

# Comparative Advantage and Heterogeneous Firms

Andrew Bernard, Tuck and NBER

Stephen Redding, LSE and CEPR

Peter Schott, Yale and NBER

# Introduction

How do economies respond when opening to trade?

Classical trade theory (Comparative advantage)

- Reallocation across industries
- Changes in factor rewards

New firm-based trade theories (Heterogeneous Firms)

- Reallocation across firms
  - # of firms
  - Average firm size
  - Entry and exit
  - Productivity range of producing firms
  - Proportion of exporting firms

How do these two sources of reallocation combine in GE?

# What Does This Paper Do?

Derives new (and more realistic) predictions about trade liberalization by embedding heterogeneous firms in a model of comparative advantage

- Analyze how firm, country and industry characteristics interact as trade costs fall

Trade liberalization generates simultaneous job creation and destruction in all industries

- Net job creation in CA industries
- Net job destruction in CDA industries

Steady-state creative destruction of firms occurs in all industries

- More concentrated in CA industries than CDA industries

# What Does This Paper Do?

Trade liberalization induces exit by low productivity firms and redistributes output towards high productivity exporting firms

- Aggregate productivity rises in all industries
- Productivity rises most in CA industries

The price declines associated with these productivity increases have implications for income distribution

- The real wage gains of abundant factors are inflated
- The real wage losses of scarce factors are dampened and potentially overturned

Larger increases in productivity in CA industries magnify *ex ante* patterns of comparative advantage based on factor abundance

- A new source of welfare gains from trade

# What Does This Paper Do?

The model we develop sheds light on the recent findings documenting the poor empirical performance of the standard HOV model

- Trade costs
- Factor price inequality
- Endogenous non-neutral technology differences

The theoretical framework explains why

- Some countries export more in certain industries
  - HO comparative advantage
- Nonetheless, we observe two-way trade within industries
  - Firm-level product differentiation and IRS
- Within industries engaged in these two forms of trade, some firms export and others do not
  - Heterogeneous firms and export costs

# Relationship to Existing Literature

As in Helpman and Krugman (1985), we integrate imperfect competition and scale economies into Heckscher-Ohlin theory

- Extend to a framework with heterogeneous firms

As in Melitz 2003, we model firms as heterogeneous in productivity

- Introduce cross-country differences in factor abundance and cross-industry differences in factor intensity (comparative advantage)

# Structure of the Presentation

Model with costless trade

Properties of the free trade equilibrium

Model with costly trade

Properties of the costly trade equilibrium

Numerical solutions

# The Model

## H-O

- 2 countries, 2 industries, 2 factors, continuum of firms
- Country 1 (H) is more skill-abundant than Country 2 (F)
- Industry 1 is more skill-intensive than Industry 2
- Cross-country differences in factor endowments and cross-industry differences in factor intensity

## H-K

- Representative consumer, taste for each industry, love of variety
- In equilibrium, each firm produces a unique horizontally-differentiated variety within an industry
- Fixed and variable costs of production (common skill intensity)

## M-M

- Sunk cost of entry (uses both factors)
- After entry, firms observe productivity, decide to produce or not
- Constant (exogenous) probability of death



# Model with Costless Trade

Factor endowments

$$\bar{S}^H / \bar{L}^H > \bar{S}^F / \bar{L}^F$$

Consumption

$$U = C_1^\alpha C_2^{1-\alpha}$$

$$C_i = \left[ \int_{\omega \in \Omega_i} q_i(\omega)^\rho d\omega \right]^{\frac{1}{\rho}} \quad P_i = \left[ \int_{\omega \in \Omega_i} p_i(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}$$

Production (Cost)

- Similar to Melitz (2003), but multiple factors of production and factor intensity differences across sectors

$$\Gamma_i = \left[ f_i + \frac{q_i}{\phi} \right] (w_S)^{\beta_i} (w_L)^{1-\beta_i} \quad 1 > \beta_1 > \beta_2 > 0$$

# Zero-Profit Productivity Cutoff and Free Entry

Profit maximization

$$p_i(\varphi) = \left( \frac{\sigma}{\sigma-1} \right) \frac{(w_S)^{\beta_i} (w_L)^{1-\beta_i}}{\varphi}$$

With free trade, firms that produce do so for both domestic and export markets and the price charged is the same

Equilibrium profits

$$\pi_i(\varphi) = \frac{r_i(\varphi)}{\sigma} - f_i (w_S)^{\beta_i} (w_L)^{1-\beta_i}$$

Zero-Profit Productivity Cutoff in each sector

$$r_i(\varphi_i^*) = \sigma f_i (w_S)^{\beta_i} (w_L)^{1-\beta_i}$$

Free entry in each sector

$$V_i = \frac{[1-G(\varphi_i^*)]}{\delta} \bar{\pi}_i = f_{ei} (w_S)^{\beta_i} (w_L)^{1-\beta_i}$$

Sunk entry cost uses both factors and begin by assuming factor intensity is the same as production

# Conditions for Integrated Equilibrium

$$\{\hat{\varphi}_1^*, \hat{\varphi}_2^*, \hat{P}_1, \hat{P}_2, \hat{R}, \hat{p}_1(\varphi), \hat{p}_2(\varphi), w_S, w_L\}$$

Nine endogenous variables and nine equilibrium conditions

1. Equilibrium pricing (2 equations)

2. Free entry (2 equations)

$$V_i = \frac{f_i}{\delta} \int_{\varphi_i^*}^{\infty} \left[ \left( \frac{\varphi}{\varphi_i^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi = f_{ei}$$

Independent of factor prices when production and entry have the same factor intensity

3. Labor market clearing (2 equations)

4. Equilibrium price indices (2 equations)

$$P_i = \left[ M_i(p_i(\tilde{\varphi}_i))^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

5. Equilibrium expenditure shares (1 equation)

$$\frac{R_1}{R} = \alpha \quad \Rightarrow \quad \frac{R_2}{R} = (1 - \alpha)$$

# Existence of Integrated Equilibrium and FPE

## Proposition 1:

There exists a unique integrated equilibrium, referenced by the vector  $\{\hat{\varphi}_1^*, \hat{\varphi}_2^*, \hat{P}_1, \hat{P}_2, \hat{R}, \hat{p}_1(\varphi), \hat{p}_2(\varphi), w_S, w_L\}$ . Under free trade, there exist a set of allocations of world factor endowments to the two countries individually such that the unique free trade equilibrium is characterized by factor price equalization (FPE) and replicates the resource allocation of the integrated world economy.

All four major theorems of the HO model continue to hold

# New Properties of the Free Trade Equilibrium

## Proposition 2:

With identical factor intensities in entry and production, a move from autarky to free trade leaves the zero-profit productivity cutoff and average industry productivity unchanged

$$V_i = \frac{f_i}{\delta} \int_{\varphi_i^*}^{\infty} \left[ \left( \frac{\varphi}{\varphi_i^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi = f_{ei}$$

# Model with Costly Trade

## Fixed and variable costs of trade

- We examine how these interact with comparative advantage to shape between and within-industry reallocation

## Equilibrium pricing

$$p_{ix}^H(\varphi) = \frac{\tau_i (w_S^H)^{\beta_i} (w_L^H)^{1-\beta_i}}{\rho\varphi} = \tau_i p_{id}^H(\varphi)$$

## Equilibrium revenue and profits

$$r_i^H(\varphi) = \begin{cases} r_{id}^H(\varphi) & \text{no exports} \\ r_{id}^H(\varphi) \left[ 1 + \tau_i^{1-\sigma} \left( \frac{P_i^F}{P_i^H} \right)^{\sigma-1} \left( \frac{R^F}{R^H} \right) \right] & \text{exports.} \end{cases}$$

$$\pi_i^H(\varphi) = \pi_{id}^H(\varphi) + \max\{0, \pi_{ix}^H(\varphi)\}$$

# Decision to Produce / Export and Free Entry

Zero-profit productivity cutoff and export productivity cutoff

$$r_{id}^H(\varphi_i^{*H}) = \sigma f_i (w_S^H)^{\beta_i} (w_L^H)^{1-\beta_i}$$

$$r_{ix}^H(\varphi_{ix}^{*H}) = \sigma f_{ix} (w_S^H)^{\beta_i} (w_L^H)^{1-\beta_i}$$

Equilibrium relationship between the productivity cutoffs

$$\varphi_{ix}^{*H} = \Lambda_i^H \varphi_i^{*H} \quad \text{where} \quad \Lambda_i^H \equiv \tau_i \left( \frac{P_i^H}{P_i^F} \right) \left( \frac{R^H}{R^F} \frac{f_{ix}}{f_i} \right)^{\frac{1}{\sigma-1}}$$

Free entry condition

$$V_i^H = \frac{f_i}{\delta} \int_{\varphi_i^{*H}}^{\infty} \left[ \left( \frac{\varphi}{\varphi_i^{*H}} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi \\ + \frac{f_{ix}}{\delta} \int_{\varphi_{ix}^{*H}}^{\infty} \left[ \left( \frac{\varphi}{\varphi_{ix}^{*H}} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi = f_{ei}$$

# Existence of Costly Trade Equilibrium

**Proposition 3:** There exists a unique costly trade equilibrium referenced by the following pair of equilibrium vectors for  $k \in \{H, F\}$

$$\{\hat{\varphi}_1^{*k}, \hat{\varphi}_2^{*k}, \hat{\varphi}_{1x}^{*k}, \hat{\varphi}_{2x}^{*k}, \hat{P}_1^k, \hat{P}_2^k, \hat{p}_1^k(\varphi), \hat{p}_2^k(\varphi), \hat{p}_{1x}^k(\varphi), \hat{p}_{2x}^k(\varphi), w_S^k, w_L^k, \hat{R}^k\}$$



# Properties of the Costly Trade Equilibrium

## Proposition 6:

- (a) Opening a closed economy to costly trade will increase the zero-profit productivity cutoff,  $\varphi_i^*$ , below which firms exit the industry
- (b) Other things equal, the zero-profit productivity cutoff,  $\varphi_i^*$ , will rise by more if a country is small relative to its trade partner ( $R^H$  &  $R^F$ ), if domestic competition is high relative to foreign competition within the industry ( $P_i^H$  &  $P_i^F$ ), or if fixed and variable trade costs are low ( $f_{ix}$  &  $\tau_i$ )

$$V_i^H = \frac{f_i}{\delta} \int_{\varphi_i^{*H}}^{\infty} \left[ \left( \frac{\varphi}{\varphi_i^{*H}} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi + \frac{f_{ix}}{\delta} \int_{\Lambda_i^H \varphi_i^{*H}}^{\infty} \left[ \left( \frac{\varphi}{\Lambda_i^H \varphi_i^{*H}} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi = f_{ei}$$

$$\Lambda_i^H \equiv \tau_i \left( \frac{P_i^H}{P_i^F} \right) \left( \frac{R^H f_{ix}}{R^F f_i} \right)^{\frac{1}{\sigma-1}}$$

# Properties of the Costly Trade Equilibrium

**Proposition 7:** Other things equal, the opening of a closed economy to costly trade will

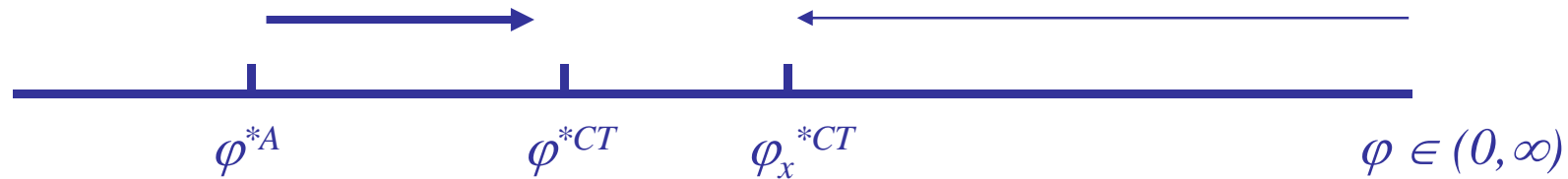
- (a) Raise the zero-profit productivity cutoff in the CA industry ( $\varphi_1^{*H}$  &  $\varphi_2^{*F}$ ) relative to that in the CDA industry ( $\varphi_2^{*H}$  &  $\varphi_1^{*F}$ )
- (b) Magnify CA by inducing endogenous Ricardian productivity differences at the industry level ( $\tilde{\varphi}_1^H/\tilde{\varphi}_2^H > \tilde{\varphi}_1^F/\tilde{\varphi}_2^F$ )
- (c) Result in a higher probability of exporting in a country's CA industry ( $\chi_1^H$  &  $\chi_2^F$ ) than in the CDA industry ( $\chi_2^H$  &  $\chi_1^F$ )

$$\frac{\Lambda_1^H}{\Lambda_2^H} = \frac{\tau_1}{\tau_2} \left( \frac{f_{1x}/f_1}{f_{2x}/f_2} \right)^{\frac{1}{\sigma-1}} \frac{P_1^H/P_2^H}{P_1^F/P_2^F}$$

$$V_i^H = \frac{f_i}{\delta} \int_{\varphi_i^{*H}}^{\infty} \left[ \left( \frac{\varphi}{\varphi_i^{*H}} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi + \frac{f_{ix}}{\delta} \int_{\Lambda_i^H \varphi_i^{*H}}^{\infty} \left[ \left( \frac{\varphi}{\Lambda_i^H \varphi_i^{*H}} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi = f_{ei}$$

# From Autarky to Costly Trade

Comparative Advantage Industry



Comparative Disadvantage Industry



A = autarky

CT = costly trade

# Implications for Income Distribution

In standard HO, the rise in the relative price of a country's CA good following the opening of trade leads to a rise in abundant factor's real reward and a decline in scarce factor's real reward

In our heterogeneous firm framework, two additional effects are present

- The rise in average productivity in both sectors reduces the consumer price index for both goods
- As in Helpman-Krugman, trade may expand the number of varieties available for domestic consumption, which will again reduce the consumer price index

$$W_S^H = \frac{w_S^H}{(P_1^H)^\alpha (P_2^H)^{1-\alpha}} \quad W_L^H = \frac{w_L^H}{(P_1^H)^\alpha (P_2^H)^{1-\alpha}}$$

# Job Creation and Job Destruction

There are both within and between-industry reallocations of resources following a reduction in trade costs

Unlike HO, there is *gross* job creation and destruction in both CA and CDA industries

- In CDA industries, where there is *net job destruction*, jobs are *created* at high productivity exporters

Within each industry, the change in employment following a reduction in trade costs can be decomposed into:

- (a) Change in employment in the sunk costs of entry
- (b) Change in employment for domestic production due to entry/exit
- (c) Change in employment for domestic production at continuing firms
- (d) Change in employment for the export market due to entry/exit of firms into exporting
- (e) Change in employment for the export market at continuing exporters

# Numerical Solutions

Consider a reduction in variable trade costs from 100% to 20% (i.e. from  $\tau = 2$  to  $\tau = 1.2$ )

Assume a Pareto productivity distribution

➤  $g(\varphi) = a k^a \varphi^{-(a+1)}$  where  $k > 0$ ,  $\varphi \geq k$ ,  $a > 0$

Factor endowments and intensities

➤  $\{S^H = 1200, L^H = 1000\}$  and  $\{S^F = 1000, L^F = 1200\}$

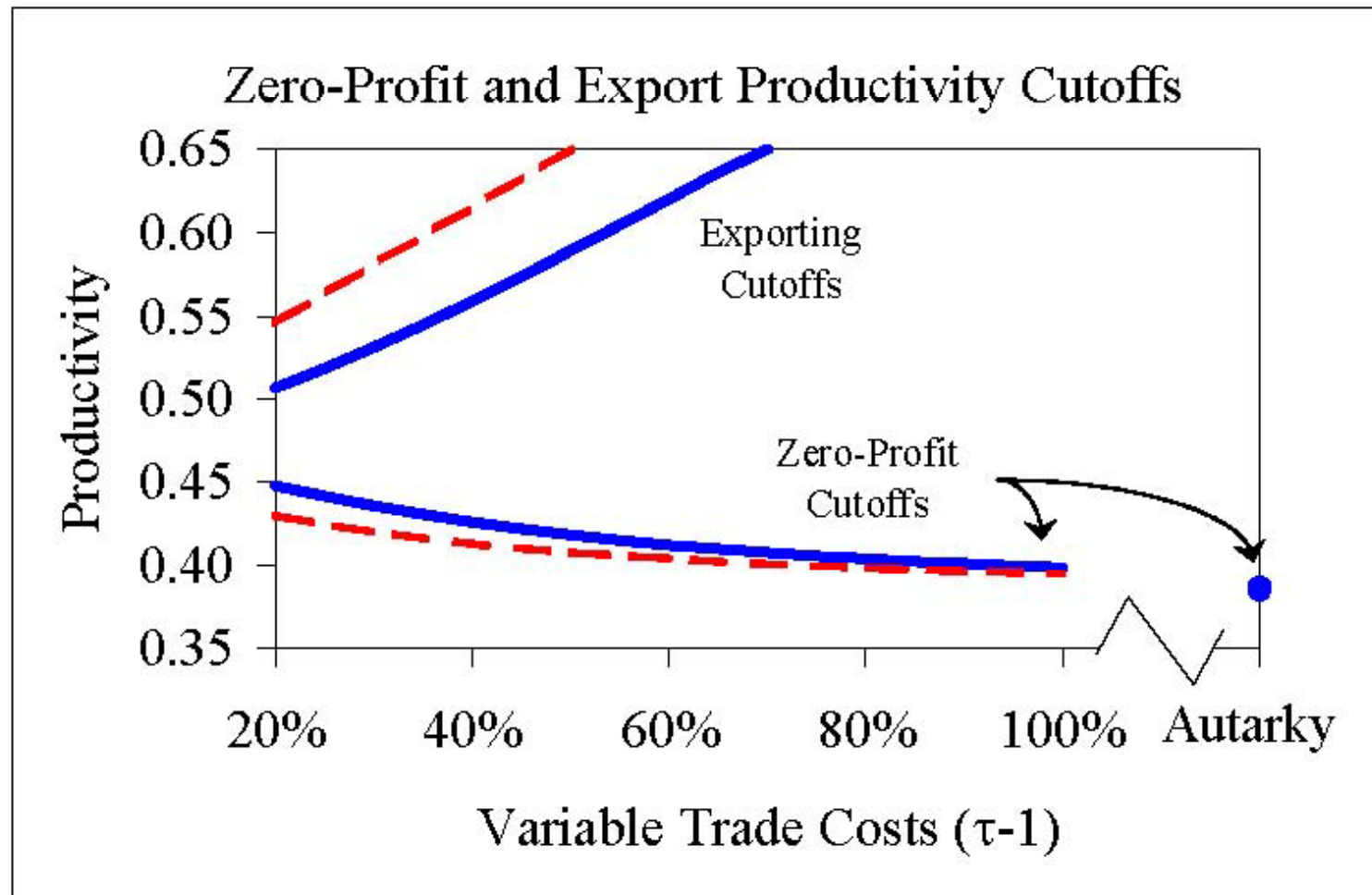
➤  $\{\beta_1 = 0.6\}$  and  $\{\beta_2 = 0.4\}$

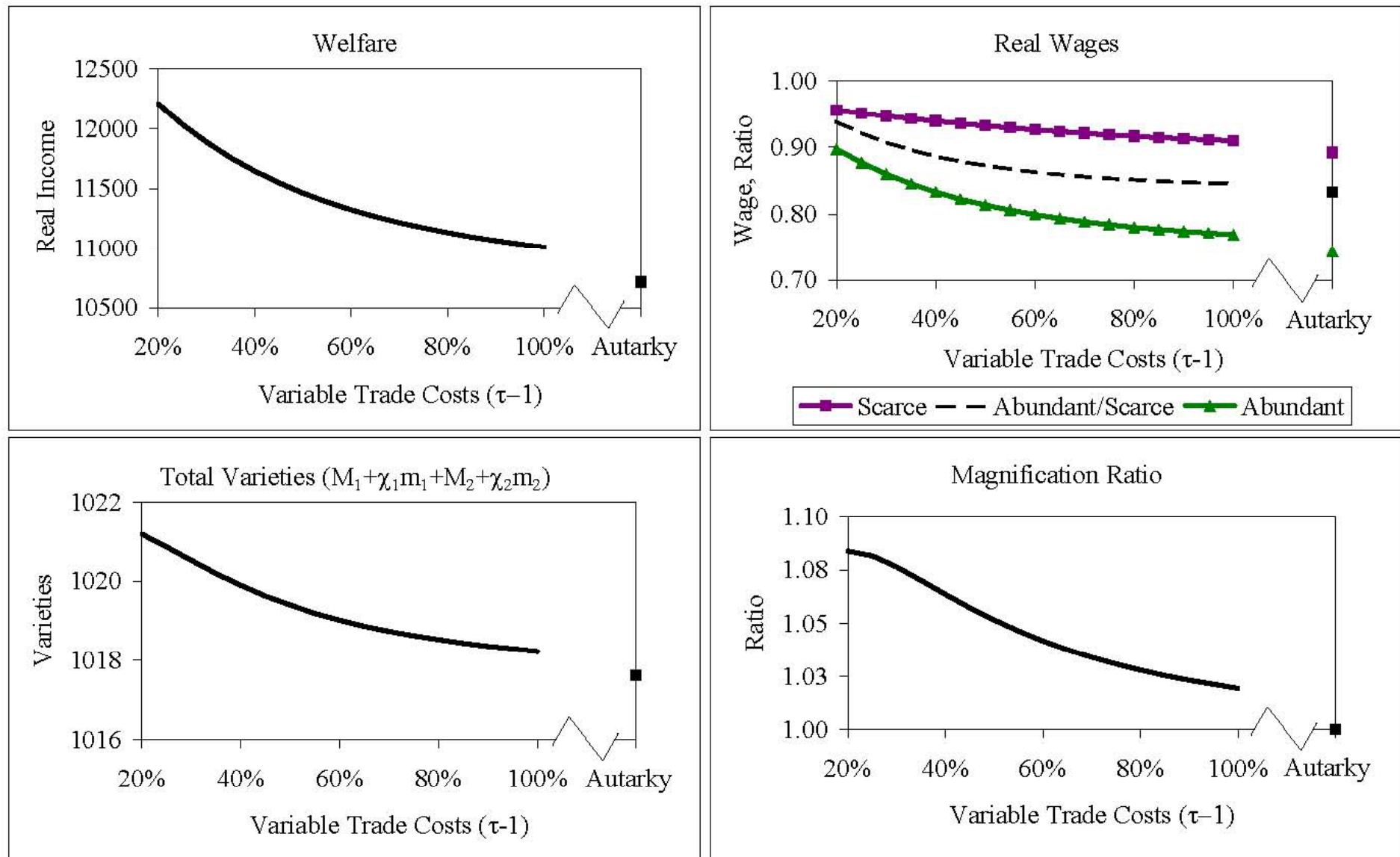
Choose other parameter values based on Bernard, Eaton, Jenson and Kortum (2003) and Ghironi and Melitz (2004)

➤ For example,  $\sigma = 3.8$

➤ To focus on CA, all parameters except factor intensity are the same across industries

# Numerical Solutions : Productivity Cutoffs





Note: Endogenous productivity differential is the ratio of Home versus Foreign average industry productivity in the comparative advantage industry to the same relative quantity for the comparative disadvantage industry. See text for formal definition.

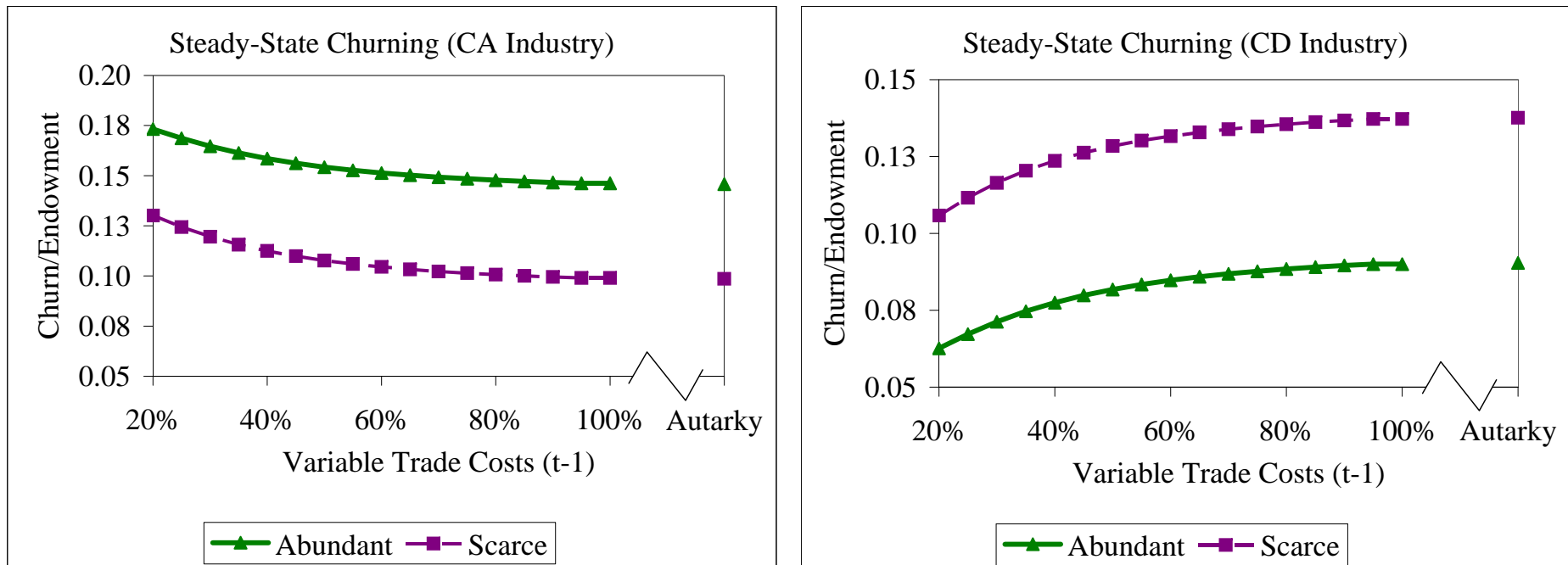
Figure 5: Welfare and Its Components



# Numerical Solutions : Job Turnover

	Comparative Advantage Industry		Comparative Disadvantage Industry	
	Job Turnover	Decline From Autarky to 20%	Job Turnover	Decline From Autarky to 20%
Abundant Factor	Total	20.7	Total	14.3
	Between-Industry	7.3	Between-Industry	-7.3
	Within-Industry	13.3	Within-Industry	7.0
Scarce Factor	Total	15.6	Total	20.1
	Between-Industry	6.9	Between-Industry	-6.9
	Within-Industry	8.7	Within-Industry	13.2

# Numerical Solutions : Steady-state Churning



Note: Factors employed in steady-state churning are those used for entry and by exiting firms.

Figure 6: Steady State Employment Churning

# Conclusions

We develop a heterogeneous firm model of international trade which encompasses

- Inter-industry trade
- Intra-industry trade
- Microeconomic features of export markets

A move from autarky to free trade

- Induces firm-level responses along a variety of adjustment margins
- Relative to the other industry, the comparative advantage industry experiences increases in
  - the share of skilled and unskilled labor
  - the mass of firms
  - the amount of entry and exit
  - average firm size

# Conclusions

Opening to costly trade induces two additional adjustment margins

- The productivity range of producing and exporting firms

The between-industry reallocations of Heckscher-Ohlin theory interact with the within-industry reallocations of heterogeneous firm models

- Average productivity increases by more in CA industries
- The probability of exporting is greater in CA industries
- Both industries experience gross job creation and destruction
  - Excess job reallocation is greatest for the abundant factor in the CA industry

Trade induces endogenous Ricardian productivity differences at the industry level that *magnify* HO comparative advantage

- The Stolper-Samuelson effect is augmented by changes in average industry productivity and the number of available varieties
  - The real reward of the scarce factor falls by less than in HO

Thank You

# Factor Intensity Differences in Entry and Production

Free entry condition becomes:

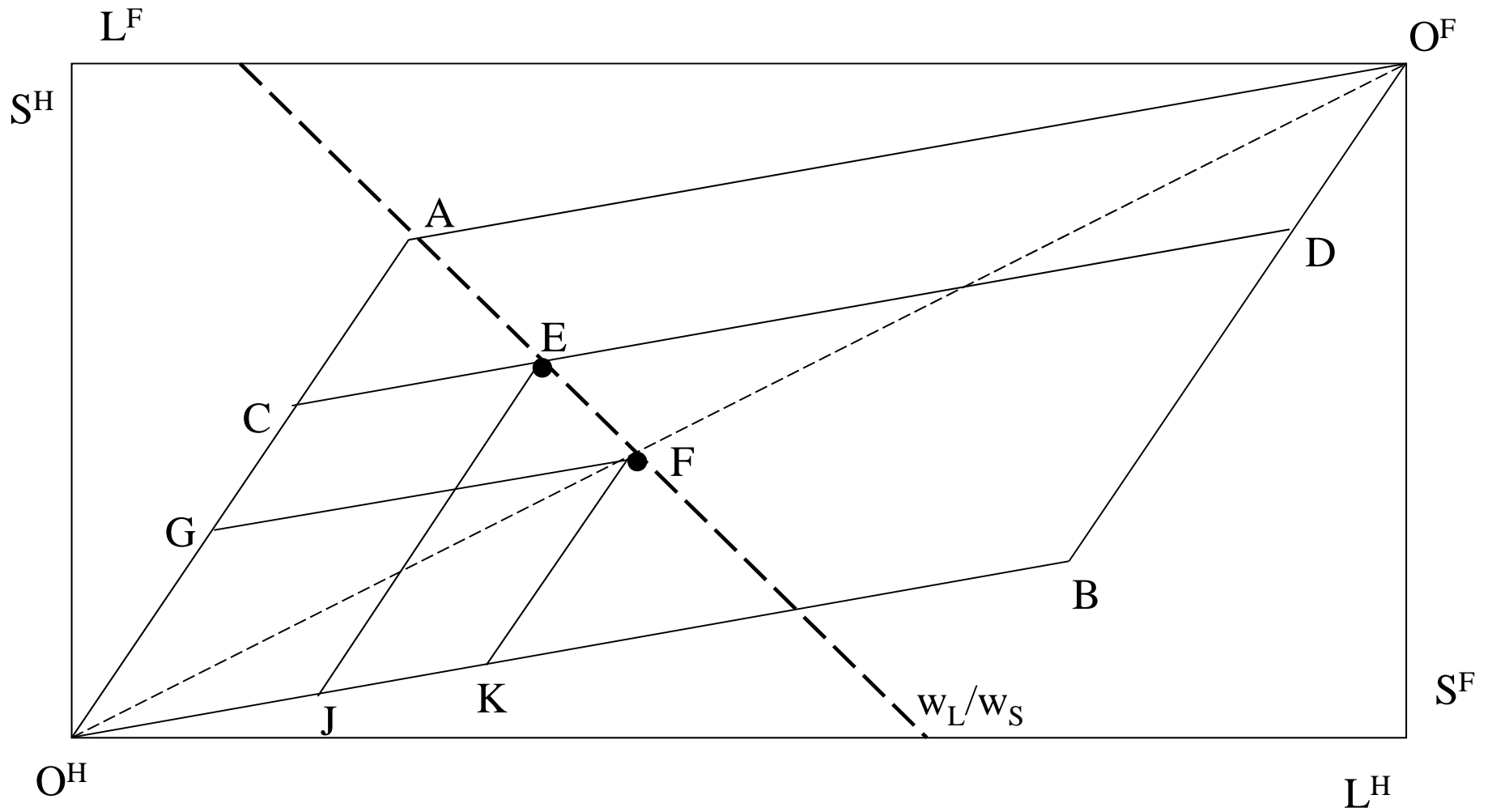
$$V_i = \frac{f_i}{\delta} \int_{\varphi_i^*}^{\infty} \left[ \left( \frac{\varphi}{\varphi_i^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi = f_{ei} \left( \frac{w_S}{w_L} \right)^{\eta_i - \beta_i}$$

Suppose entry skill intensive relative to production:  $\eta_i > \beta_i$

- In the labor abundant country, the opening of trade leads to a fall in the relative skilled wage  $w_S/w_L$
- Since entry is more skill intensive than production, this reduces the sunk cost of entry relative to the expected value of entry
- Since the expected value of entry is decreasing in  $\varphi_i^*$ , the equilibrium zero-profit productivity cutoff must rise in order for the expected value of entry to equal the sunk cost

Interaction between relative factor prices & entry / exit decisions

# Factor Price Equalization Equilibrium



# Solving for FPE Equilibrium

Aggregate labor payments in each sector equal revenue

$$w_S S_i^p + w_L L_i^p = R_i - \Pi_i$$

$$w_S S_i^e + w_L L_i^e = M_{ei} f_{ei} (w_S)^{\beta_i} (w_L)^{1-\beta_i} = M_i \bar{\pi}_i = \Pi_i$$

Equilibrium labor demand

$$S_i = S_i^p + S_i^e, \quad L_i = L_i^p + L_i^e$$

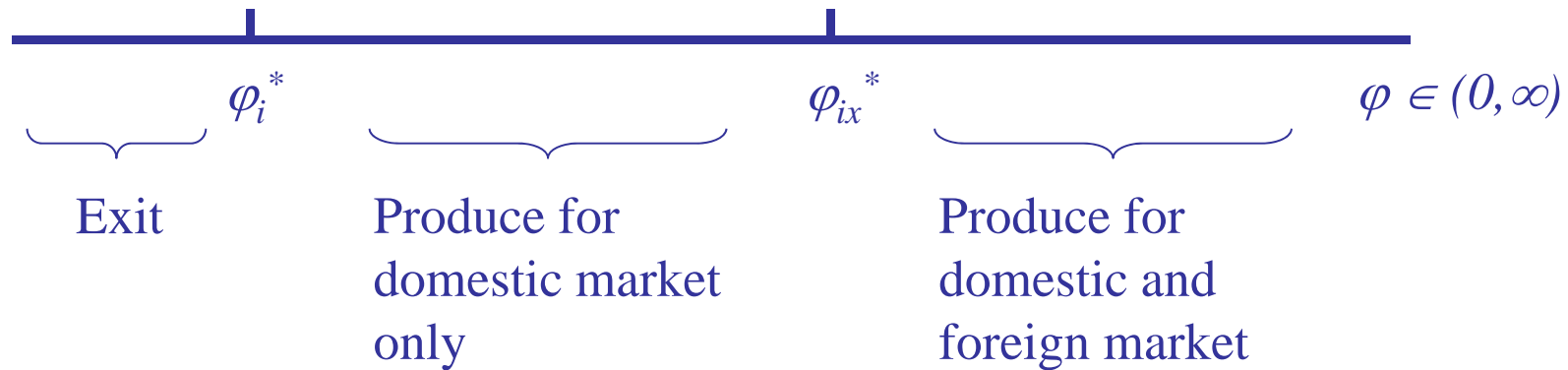
$$S_i = \frac{\beta_i R_i}{w_S}, \quad L_i = \frac{(1-\beta_i) R_i}{w_L}$$

Factor market clearing

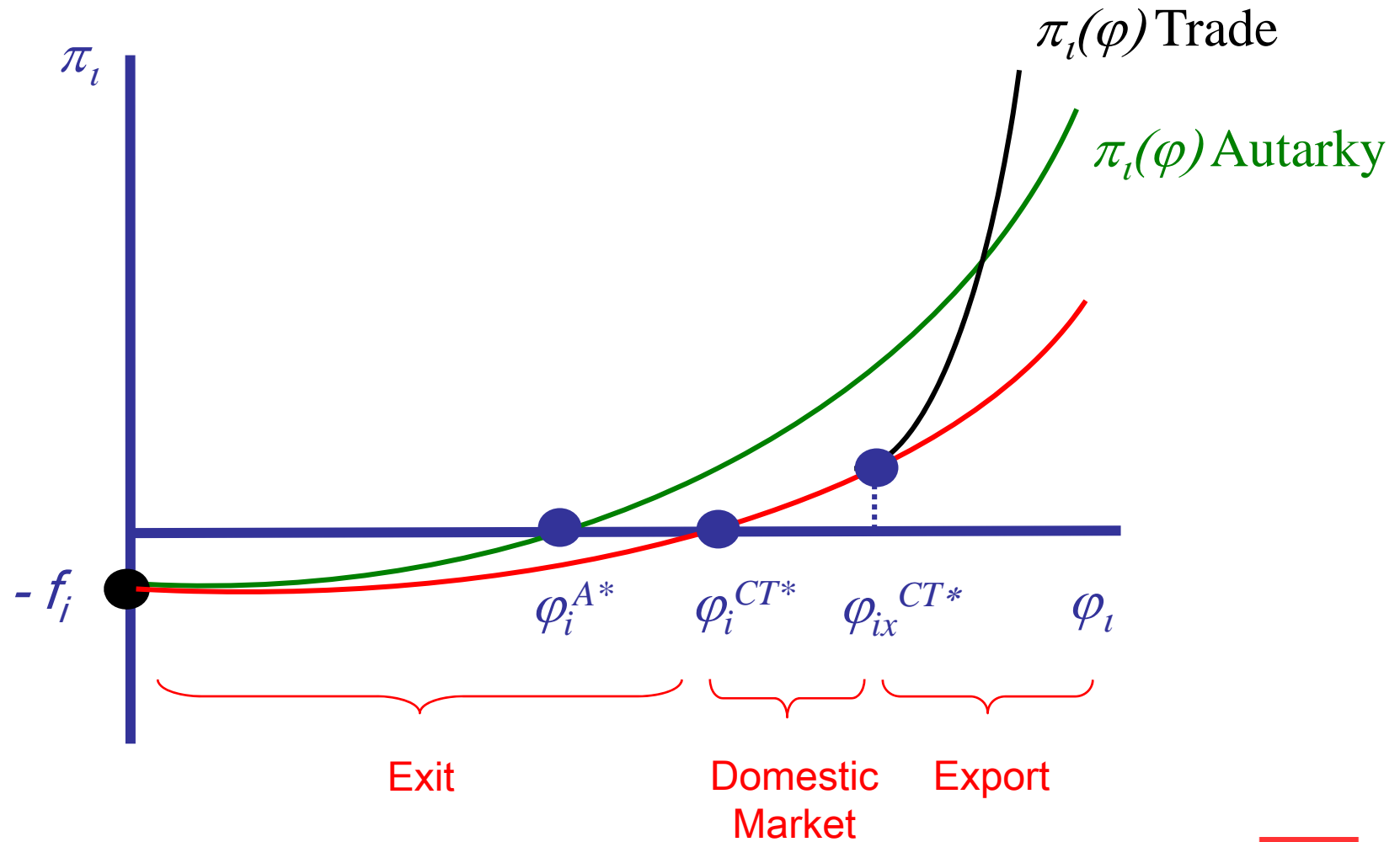
$$S_1 + S_2 = \bar{S}, \quad L_1 + L_2 = \bar{L}$$



# Zero-profit and Exporting Productivity Cutoffs



# Equilibrium with Fixed and Variable Trade Costs



# Numerical Solutions : Mass of Firms

