



RECITATION NOTES #10

Information Asymmetry and Transfer Pricing

Friday - December 3, 2004

OUTLINE OF TODAY'S RECITATION

1. **Asymmetric Information:** definition of the problem and possible solutions
2. **Numeric Example on Comparative Advantage**
3. **Transfer Pricing:** definition and optimization problems
4. **Numeric Example on Transfer Pricing:** learning how to solve a transfer price problem

1. ASYMMETRIC INFORMATION

1.1 Definitions

1.2 Possible solutions to information asymmetry

1.1 Definitions

The problem of asymmetric information consists of distortions of the traditional market power models due to differences in the availability of information to different players. These information differences can refer to either hidden attributes of the goods or hidden behaviors of the players. We will here analyze these two cases.

- **Adverse selection:** Information asymmetry can originate from the knowledge of one player about some **hidden attribute of a good**. An example of this situation is the market for used cars, where the car dealer has much more information than the buyer about the real conditions of a vehicle.
The problem in this kind of situation is that the buyers – feeling that they do not have perfect information – will tend to attribute to the goods a lower value than the one actually requested by the seller. Because the sellers will not want to sell at this lower level, this is an example of a market failure due to an information asymmetry.
- **Moral hazard:** In this situation, information asymmetries can give incentive to some players to behave incorrectly. An example of this situation is the insurance market. The moral hazard problem is well expressed by the situation in which you have car insurance that covers 100%

of the damages to your vehicle. Your incentives to care for your car and drive carefully would disappear and you would drive recklessly (as the marginal cost of repairing the car after each accident for you is zero).

The problem in this situation is that insurance companies will therefore have to raise their premiums and this will result in a further market failure.

A different view of the same problem is known as the “**Principal – Agent problem**”. It arises when one person or organization (the Principal) hires another person or organization (the agent) to act on its behalf. The agent in this case may have different incentives than the principal and act in his or her own interest rather than the principal’s interest (e.g. managers and owners, tenants and homeowners)

1.2 Possible solutions to information asymmetry

Both problems originating from information asymmetry can be solved relatively easily, once the motivation behind the market failure is identified:

1. **Solution to Adverse selection:** the solution to the problem of information asymmetries regarding hidden attributes of an object relies in the role of **signals**. If the seller has a way to signal to the buyer that the good is indeed worth the price asked for it, then the cause for the market failure will be removed and the market will work.
Example: if the used car dealer can offer a warranty covering all defects of the used cars for three years from the date of purchase, this could represent a credible signal for the buyers that the cars are indeed valuable. The market failure would, therefore, be removed.
2. **Solution to moral hazard:** the solution to the problem of moral hazard consists of aligning the incentives of all players. In the case of the **Principal-Agent problem**, the solution is represented by strict monitoring of the agent’s behavior and compensation and incentive package linked to the fulfillment of the principal’s interests.
Example: in the car insurance example, the introduction of deductibles on the amount reimbursed gives drivers an incentive to drive carefully. In the managers-owners example, compensation packages based on stock options and profit sharing give the managers the incentive to maximize the stock’s returns, aligning their interest with those of the owners.

2. NUMERIC EXAMPLE OF COMPARATIVE ADVANTAGE

- Goal is to write the most lines of code per week
- Each line of code must be programmed and debugged
- How should we split the work?

Productivity (lines per day)

	Program	Debug
Anna	30	4
Barry	9	1

- Optimal solution:
 - Anna debugs all the time; Barry programs one day and debugs the other
 - This gives 4.5 lines per day (versus 4.43 if they worked on their own)
- Key Insight : Relative productivity (lines programmed / line debugged) : 7.5 for A vs. 9 for B
=> B should do the programming and A the debugging
- Principle of Comparative Advantage :
 1. What matters in allocation of tasks is comparative advantage, *not* absolute advantage.
 2. Whenever there are differences in relative productivity, there are gains from specialization and trade.

3. TRANSFER PRICING

3.1 Definition

3.2 Optimizing transfer prices

3.1 Definition

The Transfer Price is the price charged for transfer of output from one division to another of the same company. If one division charges a high price for a component that another division has to purchase, doesn't the end result come out exactly the same for the firm as a whole?

- This is true only if each division manager is working to maximize the profit of the firm as a whole.
- However, divisions are generally managed such that the division managers are compensated on the profits of the division, not of the firm as a whole.
- Senior management has a critical role in this case: set the rules for pricing such that when each division maximizes profits locally, they maximize profits globally.

3.2 Optimizing transfer prices

Optimization with transfer pricing is variable and depends on the different behaviors of top management. The following examples provide a better understanding of pricing internally to the company.

4. NUMERIC EXAMPLE OF TRANSFER PRICES

We have a company with two divisions. The downstream division makes lockers.

The demand for lockers is given by: $P_L = 10,000 - Q_L$

The downstream cost of locker production (excluding the transfer price of steel) is $1000Q_L$.

The upstream division makes specialized sheet steel used to produce these lockers. There is no outside sheet steel market. Politically, the upstream division has all the bargaining power, and the downstream division has no control over the price or quantity of steel.

$$\Rightarrow \text{NMR} = 9,000 - 2Q_L$$

One may view Net Marginal Revenue in several ways:

- Marginal downstream revenue *net* marginal downstream production costs
- Marginal downstream profits before transfer costs from upstream
- “Marginal” Net Revenue

The bottom line is that the Net Marginal Revenue curve is the demand curve of the downstream division for the upstream products it consumes.

The thought process is as follows:

- a) How many lockers can we produce with another sheet of steel? (We assume 1.)
- b) How much marginal revenue will this earn us (the downstream company)?
- c) What are the downstream costs associated with this marginal production? (not including transfer costs)
- d) Take marginal downstream production costs out of the marginal revenue.
 - i) What is the result?
 - ii) This is the net marginal revenue, or the marginal profit before transfer costs.
- e) NMR (\approx marginal profit before steel) gives downstream reservation price for steel.
- f) If $\text{NMR} \geq P_S$, buy it to make another locker. Otherwise, the purchase is not justified.

A) Double Marginalization:

Maintain the assumption that the upstream steel division has bargaining power over the downstream locker division. The upstream division maximizes its own profits by exercising monopoly power on the downstream division. The downstream division, in turn, exercises market power on the locker market. There is still no outside market for the sheet steel.

To maximize its profits under monopoly power, the upstream division will produce steel only up to the point where $MC_S = MR_S$. Assume the total cost of steel production is Q_S^2 . The demand curve facing the steel division is the NMR curve of the downstream locker company:

$$P_S = 9,000 - 2Q_S$$

Therefore:

$$TR_S = P_S * Q_S = 9,000Q_S - 2Q_S^2$$

$$MR_S = 9,000 - 4Q_S$$

$$TC_S = Q_S^2$$

$$MC_S = 2Q_S$$

Setting $MR_S = MC_S$, we have:

$$MR_S = MC_S$$

$$\Rightarrow 9,000 - 4Q_S = 2Q_S$$

$$\Rightarrow Q_S = 1,500 \text{ sheets}$$

$$\Rightarrow P_S = 9,000 - 2 * 1,500 = \$6,000$$

Profits for the upstream manufacturer are then:

$$\Pi_S = TR_S - TC_S$$

$$\Rightarrow \Pi_S = P_S * Q_S - Q_S^2$$

$$\Rightarrow \Pi_S = 6,000 * 1,500 - (1,500)^2 = \$6.75 \text{ million}$$

Now that we have the cost of sheet steel, we have the complete total cost curve for lockers:

$$TC_L = (1,000 + 6,000) * Q_L = 7,000Q_L$$

This, plus the fact that $Q_L = Q_S = 1,500$, permits us to calculate the downstream profits:

$$\Pi_L = TR_L - TC_L$$

$$\Rightarrow \Pi_L = (10,000 - Q_L) * Q_L - 7,000Q_L$$

$$\Rightarrow \Pi_L = (10,000 - 1,500) * 1,500 - 7,000 * 1,500 = 1,500 * 1,500$$

$$\Rightarrow \Pi_L = \$2.25 \text{ million}$$

\Rightarrow

Downstream profit may also be written as Net Revenue less the price paid for steel:

$$\Pi_L = NR_L - TC_L^U$$

$$\Rightarrow \Pi_L = (9,000Q_L - Q_L^2) - 6,000Q_L$$

$$\Rightarrow \Pi_L = 9,000 * 1,500 - (1,500)^2 - 6,000 * 1,500$$

$$\Rightarrow \Pi_L = \$2.25 \text{ million}$$

However one approaches the calculations, the combined profit will be \$9 million.

Before continuing, note that when we calculate the total profits for the value chain, the revenues and expenses for the transferred steel simply cancel out:

$$\begin{array}{r} \Pi_S = P_S * Q_S - TC_S \\ \Pi_L = NR_L - P_S * Q_S \quad (\text{where } Q_S = Q_L) \\ \hline \Pi_T = NR_L - TC_S \end{array}$$

Total firm profits are equal to Net Revenue minus steel production costs. To maximize firm profits, we would like to produce until Net Marginal Revenue is equal to marginal steel production costs. (Did we do that here? Hint: NO.)

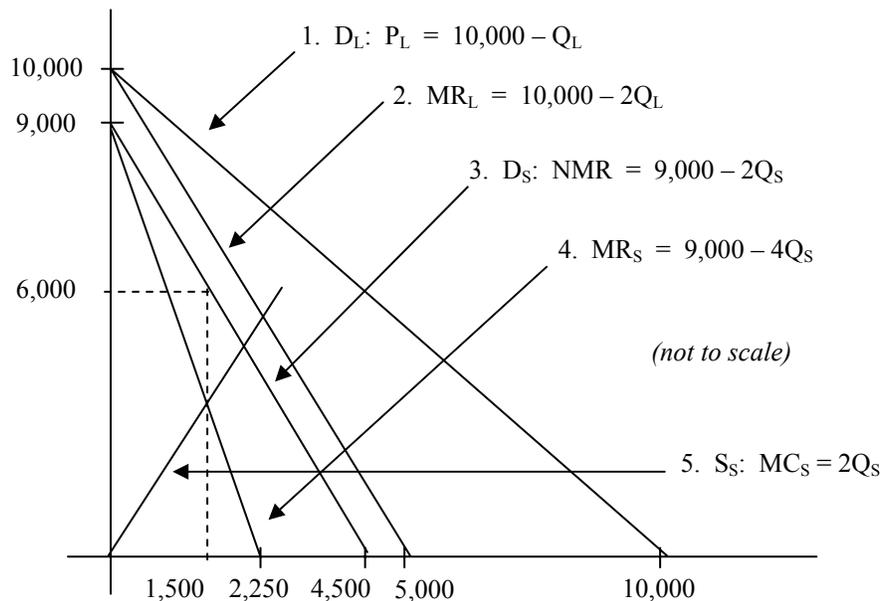
What about consumer surplus? The price of each locker will be:

$$P_L = 10,000 - 1,500 = \$8,500$$

Consumer surplus in the locker market is the area of the triangle (not pictured here) below the locker demand curve and above the locker price line:

$$\begin{aligned} CS &= (\text{Price intercept} - P_L) * Q_L * 0.5 \\ \Rightarrow CS &= (10,000 - 8,500) * 1,500 * 0.5 = \$1.125 \text{ million} \end{aligned}$$

Graphically, this is what we did:



This situation is referred to as double marginalization because both divisions in the value chain exercise monopoly power by restricting output. This creates two instances of deadweight loss, greatly reducing general welfare.

As the next step demonstrates, more wealth would have been created in the value chain by setting the transfer price at the price level where NMR and MC_S meet.

B) Cooperation Metropolis:

Now assume that company headquarters takes charge and forces the upstream and downstream divisions to accept a dictated transfer price. What transfer price should headquarters pick to maximize total firm profits? We maintain the assumption that there is no outside market for the steel sheets in question.

To maximize firm profits, the upstream producer should make sheet steel and sell it to the downstream entity until the marginal cost of producing another sheet equals net marginal revenue. This effectively sets upstream supply equal to downstream demand, eliminating deadweight loss in the transfer of steel:

$$\begin{aligned} MC_S &= NMR \\ \Rightarrow 2Q_S &= 9,000 - 2Q_S \\ \Rightarrow Q_S &= 2,250 \text{ sheets} \end{aligned}$$

The transfer price P_S will be set so that $P_S = MC_S = NMR$:

$$P_S = 2Q_S = 2 * 2,250 = \$4,500$$

Let's calculate the profit for each division. Upstream profit is equal to:

$$\begin{aligned} \Pi_S &= TR_S - TC_S \\ \Rightarrow \Pi_S &= P_S * Q_S - Q_S^2 \\ \Rightarrow \Pi_S &= 4,500 * 2,250 - (2,250)^2 = \$5.0625 \text{ million} \end{aligned}$$

With the new price of steel, the downstream total cost curve changes:

$$TC_L = (1,000 + 4,500) * Q_L = 5,500Q_L$$

This, plus the fact that $Q_L = Q_S = 2,250$, permits us to calculate the downstream profits:

$$\begin{aligned} \Pi_L &= TR_L - TC_L \\ \Rightarrow \Pi_L &= (10,000 - Q_L) * Q_L - 5,500Q_L \\ \Rightarrow \Pi_L &= (10,000 - 2,250) * 2,250 - 5,500 * 2,250 = 2,250 * 2,250 \\ \Rightarrow \Pi_L &= \$5.0625 \text{ million} \end{aligned}$$

Between the two companies, the profit will be \$10.125 million. The price of each locker will be:

$$P_L = 10,000 - 2,250 = \$7,750$$

Consumer surplus will be:

$$\begin{aligned} CS &= (\text{Price intercept} - P_L) * Q_L * 0.5 \\ \Rightarrow CS &= (10,000 - 7,750) * 2,250 * 0.5 = \$2.531 \text{ million} \end{aligned}$$

Notice that not only do the two firms collectively make more profit (\$10.125M vs. \$9M), but also consumer surplus is higher (\$2.531M vs. \$1.125M). This extra profit is not a transfer of wealth from consumers to producers, but rather the creation of wealth.

C) Competitive Outside Market:

We maintain the assumption that the steel and locker companies are divisions of the same company. Now, however, one can buy and sell steel sheet in an outside market for \$5,000. What is the optimal transfer price, and what would production levels be? What would the locker price be?

When there is a competitive market for the intermediate good, one sets the transfer price equal to the competitive market price. Thus, the upstream division will produce sheet steel until $P = MC$:

$$\begin{aligned} P_S &= MC_S \\ \Rightarrow 5,000 &= 2Q_S \\ \Rightarrow Q_S &= 2,500 \text{ sheets} \end{aligned}$$

Will the downstream locker division automatically consume all this sheet steel? Not necessarily; it will depend on the price. Since the transfer price P_S is equal to the competitive market price, we have:

$$\begin{aligned} P_S &= \$5,000 \\ \Rightarrow TC_L &= (1,000 + 5,000) * Q_L = 6,000 * Q_L \\ \Rightarrow MC_L &= 6,000 \end{aligned}$$

Given this constraint, the downstream division will produce until $MC_L = MR_L$:

$$\begin{aligned} MC_L &= MR_L \\ \Rightarrow 6,000 &= 10,000 - 2Q_L \\ \Rightarrow Q_L &= 2,000 \text{ lockers} \\ \Rightarrow P_L &= 10,000 - 2,000 = \$8,000 \text{ (reading from the locker demand curve)} \end{aligned}$$

Note that in this case the downstream division does not consume all the output of the upstream division. The upstream division will sell the extra steel to other companies.

The profits of each division will be:

$$\begin{aligned} \Pi_S &= TR_S - TC_S \\ \Rightarrow \Pi_S &= P_S * Q_S - Q_S^2 \\ \Rightarrow \Pi_S &= 5,000 * 2,500 - (2,500)^2 = \$6.25 \text{ million} \\ \\ \Pi_L &= TR_L - TC_L \\ \Rightarrow \Pi_L &= (10,000 - Q_L) * Q_L - 6,000Q_L \\ \Rightarrow \Pi_L &= (10,000 - 2,000) * 2,000 - 6,000 * 2,000 = 2,000 * 2,000 \\ \Rightarrow \Pi_L &= \$4.0 \text{ million} \end{aligned}$$

This gives the integrated company a total profit of \$10.25 million. Note this is more profit than in the case in which there is no outside market and we set $P_S = MC_S = NMR$.

D) Monopoly Power in Outside Market:

The two divisions are still together and cooperating. There is an external market for steel. Now, however, the steel market is not competitive, and the upstream division has market power (Oh, yeah!). It faces a demand curve of:

$$P_{S,External} = 12,000 - 2Q_{S,External}$$

What is the ideal transfer price, and how much steel would be consumed internally? How much steel would be sold externally, and at what price? What would firm profits be?

In this case, one adds the NMR and the external marginal revenue curve to come up with an overall marginal revenue curve. We produce until the marginal cost equals the net marginal revenue equals the external marginal revenue. To eliminate internal deadweight loss, we price internally such that $P_{S,Internal} = NMR$. To maximize external profits on the sheet steel, we price $P_{S,External}$ using the external demand curve.

We have our net marginal revenue curve for internal sales from earlier:

$$\text{NMR} = 9,000 - 2Q_{S,\text{Internal}}$$

To calculate the external marginal revenue, we do the usual doubling of slope because demand is linear:

$$\begin{aligned} D_{S,\text{External}}: P_{S,\text{External}} &= 12,000 - 2Q_{S,\text{External}} \\ \Rightarrow \text{MR}_{S,\text{External}} &= 12,000 - 4Q_{S,\text{External}} \end{aligned}$$

Knowing that the marginal revenues must be equal, we rewrite the equations to calculate $Q_{S,\text{Total}} = Q_{S,\text{Internal}} + Q_{S,\text{External}}$. Note that we will allocate production so that the marginal revenue from the two sources are equal:

$$\begin{aligned} Q_{S,\text{Internal}} &= 4,500 - (1/2)*\text{MR}_{S,\text{Overall}} \\ Q_{S,\text{External}} &= 3,000 - (1/4)*\text{MR}_{S,\text{Overall}} \\ \Rightarrow Q_{S,\text{Total}} &= Q_{S,\text{External}} + Q_{S,\text{Internal}} = 7,500 - (3/4)*\text{MR}_{S,\text{Overall}} \\ \Rightarrow \text{MR}_{S,\text{Overall}} &= 10,000 - (4/3)*Q_{S,\text{Total}} \end{aligned}$$

(Remember: the same technique was used when we looked at the two plant monopoly example in recitation 5)

Or, more simply:

$$\text{MR}_S = 10,000 - (4/3)*Q_S$$

(Technically, this only applies for $Q_S > 750$. For $0 \leq Q_S \leq 750$, the MRS curve is only the $\text{MR}_{S,\text{External}}$ curve, not the horizontal sum of the $\text{MR}_{S,\text{External}}$ and NMR curves.)

The upstream steel division will produce until $\text{MC}_S = \text{MR}_S$:

$$\begin{aligned} \text{MC}_S &= \text{MR}_S \\ \Rightarrow 2Q_S &= 10,000 - (4/3)*Q_S \\ \Rightarrow Q_S &= 3,000 \text{ sheets} \end{aligned}$$

In this case, the marginal revenue on the next sheet of steel is:

$$MR_S = MC_S = 2Q_S = \$6,000$$

This corresponds to the following quantity of steel consumed internally:

$$Q_{S,Internal} = 4,500 - (1/2)*MR_S = 4,500 - (1/2)*6,000 = 1,500 \text{ sheets}$$

Note that since the above expression was derived from the NMR curve, the quantity of 1,500 internal sheets corresponds to a transfer price of \$6,000. (The interested student can verify this by plugging 1,500 into the NMR equation and solving for $P_{S,Internal}$.)

The quantity of steel sold outside the firm can be calculated as follows:

$$Q_{S,External} = Q_{S,Total} - Q_{S,Internal} = 3,000 - 1,500 = 1,500 \text{ sheets}$$

The upstream division will price external steel sales using the external demand curve:

$$P_{S,External} = 12,000 - 2Q_{S,External} = 12,000 - 2*1,500 = \$9,000$$

Now we can plug & chug firm profits:

$$\begin{aligned} \Pi_T &= NR_L + TR_{S,External} - TC_{S,Total} \\ \Rightarrow \Pi_T &= (9,000*Q_L - Q_L^2) + (P_{S,External}*Q_{S,External}) - (Q_{S,Total}^2) \\ \Rightarrow \Pi_T &= 11.25\text{mm} + 13.5\text{mm} - 9.0\text{mm} \\ \Rightarrow \Pi_T &= \$15.75 \text{ million} \end{aligned}$$

The interested student can confirm that we would get the same result if we calculated the profits for each division separately and added them together. (Upstream revenues and downstream expenses for the transferred steel cancel out.)

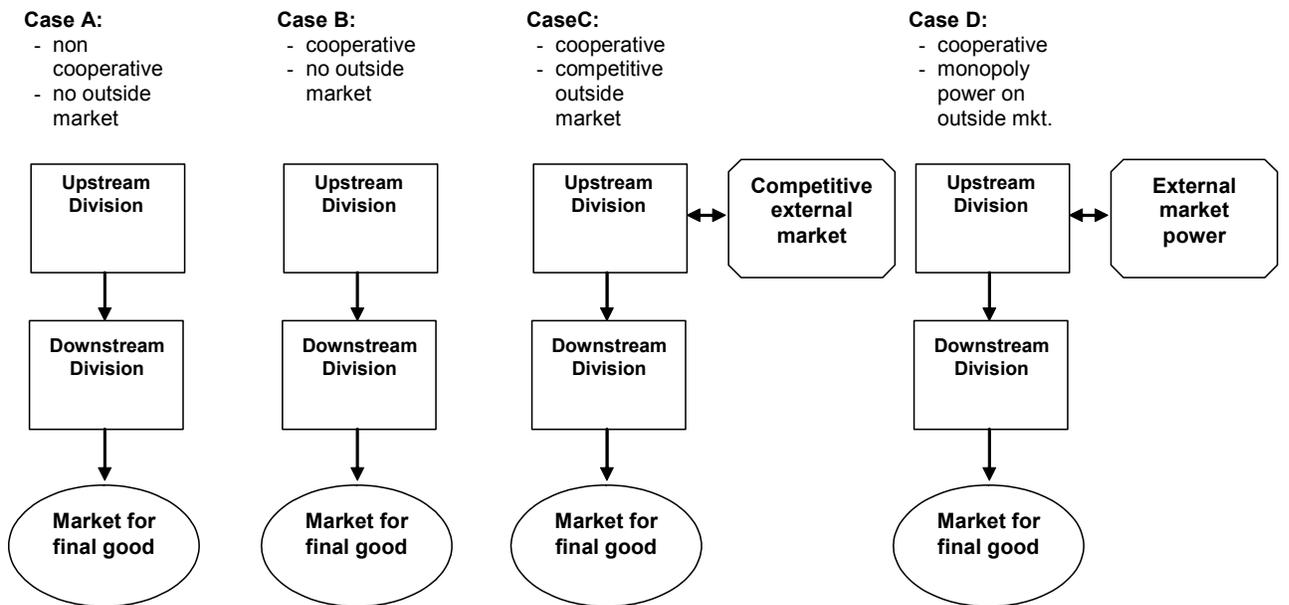
APPENDIX

The following table summarizes the scenarios in each of the above examples and offers a brief overview of the profit maximizing behaviors of both divisions.

NOTE: The first case is called Double Marginalization, as both divisions maximize their own profits, making margins in one case on the Downstream division and in the second case on the market. Hence, there is a double loss of surplus as market power is exercised twice (to the external and to the internal market).

Us = Upstream

Ds = Downstream



Maximization of Profits for:

- Upstream Div.:

MC = MR, where demand is given by NMR of Ds firm

- Downstream Div.:

MC = MR, where demand is given by market demand

- Upstream Div.:

MC = P, where P is set by the firm equal to MC and NMR_{Ds}

- Downstream Div.:

MC = MR, where demand is given by market demand

- Upstream Div.:

MC = P, where P is equal to the competitive market price for the Us firm's component. NOTE: the firm can buy from/sell to the outside market.

- Downstream Div.:

MC = MR, where demand is given by market demand.

- Upstream Div.:

MC = NMR_{Ds} = $MR_{outside}$; $P_{transfer} < P_{market}$

- Downstream Div.:

MC = MR, where demand is given by market demand