7 High-Technology Export Subsidies

We turn now from rare earth minerals, which are used in the production of high-tech products, to consider high-technology products themselves. The high-tech sector of an economy also receives substantial assistance from government, and an important example is the subsidies to the aircraft industries in both the United States and Europe. In the United States, subsidies take the form of low-interest loans provided by the Export-Import Bank to foreign firms or governments that want to purchase aircraft from Seattle-based Boeing. (The Export-Import Bank is a U.S. government agency that finances export-related projects.) In the European Union, government support for research and development and other subsidies are given to Airbus, which produces parts and assembles its finished products in a number of European countries. In Japan and South Korea, direct subsidies have been given to high-tech manufacturing firms that achieve certain targets for increasing their export sales. High-tech subsidies are given by many other countries, too.

Why do governments support their high-technology industries? In the case of agricultural products, subsidies are instituted primarily because of the political clout of those industries. Although politics plays a role in subsidies for high-tech industries, governments also subsidize these industries because they may create benefits that spill over to other firms in the economy. That is, governments believe that high-tech industry produces a positive **externality.** This argument for a subsidy is similar to the infant industry argument used to justify protective tariffs (see Chapter 9), except that the protection is applied to an export industry rather than an import-competing industry.

"Strategic" Use of High-Tech Export Subsidies

In addition to the spillover argument for export subsidies, governments and industries also argue that export subsidies might give a **strategic advantage** to export firms that are competing with a small number of rivals in international markets. By a strategic advantage, we mean that the subsidized industry can compete more effectively with its rivals on the world market. Think of the aircraft industry, which currently has just two producers of large, wide-bodied airplanes: Boeing in the United States and Airbus in Europe. Each of these firms receives some type of subsidy from its government. If high-tech subsidies allow firms to compete more effectively and earn more profits in international markets, and if the extra profits are more than the amount of the subsidy, then the exporting country will obtain an overall benefit from the export subsidy, similar to the benefit that comes from a large country applying a tariff.

To examine whether countries can use their subsidies strategically, we use the assumption of **imperfect competition.** We already used this assumption in Chapter 9, in which we considered the cases of Home monopoly and Foreign monopoly. Now we allow for two firms in the market, which is called a **duopoly.** In that case, each firm can set the price and quantity of its output (and hence maximize its profits) based on the price and quantity decisions of the other firm. When a government uses subsidies to affect this interaction between firms and to increase the profits of its own domestic firm, the government is said to be acting strategically. In this section, we examine the effects of strategic export subsidies to determine whether profits of the exporting firm will rise enough to offset the cost of the subsidy to the government.

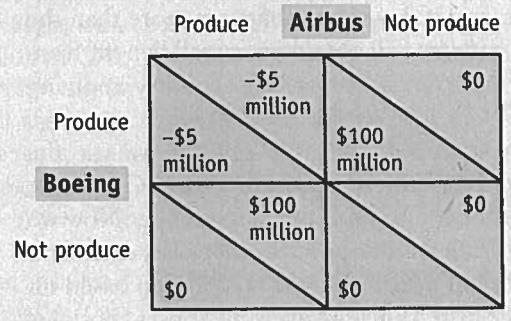
Because we now assume that certain high-tech industries operate in imperfectly competitive markets, we need to use a different set of tools to model their supply decisions than we have used thus far in this chapter. To capture the strategic decision making of two firms, we use **game theory,** the modeling of strategic interactions (games) between firms as they choose actions that will maximize their returns. The main goal in this section is to model the strategic interaction of high-tech firms in Home and Foreign, and then to see the impact of export subsidies on their respective decisions and payoffs.

To examine the effect of an export subsidy, we start with the free-trade situation, before any subsidies are in place. Suppose there are two firms that are competing for sales of a new type of aircraft. For example, one of the newest aircraft that Airbus sells is the double-decker A380, which Boeing has no plans to copy. One of the newest aircraft that Boeing sells is the smaller 787 Dreamliner, and Airbus has developed a similar model called the A350 (discussed later in the chapter). For convenience, we focus on the decision of each firm to produce a relatively new aircraft that competes with the other firm for sales to the rest of the world. By ignoring sales to firms in their own countries, we will not have to keep track of consumer surplus in the United States or Europe. Instead, the measure of welfare for these countries will depend only on the profits earned by Boeing or Airbus from their sales to the rest of the world.

Payoff Matrix In Figure 10-9, we show a **payoff matrix** for Boeing and Airbus, each of which has to decide whether to produce the new aircraft. Each quadrant of the matrix shows the profits earned by Boeing in the lower-left corner and the profits of Airbus in the upper-right corner. When both firms produce (upper-left quadrant), their prices are reduced through competition, and they both end up making negative profits (i.e., losses) of $5 million.[7]

If Airbus produces the new aircraft and Boeing does not (lower-left quadrant), then Boeing earns nothing, whereas Airbus, the only supplier, earns high profits of $100 million. Conversely, if Boeing produces and Airbus does not (upper-right quadrant), Airbus earns nothing, and Boeing, now the only supplier, earns high profits of $100 million. Finally, if both firms choose to not produce (lower-right quadrant), then they both earn profits of 0.

FIGURE 10-9



Payoff Matrix Between Two Firms The lower-left number in each quadrant shows the profits of Boeing, and the upper-right number shows the profits of Airbus. Each firm must decide whether to produce a new type of aircraft. A Nash equilibrium occurs when each firm is making its best decision, given the action of the other. For this pattern of payoffs, there are two Nash equilibria, in the upper-right and lower-left quadrants, where one firm produces and the other does not.

[7] The numbers we are using in the payoff matrix are made up for convenience, but they illustrate the idea of competition between the firms for the sale of a new aircraft.

Nash Equilibrium With the pattern of payoffs shown in Figure 10-9, we want to determine what the outcome of this game between the two firms will be. At first glance, this seems like a difficult problem. It is hard for each firm to decide what to do without knowing whether the other firm is going to produce. To solve this problem, we use the concept of the Nash equilibrium, named after John Nash, a winner of the Nobel Prize in economics.[8]

The idea of a **Nash equilibrium** is that each firm must make its own best decision, taking as given each possible action of the rival firm. When each firm is acting that way, the outcome of the game is a Nash equilibrium. That is, the action of each player is the best possible response to the action of the other player.

Best Strategy for Boeing To determine the Nash equilibrium, we proceed by checking each quadrant of the payoff matrix. Let us look at Boeing's possible strategies, starting with the case in which its rival, Airbus, chooses to produce. If Boeing knows that Airbus will produce, then Boeing needs to decide whether to produce. If Boeing produces, then it earns −$5 million (in the upper-left quadrant); if Boeing does not produce, then it earns 0 (in the lower-left quadrant). Therefore, if Airbus produces, then Boeing is better off *not* producing. This finding proves that having both firms produce is not a Nash equilibrium. Boeing would never stay in production, since it prefers to drop out of the market whenever Airbus produces.

Best Strategy for Airbus Let's continue with the case in which Boeing does not produce but Airbus does (lower-left quadrant of Figure 10-9). Is this the best strategy for Airbus? To check this, suppose that Airbus chooses instead to not produce. That would move us from the lower-left quadrant to the lower-right quadrant in Figure 10-9, meaning that Airbus's profits fall from $100 million to 0. This outcome is worse for Airbus, so it would not change its decision: it would still choose to produce. We conclude that the decision illustrated in the lower-left quadrant, with Airbus producing and Boeing not producing, is a Nash equilibrium because each firm is making its best decision given what the other is doing. When Airbus produces, then Boeing's best response is to not produce, and when Boeing does not produce, then Airbus's best response is to produce. There is no reason for either firm to change its behavior from the Nash equilibrium.

Multiple Equilibria Is it possible to find more than one Nash equilibrium? To check for this, we need to check the other quadrants in Figure 10-9. Let us try the case in the upper-right quadrant, where Boeing produces but Airbus does not. Consider Airbus making the decision to produce or not, given that Boeing produces, or Boeing making the decision to produce or not, given that Airbus does not produce. Using the same logic we have already gone through, you can confirm that neither firm would want to change the decision it has made as seen in the upper-right quadrant: if either firm changed its choice, its profits would fall. If Boeing decides not to produce, then its profits fall to 0 (from the upper-right to the lower-right quadrant), whereas if Airbus decides to produce, its profits fall to −$5 million (from the upper-right to the upper-left quadrant). So we conclude that the upper-right quadrant, with Boeing producing and Airbus not producing, is *also* a Nash equilibrium. When Boeing produces, then Airbus's best response is to

[8] The book and movie *A Beautiful Mind* describes the career of John Nash.

not produce, and when Airbus does not produce, then Boeing's best response is to produce. Finally, by applying the same logic to the other quadrants, we can confirm that there are no more Nash equilibria.

When there are two Nash equilibria, there must be some force from outside the model that determines in which equilibrium we are. An example of one such force is the **first mover advantage,** which means that one firm is able to decide whether to produce before the other firm. If Boeing had this advantage, it would choose to produce, and Airbus, as the second mover, would not produce, so we would be in the upper-right quadrant. Let us suppose that is the Nash equilibrium from which we start. Because Airbus is not producing, it is making zero profits. In this situation, the government in Europe might want to try to change the Nash equilibrium so that Airbus would instead earn positive profits. That is, by providing subsidies to Airbus, we want to determine whether the payoffs in the matrix change such that the Nash equilibrium also changes.

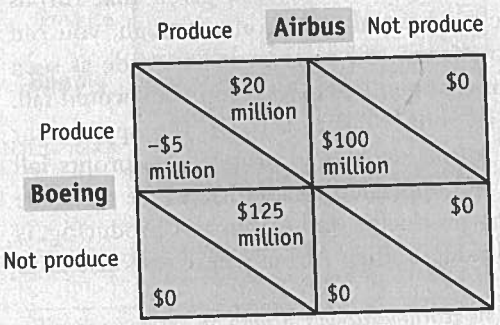
The type of subsidy we consider in our model is a cash payment to Airbus. In practice, however, subsidies are of many kinds: Boeing has benefited from U.S. military contracts, where the research and development (R&D) done for those contracts has been used in its civilian aircraft, too. Airbus, on the other hand, has benefited from direct R&D subsidies to defray the "launch costs" of getting a new aircraft off the ground. Both companies have benefited from low-cost loans provided by their governments to purchasers of aircraft. Later in the chapter, we examine in more detail actual export subsidies that are used in the aircraft industry.

Effect of a Subsidy to Airbus

Suppose the European governments provide a subsidy of $25 million to Airbus. With this subsidy in place, Airbus's profits will increase by $25 million when it produces. In Figure 10-10, we add that amount to the payoffs for Airbus and check to see whether the Nash equilibria have changed. Recall that the free-trade Nash equilibria occur when one firm produces and the other does not.

Best Strategy for Airbus Let us start with the free-trade Nash equilibrium in which Boeing produces but Airbus does not (upper-right quadrant) and see whether

FIGURE 10-10



Payoff Matrix with Foreign Subsidy When the European governments provide a subsidy of $25 million to Airbus, its profits increase by that much when it produces a new aircraft. Now there is only one Nash equilibrium, in the lower-left quadrant, with Airbus producing but Boeing not producing. The profits for Airbus have increased from 0 to $125 million, while the subsidy cost only $25 million, so there is a net gain of $100 million in European welfare.

it changes when Airbus receives a government subsidy. After the subsidy, that option is no longer a Nash equilibrium: if Boeing is producing, then Airbus is now better off by *also* producing because then it receives a $25 million subsidy from the government. With the subsidy, it will now earn $20 million ($5 million in negative profits plus the $25 million subsidy) even when Boeing produces. Recall that in the original situation, if Boeing produced, then Airbus would not choose to produce because otherwise it would lose $5 million. With the subsidy, Airbus now earns $20 million by producing instead of losing $5 million.

Best Strategy for Boeing Is this new position a Nash equilibrium? To answer that, we need to see whether Boeing would still be making the right decision given that Airbus is producing. When Airbus produces, Boeing loses $5 million when it produces (upper-left quadrant) but loses nothing when it does not produce (lower-left quadrant). Therefore, Boeing will want to drop out of the market. Once Boeing makes the decision not to produce, Airbus's decision doesn't change. It still chooses to produce, but its payoff increases dramatically from $20 million to $125 million, and we move to the lower-left quadrant, with Airbus producing and Boeing not.

Nash Equilibrium You can readily check that the lower-left quadrant is a unique Nash equilibrium: each firm is making its best decision, given the action of the other. Furthermore, it is the *only* Nash equilibrium. The effect of the European governments' subsidy has been to shift the equilibrium from having Boeing as the only producer (where we started, in the upper-right quadrant) to having Airbus as the only producer (in the lower-left quadrant).

European Welfare The European subsidy has had a big impact on the equilibrium of the game being played between the two firms. But can we necessarily conclude that Europe is better off? To evaluate that, we need to add up the welfare of the various parties involved, much as we did earlier in the chapter.

The calculation of European welfare is simplified, however, because of our assumption that production is for export to the rest of the world. From Europe's point of view, we do not need to worry about the effect of the subsidy on consumer surplus in its own market. The only two items left to evaluate, then, are the profits for Airbus from its sales to the rest of the world and the cost of the subsidy to the European government.

Airbus's profits have increased from 0 (when it was not producing but Boeing was) to $125 million (now that Airbus is producing but Boeing is not). The revenue cost of the subsidy to Europe is $25 million. Therefore, the net effect of the subsidy on European welfare is

Rise in producer surplus:	+125
Fall in government revenue:	−25
Net effect on European welfare:	**+100**

In this case, the subsidy led to a net gain in European welfare because the increase in profits for Airbus is more than the cost of the subsidy.[9]

[9] Notice that if the initial equilibrium was one in which Airbus produced and Boeing did not, then the only effect of the subsidy would be to make this equilibrium unique; it would not change the decision of either firm. Moreover, the effect on total European welfare would be zero because the subsidy would be just a transfer from the European government to Airbus.

Subsidy with Cost Advantage for Boeing

Our finding that the subsidy can raise European welfare depends, however, on the numbers we assumed so far. Let us now consider another case in which Boeing has a cost advantage over Airbus. In this case, we assume that the cost advantage is the result not of U.S. subsidies but of U.S. comparative advantage in aircraft production.

When Boeing has a cost advantage in aircraft production, the payoff matrix is as shown in Figure 10-11. Boeing earns profits of $5 million when both firms produce and profits of $125 million when Airbus does not produce. There is now only one Nash equilibrium, and it is in the upper-right quadrant in which Boeing produces and Airbus does not. The alternative free-trade Nash equilibrium in Figure 10-9 (in which Airbus produces and Boeing does not) is no longer a Nash equilibrium because, with the cost advantage we are now assuming Boeing has, even if Airbus chooses to produce, it is better for Boeing to produce and earn profits of $5 million than not produce and earn 0 profits.

Now suppose, once again, that the European governments provide a $25 million subsidy to Airbus. We add that amount to the payoffs of Airbus when it produces (still assuming that Boeing has a cost advantage over Airbus), as shown in Figure 10-12.

FIGURE 10-11

		Airbus: Produce	Airbus: Not produce
Boeing	Produce	−$5 million, $5 million	$0, $125 million
	Not produce	$100 million, $0	$0, $0

Another Payoff Matrix, with Boeing Cost Advantage If Boeing has a cost advantage in the production of aircraft, the payoffs are as shown here. Boeing earns profits of $5 million when both firms are producing, and profits of $125 million when Airbus does not produce. Now there is only one Nash equilibrium, in the upper-right quadrant, where Boeing produces and Airbus does not.

FIGURE 10-12

		Airbus: Produce	Airbus: Not produce
Boeing	Produce	$20 million, $5 million	$0, $125 million
	Not produce	$125 million, $0	$0, $0

Another Payoff Matrix with Foreign Subsidy When the European governments provide a subsidy of $25 million to Airbus, its profits increase by that much when it produces. Now the only Nash equilibrium is in the upper-left quadrant, where both firms produce. The profits for Airbus have increased from 0 to $20 million, but the subsidy costs $25 million, so there is a net loss of $5 million in European welfare.

Best Strategy for Airbus Let's see how the subsidy has affected the previous Nash equilibrium in which Boeing produces and Airbus does not (upper-right quadrant). Given that Boeing produces, the decision to not produce is no longer the best one for Airbus: with the subsidy now in place and Boeing producing, Airbus's best decision is to produce and to earn profits of $20 million (upper-left quadrant) rather than 0.

Best Strategy for Boeing Is this new position a Nash equilibrium? Once again, we need to check to see whether, given Airbus's new postsubsidy decision to produce, Boeing is still making the right decision. Given that Airbus produces, then Boeing earns profits of $5 million when it produces and 0 when it does not. Therefore, Boeing will stay in the market, and we have proved that having both firms produce is a Nash equilibrium.

European Welfare Once Again When Boeing has a cost advantage, the European subsidy allows Airbus to enter the market, but it *has not* resulted in the exit of Boeing as it did in the earlier no-cost-advantage scenario. Let us evaluate the effect on European welfare under these circumstances.

Airbus's profits have increased from 0 (when it was not producing, but Boeing was) to 20 (now that both firms are producing). The revenue cost of the subsidy to Europe is still 25. Therefore, the net effect of the subsidy on European welfare is

Rise in producer profits:	+20
Fall in government revenue:	−25
Net effect on European welfare:	**−5**

When Boeing has a cost advantage, then, the subsidy leads to a *net loss* in European welfare because the increase in profits for Airbus is less than the cost of the subsidy.

Summary The lessons that we should draw from these various examples is that under conditions of imperfect competition, a subsidy by one government to its exporting firm might increase welfare for its nation, but it might not. Although profits for the exporting firm certainly rise, there is an increase in welfare only if profits rise by more than the cost of the subsidy. This condition is more likely to be satisfied if the subsidy leads to the *exit* of the other firm from the market. In that case, the profits earned by the single firm could very well exceed the cost of the subsidy. When both firms remain in the market after the subsidy, however, it is unlikely that the increase in profits for the subsidized firm will exceed the subsidy cost. In the following application, we are especially interested in whether subsidies in the aircraft industry have kept one firm out of a market segment in which another produces.

APPLICATION
Subsidies to Commercial Aircraft

In the large passenger aircraft industry, there have been just three competitors: Boeing and McDonnell-Douglas in the United States and Airbus in Europe. The former two companies merged on August 1, 1997, so the industry effectively became a duopoly. The United States and Europe have used various types of subsidies to support their respective firms. First, there are indirect subsidies that arise because in the production of civilian and military aircraft, the research and development (R&D) for the military versions effectively subsidize R&D for the civilian aircraft.