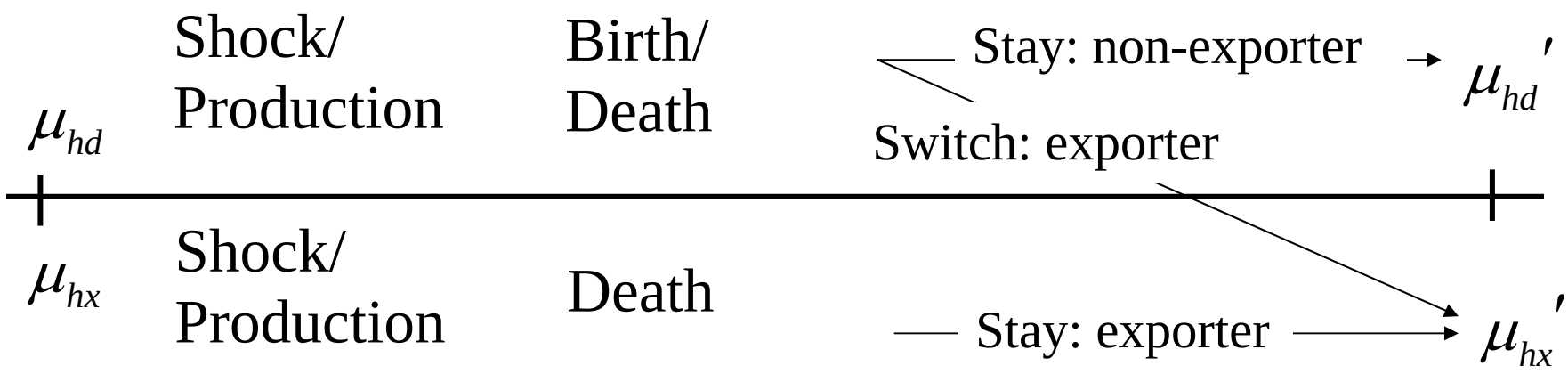
- ν plants born each period with distribution $F(\phi,\kappa)$
- Fraction δ of plants exogenously die each period

Timing

$\mu_{hx}(\phi,\kappa)$: plants of type (ϕ,κ) who paid entry cost

$\mu_{hd}(\phi,\kappa)$: plants of type (ϕ,κ) who have not paid entry cost

$\mu = (\mu_{hd}, \mu_{hx}, \mu_{fd}, \mu_{fx})$



Consumers

$$\max_{q,c_h^h(\iota),c_f^h(\iota)} \gamma \log\left(C\right)+\left(1-\gamma\right)\log\left(A\right)$$

s.t.

$$C=\left[\int_{\iota\in \mathrm{I}_h^h(\mu)} c_h^h\left(\iota\right)^\rho d\iota+\int_{\iota\in \mathrm{I}_f^h(\mu)} c_f^h\left(\iota\right)^\rho d\iota\right]^{\frac{1}{\rho}}$$

$$\int_{\iota\in \mathrm{I}_h^h(\mu)} p_h^h\left(\iota\right)c_h^h\left(\iota\right)d\iota \;+\int_{\iota\in \mathrm{I}_f^h(\mu)} \left(1+\tau\right)p_f^h\left(\iota\right)c_f^h\left(\iota\right)d\iota+p_{hA}A=L+\Pi_h$$

Non-traded Good

$$\max \; p_{hA}(\eta, \mu) A - l$$

$$\text{s.t.} \; A = z_h(\eta) l$$

Normalize $w_h = 1$, implying $p_{hA}(\eta, \mu) = z_h(\eta)$

Traded Goods: Static Profit Maximization

$$\pi_d\left(p_h^h, l; \phi, \kappa, \eta, \mu\right) = \max_{p_h^h,\, l} \; p_h^h \, z\left(\eta\right)\phi l - l$$

$$\text{s.t.} \qquad z\left(\eta\right)\phi l = \tilde{c}_h^h\left(p_h^h; \eta, \mu\right)$$

$$\pi_x\left(p_h^f, l; \phi, \kappa, \eta, \mu\right) = \max_{p_h^f,\, l} \; p_h^f \, z\left(\eta\right)\phi l - l$$

$$\text{s.t.} \qquad z\left(\eta\right)\phi l = \tilde{c}_h^f\left(p_h^f; \eta, \mu\right)$$

Pricing rules:

$$p_h^h\left(\phi, \kappa, \eta, \mu\right) = p_h^f\left(\phi, \kappa, \eta, \mu\right) = \frac{1}{\rho\phi z\left(\eta\right)}$$

Dynamic Choice: Export or Sell Domestically

- Exporter's Value Function:

$$V_x(\phi,\kappa,\eta,\mu) = d(\eta,\mu)\left(\pi_d(\phi,\kappa,\eta,\mu) + \pi_x(\phi,\kappa,\eta,\mu)\right) + (1-\delta)\beta\sum_{\eta'} V_x(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'}$$

s.t. $\mu' = \mathrm{M}(\eta,\mu)$

- $d(\eta,\mu)$ = multiplier on budget constraint

- Non-exporter's Value Function:

$$V_d(\phi,\kappa,\eta,\mu) =$$

$$\max\Big\{\pi_d(\phi,\kappa,\eta,\mu)d(\eta,\mu)+\beta(1-\delta)\sum_{\eta'}V_d(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'},$$

$$\Big[\pi_d(\phi,\kappa,\eta,\mu)-\kappa\Big]d(\eta,\mu)+\beta(1-\delta)\sum_{\eta'}V_x(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'}\Big\}$$

s.t. $\mu' = \mathrm{M}(\eta,\mu)$

Equilibrium

- Cutoff level of productivity for each value of the entry cost
- For a plant of type (ϕ, κ)

  If $\phi \geq \hat{\phi}_{\kappa}(\eta, \mu)$ export and sell domestically

  If $\phi < \hat{\phi}_{\kappa}(\eta, \mu)$ only sell domestically

- In Equilibrium
  - "Low" productivity/"high" entry cost plants sell domestic
  - "High" productivity/"low" entry cost plants also export
  - Similar to Melitz (2003)

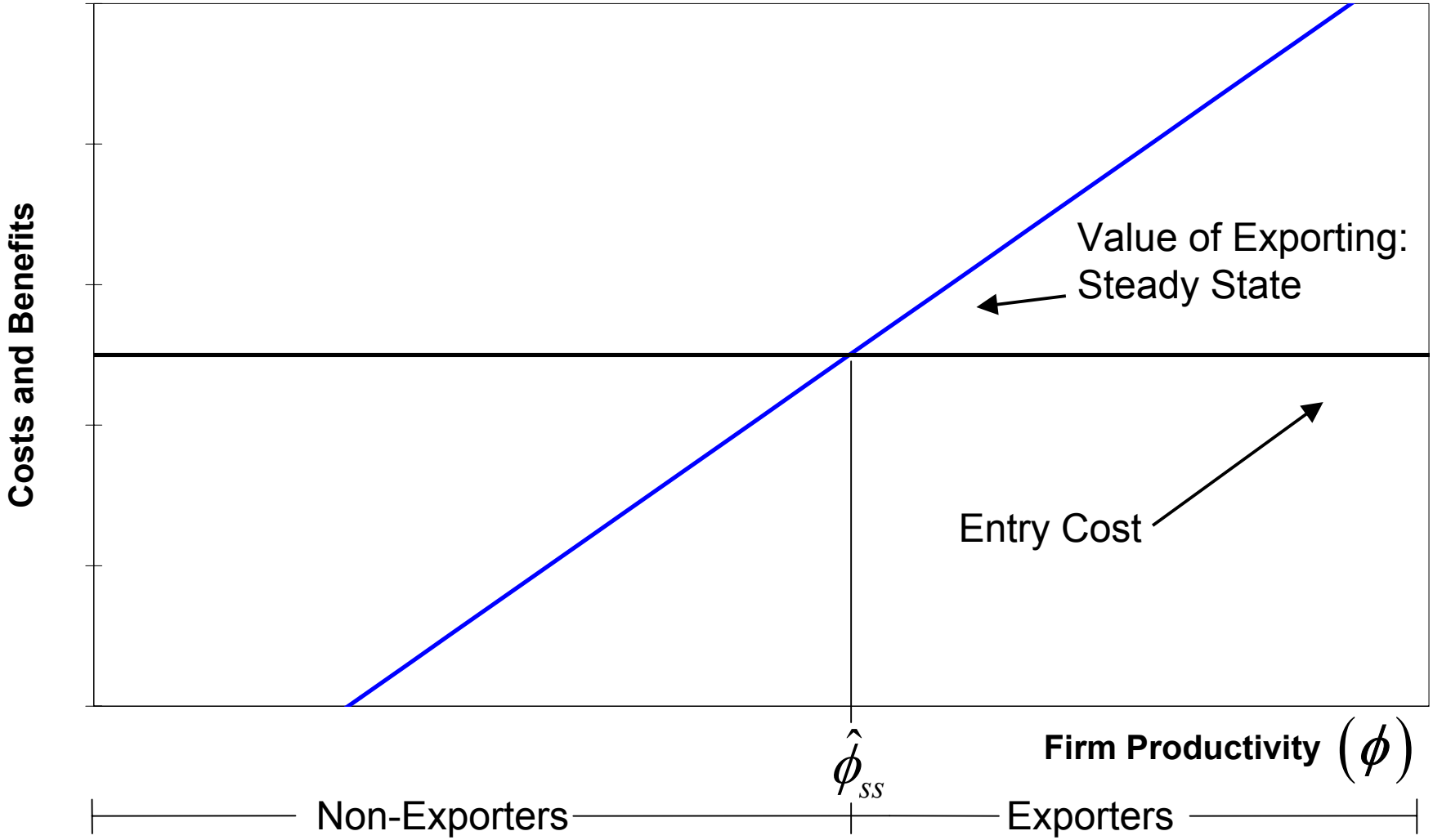
Determining Cutoffs

- For the cutoff plant:
    - entry cost = discounted, expected value of exporting

- $\hat{\phi}_{\kappa}(\eta,\mu)$ is the level of productivity, ϕ, that solves:

$$\underbrace{d\ (\eta,\mu)\kappa}_{\text{entry cost}} = \underbrace{(1-\delta)\beta\left[\sum_{\eta'} V_x(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'} - \sum_{\eta'} V_d(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'}\right]}_{\text{expected value of exporting}}$$

Finding the Cutoff Producer



Choosing Parameters

- Set $\sigma = \dfrac{1}{1-\rho} = 2$ and $\tau = 0.15$
- Calibrate to the United States (1987) and a symmetric partner.

Parameters	
β	Annual real interest rate (4%)
γ	Share of manufactures in GDP (18%)
δ	Annual loss of jobs from plant deaths as percentage of employment (Davis et. al., 1996) (6%)

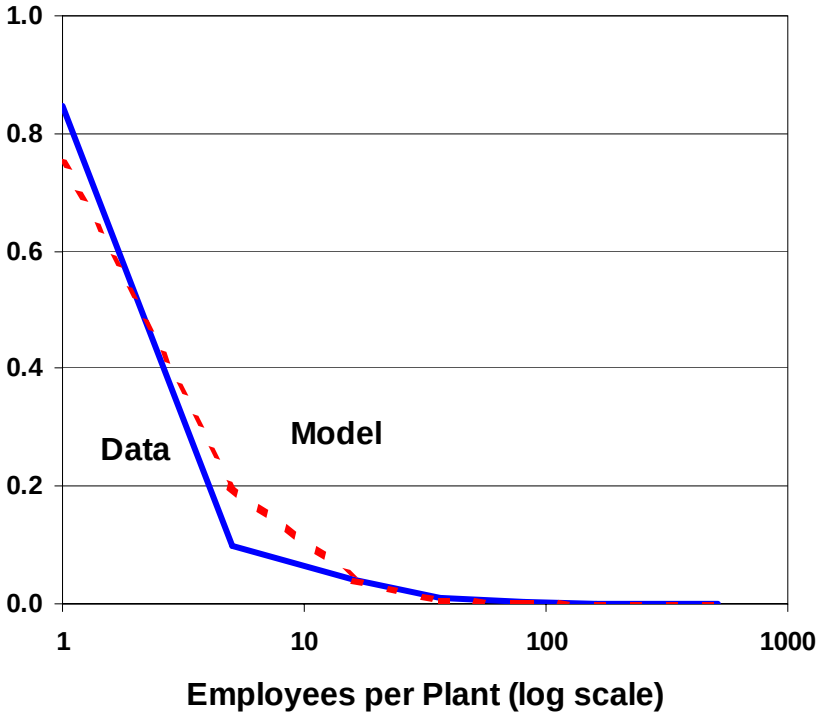
Other Parameters

- Distribution over new plants:

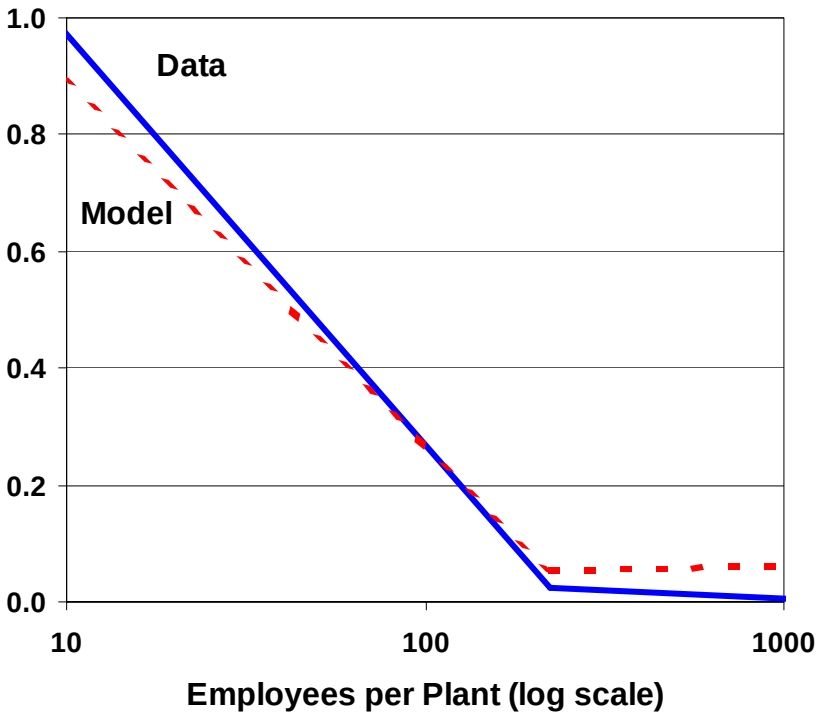
$$F_{\kappa}\left(\phi\right)=\frac{1}{\phi^{\theta_{\phi}}} \qquad\qquad F_{\phi}\left(\kappa\right)=\frac{1}{\left(\overline{\kappa}-\kappa\right)^{\theta_{\kappa}}}$$

- $\overline{\kappa}$, $\overline{\phi}$, ν, θ_{ϕ},θ_{κ} jointly determine:
    - Average plant size (12 employees)
    - Standard deviation of plant sizes (892)
    - Average exporting plant size (15 employees)
    - Standard deviation of exporting plant sizes (912)
    - Fraction of production that is exported (9%)

Plant Size Distribution:
All Plants



Plant Size Distribution:
Exporting Plants



Productivity Process

- Two shocks, low and high:

$$z_i = 1 - \varepsilon$$

$$z_i = 1 + \varepsilon$$

- Countries have symmetric processes with Markov Matrix

$$\Lambda_i = \begin{bmatrix} \bar{\lambda} & 1-\bar{\lambda} \\ 1-\bar{\lambda} & \bar{\lambda} \end{bmatrix}$$

- ε: standard deviation of the U.S. Solow Residuals (1.0%)
- $\bar{\lambda}$: autocorrelation of the U.S. Solow Residuals (0.90)

How does Trade Liberalization Differ from Business Cycles?

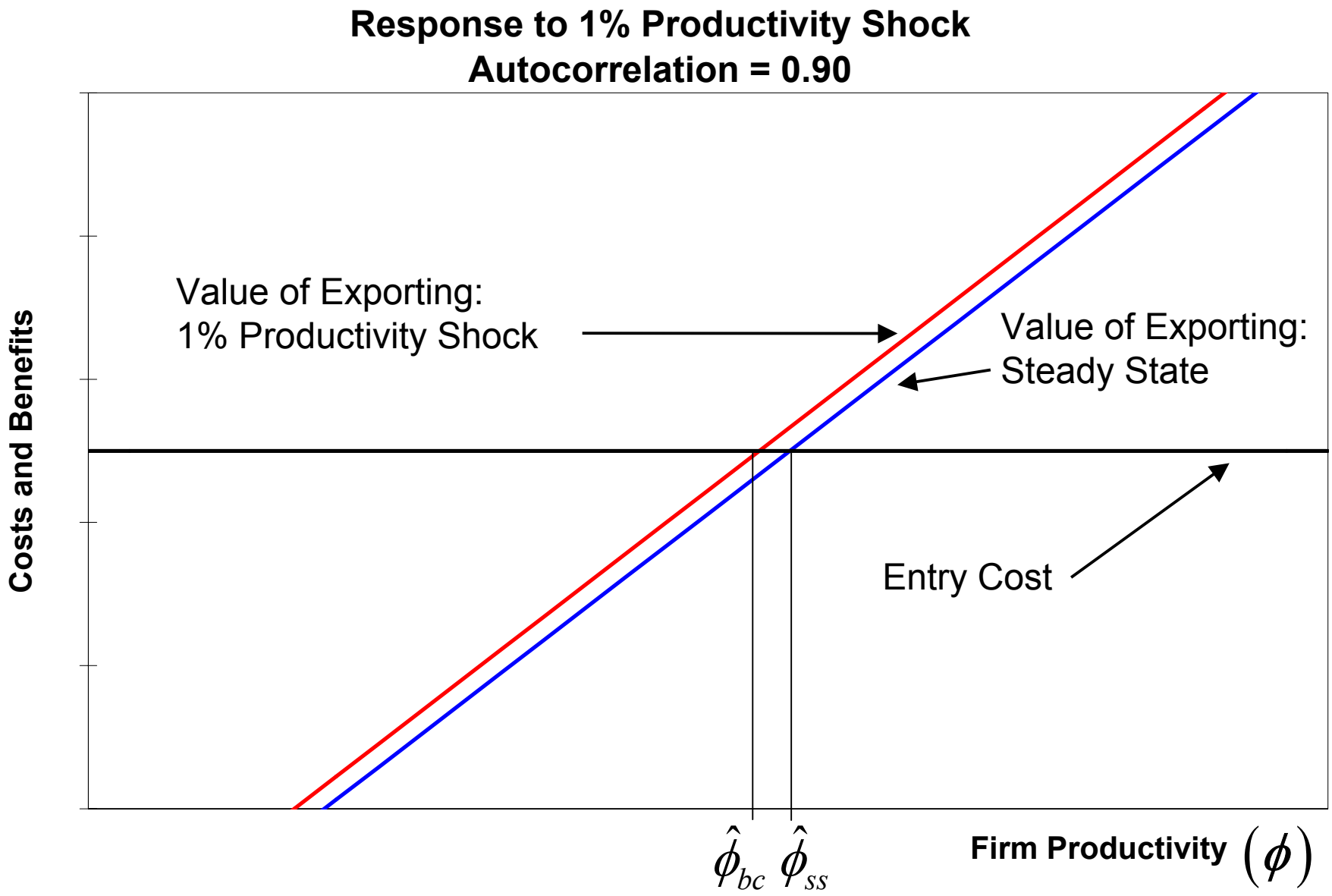
- Trade liberalization
  - Permanent changes
  - Large magnitudes

- Business cycles
  - Persistent, but not permanent changes
  - Small magnitudes

Developing Intuition: Persistent vs. Permanent Shocks

- 1% positive productivity shock in foreign country
    - Shock is persistent – autocorrelation of 0.90

- 1% decrease in tariffs
    - Change in tariffs is permanent

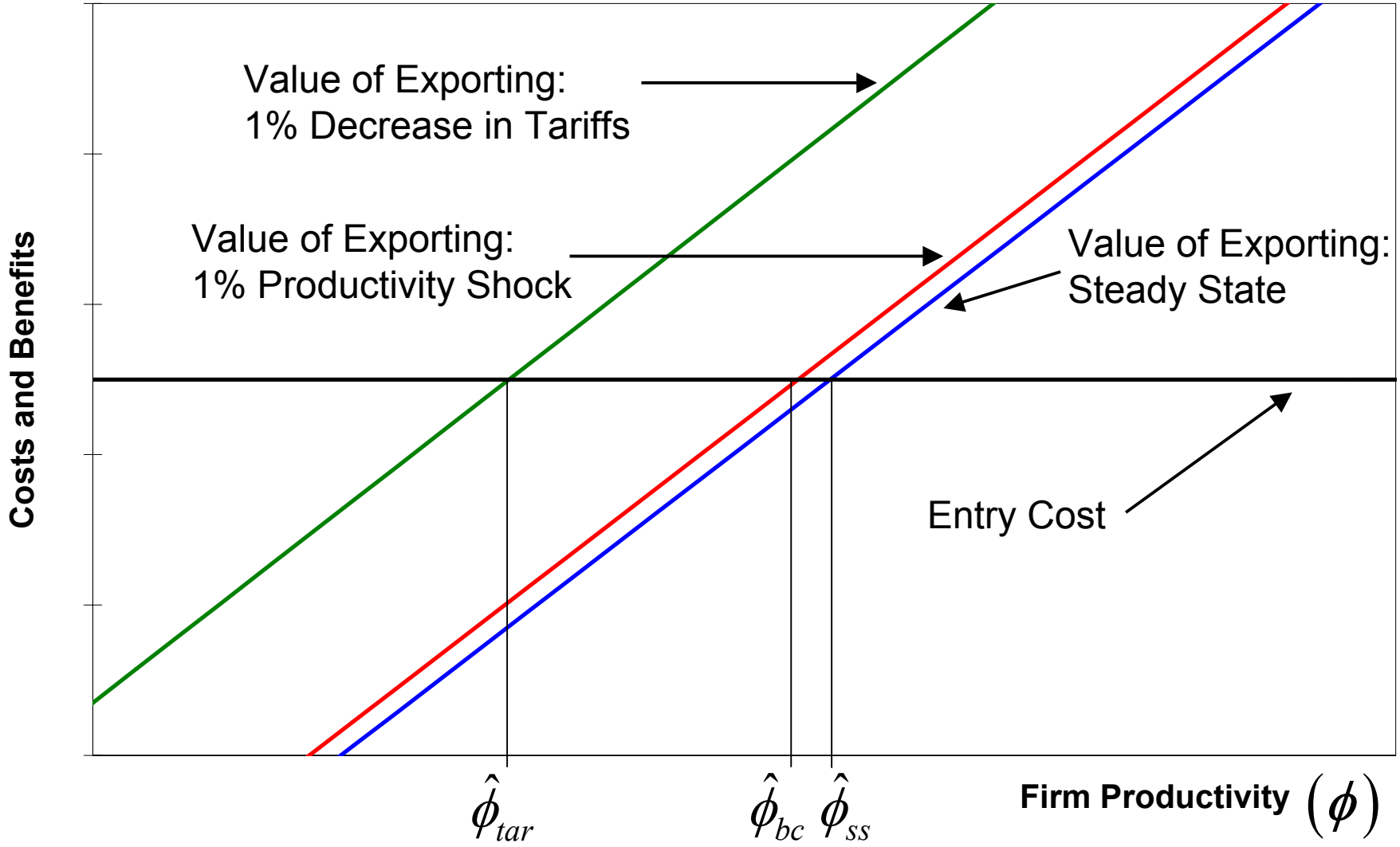

Response to 1% Productivity Shock
Autocorrelation = 0.90
Costs and Benefits
Value of Exporting:
1% Productivity Shock
Value of Exporting:
Steady State
Entry Cost
$\hat{\phi}_{bc}$
$\hat{\phi}_{ss}$
Firm Productivity (ϕ)

Response to a 1% Foreign Productivity Shock

Increase in imports on intensive margin	=	1.89%
Increase in imports on extensive margin	=	0.16%
Total increase in imports	=	2.05%
Change in consumption of home goods	=	-0.10%

$$\frac{\%\ \text{Change Imports/Dom. Cons.}}{\%\ \text{Change Price}} = \frac{2.17}{0.99} = 2.19$$

Response to 1% Permanent Decrease in Tariffs



Response to a 1% Tariff Reduction

Increase in imports on intensive margin	=	1.42%
Increase in imports on extensive margin	=	3.04%
Total increase in imports	=	4.46%
Change in consumption of home goods	=	-0.33%

$$\frac{\%\ \text{Change Imports/Dom. Cons.}}{\%\ \text{Change Tariff}} = \frac{4.81}{1.00} = 4.81$$

Quantitative Results

- Two experiments

- Trade liberalization
    - Eliminate 15% tariff
    - Compute elasticity across tariff regimes

- Time series regressions
    - Use model to generate simulated data
    - Estimate elasticity as in the literature

Trade Liberalization Elasticity

Variable	Entry Costs (% change)	No Entry Costs (% change)
Exports	87.1	30.5
Imports/Dom. Cons.	93.0	32.2
Exporting Plants	37.7	0.0
Implied Elasticity	6.2	2.1

Elasticity in the Time Series

- Simulate: produce price/quantity time series
- Regress:

$$\log\left(C_{f,t} / C_{h,t}\right) = \alpha + \sigma \log\left(p_{h,t} / p_{f,t}\right) + \varepsilon_t$$

Parameter	Estimate
α	-0.015
(standard error)	(6.36e-04)
σ	1.39
(standard error)	(0.06)
R- squared	0.30

Conclusion

- Gap between dynamic macro models and trade models
    - Partially closes the gap
    - Modeling firm behavior as motivated by the data
    - Step towards better modeling of trade policy

- Single model can account for the elasticity puzzle
    - Time series elasticity of 1.4
    - Trade liberalization elasticity of 6.2