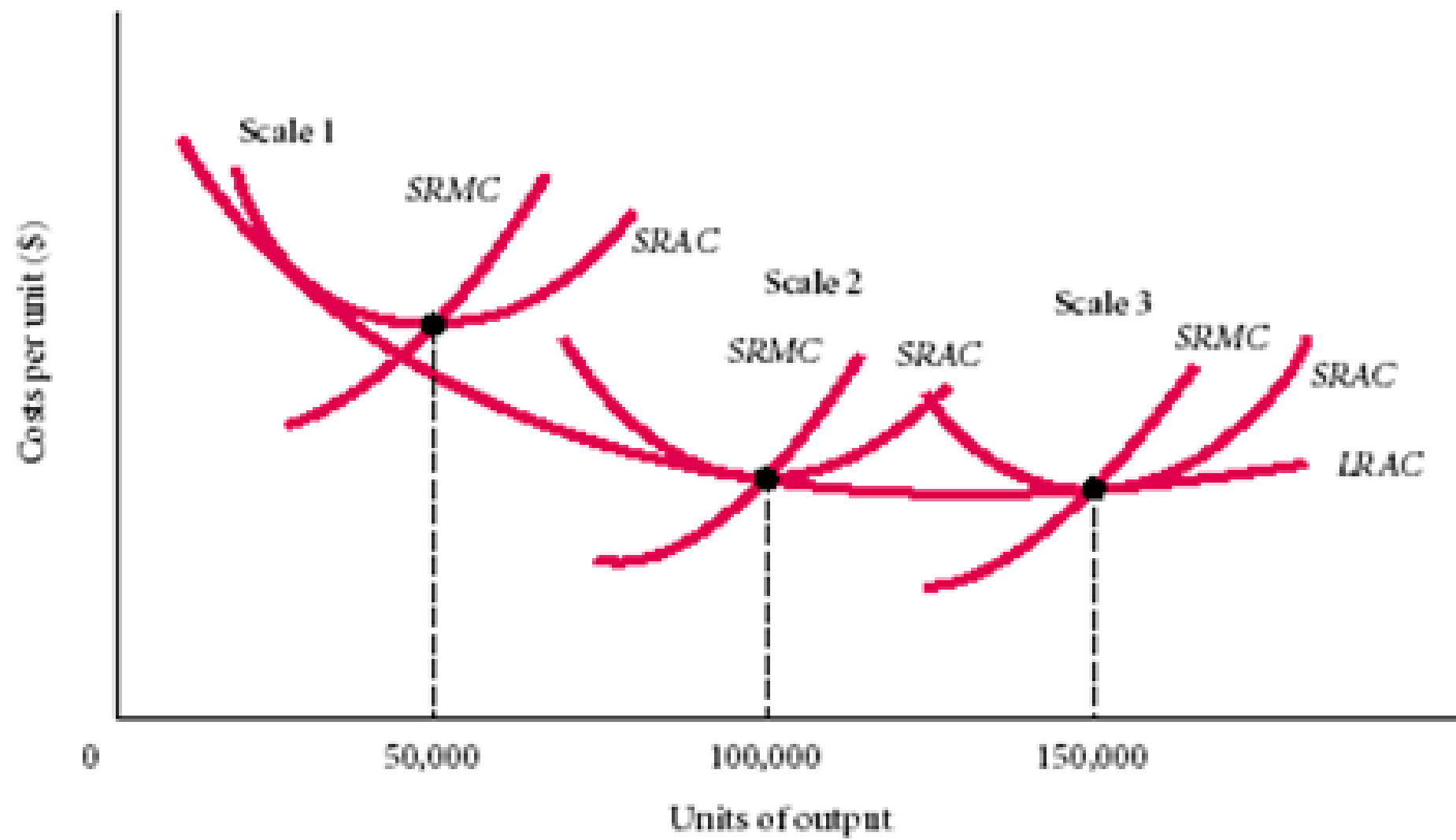# ECO 610:  Lecture 4

## Horizontal Boundaries of the Firm

# Horizontal Boundaries of the Firm: Outline

- Long-run average cost (LRAC) curve
- Shape of the LRAC: economies and diseconomies of scale
- Optimal plant size: minimum efficient scale (MES)
- MES, market demand, and market structure
- Horizontal boundaries vs. vertical boundaries
- Reasons why economies of scale might occur
  - Product-level economies
  - Plant-level economies
  - Firm-level economies
- Economies of scope

# The LRAC curve and economies of scale

- Given sufficient time to plan and execute, firms can vary all inputs optimally for whatever scale of operation they desire.

- So in reality, firms can choose from many different plant sizes.  The LRAC curve is the envelope of all the SRATC curves associated with each different plant size.

- The LRAC curve tells us the minimum possible average total cost for producing each output level.

- The shape of the LRAC curve tells us how per unit costs change as the firm changes the scale of its operations.

Scale 1

SRMC

SRAC

Scale 2

SRMC    SRAC

Scale 3    SRMC

SRAC

LRAC

Costs per unit ($)

0          50,000          100,000          150,000

Units of output
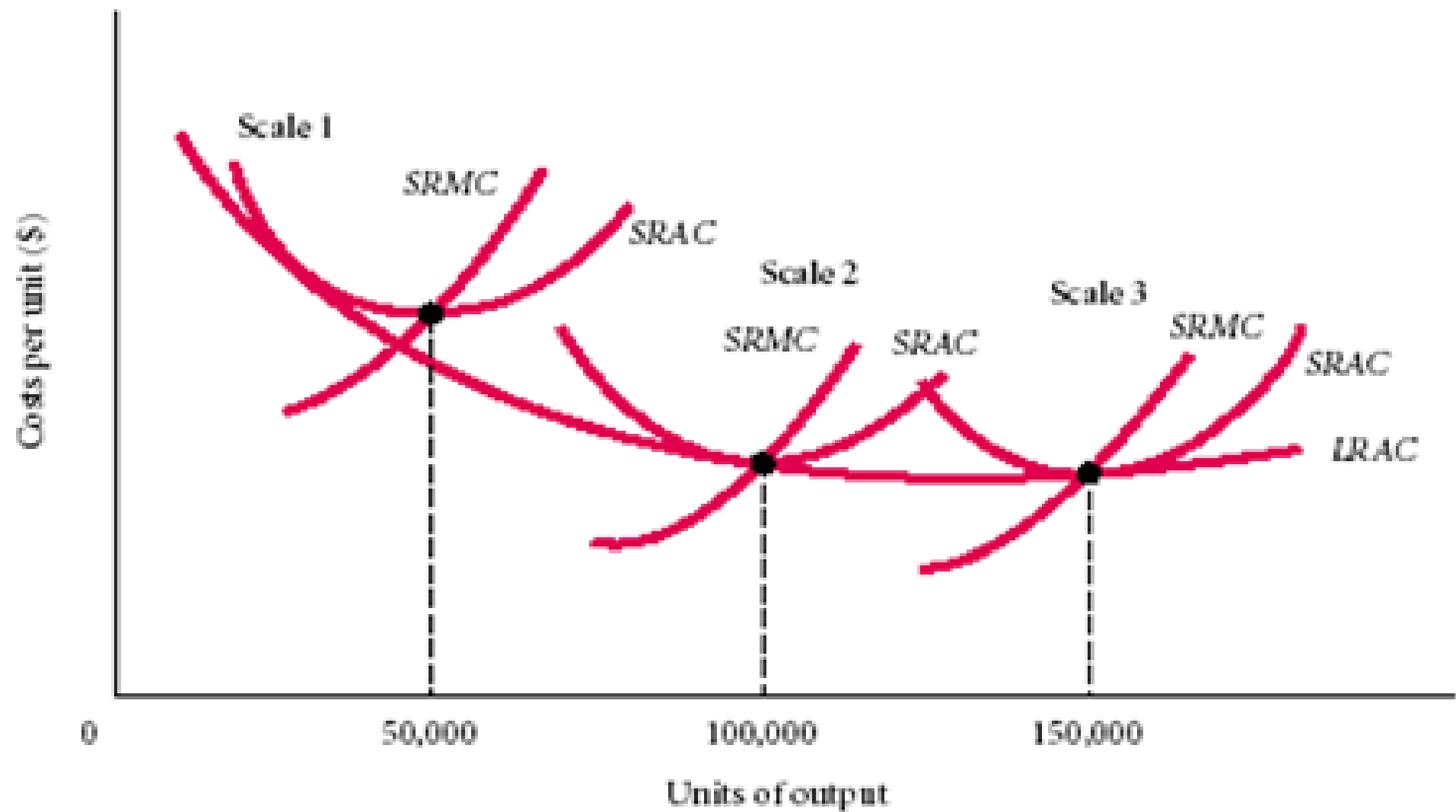
# Economies and diseconomies of scale

- If per unit costs fall as the firm increases the scale of its operations, the LRAC curve will be downward sloping.  We say that the firm experiences <span style="color:red">economies of scale</span>.

- If per unit costs do not change as the firm increases the scale of its operations, the LRAC curve will be flat.  We say that the firm experiences <span style="color:red">constant returns to scale</span>.

- If per unit costs rise as the firm increases the scale of its operations, the LRAC curve will be upward sloping.  We say that the firm experiences <span style="color:red">diseconomies of scale</span>.

# The Minimum Efficient Scale
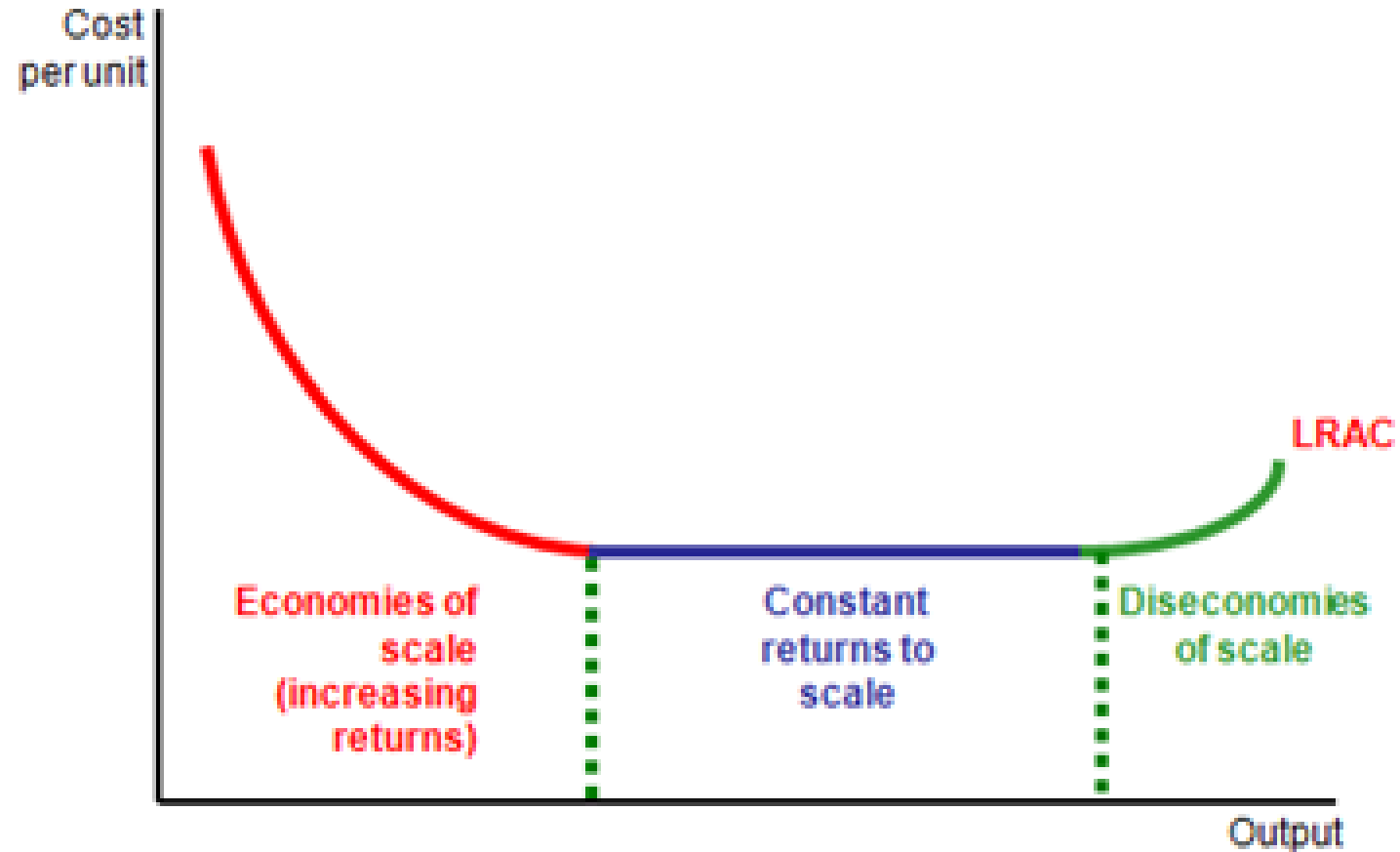
# Minimum Efficient Scale (MES)

- How big does the firm have to be in order to produce the product as cheaply as possible?

- We call the scale of operations (Q) at which the LRAC curve reaches its minimum level of cost the Minimum Efficient Scale, or MES.

- Firms operating at a smaller scale could lower their per unit costs by increasing their scale. Firms operating at a sub-optimal scale will be at a competitive disadvantage relative to firms that have attained MES.

- Compare the per unit costs of firms operating at a scale of 50k, 100k, and 150k output per period. Cost disadvantage?

Scale 1

*SRMC*

*SRAC*

Scale 2

*SRMC* *SRAC*

Scale 3

*SRMC*

*SRAC*

*LRAC*

Costs per unit ($)

0          50,000          100,000          150,000

Units of output

# MES and market structure

- How many fast-food restaurants are there in Lexington?  In Lawrenceburg? Why? https://www.yellowpages.com/search?search_terms=Fast+Food+Restaurants&geo_location_terms=lawrenceburg+ky

- The relationship between minimum efficient scale of production and market demand explains a lot of what we observe about market structure.

- If MES is large relative to market demand, there is limited room in the market for efficient-sized producers.  In the limit we have natural monopoly—a market that will support only one MES firm, e.g. Floyd, VA https://www.yellowpages.com/search?search_terms=Fast+Food+Restaurants&geo_location_terms=floyd+va

- If MES is small relative to market demand, there is room for many efficient-sized producers.

# Horizontal vs. Vertical Boundaries of the Firm

- Vertical boundaries have to do with the vertical chain of production: the relevant question is how vertically integrated will an efficient producer be? For example, in the aluminum industry, should a primary aluminum smelting company be vertically integrated upstream into alumina refining and bauxite mining? Should it be vertically integrated downstream into rolling, casting, and extruding and then into finished aluminum products?

- Horizontal boundaries have to do with how big (scale of operations) does a firm producing at any given stage in the vertical chain, e.g. aluminum smelting, need to be to attain MES? A related question is whether the firm should produce a single product or a set of related products.

# Vertical Boundaries: The Vertical Chain of Aluminum Production
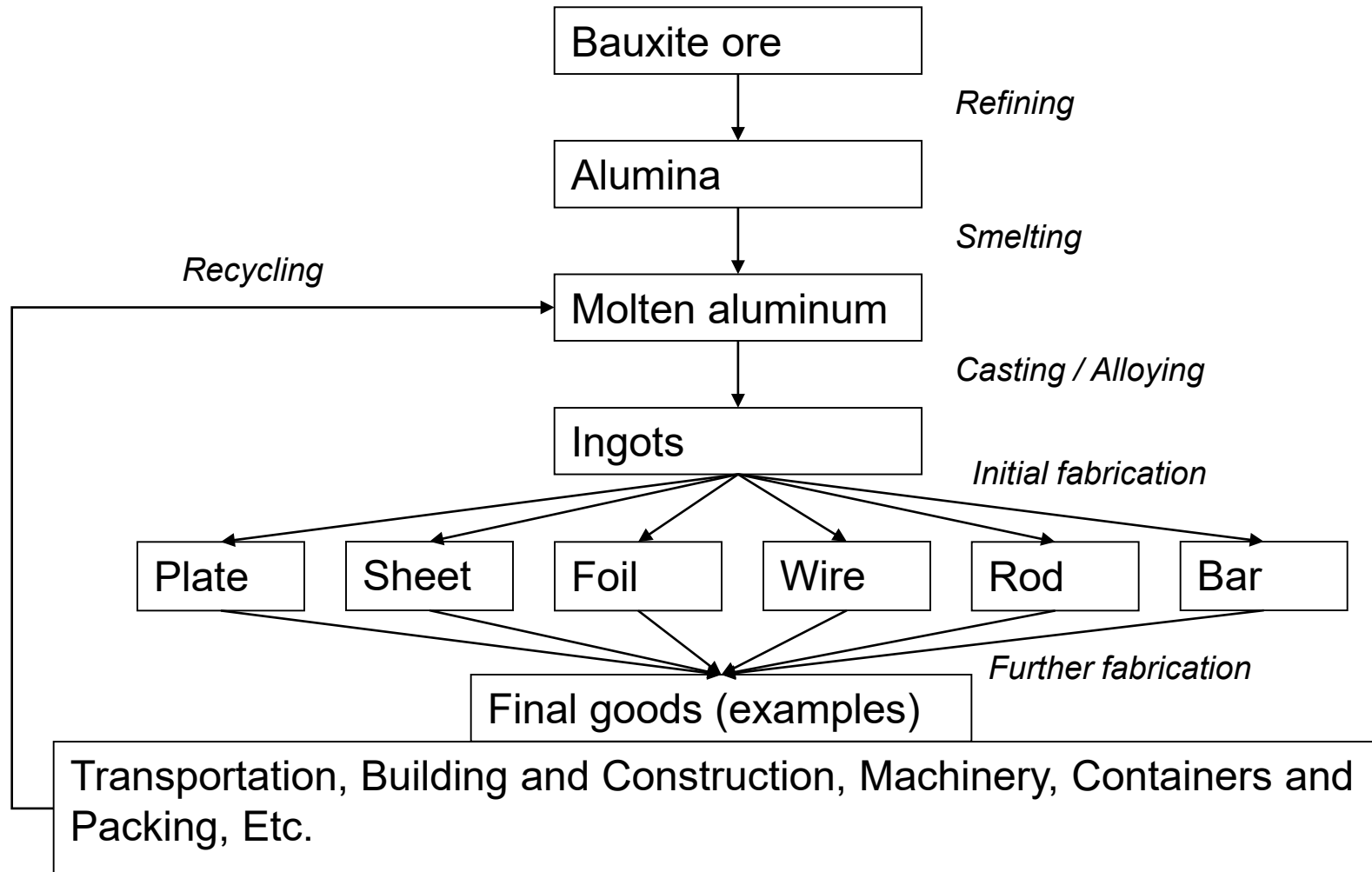
# Horizontal Boundaries: Economies of Scale in Aluminum Smelting

## PRIMARY SMELTERS CAPACITY IN THE GULF

| COUNTRY | COMPANY | ANNUAL PRODUCTION CAPACITY | YEAR COMMISSIONED | OWNERSHIP |
|---|---|---|---|---|
| BAHRAIN | ALBA | 870,000 | 1971 | Bahrain – 78.5%<br>SABIC – 21.5% |
| DUBAI | DUBAL | 950,000 | 1979 | Dubai Government – 100% |
| OMAN | SOHAR | 360,000 | 2008 | Oman Oil co. – 40%<br>Abu Dhabi water & elec. Authority – 40%<br>Rio Tinto Alcan – 20% |
| QATAR | QATALUM | 585,000 | 2010 | Qatar Aluminium – 50%<br>Hydro Aluminium – 50% |
| ABU DHABI | EMAL | 720,000 | 2010 | DUBAL – 50%<br>Mabadala – 50% |
| SAUDI ARABIA | MA'ADEN | 720,000 | 2012 | Ma'aden – 75%<br>ALCOA – 25% |

# Reasons why economies of scale may occur

- Aspects of economies of scale:
- Product-level economies
  - Fixed set-up costs
  - Specialization of inputs
  - Learning by doing
- Plant-level economies
  - Engineering relationships
  - Economies of massed reserves (inventories)
  - "Meshing" or indivisibilities
- Firm-level economies
  - Multi-plant operations
  - Economies in input procurement
  - Economies in sales promotion

# Product-level economies: fixed setup costs

- Setup costs: for many production processes there are setup costs that do not vary with the length of the production run.

- Example: https://www.youtube.com/watch?v=mTtbXot3lik

- Fixed setup costs are obviously smaller on a per unit basis the longer the production run.

- Tradeoff: inventory holding costs vs. per unit production costs—a problem for us to solve in operations management.

# Product-level economies: specialization of inputs

- With greater output, it makes sense to break down the production process into smaller and smaller steps and to specialize tasks among inputs.

- This applies to both human inputs (labor) and machinery and equipment (capital).

- https://www.youtube.com/watch?v=PKG_TObuyNk

- https://www.youtube.com/watch?v=hWhPaZjd2CA

- MBA degree: general human capital or specific human capital?

# Product-level economies: learning by doing

- When intricate labor operations must be performed or when complex adjustments must worked out by trial and error, per unit costs fall as the cumulative volume of production increases and workers learn by doing.

- This phenomenon is known as the Learning Curve.

- Would you as an airline passenger like to be part of the learning process that Boeing workers go through? http://search.proquest.com.ezproxy.uky.edu/docview/1558679198/EF4B7FDC62864519PQ/72?accountid=11836 .

- Is there a similar learning curve phenomenon associated with Toyota's introduction of a new model of the Camry?

# Plant-level economies: engineering relationships

- The output of a processing unit tends within certain physical limits to be roughly proportional to the volume of the unit, while the amount of materials and fabrication effort required to construct the unit is more closely proportional to the surface area of the unit's reaction chambers, storage tanks, connecting pipes, etc.

- Rule of two-thirds: the area of a sphere or cylinder varies as the two-thirds power of volume.

- What does it all mean, if all you want to do is brew some beer?

Gold King Brewery Equipment Co.,Ltd.

2176867

# Plant-level economies: economies of massed reserves (inventories)

- Machines sometimes break down. Employees sometimes don't show up for work. Input suppliers sometimes don't deliver. What to do? Shut down? Hold inventories?

- Risk Management: how do the reserves (machines, workers, inputs) that you must hold to attain a certain level of reliability vary with the scale of your operations?

- Probability of a robot welding machine breaking down (or a line worker not showing up) is 5%, i.e. one day out of twenty. If you have one robot welder in your production line, how many robot welders do you need to hold in reserve in order to reduce the probability of a factory shutdown to 1%? Suppose you scale up by a factor of ten, and have ten robot welders? How many do you need to hold in reserve now?

# Plant-level economies: "Meshing" or indivisibilities

- Many inputs come in lumpy units, with different rates of through-put.

- How well inputs at different stages of the production process with different through-put rates "mesh" with one another gets better as the scale of operations increases.

- Example: hydraulic stamping machine can process 15 parts per hour. Robot welding machine can process 10 parts per hour. If the desired rate of output is 10 parts per hour, how many of each machine do we need? If desired rate of output is 15 parts per hour? 20 parts per hour? 30 parts per hour? https://www.tourtoyota.com/kentucky

# Firm-level economies: multi-plant operations

- Suppose the firm serves a market of non-zero geographic expanse, and the costs of delivering output to customers (or bringing customers to the place where service is provided) are non-trivial.

- If it must reach out to more distant customers in order to increase output, then the firm faces a tradeoff between transportation costs, which increase with distance, and per-unit production costs, which may vary with scale of production.

- If shipping costs are low (high value-to-weight ratio) and economies of scale are significant, what configuration of plants is optimal?

- If shipping costs are high (low value-to-weight ratio) and economies of scale are not significant, what configuration of plants is optimal?

# Multi-plant operations: ABInbev vs. P&G

- A market of considerable geographic expanse is served and outbound transportation costs are appreciable:
  - ➤ https://en.wikipedia.org/wiki/Anheuser-Busch#Brewery_operations
- Shipping costs are low relative to the value of the product, but the firm has complex product lines:
  - ➤ http://www.pglocations.com/
  - ➤ http://www.pglocations.com/cape-girardeau/welcome
  - ➤ http://www.bizjournals.com/cincinnati/news/2015/02/10/p-g-to-build-500m-manufacturing-plant.html

# Economies of Scope: multi-product firms

- Sometimes there are shared inputs or other reasons that make it cheaper to produce two products together rather than produce each separately. When that is the case, we say that there are Economies of Scope across the production of the two products.

- Economies of scope exist if   C(X, Y) < C(X, 0) + C(0, Y) .

- Examples?  Dairy processing plant, with fluid milk, cottage cheese, and ice cream?  Alligators and chickens? http://www.nytimes.com/2000/06/18/us/camilla-journal-new-role-for-the-gator-chicken-farmer-s-friend.html?pagewanted=all&src=pm

- Implications for mergers and divestitures? http://www.convergencealimentaire.info/map.jpg http://ezproxy.uky.edu/login?url=http://search.proquest.com/docview/908477763/13873A4DA7C70384EF8/83?accountid=11836

**<u>Required Outside readings</u>:**

"Power Pork: Corporations Begin to Turn Hog Business into an Assembly Line," *WSJ,* 3/28/94.
http://ezproxy.uky.edu/login?url=http://search.proquest.com/docview/398373847?accountid=11836.

"Meet the World's Largest Cargo Ships," *WSJ*, 1/8/13.
http://search.proquest.com.ezproxy.uky.edu/docview/1266990140/A537F218D2EE4AFCPQ/71?accountid=11836

"New Role for the Gator: Chicken Farmer's Friend," *New York Times*, 6/18/2000.
http://www.nytimes.com/2000/06/18/us/camilla-journal-new-role-for-the-gator-chicken-farmer-s-friend.html?pagewanted=all&src=pm