

# Econ 39: International Trade

Week #7: Firms and Trade

Treb Allen

Winter 2018

# Avindash Dixit



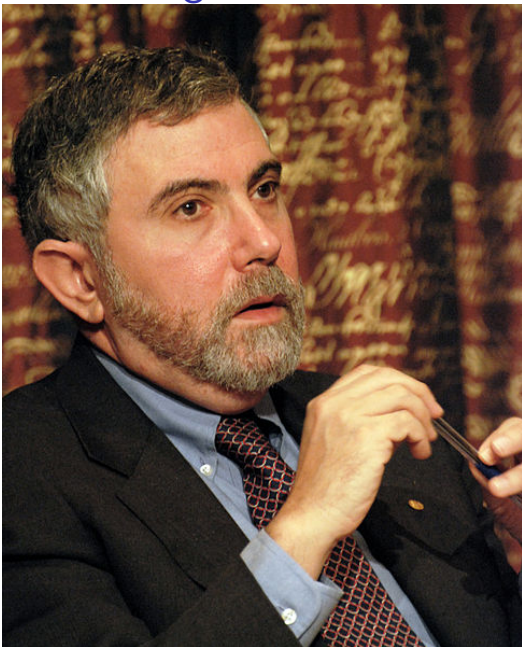
- ▶ Professor of Economics at Princeton.
- ▶ Really nice guy.

# Joseph Stiglitz



- ▶ Has been a professor at Princeton, Yale, MIT (while getting his PhD!), Stanford....
- ▶ Won Nobel Prize in 2001.
- ▶ (Unsubstantiated) rumor: clause in his employment contract at Yale that he couldn't live in his office.

# Paul Krugman



- ▶ You know who Paul Krugman is.
- ▶ He won the Nobel Prize in 2008, due in large part to the model you'll see today!

# Marc Melitz



- ▶ Professor of Harvard (formerly of Princeton).
- ▶ Author of your book.
- ▶ One of the top 8 young economists in the world (according to the Economist in 2008).
- ▶ Also super nice guy.

## “New” trade theory

- ▶ Pioneered by Krugman in late 1970s and meant to supplant the “standard” trade model we have considered thus far.
- ▶ Based on a simple mathematical structure developed by Dixit and Stiglitz.

## “New” trade theory

- ▶ The basic idea is best summarized by Krugman (AER 1980):

*“For some time now there has been considerable skepticism about the ability of comparative cost theory to explain the actual pattern of international trade. Neither the **extensive trade among the industrial countries**, nor the prevalence in this trade of **two-way exchanges of differentiated products**, make much sense in terms of standard theory. As a result, many people have concluded that a new framework for analyzing trade is needed.”*

- ▶ [Class question: why are the highlighted phrases inconsistent with what we have seen so far?]

# Building blocks of “new” trade theory

- ▶ Economies of scale
  - ▶ The average cost of producing each unit declines as firms produce more.
- ▶ Opening up to trade increases the market that a firm can sell to, allowing it to capitalize on the economies of scale.



# Building blocks of “new” trade theory

- ▶ Product differentiation
  - ▶ Up until now, there has not been a concept of a firm, since countries only traded two products.
  - ▶ In reality, firms produce different products (and consumers get utility from consuming many different products).

# Building blocks of “new” trade theory

- ▶ Imperfect competition
  - ▶ If firms produce different products, then they are price setters (unlike perfect competition where they are price takers).
  - ▶ Note that economies of scale and perfect competition are incompatible, as firms would earn negative profits and be forced into bankruptcy.

# How to model economies of scale?

- ▶ Key requirement for economies of scale: the more a firm produces, the lower its average cost.
- ▶ Easiest way:
  - ▶ Suppose that to produce anything, a firm has to incur fixed cost  $f$ .
  - ▶ Then suppose there is a constant marginal cost  $c$  for each good produced.
- ▶ Total cost for quantity  $q$  produced:

$$C(q) = cq + f$$

- ▶ Note: Average cost is  $C(q)/q = c + \frac{f}{q}$ , so as  $q$  goes up, average cost goes down.

# How to model product differentiation?

- ▶ Key requirement for product differentiation: multiple products (obvi.)
- ▶ Easiest way:
  - ▶ Suppose each firm produces its own unique differentiated product.
  - ▶ [Class question: does this seem reasonable?]

# How to model imperfect competition?

- ▶ Key requirement for imperfect competition: firms choose prices.
- ▶ Easiest way:
  - ▶ Suppose there are many firms, none of which has a substantial market share.
  - ▶ This is known as **monopolistic competition**.
- ▶ Assume demand for a firm's product is:
  - ▶ Decreasing in the price that the firm charges.
  - ▶ Increasing in the price that other firm's charge.
  - ▶ Decreasing in the number of other firms.

# Dixit-Stiglitz preferences

- ▶ Dixit and Stiglitz developed a very simple mathematical framework.
- ▶ Without going into details, they yield the following demand for firm's  $\varphi$  product:

$$q(\varphi) = p(\varphi)^{-\sigma} Y P^{\sigma-1},$$

where:

- ▶  $P \equiv \left( \int_{\Omega} p(\varphi)^{1-\sigma} d\varphi \right)^{\frac{1}{1-\sigma}}$  is the **Dixit-Stiglitz Price Index**.
- ▶  $\sigma > 1$  is the elasticity of substitution.
- ▶  $\Omega$  is the set of all the firms that produce.
- ▶  $Y$  is the income of the consumers.

# Dixit-Stiglitz preferences

- ▶ Consumer welfare is simply their **real** income:

$$W = \frac{Y}{P},$$

where recall:

$$P \equiv \left( \int_{\Omega} p(\varphi)^{1-\sigma} d\varphi \right)^{\frac{1}{1-\sigma}}$$

- ▶ [Class question: how does consumer welfare depend on the number of firms and the prices charged?]

# Model Parameters and Outcomes

- ▶ Exogenous model parameters:
  - ▶ The income  $Y$
  - ▶ The marginal cost  $c$
  - ▶ The fixed cost  $f$
  - ▶ [Note: in actual model,  $Y = wL$  and  $L$  is exogenous. This is equivalent with no trade costs.]
- ▶ Endogenous model outcomes:
  - ▶ Prices charged by each firm  $p(\varphi)$
  - ▶ Quantities produced by each firm  $q(\varphi)$
  - ▶ Set of firms that produce  $\Omega$



# Equilibrium

- ▶ Equilibrium conditions:
  1. Given every other firm's behavior and consumer demand, each firm chooses its price to maximize its profits.
  2. Consumer's maximize their utility given their income [I already solved this to get the demand function].
  3. In equilibrium, there is **free entry**, which implies the number of firms are set so that that there are no profits.
- ▶ [Class question: why does free entry imply zero profits?]

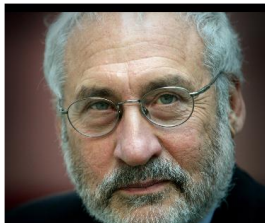
# Logistics

- ▶ Problem set #5 due today.
- ▶ Final exam assigned today:
  - ▶ Due in my inbox by Tuesday March 14\3 at 12:00pm EST (noon) (no exceptions)
  - ▶ Open book (but no discussions with any other students).
- ▶ Good news:
  - ▶ Learned that I can count those that dropped against departmental relative grade rankings...
  - ▶ ... so I will bump up people on the boundary between grades to the fullest extent possible!

# Plan for Today

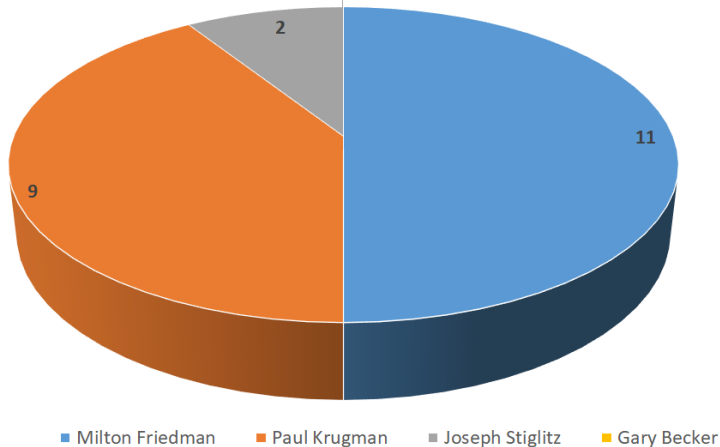
- ▶ Finish the discussion of “new” trade theory we began before midterm #2.

# Today's Teams



# Today's Teams

## Nobel winning economists



# Recall: Building blocks of “new” trade theory

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# Recall: Building blocks of “new” trade theory

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## Recall: Building blocks of “new” trade theory

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  - ▶ Note that economies of scale and perfect competition are incompatible, as firms would earn negative profits and be forced into bankruptcy.



# Profits

- ▶ A firm  $\varphi$  chooses how much to produce and what price to charge in order to maximize its profits  $\pi(\varphi)$ :

$$\pi(\varphi) = \max_{q(\varphi), p(\varphi)} p(\varphi) q(\varphi) - cq(\varphi) - f$$

subject to the consumer demand function:

$$q(\varphi) = p(\varphi)^{-\sigma} YP^{\sigma-1}$$

- ▶ Substituting in the constraint yields a simple maximization problem where the firm just chooses the price:

$$\pi(\varphi) = \max_{p(\varphi)} p(\varphi)^{1-\sigma} YP^{\sigma-1} - cp(\varphi)^{-\sigma} YP^{\sigma-1} - f$$

# Optimal price

- From last slide:

$$\pi(\varphi) = \max_{p(\varphi)} \left( p(\varphi)^{1-\sigma} - c p(\varphi)^{-\sigma} \right) Y P^{\sigma-1} - f$$

- First order conditions:

$$\begin{aligned} \left( (1 - \sigma) p(\varphi)^{-\sigma} + \sigma c p(\varphi)^{-\sigma-1} \right) Y P^{\sigma-1} &= 0 \iff \\ (\sigma - 1) p(\varphi)^{-\sigma} &= \sigma c p(\varphi)^{-\sigma-1} \iff \\ p(\varphi) &= \frac{\sigma}{\sigma - 1} c \end{aligned}$$

- Hence prices are just a constant mark-up over the marginal cost  $c$ !

# Price index

- If all firms have the same marginal cost, then the price index becomes:

$$\begin{aligned}P &\equiv \left( \int_{\Omega} p(\varphi)^{1-\sigma} d\varphi \right)^{\frac{1}{1-\sigma}} \iff \\P &\equiv \left( \int_{\Omega} \left( \frac{\sigma}{\sigma-1} c \right)^{1-\sigma} d\varphi \right)^{\frac{1}{1-\sigma}} \iff \\P &\equiv \left( \frac{\sigma}{\sigma-1} \right) c \left( \int_{\Omega} d\varphi \right)^{\frac{1}{1-\sigma}} \iff \\P &\equiv \left( \frac{\sigma}{\sigma-1} \right) c N^{\frac{1}{1-\sigma}},\end{aligned}$$

- $N \equiv \int_{\Omega} d\varphi$  is the number (measure) of firms.

# Firms and welfare

- ▶ Recall that welfare is the real income:

$$W = \frac{Y}{P}$$

- ▶ Since  $P = \left(\frac{\sigma}{\sigma-1}\right) cN^{\frac{1}{1-\sigma}}$ , this implies that welfare can be written as:

$$W = \left(\frac{\sigma-1}{\sigma}\right) \frac{1}{c} Y N^{\frac{1}{\sigma-1}}.$$

- ▶ Since  $\sigma > 1$ , welfare is increasing in the number of firms  $N$ .
- ▶ [Class question: What is the intuition for this?]

# Firm profits

- ▶ Things we know about firms:
  - ▶ From consumer demand, firms sell a quantity  $q(\varphi) = p(\varphi)^{-\sigma} Y P^{\sigma-1}$ .
  - ▶ From profit maximization, firms charge a price  $p(\varphi) = \frac{\sigma}{\sigma-1} c$ .
- ▶ Together (and with a little algebra), this implies their profits are:

$$\pi(\varphi) = p(\varphi) q(\varphi) - c q(\varphi) - f \iff$$

$$\pi(\varphi) = \left( p(\varphi)^{1-\sigma} - c p(\varphi)^{-\sigma} \right) Y P^{\sigma-1} - f \iff$$

$$\pi(\varphi) = \frac{1}{\sigma} \left( \frac{\sigma}{\sigma-1} \right)^{1-\sigma} c^{1-\sigma} Y P^{\sigma-1} - f$$

- ▶ [Class question: why are profits increasing in  $Y$  and  $P$  and decreasing in  $c$ ?]

# Firm profits

- ▶ From last slide:

$$\pi(\varphi) = \frac{1}{\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} c^{1-\sigma} Y P^{\sigma-1} - f$$

- ▶ Recall that the price index can be written as:

$$P = \left( \frac{\sigma}{\sigma - 1} \right) c N^{\frac{1}{1-\sigma}}$$

- ▶ Combining the two yields [beautifully!]:

$$\pi(\varphi) = \frac{1}{\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} c^{1-\sigma} Y \left( \left( \frac{\sigma}{\sigma - 1} \right) c N^{\frac{1}{1-\sigma}} \right)^{\sigma-1} - f \iff$$

$$\pi(\varphi) = \frac{1}{\sigma} \frac{Y}{N} - f$$

- ▶ [Class question: why are profits decreasing in  $N$  and  $\sigma$ ?]

# Free entry

- ▶ From last slide:

$$\pi(\varphi) = \frac{1}{\sigma} \frac{Y}{N} - f$$

- ▶ The free entry condition requires that firms continue to enter until profits go to zero:

$$\frac{1}{\sigma} \frac{Y}{N} - f = 0 \iff$$

$$N = \frac{1}{\sigma} \frac{Y}{f}$$

- ▶ [Class question: why are the number of firms increasing in  $Y$  and decreasing in  $f$ ?]

# Recap

- ▶ Every firm produces a differentiated variety and maximizes profits given consumer demand.
  - ▶ Equation for profits:  $\pi(\varphi) = \frac{1}{\sigma} \frac{Y}{N} - f$ .
  - ▶ Equation for price index:  $P = \left( \frac{\sigma}{\sigma-1} \right) c N^{\frac{1}{1-\sigma}}$ .
- ▶ As the number of firms producing increases, the profits for each firm declines as they face more competition.
  - ▶ Implies equilibrium number of firms:  $N = \frac{1}{\sigma} \frac{Y}{f}$ .



# How to model trade?

- ▶ The simplest way to model trade to assume that firms can sell to a bigger market.

- ▶ [Class question: how do we model a bigger market?]

- ▶ Answer:

$$Y = Y_{US} + Y_{MEX}$$

- ▶ So to examine the welfare effect of trade, we just need to examine how an increase in income affects welfare!
- ▶ For simplicity, suppose that  $Y_{US} = Y_{MEX}$ , so that opening up to trade doubles the income of the market.

# Gains from Trade in “New” Trade Theory

- ▶ Equilibrium number of firms:

$$N = \frac{1}{\sigma} \frac{Y}{f}$$

- ▶ Recall that welfare can be written as:

$$W = \frac{Y}{P} = \left( \frac{\sigma - 1}{\sigma} \right) \frac{1}{c} Y N^{\frac{1}{\sigma-1}}$$

- ▶ Substituting in the optimal number of firms yields:

$$W = \left( \frac{\sigma - 1}{\sigma} \right) \frac{1}{c} Y \left( \frac{1}{\sigma} \frac{Y}{f} \right)^{\frac{1}{\sigma-1}} \iff$$

$$W = \left( \frac{\sigma - 1}{\sigma} \right) \left( \frac{1}{\sigma f} \right)^{\frac{1}{\sigma-1}} \frac{1}{c} Y^{\frac{\sigma}{\sigma-1}}$$

# Gains from Trade in “New” Trade Theory

- ▶ From last slide:

$$W = \left( \frac{\sigma - 1}{\sigma} \right) \left( \frac{1}{\sigma f} \right)^{\frac{1}{\sigma-1}} \frac{1}{c} Y^{\frac{\sigma}{\sigma-1}}$$

- ▶ Note that  $\frac{\sigma}{\sigma-1} > 1$ , which implies that doubling income more than doubles welfare!
- ▶ Hence, opening up to trade improves the *per capita* welfare of both countries!

# Gains from Trade in “New” Trade Theory

- ▶ What's going on?
  - ▶ As the income increases, the profits for any firm also increases (since the demand for their good goes up).
  - ▶ In equilibrium, this will cause more firms to enter the market.
  - ▶ More firms decreases the price index (because of consumer's love of variety).
  - ▶ Hence it is less costly for consumers to get the same amount of welfare!

## “New new” trade theory

- ▶ In the Krugman framework, all firms are assumed to be identical.
- ▶ Yet in reality, firms differ substantially.
- ▶ In particular, larger firms are much more likely to engage in trade (export). From Bernard et al. (JEP 2007):
  - ▶ Only 4% of firms export.
  - ▶ 10% of exporting firms account for 96% of exports.
- ▶ Melitz' major innovation was to take extend the Krugman trade model to allow for firms to vary in their productivities.
- ▶ As we will see, this “new new” trade theory predicts that trade will increase competition, causing the least productive firms to exit and improving the overall productivity in the economy.

# Firm heterogeneity

- ▶ Suppose that firms are heterogeneous (i.e. different).
  - ▶ What is the easiest way to model this?
  - ▶ Suppose that firms differ in their marginal cost  $c$  of production.
- ▶ Furthermore, suppose a firm incurs a fixed cost  $f_{US}$  for selling to the U.S. and  $f_{MEX}$  for selling to Mexico, where  $f_{US} < f_{MEX}$  for U.S. firms.
- ▶ Finally, suppose a firm incurs an entry cost  $f_e$  for producing anything.

# Firm heterogeneity and prices

- ▶ Better firms are more productive (i.e. have lower  $c$ ).
- ▶ Recall from profit maximization that optimal price is:

$$p(\varphi) = \frac{\sigma}{\sigma - 1} c(\varphi),$$

where  $c(\varphi)$  is the marginal cost of the firm producing good  $\varphi$ .

- ▶ Hence more productive firms will charge lower prices.
- ▶ [Note: old equation for price index no longer holds since price charged varies across firms].

# Firm heterogeneity and production

- ▶ Recall consumer demand function:

$$q(\varphi) = p(\varphi)^{-\sigma} Y P^{\sigma-1}$$

- ▶ Hence, if they produce, more productive firms will sell greater quantities.
- ▶ Variable profits (i.e. without fixed costs) are:

$$\pi_i(\varphi) = \frac{1}{\sigma} \left( \frac{\sigma}{\sigma-1} \right)^{1-\sigma} c^{1-\sigma} Y_i P_i^{\sigma-1}$$

for  $i \in \{US, MEX\}$ .

- ▶ Hence more productive firms will also have higher profits.



# Firm heterogeneity and entry decisions

- ▶ Profits for selling to country  $i \in \{US, MEX\}$  are:

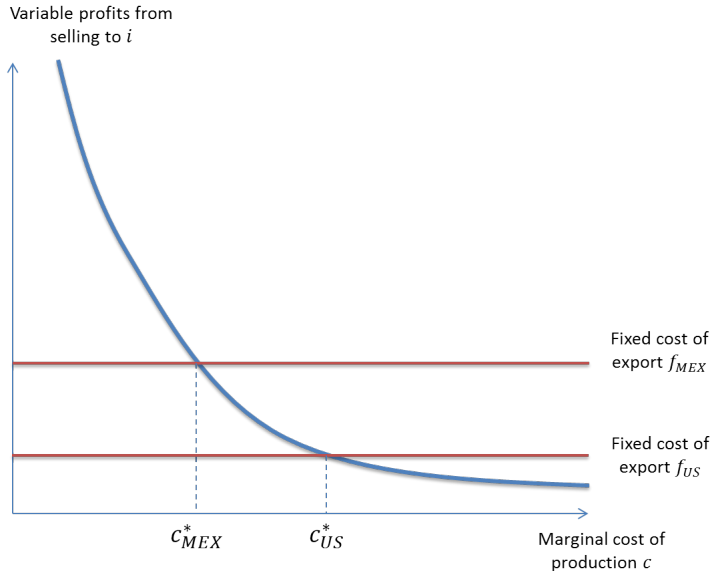
$$\pi_i(\varphi) = \frac{1}{\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} c^{1-\sigma} Y_i P_i^{\sigma-1} - f_i$$

- ▶ Will only sell to the country if  $\pi_i(\varphi) \geq 0$ :

$$\frac{1}{\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} c^{1-\sigma} Y_i P_i^{\sigma-1} - f_i \geq 0 \iff$$
$$c \leq \frac{\sigma - 1}{\sigma} \left( \frac{Y_i}{\sigma f_i} \right)^{\frac{1}{\sigma-1}} P_i$$

- ▶ If  $f_{MEX} > f_{US}$  for U.S. firms, some (less-productive) firms will only sell domestically, while the most productive firms will export.

# Firm export decisions



[Class question: who exports and who does not?]

# Firm export decisions



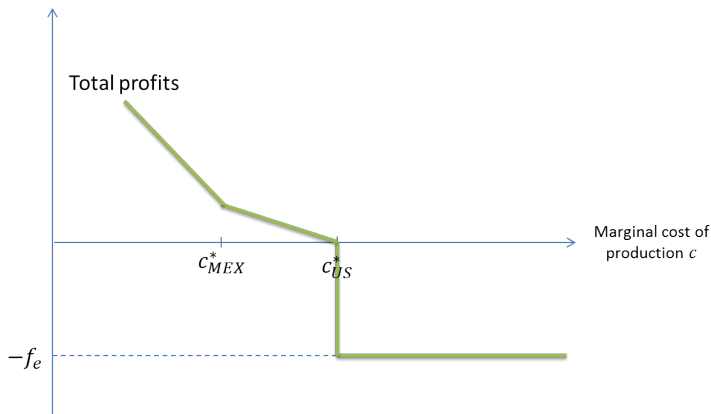
# Free entry

- ▶ We can modify the free entry condition to say the expected profits of a firm are equal to zero:

$$E[\pi_{US}(\varphi) + \pi_{MEX}(\varphi) - f_e] = 0$$

- ▶ Justify this by assuming that firms pay the entry cost  $f_e$  before realizing their marginal cost  $c$ .
- ▶ This means that some firms can realize that they have very high marginal costs and choose not to produce at all, but still have to pay  $f_e$ .

# Free entry



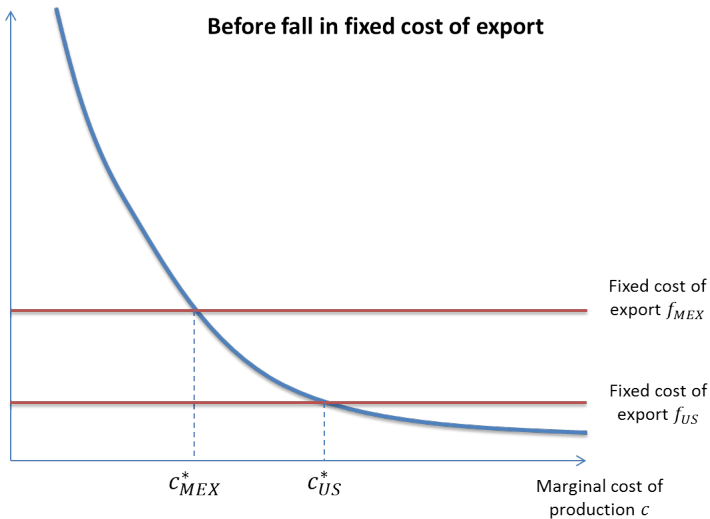
[Class questions: Why is there a kink at  $c_{MEX}^*$ ? How do we see the free entry condition on this figure?]

## Effect of (more free) trade

- ▶ Suppose that the cost of exporting to Mexico  $f_{MEX}$  declines, so that the two countries become more integrated. What happens?
- ▶ First, lowering  $f_{MEX}$  causes less productive firms to begin exporting to Mexico.
- ▶ Second, exporting to Mexico raises these firms profits, which raises the expected profits of all firms.
  - ▶ This causes more firms to begin entering the market, which drives down the profits for all firms.
  - ▶ Firms that were before indifferent between selling in the U.S. now do not find it profitable to do so.
  - ▶ Hence,  $c_{US}^*$  decreases, meaning that the average productivity of firms producing domestically increases!

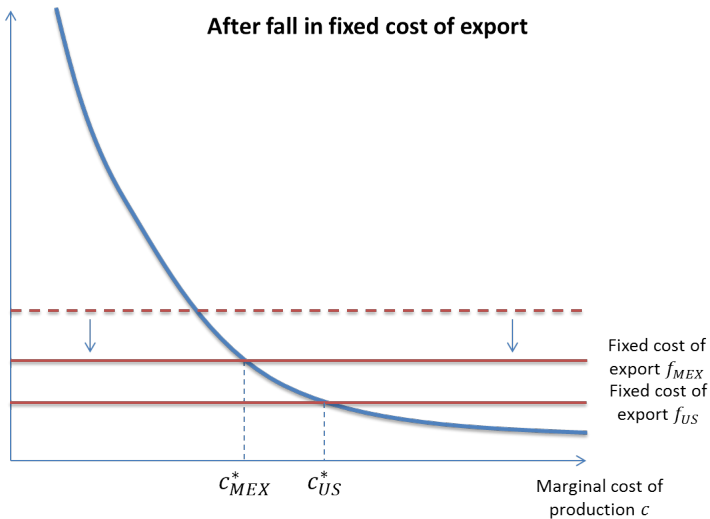
Variable profits from  
selling to  $i$

**Before fall in fixed cost of export**



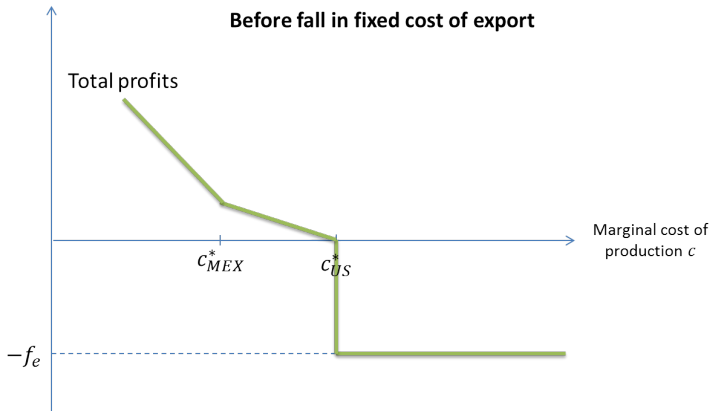
Variable profits from  
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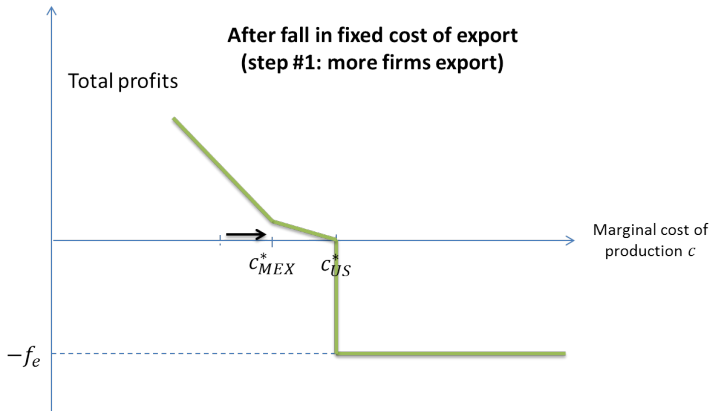
**After fall in fixed cost of export**

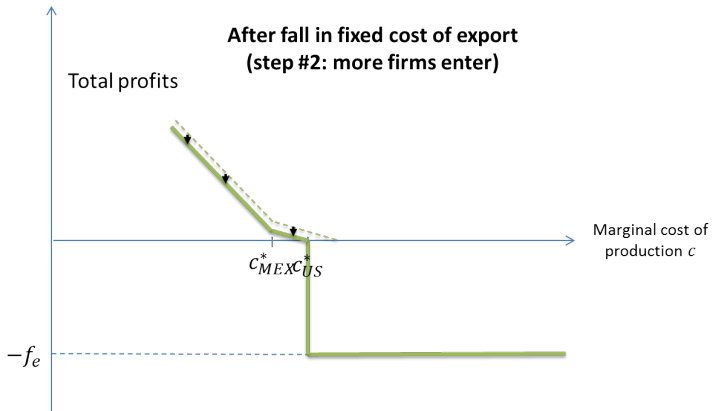




### Before fall in fixed cost of export

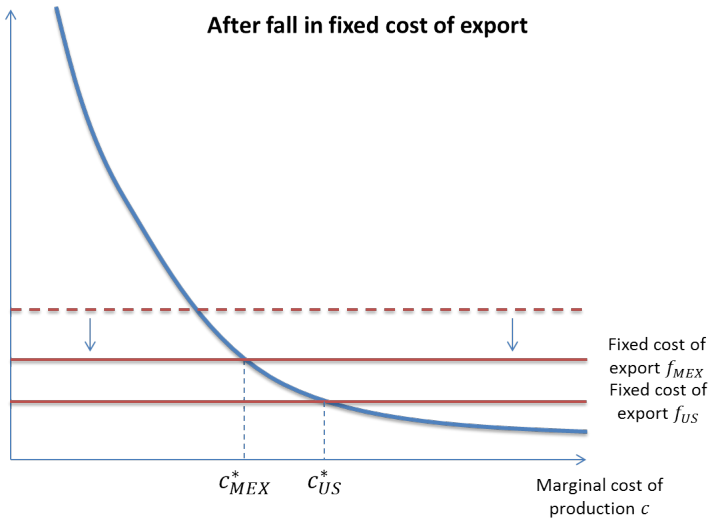






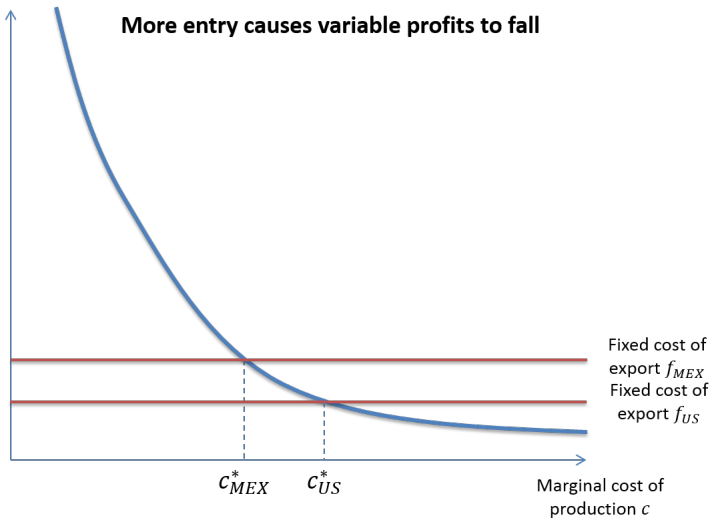
Variable profits from  
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**After fall in fixed cost of export**



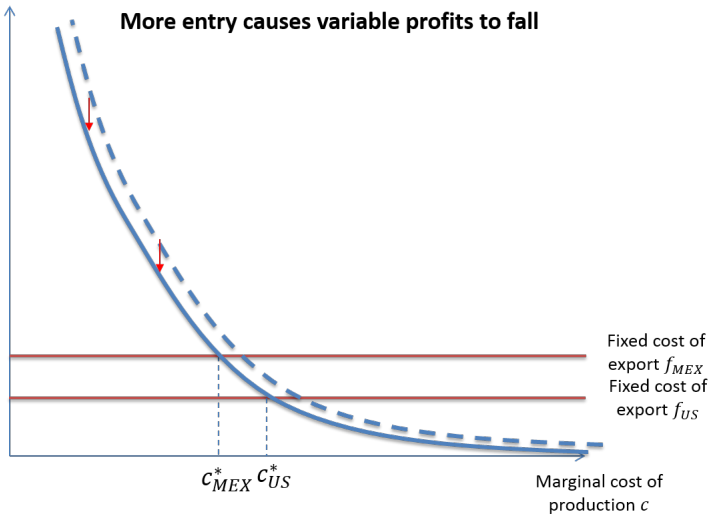
Variable profits from  
selling to  $i$

**More entry causes variable profits to fall**



Variable profits from  
selling to  $i$

**More entry causes variable profits to fall**



# Gains from Trade in “New New” Trade Theory

- ▶ Still gains from trade resulting from increased varieties (as in the “new” trade theory)
- ▶ In addition, opening up to trade increases the potential profits of firms, which increases the competition amongst entrants.
- ▶ This increased competition amongst entrants means that the least profitable firms no longer produce.
- ▶ Hence, trade increases the average productivity of a country!

# Gains from Trade in “New New” Trade Theory

- ▶ This “new new” gain from trade is a (rare) example of academic theory that has impacted public discourse:  
*“Trade has the potential to allow the U.S. economy to expand output in areas where it is more productive and to enable higher-productivity firms to expand” - Chapter 10, 2010 Economic Report of the President*
- ▶ [Class question: In order to achieve these gains, what must happen in the short-run?]



## Gains from Trade in “New New” Trade Theory

*“While the act of specializing should lift living standards over time, it requires shifting resources from one sector to another, and so can generate short-run dislocations. As a result, it is essential to strengthen both targeted and more general policies that seek to ensure all can benefit from increases in trade.” - Chapter 10, 2010 Economic Report of the President (later on)*

# Conclusion

- ▶ “New” trade theory and “new new” trade theory has created a revolution (of sorts) in the study of international trade.
  - ▶ Focuses on the market power of individual firms rather than comparative advantage.
  - ▶ Emphasizes new gains from trade based on competition amongst firms.
- ▶ [Class question: Which economic forces do you think are more important in the real world: comparative advantage or competition amongst firms?]