varies to some extent when the tariff begins and ends, it varies much less than does the percentage imported from China itself. In other words, other Asian countries made up for the reduction in China exports by increasing their own exports; similarly, Mexico (included within the top area in the graph) also increased its exports to the United States during the time the tariff was applied.

This increase in sales from other Asian countries and Mexico is consistent with Figure 8-6, which shows that sales from other exporters increase from X_1^* to X_2^* due to the tariff on China. The evidence also indicates that these other exporters were able to charge higher prices for the tires they sold to the United States. For car tires, the average price charged by countries other than China increased from \$54 to \$64 during the times of the tariff, while for light truck tires, the average prices increased from \$76 to \$90. Both these increases are higher than we would expect from inflation during 2009–12. As shown in Figure 8-6, these price increases for other exporters occur because they are competing with Chinese exporters who must pay the tariff.

An estimate of the area *e*—which is the total increase in the amount paid to tire exporters other than China—is \$716 million per year for imports of car tires and another \$101 million per year for imports of light truck tires, totaling \$817 million per year.[12] This is in addition to the deadweight loss $b + d$. This area e for the tire tariff substantially exceeds the deadweight loss of for the steel tariff of \$185 million per year that we calculated above. So we see that a discriminatory tariff, applied against just one exporting country, can be more costly than an equal tariff applied against all exporters.

At the beginning of the chapter we included a quote from President Obama in his State of the Union address in 2012, in which he said that "over a thousand Americans are working today because we stopped a surge in Chinese tires." Although 1,000 jobs in the tire industry is roughly the estimate of how many jobs were saved, we have shown that these jobs came at a very high cost because the tariff was discriminatory.[13] In a later chapter we will discuss another example like this that shows that opening up free trade with just one country can have a surprising negative effect on welfare as compared with opening up free trade with all countries.

4 Import Tariffs for a Large Country

Under the small-country assumption that we have used so far, we know for sure that the deadweight loss is positive; that is, the importing country is always harmed by the tariff. The small-country assumption means that the world price P^W is unchanged by the tariff applied by the importing country. If we consider a large enough importing country or a **large country**, however, then we might expect that its tariff will change the world price. In that case, the welfare for a large importing country can be improved by a tariff, as we now show.

[12] See Gary Clyde Hufbauer and Sean Lowry, 2012, "U.S. Tire Tariffs: Saving Few Jobs at High Cost," Peterson Institute for International Economics, Policy Brief no. PB12-9.

[13] According to Gary Clyde Hufbauer and Sean Lowry, 2012, cited in the previous footnote, there were 1,200 jobs saved in the tire industry. But taking the area e cost of \$817 million and dividing it by 1,200 jobs gives an annual cost per job of \$681,000, which is many times more than the annual earnings of a tire worker. So the discriminatory tariff was an expensive way to save these jobs.

Foreign Export Supply

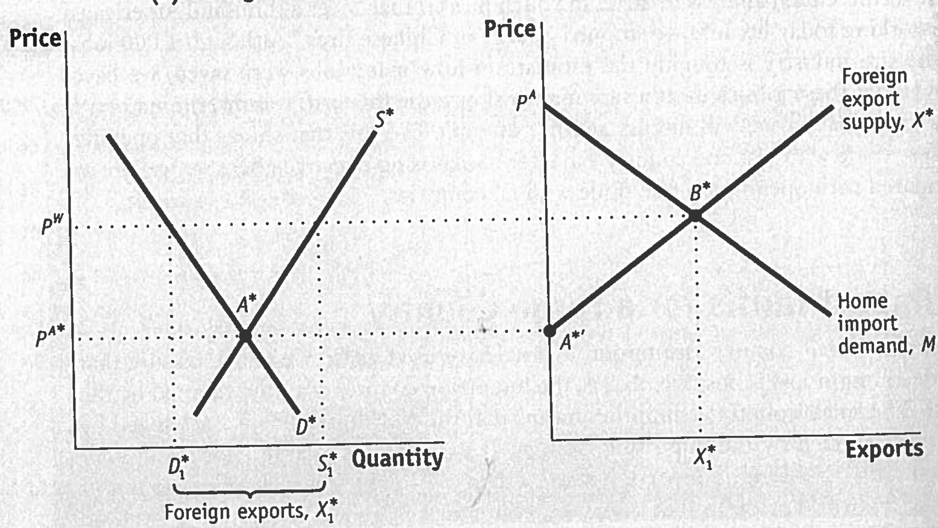
If the Home country is large, then we can no longer assume that it faces a Foreign export supply curve X^* that is horizontal at the given world price P^W. Instead, we need to derive the Foreign export supply curve using the Foreign market demand and supply curves. In panel (a) of Figure 8-8, we show the demand curve D^* and supply curve S^* for Foreign. These intersect at the point A^*, with a no-trade equilibrium price of P^{A^*}. Because Foreign demand equals supply at that price, Foreign exports are zero, which we show by point $A^{*\prime}$ in panel (b), where we graph Foreign exports against their price.

Now suppose the world price P^W is above the Foreign no-trade price of P^{A^*}. At the price of P^W, the Foreign quantity demanded is lower, at D_1^* in panel (a), but the quantity supplied by Foreign firms is larger, at S_1^*. Because Foreign supply exceeds demand, Foreign will export the amount $X_1^* = S_1^* - D_1^*$ at the price of P^W, as shown by the point B^* in panel (b). Drawing a line through points $A^{*\prime}$ and B^*, we obtain the upward-sloping Foreign export supply curve X^*.

We can then combine the Foreign export supply curve X^* and Home import demand curve M, which is also shown in panel (b). They intersect at the price P^W, the world equilibrium price. Notice that the Home import demand curve starts at the no-trade price P^A on the price axis, whereas the Foreign export supply curve starts at the

FIGURE 8-8

(a) Foreign Market **(b) World Market**



Foreign Export Supply In panel (a), with Foreign demand of D^* and Foreign supply of S^*, the no-trade equilibrium in Foreign is at point A^*, with the price of P^{A^*}. At this price, the Foreign market is in equilibrium and Foreign exports are zero—point A^* in panel (a) and point $A^{*\prime}$ in panel (b), respectively. When the world price P^W is higher than the Foreign no-trade price, the quantity supplied by Foreign, S_1^*, exceeds the quantity demanded by Foreign, D_1^*, and Foreign exports $X_1^* = S_1^* - D_1^*$. In panel (b), joining up points $A^{*\prime}$ and B^*, we obtain the upward-sloping export supply curve X^*. With the Home import demand of M, the world equilibrium is at point B^*, with the price P^W.

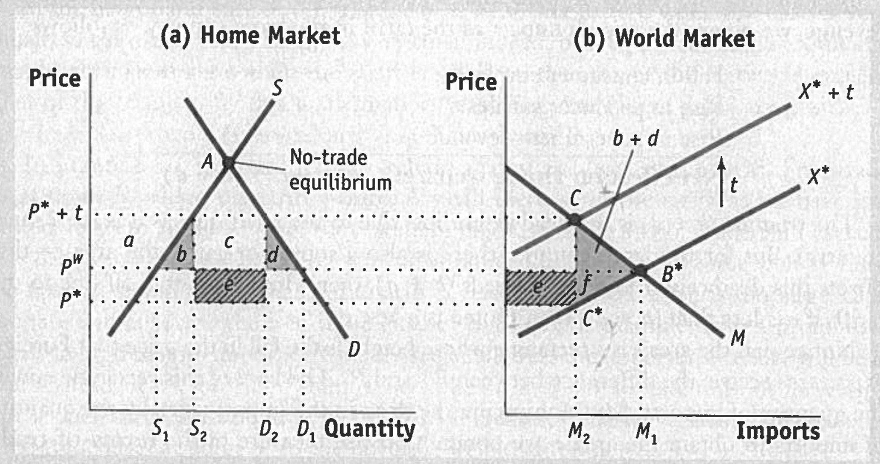
price P^{A^*}. As we have drawn them, the Foreign no-trade price is lower, $P^{A^*} < P^A$. In Chapter 2 through Chapter 5 of this book, a country with comparative advantage in a good would have a lower no-trade relative price and would become an exporter when trade was opened. Likewise, in panel (b), Foreign exports the good since its no-trade price P^{A^*} is lower than the world price, and Home imports the good since its no-trade price P^A is higher than the world price. So the world equilibrium illustrated in panel (b) is similar to that in some of the trade models presented in earlier chapters.

Effect of the Tariff

In panel (b) of Figure 8-9, we repeat the Home import demand curve M and Foreign export supply curve X^*, with the world equilibrium at B^*. When Home applies a tariff of t dollars, the cost to Foreign producers of supplying the Home market is t more than it was before. Because of this increase in costs, Foreign export supply curve shifts up by exactly the amount of the tariff, as shown in panel (b) with the shift from X^* to $X^* + t$. The $X^* + t$ curve intersects import demand M at point C, which establishes the Home price (including the tariff) paid by consumers. On the other hand, the Foreign exporters receive the net-of-tariff price, which is directly below the point C by exactly the amount t, at point C^*. Let us call the price received by Foreign exporters P^*, at point C^*, which is the new world price.

The important feature of the new equilibrium is that the price Home pays for its imports, $P^* + t$, rises by *less than* the amount of the tariff t as compared with the initial world price P^W. The reason that the Home price rises by less than the full amount of the tariff is that the price received by Foreign exporters, P^*, has fallen as compared with the initial world price P^W. So Foreign producers are essentially "absorbing"

FIGURE 8-9



Tariff for a Large Country The tariff shifts up the export supply curve from X^* to $X^* + t$. As a result, the Home price increases from P^W to $P^* + t$, and the Foreign price falls from P^W to P^*. The deadweight loss in Home is the area of the triangle $(b + d)$, and Home also has a terms-of-trade gain of area e. Foreign loses the area $(e + f)$, so the net loss in world welfare is the triangle $(b + d + f)$.

a part of the tariff, by lowering their price from P^W (in the initial free-trade equilibrium) to P^* (after the tariff).

In sum, we can interpret the tariff as driving a wedge between what Home consumers pay and what Foreign producers receive, with the difference (of t) going to the Home government. As is the case with many taxes, the amount of the tariff (t) is shared by both consumers and producers.

Terms of Trade In Chapter 2, we defined the **terms of trade** for a country as the ratio of export prices to import prices. Generally, an improvement in the terms of trade indicates a gain for a country because it is either receiving more for its exports or paying less for its imports. To measure the Home terms of trade, we want to use the net-of-tariff import price P^* (received by Foreign firms) since that is the total amount transferred from Home to Foreign for each import. Because this price has fallen (from its initial world price of P^W), it follows that the Home terms of trade have increased. We might expect, therefore, that the Home country gains from the tariff in terms of Home welfare. To determine whether that is the case, we need to analyze the impact on the welfare of Home consumers, producers, and government revenue, which we do in Figure 8-9.

Home's Welfare In panel (a), the Home consumer price increases from P^W to $P^* + t$, which makes consumers worse off. The drop in consumer surplus is represented by the area between these two prices and to the left of the demand curve D, which is shown by $(a + b + c + d)$. At the same time, the price received by Home firms rises from P^W to $P^* + t$, making Home firms better off. The increase in producer surplus equals the area between these two prices, and to the left of the supply curve S, which is the amount a. Finally, we also need to keep track of the changes in government revenue. Revenue collected from the tariff equals the amount of the tariff (t) times the new amount of imports, which is $M_2 = D_2 - S_2$. Therefore, government revenue equals the area $(c + e)$ in panel (a).

By summing the change in consumer surplus, producer surplus, and government revenue, we obtain the overall impact of the tariff in the large country, as follows:

Fall in consumer surplus:	$-(a + b + c + d)$
Rise in producer surplus:	$+a$
Rise in government revenue:	$+(c + e)$
Net effect on Home welfare:	$\boldsymbol{+e - (b + d)}$

The triangle $(b + d)$ is the deadweight loss due to the tariff (just as it is for a small country). But for the large country, there is also a source of gain—the area e—that offsets this deadweight loss. If e exceeds $(b + d)$, then Home is better off due to the tariff; if e is less than $(b + d)$, then Home is worse off.

Notice that the area e is a rectangle whose height is the fall in the price that Foreign exporters receive, the difference between P^W and P^*. The base of this rectangle equals the quantity of imports, M_2. Multiplying the drop in the import price by the quantity of imports to obtain the area e, we obtain a precise measure of the **terms-of-trade gain** for the importer. If this terms-of-trade gain exceeds the deadweight loss of the tariff, which is $(b + d)$, then Home gains from the tariff.

Thus, we see that a large importer might gain by the application of a tariff. We can add this to our list of reasons why countries use tariffs, in addition to their being a source of government revenue or a tool for political purposes. However, for the large country, any net gain from the tariff comes at the expense of the Foreign exporters, as we show next.

Foreign and World Welfare Although Home might gain from the tariff, Foreign, the exporting country, definitely loses. In panel (b) of Figure 8-9, the Foreign loss is measured by the area $(e + f)$. We should think of $(e + f)$ as the loss in Foreign producer surplus from selling fewer goods to Home at a lower price. Notice that the area e is the terms-of-trade gain for Home but an equivalent terms-of-trade *loss* for Foreign; Home's gain comes at the expense of Foreign. In addition, the large-country tariff incurs an extra deadweight loss of f in Foreign, so the combined total outweighs the benefits to Home. For this reason, we sometimes call a tariff imposed by a large country a "beggar thy neighbor" tariff.

Adding together the change in Home's welfare and Foreign welfare, the area e cancels out and we are left with a *net loss* in world welfare of $(b + d + f)$, the triangle in panel (b). This area is a deadweight loss for the world. The terms-of-trade gain that Home has extracted from the Foreign country by using a tariff comes at the expense of the Foreign exporters, and in addition, there is an added world deadweight loss. The fact that the large-country tariff leads to a world deadweight loss is another reason that most economists oppose the use of tariffs.

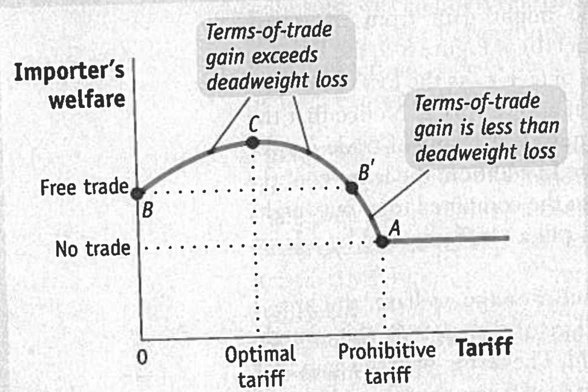
Optimal Tariff for a Large Importing Country We have found that a large importer might gain by the application of tariffs, but have yet to determine what *level* of tariff a country should apply in order to maximize welfare. It turns out there is a shortcut method we can use to evaluate the effect of the tariff on the welfare of a large importing country. The shortcut method uses the concept of the **optimal tariff.**

The optimal tariff is defined as the tariff that leads to the maximum increase in welfare for the importing country. For a large importing country, a small tariff initially increases welfare because the terms-of-trade gain exceeds the deadweight loss. That is, the area of the rectangle e in panel (a) of Figure 8-9 exceeds the area of the triangle $(b + d)$ in panel (b) when the tariff is small enough. The reason for this is that both the height and base of the triangle $(b + d)$ shrink to zero when the tariff is very small, so the area of the triangle is very small indeed; but for the rectangle e, only the height shrinks to zero when the tariff is small, so the area of the rectangle exceeds that of the triangle. By this mathematical reasoning, the Home gains are positive—$e > (b + d)$—when the Home tariff is sufficiently small.

In Figure 8-10, we graph Home welfare against the level of the tariff. Free trade is at point B, where the tariff is zero. A small increase in the tariff, as we have just noted, leads to an *increase* in Home welfare (because the terms-of-trade gain exceeds the deadweight loss). Therefore, starting at point B, the graph of Home welfare must be upward-sloping. But what if the tariff is very large? If the tariff is too large, then welfare will fall *below* the free-trade level of welfare. For example, with a prohibitive tariff so high that no imports are purchased at all, then the importer's welfare will be at the no-trade level, shown by point A. So while the graph of welfare must be increasing for a small tariff from point B, as the tariff increases, welfare eventually falls past the free-trade level at point B' to the no-trade welfare at point A.

Given that points B and A are both on the graph of the importer's welfare (for free trade and no trade, respectively) and that welfare must be rising after point B, it follows that there must be a highest point of welfare, shown by point C. At this point, the importer's welfare is highest because the difference between the terms-of-trade gain and deadweight loss is maximized. We will call the tariff at that point

FIGURE 8-10



Tariffs and Welfare for a Large Country For a large importing country, a tariff initially increases the importer's welfare because the terms-of-trade gain exceeds the deadweight loss. So the importer's welfare rises from point *B*. Welfare continues to rise until the tariff is at its optimal level (point *C*). After that, welfare falls. If the tariff is too large (greater than at *B*′), then welfare will fall below the free-trade level. For a prohibitive tariff, with no imports at all, the importer's welfare will be at the no-trade level, at point *A*.

the "optimal tariff." For increases in the tariff beyond its optimal level (i.e., between points *C* and *A*), the importer's welfare falls because the deadweight loss due to the tariff overwhelms the terms-of-trade gain. But whenever the tariff is below its optimal level, between points *B* and *C*, then welfare is higher than its free-trade level because the terms-of-trade gain exceeds the deadweight loss.

Optimal Tariff Formula It turns out that there is a simple formula for the optimal tariff. The formula depends on the elasticity of Foreign export supply, which we call E_X^*. Recall that the elasticity of any supply curve is the percentage increase in supply caused by a percentage increase in price. Likewise, the elasticity of the Foreign export supply curve is the percentage change in the quantity exported in response to a percent change in the world price of the export. If the export supply curve is very steep, then there is little response of the quantity supplied, and so the elasticity E_X^* is low. Conversely, if the export supply curve is very flat, there is a large response of the quantity supplied due to a change in the world price, and so E_X^* is high. Recall also that a small importing country faces a perfectly horizontal, or perfectly elastic, Foreign export supply curve, which means that the elasticity of Foreign's export supply is infinite.

Using the elasticity of Foreign export supply, the optimal tariff equals

$$\text{optimal tariff} = \frac{1}{E_X^*}$$

That is, the optimal tariff (measured as a percentage) equals the inverse of the elasticity of Foreign export supply. For a small importing country, the elasticity of Foreign export supply is infinite, and so the optimal tariff is zero. That result makes sense, since any tariff higher than zero leads to a deadweight loss for the importer (and no terms-of-trade gain), so the best tariff to choose is zero, or free trade.

For a large importing country however, the Foreign export supply is less than infinite, and we can use this formula to compute the optimal tariff. As the elasticity of Foreign export supply decreases (which means that the Foreign export supply curve is steeper), the optimal tariff is higher. The reason for this result is that with a steep Foreign export supply curve, Foreign exporters will lower their price more in response to the tariff.[14] For instance, if E_X^* decreases from 3 to 2, then the optimal tariff increases from $\frac{1}{3} = 33\%$ to $\frac{1}{2} = 50\%$, reflecting the fact that Foreign producers are willing to lower their prices more, taking on a larger share of the tariff burden. In that case, the Home country obtains a larger terms-of-trade increase and hence the optimal level of the tariff is higher.

APPLICATION

U.S. Tariffs on Steel Once Again

Let us return to the U.S. tariff on steel, and reevaluate the effect on U.S. welfare in the large-country case. The calculation of the deadweight loss that we did earlier in the application assumed that the United States was a small country, facing fixed world prices for steel. In that case, the 30% tariff on steel was fully reflected in U.S. prices, which rose by 30%. But what if the import prices for steel in the United States did not rise by the full amount of the tariff? If the United States is a large enough importer of steel, then Foreign export price will fall and the U.S. import price will rise by less than the tariff. It is then possible that the United States gained from the tariff.

To determine whether the United States gained from the tariff on steel products, we can compute the deadweight loss (area $b + d$) and the terms-of-trade gain (area e) for each imported steel product using the optimum tariff formula.

Optimal Tariffs for Steel Let us apply this formula to the U.S. steel tariffs to see how the tariffs applied compare with the theoretical optimal tariff. In Table 8-2, we show various steel products along with their respective elasticities of export supply to the United States. By taking the inverse of each export supply elasticity, we obtain the optimal tariff. For example, alloy steel flat-rolled products (the first item) have a low export supply elasticity, 0.27, so they have a very high optimal tariff of $1/0.27 = 3.7 = 370\%$. In contrast, iron and nonalloy steel flat-rolled products (the last item)

TABLE 8-2

Optimal Tariffs for Steel Products This table shows optimal tariffs for steel products, calculated with the elasticity formula.

Product Category	Elasticity of Export Supply	Optimal Tariff (%)	Actual Tariff (%)
Alloy steel flat-rolled products	0.27	370	30
Iron and steel rails and railway track	0.80	125	0
Iron and steel bars, rods, angles, shapes	0.80	125	15–30
Ferrous waste and scrap	17	6	0
Iron and steel tubes, pipes, and fittings	90	1	13–15
Iron and nonalloy steel flat-rolled products	750	0	0

Data from: Elasticities of export supply provided by Christian Broda and David Weinstein, May 2006, "Globalization and the Gains from Variety," Quarterly Journal of Economics, 121(2), 541–585.

[14] See Problem 4 at the end of the chapter, where you will show that steeper export supply leads Foreign to absorb more of the tariff.