Lecture 3
The Horizontal Boundaries of the Firm: Economies of Scale and Scope
Overview

Where do economies of scale come from?
- Definition of economies of scale
- Definition of economies of scope

Special sources of economies of scope

Sources of diseconomies of scale

The learning curve

Diversification
Economies of Scale

- Economies of scale occur when the average cost of producing additional output falls as you produce more.
  - The cost of producing an additional unit is less than the cost of producing the previous unit.
Economies of Scale

- Diseconomies of scale occur when the average cost of producing additional output rises as you produce more output.
  - The cost of producing an additional unit is more than the cost of producing the previous unit.
Economies of Scale

Q* is the minimum efficient size of the firm
Another Example

The graph illustrates the relationship between price per unit and quantity, with a focus on economies of scale and constant average cost. The curve shows how price per unit decreases with increasing quantity, highlighting the concept of economies of scale. The horizontal line representing constant average cost (AC) is drawn at a point where economies of scale are maximized, typically at the Minimum Efficient Scale (MES).
MES and market structure

- How many fast-food restaurants are there in Athens? In Kalamata? Why?
- 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.
- 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

Bauxite ore → Refining → Alumina
Alumina → Smelting → Molten aluminum
Molten aluminum → Casting / Alloying → Ingots

Ingots → Initial fabrication
- Plate
- Sheet
- Foil
- Wire
- Rod
- Bar

Final goods (examples)

Recycling

Further fabrication

Transportation, Building and Construction, Machinery, Containers and Packing, Etc.
Horizontal Boundaries: Economies of Scale in Aluminum Smelting

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>COMPANY</th>
<th>ANNUAL PRODUCTION CAPACITY</th>
<th>YEAR COMMISSIONED</th>
<th>OWNERSHIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAHRAIN</td>
<td>ALBA</td>
<td>870,000</td>
<td>1971</td>
<td>Bahrain – 78.5% SABIC – 21.5%</td>
</tr>
<tr>
<td>DUBAI</td>
<td>DUBAL</td>
<td>950,000</td>
<td>1979</td>
<td>Dubai Government – 100%</td>
</tr>
<tr>
<td>OMAN</td>
<td>SOHAR</td>
<td>360,000</td>
<td>2008</td>
<td>Oman Oil co. – 40% Abu Dhabi water &amp; elec. Authority – 40% Rio Tinto Alcan – 20%</td>
</tr>
<tr>
<td>QATAR</td>
<td>QATALUM</td>
<td>585,000</td>
<td>2010</td>
<td>Qatar Aluminium – 50% Hydro Aluminium – 50%</td>
</tr>
<tr>
<td>ABU DHABI</td>
<td>EMAL</td>
<td>720,000</td>
<td>2010</td>
<td>DUBAL – 50% Mabadala – 50%</td>
</tr>
<tr>
<td>SAUDI ARABIA</td>
<td>MA’ADEN</td>
<td>720,000</td>
<td>2012</td>
<td>Ma’aden – 75% ALCOA – 25%</td>
</tr>
</tbody>
</table>
Jointly Producing Two Outputs

- Sometimes firms produce more than one product simultaneously.
- **Examples**
  - Book publishers—text books and novels
  - Airline manufactures—passenger planes and fighter jets.
  - Clothing manufacturers—pants and shirts.
Production with Two Outputs—Economies of Scope

- Economies of scope exist when a single firm can produce two products at a lower cost than could be achieved by two different firms each producing one of the products.

- What are the advantages of joint production?
  - Consider an automobile company producing cars and tanks
Production with Two Outputs—Economies of Scope

Advantages

1) Both use similar capital and labor.
2) The firms share management resources.
3) Both use the same labor skills and type of machinery.
Production with Two Outputs—Economies of Scope

- Want some way to measure economies of scope.

- The *degree of economies of scope* measures the savings in cost and can be written:

\[
SC = \frac{C(Q_1) + C(Q_2) - C(Q_1, Q_2)}{C(Q_1, Q_2)}
\]

- \(C(Q_1)\) is the cost of producing \(Q_1\)
- \(C(Q_2)\) is the cost of producing \(Q_2\)
- \(C(Q_1Q_2)\) is the joint cost of producing both products
Production with Two Outputs—Economies of Scope

- If \( SC > 0 \) -- Economies of scope
- If \( SC < 0 \) -- Diseconomies of scope
- There is no direct relationship between economies of scope and economies of scale.
  - May experience economies of scope and diseconomies of scale
  - May have economies of scale and not have economies of scope
Production with Two Outputs—Economies of Scope

- Example—Merger between AOL and Time-Warner.
- Biggest merger in history at the time
- AOL a profitable provider of internet services.
- Time Warner a profitable entertainment company.
Both parties believed that the production of these goods used similar inputs, so they could save costs by producing them jointly.

In the end it proved too difficult to merge two different management structures (which is one of the inputs into production).

May have been diseconomies of scope.
In 2006 GM was losing money, -$10.6B
Most profitable part of the company was GMAC—it’s financing arm
Decided to sell 51% of GMAC to Cerberus for $7.4B
Felt GMAC could obtain better access to money if they were separate from GM
Diseconomy of Scope—GM & GMAC

- GMAC promptly began to make sub-prime home loans
- U.S. Treasury invested $16.3B in GMAC through TARP
- Currently, Federal Government owns 37% of Ally Financial (new name for GMAC)
IF I WANT TO GAMBLE WITH MY RETIREMENT MONEY I’LL GO TO VEGAS.

Ally IRA Savings and CDs.
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Comparing Scale and Scope

- **Economies of scale**
  - Looks at production of one good
  - Focuses on average cost of that good

- **Economies of scope**
  - Looks at production of multiple goods
  - Focuses on total costs for multiple goods or “set” of goods
Economies of Scope in the Trucking Industry

Issues
- Truckload versus less than truck load
- Direct versus indirect routing
- Length of haul
Economies of Scope in the Trucking Industry

Questions:

- Economies of Scale
  - Are large-scale, direct hauls cheaper and more profitable than indirect hauls by small trucks?
  - Are there cost advantages from operating both direct and indirect hauls?
Economies of Scope in the Trucking Industry

Empirical Findings

- An analysis of 105 trucking firms examined four distinct outputs.
  - Short hauls with partial loads
  - Intermediate hauls with partial loads
  - Long hauls with partial loads
  - Hauls with total loads
Economies of Scope in the Trucking Industry

Empirical Findings

- Results
  - SC = 1.576 for reasonably large firm
  - SC = 0.104 for very large firms

- Interpretation
  - Combining partial loads at an intermediate location lowers costs, management difficulties with very large firms.
Reasons why economies of scale or scope 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
Setup costs: for many production processes there are setup costs that do not vary with the length of the production run.

- firm has to pay the same costs of renting / owning the factory if they operate the factory 8 or 24 hours a day

Example:  
https://www.youtube.com/watch?v=9ZnOScQUGKo

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=PKG_TObuyNk)
- [https://www.youtube.com/watch?v=SXEsDq7JAMI](https://www.youtube.com/watch?v=SXEsDq7JAMI)
- European Union?

Specialization – Examples

Adam Smith’s pin factory

One man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on, is a peculiar business, to whiten the pins is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations …

Those ten persons, therefore, could make among them upwards of forty-eight thousand pins in a day. Each person, therefore, making a tenth part of forty-eight thousand pins, might be considered as making four thousand eight hundred pins in a day. But if they had all wrought separately and independently, and without any of them having been educated to this peculiar business, they certainly could not each of them have made twenty, perhaps not one pin in a day; that is, certainly, not the two hundred and fortieth, perhaps not the four thousand eight hundredth part of what they are at present capable of performing, in consequence of a proper division and combination of their different operations.
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?
Plant-level economies: engineering relationships


➢ Here is an example of how a simple idea, such as putting things in a box, can revolutionize markets:
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?
- 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?
Inventories – Examples

Example 1 – Wal-Mart Superstores, Sam’s Club, Neighborhood Markets
- All part of Wal-Mart
- They share inventories, reducing each store’s inventory need

Example 2 – Skyteam Alliance
- Co-operation of 20 airlines
- If they share airplanes, they can reduce their inventory of extra airplanes
Purchasing

- Large buyers receive volume discount
  - Reduced transaction costs
  - Cost of service (per unit) is lower for large buyers
  - Assured flow of business for the supplier

- Example: large brewery may be able to buy glass (for bottles) at lower prices than small micro-breweries
Advertising

Larger firms may experience lower cost per potential customer when compared with small regional firms

– Consider Meijer vs. Kroger

• If two ads cost the same per-unit (the same price per 1,000 print ads), then, because Kroger has a larger market, they have a lower cost per potential customer
Advertising (Continued)

- Large firms may convert larger share of potential customers into actual customers
  - Example: Starbucks vs. Pete’s Coffee

- Umbrella branding
  - New products easier to introduce when the brand name is already established
  - Example: Apple started out producing computers before introducing iPods, iPhones and iPads
Umbrella branding

- Doesn't benefit products with much different perceived quality
  - Volkswagen, Porsche, Bentley
Research and Development

- It is not clear whether small firms or large firms have advantage for R&D
  - Average cost of innovations is smaller at large firms
  - Smaller firms may be more suitable for motivated researchers
Hiring

- Large firms have HR departments
  - Have workers who specialize in hiring
  - More information about the going wage & benefits
  - Better able to hire workers who are a good match with the firm
  - Lower average cost for hiring workers
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:

- Shipping costs are low relative to the value of the product, but the firm has complex product lines:
  - [http://www.bizjournals.com/cincinnati/news/2015/02/10/p-g-to-build-500m-manufacturing-plant.html](http://www.bizjournals.com/cincinnati/news/2015/02/10/p-g-to-build-500m-manufacturing-plant.html)
Economies of Scale and Scope in Airlines

- In the past airlines seemed to exhibit economies of scale and scope
- Operating a plane primarily involves fixed costs
  - Want planes to be full
  - With sufficient number of customers operate one big plane instead of two small planes
Economies of Scale and Scope in Airlines

➢ Led to the hub-and-spoke system
  – Smaller planes flying passengers going multiple places from smaller towns to hub in big city
  – Larger planes at hub to take passengers from a variety of places to one common location

➢ Discount airlines and lower cost regional jets are changing the size of scope economies
Diseconomies of Scale

- In some situations products produced by larger firms may be more expensive (per unit) than smaller firms.

Sources of diseconomies of scale
  - Labor intensive firms
  - Bureaucracy
  - Scarcity of specialized resources
  - Conflicts of interest
Labor Intensive Firms

- Firms that are labor-intensive are less likely to benefit from economies of scale
- Workers in large firms are paid more than “identical” workers in small firms
  - Workers may be more productive
  - Larger firms more likely to be unionized
  - Workers may prefer smaller firms
- However, turnover is lower in larger firms
Bureaucracy

As firm size grows, managers have more difficulty:

- Monitoring and communicating with workers
- Evaluating and rewarding individual performance

Larger firms may discourage creativity of workers

- Xerox & Windows
Scarcity of Specialized Resources

- Some resources have limited availability, so larger firms will have less access to this resource.

- Examples:
  - Talented managers
  - Coastline (or desirable location more generally)
Conflict of Interest

- Professional services firms may find it difficult to sign up a client if a competitor is already a client of the firm

- The need to share sensitive information may impose a limit to the growth of the firm

- Examples include advertising agencies, management consultants, and lawyers
  - Growth of multi-national law firms—Bingham
Diseconomies of Scale

  http://gattonweb.uky.edu/faculty/troske/teaching/eco411/articles/McDonalds Menu Problems WSJ 12-4-14.pdf
  http://gattonweb.uky.edu/faculty/troske/teaching/eco411/articles/Starbucks Boosts Food Sales WSJ 12-5-14.pdf
Dynamic Changes in Costs--The Learning Curve

- 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.
- The learning curve measures the impact of workers’ experience on the costs of production.
  - It describes the relationship between a firm’s cumulative output and amount of inputs needed to produce a unit of output.
The Learning Curve

Hours of labor per unit of output

Cumulative units of output produced
The Learning Curve

- The horizontal axis measures the cumulative number of hours of machine tools the firm has produced.
- The vertical axis measures the number of hours of labor needed to produce each lot.
The learning curve in the figure is based on the relationship:

\[ L = A + BN^{-\beta} \]

- \( N \) = cumulative units of output produced
- \( L \) = labor input per unit of output
- \( A, B \) and \( \beta \) are constants
- \( A \) & \( B \) are positive and \( \beta \) is between 0 and 1
Dynamic Changes in Costs--The Learning Curve

- If $N = 1$:
  - $L$ equals $A + B$ and this measures labor input to produce the first unit of output

- If $\beta = 0$:
  - Labor input remains constant as the cumulative level of output increases, so there is no learning
Dynamic Changes in Costs--The Learning Curve

If $\beta > 0$ and $N$ increases:
- $L$ approaches $A$, and $A$ represent minimum labor input/unit of output after all learning has taken place.

The larger $\beta$:
- The more important the learning effect.
The Learning Curve

The chart shows a sharp drop in lots to a cumulative amount of 20, then small savings at higher levels.

Doubling cumulative output causes a 20% reduction in the difference between the input required and minimum attainable input requirement.

\[ \beta = -0.31 \]
Observations

1) New firms may experience a learning curve, not economies of scale.

2) Older firms have relatively small gains from learning.
Economies of Scale Versus Learning

Cost ($ per unit of output)

Economies of Scale

Learning

Output

AC₁

AC₂

A

B

C
## Predicting the Labor Requirements of Producing a Given Output

<table>
<thead>
<tr>
<th>Cumulative Output (N)</th>
<th>Per-Unit Labor Requirement for each 10 units of Output (L)</th>
<th>Total Labor Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.00</td>
<td>10.0</td>
</tr>
<tr>
<td>20</td>
<td>.80</td>
<td>18.0 (10.0 + 8.0)</td>
</tr>
<tr>
<td>30</td>
<td>.70</td>
<td>25.0 (18.0 + 7.0)</td>
</tr>
<tr>
<td>40</td>
<td>.64</td>
<td>31.4 (25.0 + 6.4)</td>
</tr>
<tr>
<td>50</td>
<td>.60</td>
<td>37.4 (31.4 + 6.0)</td>
</tr>
<tr>
<td>60</td>
<td>.56</td>
<td>43.0 (37.4 + 5.6)</td>
</tr>
<tr>
<td>70</td>
<td>.53</td>
<td>48.3 (43.0 + 5.3)</td>
</tr>
<tr>
<td>80 and over</td>
<td>.51</td>
<td>53.4 (48.3 + 5.1)</td>
</tr>
</tbody>
</table>
The learning curve implies:

1) The labor requirement falls per unit.

2) Costs will be high at first and then will fall with learning.

3) After 80 units the labor requirement will be 0.51 and per unit cost will be half what it was in the first year of production.
The Learning Curve in Practice

➤ Scenario
- A new firm enters the chemical processing industry.

➤ Do they:

1) Produce a low level of output and sell at a high price?

2) Produce a high level of output and sell at a low price?
The Learning Curve in Practice

How would the learning curve influence your decision?
The Learning Curve in Practice

The Empirical Findings

- Study of 37 chemical products
  - Average cost fell 5.5% per year
  - For each doubling of plant size, average production costs fall by 11%
  - For each doubling of cumulative output, the average cost of production falls by 27%

Which is more important, the economies of scale or learning effects?
Other Empirical Findings

- In the semi-conductor industry a study of seven generations of DRAM semiconductors from 1974-1992 found learning rates averaged 20%.
- In the aircraft industry the learning rates are as high as 40%.
Would you, as an airline passenger, like to be part of the learning process that Boeing workers go through?

Is there a similar learning curve phenomenon associated with Toyota’s introduction of a new model of the Camry?
Recent study of production of a new car in an unnamed car manufacturer showed substantial evidence of learning-by-doing:

- Defects per car fell from 70 to 20 in the initial 8 weeks of production
- Defects per car fell to 10 in the remaining weeks of the production year
- Estimate show $\beta = -0.3$
The Learning Curve in Practice

Applying Learning Curves

1) To determine if it is profitable to enter an industry.

2) To determine when profits will occur based on plant size and cumulative output.
Learning by doing and economies of scale often lead to this product lifecycle.
Diversification

- So far we have focused firms operating in a single line of business
- Many firms operate in multiple lines of business
  - General Electric
  - PepsiCo
  - Siemens
  - Mitsubishi Group
Why Do Firms Diversify?

- Want to ask why firms chose to operate in multiple lines of business
- What is the primary responsibility of a corporate CEO?
- What does Coase’s *Theory of the Firm* tell us?
- Are there other reasons firms might diversify?
Why Do Firms Diversity?

Efficiency reasons for firms to diversity

- Scope economies represent main justification for diversification
  - Exploit some underutilized resource with large fixed cost
- Managerial talent is often one resource
  - Steve Jobs & Apple
  - Bill Gates, Steve Balmer & Microsoft
Why Do Firms Diverse?

Efficiency reasons for firms to diversify

- Internal Capital Markets
  - Some firms can use internal capital markets to finance diversification
  - Firms have excess working capital
  - Is this a good idea?
    - Recent debates at GM and Yahoo
BCG Growth/Share Matrix

Relative Market Share

<table>
<thead>
<tr>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising Star</td>
<td>Problem Child</td>
</tr>
<tr>
<td>Cash Cow</td>
<td>Dog</td>
</tr>
</tbody>
</table>

Relative Market Growth

High

Low
BCG Growth/Share Matrix

- Matrix based on taking advantage of learning curves and product lifecycle
  - Use money generated by cash cows to finance growth of problem-child and rising star

- Does this work?
  - Sometimes yes; sometimes no

- Already seen that learning-by-doing does not always occur

- Why not just borrow from the market?
Internal Capital Markets

- When should firms use internal capital markets?
  - Firm may have *asymmetric information*
  - Lemons problem—use external financing for least profitable opportunities
  - Hard to borrow more money if you already have debt
  - May be able to allocate best workers to new projects
Internal Capital Markets

- Problems with using internal capital markets?
  - Market provides discipline
    - If market is unwilling to finance a project is it really all that profitable?
  - How do managers decide among competing projects without prices?
  - Opportunity cost of capital
Why Do Firms Diversify?

- Questionable reasons for diversification
  - Help shareholders diversify their portfolio
  - Identifying undervalued firms
    - Why are managers of a firm better at spotting undervalued firms than professional investors?
    - Winner’s curse

- Reasons not to diversify
  - Diversification only works if there are scope economies
  - Increased bureaucracy
Why Do Firms Diversity?

- Managerial reasons to diversity
  - Increase growth (but not necessarily profits)
  - More stable growth
  - Prestige
Corporate Governance

- What are managers supposed to do?
- How do shareholders/owners ensure that managers act in their own best interest?
Publicly traded firms are vulnerable to hostile takeovers

Market for corporate control is an important constraint on the managers

If managers undertake unwise acquisitions, the stock price drops, reflecting
- Overpayment for the acquisition
- Potential future overpayment by the incumbent management
In an LBO, debt is used to buy out most of the equity.
Future free cash flows are committed to debt service.
Debt burden limits manager’s ability to expand the business.
Market for Corporate Control

- Gains in efficiencies in LBOs were substantial
- Even when firms defaulted on their debt the net effect was beneficial
- Corporate raiders profited handsomely for taking over and busting up firms that pursued unprofitable diversification
Market for Corporate Control

- LBOs may hurt other stakeholders
  - Employees
  - Bondholders
  - Suppliers

- Wealth created by LBO may be quasi-rents extracted from stakeholders

- Redistribution of wealth may adversely affect economic efficiency
Diversifying Acquisitions

- Shareholders of the acquiring firms do not benefit from the acquisitions.
- Negative effects on the acquiring firms are more severe when:
  - the managers of the acquiring firms were performing poorly before the acquisition.
  - the CEOs of the acquiring firms hold smaller share of the firms’ equity.
Diversification & Long-Term Performance

- Long term performance of diversified firms appears to be poor.
- A third to half of all acquisitions and over half of all new business acquisitions are eventually divested.
- Corporate refocusing of the 1980s could be viewed as a correction to the conglomerate merger wave of the 1960s.
- Has to be a good economic reason for diversifying—economies of scope
Diversification

- Why might a large beer producer buy a craft beer producer?

Economies of scale occur when the average cost of producing additional output falls as you produce more.

The minimum efficient scale is the size of a plant at which the long-run average costs in minimized.
Summary

- Economies of scope exist when it costs less to produce multiple products in the same factory than it costs to produce the products separately.

- An important source of economies of scale and scope is the spreading of indivisible fixed costs.
Summary

- The learning curve shows how costs change as we produce more output.
- Exploiting economies is the principle reason for diversification.
- Often hard to exploit economies of scope through diversification.