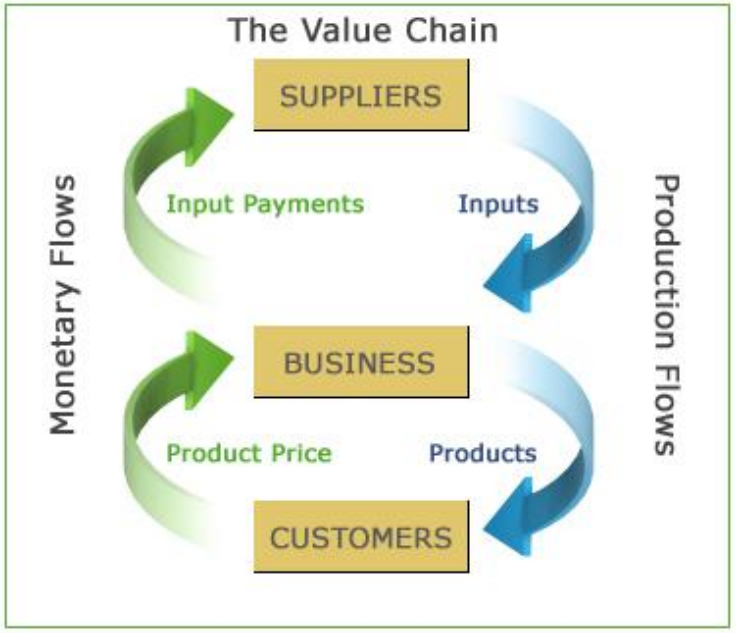
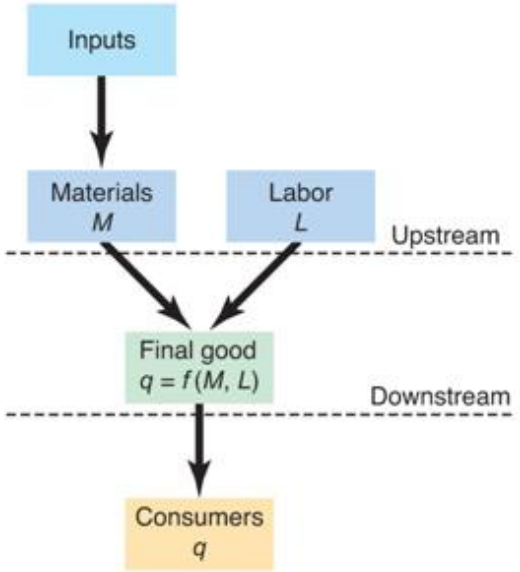
Lecture 19
Aligning Incentives I: Strategic supply (vertical) relationships and externalities

15.011/0111 Economic Analysis for Business Decisions
Oz Shy

Vertical supply chain: Illustrations of vertically dis-integrated industries

- Production processes are often visualized as chains of *vertical* transactions among firms
- Today we study the efficient and inefficient aspects of this market structure (outsourcing and insourcing decisions)
- Related concepts: vertical (dis)integration, (in)(out)sourcing decisions, double marginalization, transfer prices





Vertical supply chain: The double-marginalization problem

- Upstream firm is a chip producer (marginal cost = c_c)
- Upstream firm sells each chip at p_c
- Downstream firm buys chips and assembles tablet computers
- Assume one chip per tablet is the only input
  hence, the marginal cost of producing a tablet is:
  $c_t = p_c$ which is set by the chip producer!
- Downstream firm sells to consumers according to:
  (q_t in millions of units)

$$p_t = 12 - q_t$$

Upstream monopoly chip producer

$MC_c = c_c = \$4$

Sets $p_c = c_t$

Vertical supply chain: The double-marginalization problem: Two-stage game

Upstream monopoly chip producer

$MC_c = c_c = \$4$, sets c_t to the downstream firm

Stage 1: ↓ c_t ($=p_c$ = price of one chip)

Downstream firm (monopoly in the market for tablet)

$MC_t = c_t$ (set by the chip producer!)

Sets p_t (tablet price to consumers)

Stage 2: ↓ p_t

Consumers: $p_t = 12 - q_t$ (q_t in millions)

Vertical supply chain: The double-marginalization problem: Two-stage game: Summary

1. Monopoly chip producer sets c_t (price of a chip)

2. Monopoly tablet producer sets p_t (tablet price)

   (monopoly has to buy 1 chip for every tablet produced)

Question: How do we solve a finite-horizon dynamic game?

Hint: We have done it before! (remember Stackelberg?)

Answer: Solve it backwards !!!

The double-marginalization problem: Solving the game "backwards" Solving Stage 2: Tablet producer sets p_t

The monopoly tablet producer takes c_t (MC) as given and sets q_t to maximize monopoly profit:

$$p_t = 12 - q_t \quad \Rightarrow MR_t = 12 - 2q_t = c_t \quad \Rightarrow q_t(c_t) = \frac{12 - c_t}{2}$$

Remark 1: $q_t(c_t)$ also the demand function for chips (input) because $q_c = q_t$ (1 chip is required to assemble 1 tablet)

Remark 2: Notice that the solution to Stage 2 is a function of c_t to be determined in Stage 1 of the game. c_t is the price of a chip to be determined by the chip producer that sells chips to the tablet producer.

The double-marginalization problem: Solving the game "backwards" Solving Stage 1: Chip producer sets p_c

The monopoly chip producer takes c_c = \$4 (MC) as given and sets c_t to maximize monopoly profit.

Recall that the demand for chips is:

$$\Rightarrow q_t(c_t) = \frac{12 - c_t}{2}$$

Therefore, the inverse demand for chips is: $p_c = c_t = 12 - 2q_c$

Solving the monopoly chip producer's problem:

$$\Rightarrow MR_c = 12 - 4q_c = c_c = \$4 \qquad \Rightarrow q_c = 2$$

$$\Rightarrow p_c = c_t = 12 - 2q_c = 12 - 2 \cdot 2 = \$8$$

The monopoly profit (in \$m) of the chip producer is:

$$\pi_c = (c_t - c_c)q_c = (8 - 4)2 = \$8$$

The double-marginalization problem: Summary of results

Now that we computed c_t = \$8, go back to Stage 2 and substitute it into the equilibrium values:

$$q_t = q_c = 2 \qquad \Rightarrow p_t = 12 - q_t = \$10$$

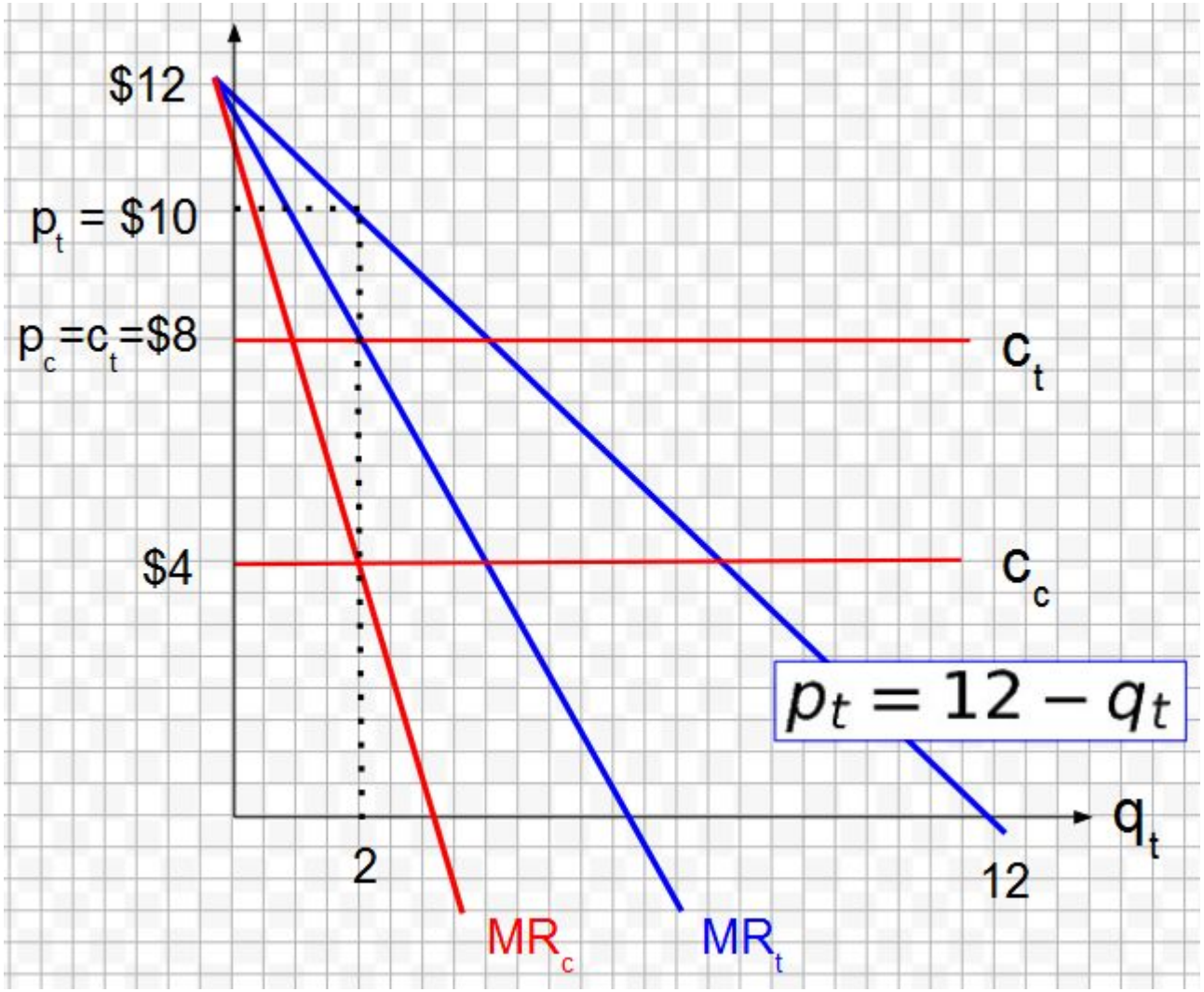
Hence, 2m tablets are sold for \$10 each

The profit of the tablet producer (\$m) is:

$$\pi_t = (p_t - c_t)q_t = (10 - 8)2 = \$4$$

Finally, total industry profit is: $\Pi = \pi_c + \pi_t = \$8 + \$4 = \$12$

The double-marginalization problem: Graphic illustration of the problem



Solving the double-marginalization problem: Vertical integration

Suppose the chip producer and the tablet producer merge into one firm, so the chip division "transfers" the chip to the tablet assembly division at marginal cost: $c_C = c_t = \$4$

Recall that before the merger, the tablet producer paid \$8 per chip

The tablet monopoly solves:

$$p_t = 12 - q_t \Rightarrow MR_t = 12 - 2q_t = c_t = \$4 \quad \Rightarrow q_t = 4 > 2$$

$$\Rightarrow p_t = 12 - q_t = 12 - 4 = \$8 < \$10$$

$$\Rightarrow \pi_t = (p_t - c_t)q_t = (8 - 4)4 = \$16 > \$12$$

Conclusion: Vertical integration has increased output, reduced price, and increased total profit from \$12 to \$16

Solving the double-marginalization problem: Summary and takeaway

Summary of the double-marginalization problem

1. If outsourced input suppliers have market power, they will price inputs above marginal cost, which
2. would increase marginal cost of assembling the final product
3. leading to 'under-production' of the final good

Summary of vertical integration

- Vertical integration requires setting transfer prices among the different divisions within the same company
- The optimal 'transfer price' should be marginal cost, or
- marginal cost plus a fixed fee (two-part tariff)

Is vertical integration always efficient? Answer: Not always!

- Managerial limitations: Managers may not be able to control several divisions in an efficient way
  (Ronald Coase, Nobel Prize laureate: Large firms may operate under diseconomies of scale. Otherwise, one firm IBM or Google will be producing everything from tomatoes to satellites)
- Outsourcing may be more efficient if suppliers outside the firm can produce the same quality components at lower costs
  Examples: Apple and Boeing

Is vertical integration always efficient?
Answer: Not always!
HP breakup in Nov. 2015

THE WALL STREET JOURNAL.

TECH

Hewlett-Packard Set to Break Up 75-Year-Old Company

H-P Would Separate PC, Printer Business from Corporate Hardware, Services; More Layoffs Ahead

Hewlett-Packard Enterprise

Enterprise Group	48%
Enterprise Services	39%
Software	7%
Financial Services	6%

- Revenue: $58.4B
- Operating Profit: $6.0B
- Operating Margin: 10.2%

- Servers
- Storage
- Networking
- Services
- Software
- Cloud
- Converged Systems

- **Meg Whitman**, Chief Executive Officer

HP Inc.

Personal Systems	59%
Printing	41%

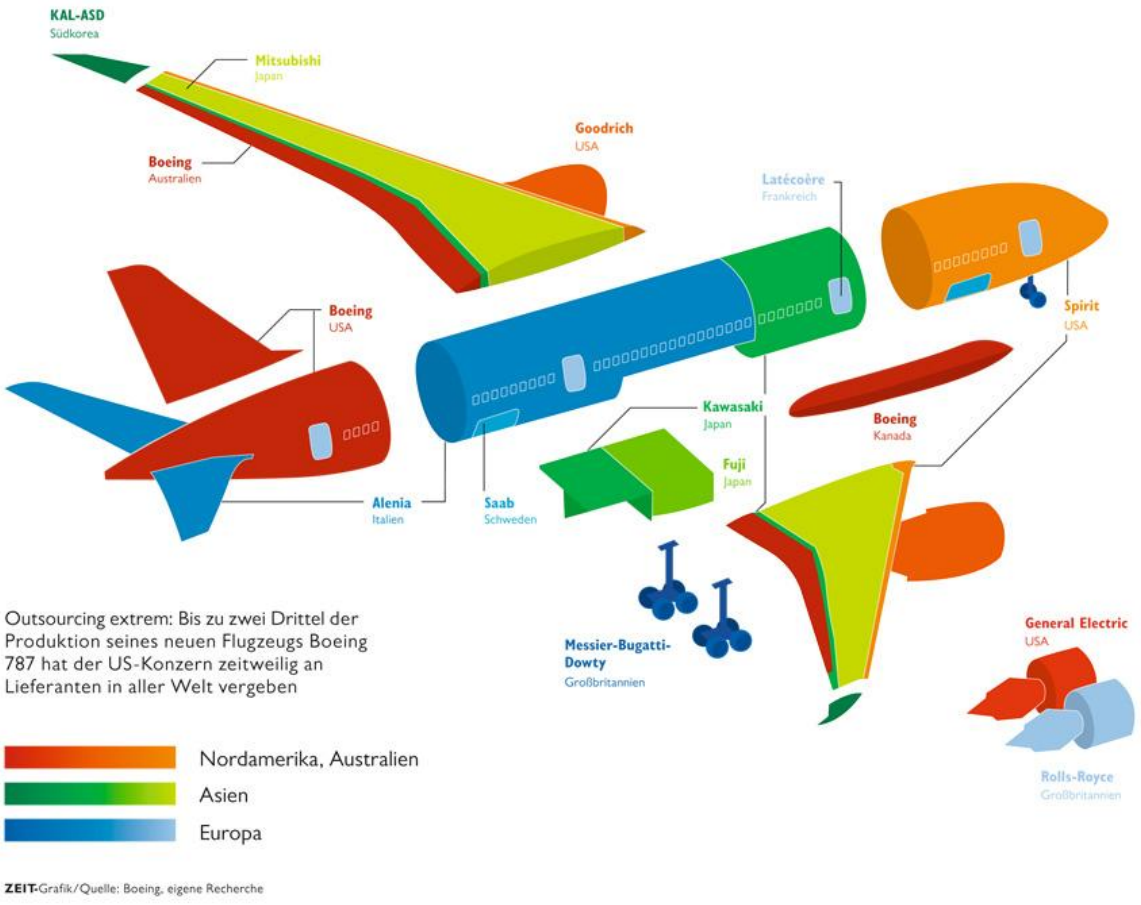
- Revenue: $57.2B
- Operating Profit: $5.4B
- Operating Margin: 9.4%

- Notebooks
- Desktops
- Mobility
- Graphics
- Ink Printing
- Laser Printing
- Managed Print Services

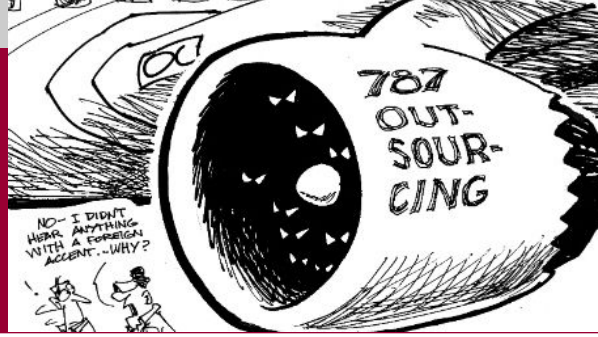
- **Dion Weisler**, Chief Executive Officer

Is vertical integration always efficient? Answer: Not always!

- Toyota outsources hundreds of components of each car model
- Boeing and Airbus rely on outsourcing of thousands of parts for each aircraft:



Is vertical integration always efficient? The Boeing 787 (Dreamliner) case



- Boeing's workers are unionized
- Production was designed to rely on outsourcing
- The delivery date was pushed back four times and was more than two years late
- The aft fuselage consisted of 6,000 components, and many of those components failed to conform to Boeing's specified engineering tolerances, resulting in significant cost and

Forbes / Leadership

JAN 21, 2013 @ 02:28 AM 136,238 VIEWS

What Went Wrong At Boeing?

REUTERS EDITION: U.S.

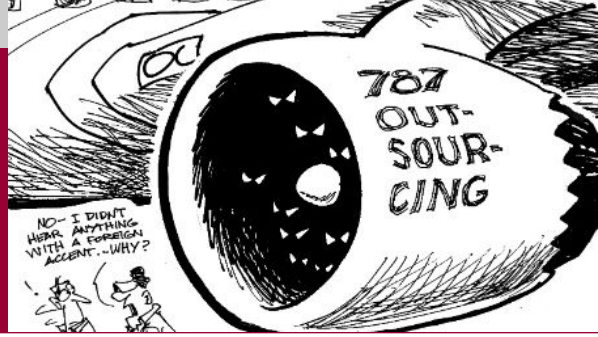
HOME BUSINESS MARKETS WORLD POLITICS TECH OPINION BREAKINGVIE

Felix Salmon

Learning from Boeing's outsourcing disaster

By Felix Salmon | February 18, 2011

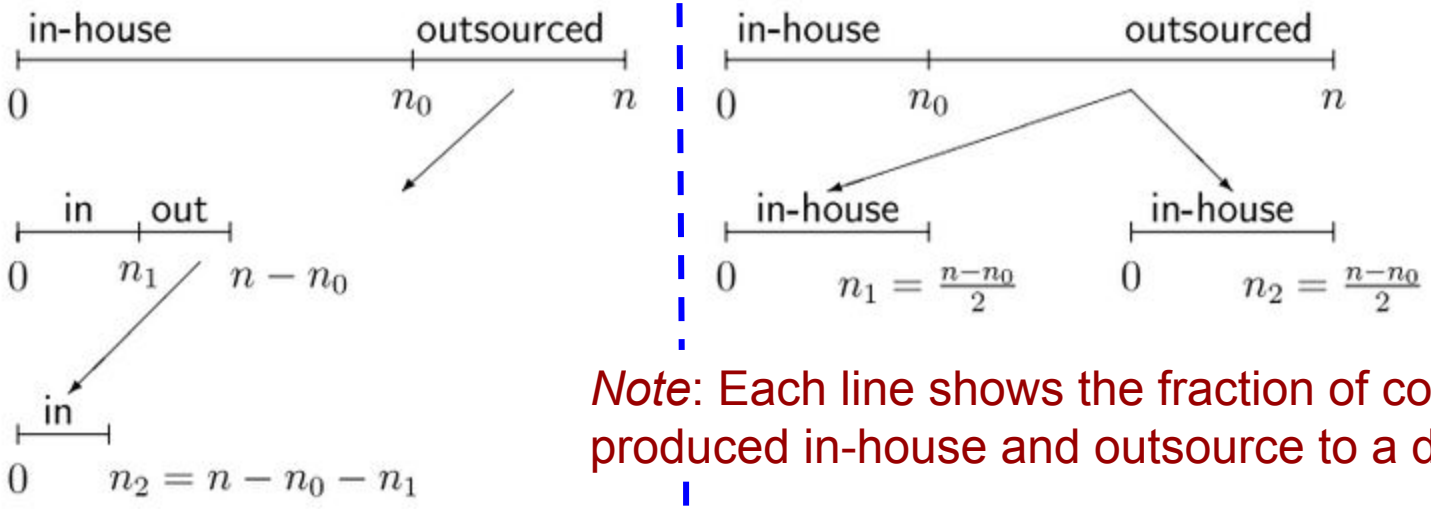
The Boeing 787 (Dreamliner) case (continued)



According to the *Wall Street Journal*, (Dec.7, 2007) the crucial mechanism behind these problems was that Boeing's subcontractor had outsourced the production of some of the components, which therefore formed chains of outsourcing contracts.

Shy & Stenbacka (2012) call it "nested" outsourcing (Fig1-Left)

O. Shy, R. Stenbacka / Economics Letters 116 (2012) 593–596



Note: Each line shows the fraction of components produced in-house and outsource to a downstream firm

Fig. 1. *Left*: Nested (vertical) outsourcing (V). *Right*: Horizontal outsourcing (H)

Vertical integration and disintegration (outsourcing): Three points of view

Adam Smith (1723-1790): Given proper incentives, each individual pursuing his or her self interest maximizes the performance of the economy

Ronald Coase (1910-2013): The nature of the industry is determined by 'transaction costs' consisting of search and information costs, bargaining costs, keeping trade secrets, and policing and enforcement costs

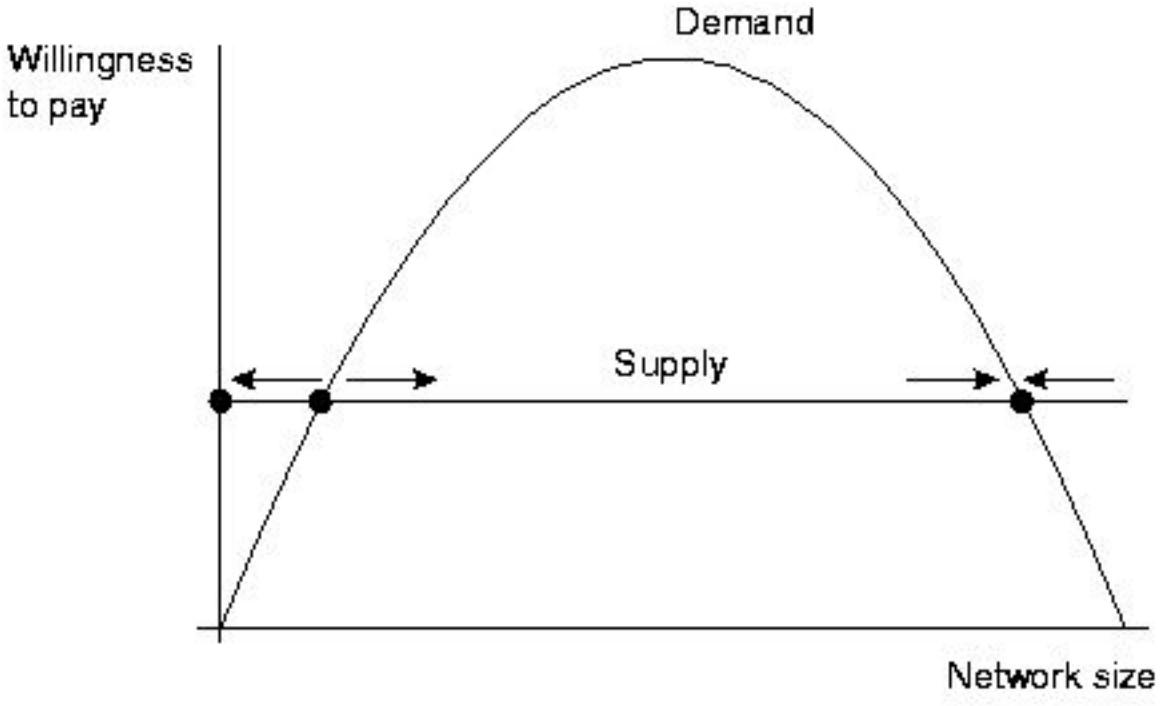
Alfred Sloan (1875-1966):

- Divided GM into separate autonomous divisions that were subject only to financial and policy controls from a small central staff
- Each division had to maximize its own profit

Consumption externalities

Positive network consumption externality

Negative consumption externality:



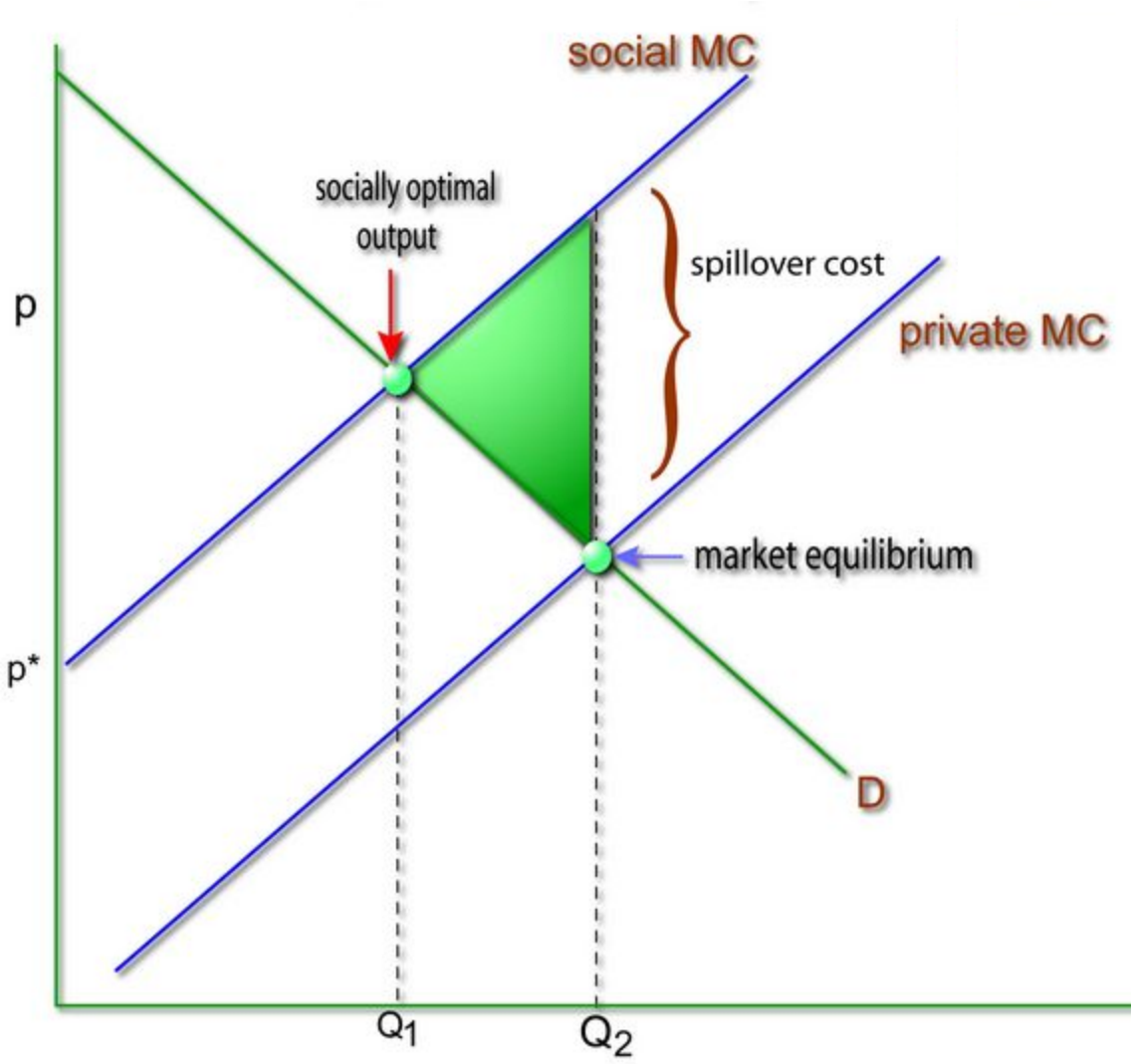
Production (pollution) externalities

Upstream factory reduces profitability of the downstream fishing industry

<u>Possible solutions</u>:

1. Tax the polluting factor
2. Give fishermen property rights over the river (factory will buy rights to pollute)
3. Give the factory property rights (fishermen will pay factory not to pollute)

Production (pollution) externalities



Competitive industry produces Q_2

Firms don't take into account cleaning costs stemming from production

Taxing firms on each unit of production is one solution