

were also interested in standardization, since that allowed them to diversify the risk associated with supplying idiosyncratic parts to a single assembler.

The Society of Automotive Engineers (SAE) carried out the standardization process, which yielded many cost advantages to the automotive industry. By the late 1920s, Ford and G.M. began to see the advantages of standardization, and joined the effort, at first focusing on the products of complementors (tires, petroleum products, and the like) but eventually playing a significant role in automobile parts standardization.

10 Systems effects

It is common in high-technology industries to see products that are useless unless they are combined into a system with other products: hardware is useless without software, DVD players are useless without content, and operating systems are useless without applications. These are all examples of *complements*, that is, goods whose value depends on their being used together.

Many of the examples we have discussed involve complementarities. Lock-in often occurs because users must invest in complementary products, such as training, to effectively use a good. Direct network effects are simply a symmetric form of complementarities: a fax machine is most useful if there are other fax machines. Indirect network effects or chicken-and-egg problems are also a form of systems effects. Standards involve a form of complementarity in that are often designed to allow for seamless interconnection of components (one manufacturer's DVDs will play on other manufacturer's machine.)

Systems of complements raise many important economic issues. Who will do the system integration: the manufacturer, the end user, or some intermediary, such as an OEM? How will the value be divided up among the suppliers of complementarity? How will bottlenecks be overcome, and how will the system evolve?

This is a vast topic, and I cannot do justice to the whole set of issues. I will limit my discussion to the most-studied issue: the pricing of complements, a topic first studied by Cournot (1838).

In one chapter of this work, Cournot analyzed the strategic interactions between producers of complementary products, considering a market with two companies: a monopoly zinc producer and a monopoly copper producer. These two supplied a large number of other companies that combined the

metals to produce brass. Cournot asked what would happen to the price of brass if the copper and zinc producers merged.

Let us assume that one unit of copper and one unit of zinc combine to create one unit of brass. Competition will push the price of brass down to its cost, which will simply be the sum of the two prices. Demand for brass can then be written as $D(p_1 + p_2)$. Given our assumptions about the technology, this is also the demand for copper and zinc.

The copper producer, say, wants to maximize the profit of producing copper:

$$\max_{p_1} p_1 D(p_1 + p_2).$$

Here we have assumed that the cost of copper production is zero for simplicity. The zinc producer has the analogous problem;

$$\max_{p_2} p_2 D(p_1 + p_2).$$

If the two complementary monopolists merged, they would solve the joint profit maximization problem

$$\max_{p_1, p_2} (p_1 + p_2) D(p_1 + p_2).$$

Cournot showed that the complementary monopolists would set prices that were higher than if they merged. The intuition is simple. If the copper producer cuts its price, brass producers will buy more zinc, thereby increasing the profits of the zinc producer. But the zinc producer's additional profits are irrelevant to the copper producer, making it reluctant to cut its price too much. The result is that the copper producer sets a price that is higher than the price that would maximize joint profits.

If, however, the copper and zinc producers merged, the merged entity would take into account that the price of copper affected the demand for zinc and set a lower price for both copper and zinc than independent producers would. Hence, a merger of complementors is a win all the way around: prices fall, making producers *and* consumers better off.

Of course a merger is only one way that prices might be coordinated; there are many other possibilities. Consider again the formula for a complementor's profit:

$$p_1 D(p_1 + p_2).$$

Cutting p_1 may or may not increase profit, depending on elasticity of demand. But cutting p_2 definitely increases revenue for firm 1 in all circumstances.

There are a variety of ways a firm might induce a complementor to cut its price.

Integrate. One complementor acquires the other, forming a merged entity which internalizes the externality. We have discussed the classic Cournot analysis above.

Collaborate. The firms set up a formula for revenue sharing, then one firm sets the price of the joint system. For example, an aircraft manufacturer and an engine manufacturer will agree on a revenue sharing arrangement, then the aircraft manufacturer will negotiate a price for the entire system with customers.

Negotiate. A firm may commit to cutting its price if the other firm also cuts its price. This apparently went on in the DVD industry, where both the content and players were introduced at relatively low prices, since the participants recognized that a low price for the entire system was critical to ensure its adoption.

Nurture. One firm works with others to reduce their costs. For example, Adobe works with printer manufacturers to ensure that they can effectively use its technology.

Commoditize. One firm attempts to stimulate competition in the other's market, thereby pushing down prices. Microsoft, for example, has established the Windows Compatibility Lab, to ensure that hardware manufacturers all produce to a common standard. This helps facilitate competition, pushing down the price of hardware.

All of these factors work towards reducing prices, thereby gaining some of the welfare benefits associated with competition. This is especially important since many of the other factors we discussed tend to lead towards high industry concentration ratios and monopoly power. When competitors are not present to discipline monopoly pricing, complementors may sometimes play a similar role.

11 Computer mediated transactions

More and more transactions are being mediated by computers. As we have seen, the data gathered can be mined for information about consumer be-