PPFs and International Trade – by Jeff Traczynski, 5/22/08

Opportunity Cost
Opportunity Cost: the production or consumption forgone when we make decisions to produce or consume something else.

Whenever economists talk about the “cost” of something, they are always referring to the notion of opportunity cost. The idea here is that the cost of something is what you give up to get it. When I choose to buy a DVD for $10, I am giving up $10 worth of consumption of other goods – for example, a $7 CD and three $1 apples. Similarly, when a producer chooses to use some wood to build a table, he is giving up the opportunity to use that wood to make a door or some chairs. This is why we so often hear the term “next best alternative” when discussing opportunity cost. When I choose the buy the DVD, what I’ve really given up was the next best alternative use for that $10.

To see this idea in action, let’s consider a simple trip to the movies. What are the opportunity costs of going out to a movie theater? I can think of three major ones:
1) Cost of the ticket 
2) Cost of transportation (car, bus, walking time) 
3) Cost of time spent watching the movie

You’re probably familiar with the first two, as these are situations where money actually comes out of your wallet, and it’s easy to think of buying your ticket or paying for gas as costs. But the third is just as important – you spent your evening doing something, and you don’t get that evening back. Let’s say that your next best alternative use of your time is to work at your part time job which pays $8/hour, and that the movie time plus the transportation time is a total of 2 hours. If tickets are $8 each and the bus fare to and from the theater is $3, then we can find the opportunity cost of going to the movies as:
1) Cost of ticket - $8 
2) Cost of transportation - $3 
3) Cost of time - $16 
Total Opportunity Cost - $27

Why do we care about opportunity cost? As mentioned above, opportunity cost is a core economic concept, and shows up every time economists discuss costs. Below, we’ll see one of these applications and get a sense of the importance of opportunity cost.

Production Possibility Frontiers
PPF: the path of points showing the maximum amount of two goods that can be produced with a given level of resources, technology, and time.

Consider a country which produces only two goods: wheat (W) and cars (C). This country has a fixed amount of resources (land, labor, and capital) which it can use to produce its two goods, and certain given technologies which dictate how the resources can be combined to produce the goods. We can use a PPF to represent the possible
maximum amounts of wheat and cars which this country can produce in a given year, as illustrated below:

Every point on the diagram represents a bundle of wheat and cars, though only the points on or inside the PPF are feasible selections for this country to produce. Furthermore, only the points on the PPF are efficient – if the country has chosen to produce at a point inside the PPF, then either some of the resources or the best available technology is not being used. When we think about what bundle an economy chooses to produce, we will generally assume that they choose a point on the PPF, since all other points are either impossible to produce or do not make full use of all the available resources.

There are three basic properties of PPFs:
1) All PPFs are downward sloping. This means that in order to produce more of one good, the country must produce less of the other.
2) PPFs may be either bowed out from the origin (like the one in the above figure) or linear, but they can never be bowed in towards the origin.
3) The slope of the PPF represents the opportunity cost between the two goods on the axes. Specifically, the absolute value of the slope is the opportunity cost of producing one unit of the good on the x-axis in terms of units of the good on the y-axis, and the reciprocal of the absolute value of the slope is the opportunity cost of producing one unit of the good on the y-axis in terms of units of the good on the x-axis.

To better understand properties 2 and 3, consider the picture below:
In the left graph, the country has a constant opportunity cost between wheat and cars. This means that for each unit of wheat the country wishes to produce, it must reduce its production of cars by a constant amount. For example, for every bushel of wheat produced, the economy must give up producing half of a car – or, equivalently, for every car produced, the economy must give up producing 2 bushels of wheat. If the opportunity cost is constant, then it doesn’t matter how many cars the economy is currently producing – every additional car the economy wishes to produce still requires it to forgo the production of 2 bushels of wheat. If the economy has an increasing opportunity cost between wheat and cars, then we have a bowed out PPF like the one pictured in the right graph. In this case, the number of cars which must be given up to produce an additional bushel of wheat increases as the economy produces more bushels of wheat. For example, if the opportunity cost of producing a car is 2 bushels of wheat when the economy is producing 50 cars, then the opportunity cost of producing a car might rise to 3 bushels of wheat once the economy is producing 100 cars. This increasing opportunity cost is sometimes called the Principle of Increasing Cost.

Principle of Increasing Cost: as the production of a good increases, the opportunity cost of producing another unit of that good also increases.

Why do economies follow the Principle of Increasing Cost? The simplest explanation is the specialization of resources. Not all resources in a society are equally well-suited to making both wheat and cars. For example, some land is very fertile, making it good for growing wheat, while land in inner-city Detroit would be best used for building car factories. Now imagine a country which devotes all its resources to growing wheat. Every piece of land in the country would be used as farmland, even the inner-city Detroit land. If the country decides to produce a few cars, it must take some resources away from wheat production. Which land will this economy choose to take away from wheat growing so that they can build car factories? Well, if they choose to build on the fertile land, they will have to give up lots of wheat production, but if they choose to build on the inner-city land, they only sacrifice a small amount of wheat. Clearly, the second option makes the best use of the available resources, so our economy will choose to use the land best suited to car production when first starting to make cars. If the country decides to make more and more cars, it must keep taking away resources from wheat production to do so. But eventually, this process will require that even the most fertile land has to be converted over to car factories, and wheat production will fall drastically once the fertile land is no longer being used to grow wheat. Thus, as the economy produces more cars,
the opportunity cost of making more cars in terms of wheat production forgone rises because the resources being used to make the additional cars are increasingly well-suited to producing wheat.

**Gains From Trade**
Economists use PPFs as one way to show how trade can benefit two countries by allowing both to consume more goods than they would be able to without trade. To discuss this, we’ll need to define two related concepts:

Absolute Advantage: a country has an absolute advantage in the production of a good if it can produce more of the good than another country.

Comparative Advantage: a country has a comparative advantage in the production of a good if it has a lower opportunity cost of producing the good than another country.

The key insight here is that while one country can have an absolute advantage in the production of both goods, no country can have a comparative advantage in both goods. This is best seen with an extended example.

Ex: Two countries, the US and Japan, produce both wheat and cars. Their PPFs are given by the two points in the following table.

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>0</td>
<td>200</td>
</tr>
<tr>
<td>Japan</td>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td>US</td>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>Japan</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

This chart shows that the US can produce either 0 bushels of wheat and 200 cars, or 400 bushels of wheat and 0 cars, and has an analogous meaning for Japan. The countries can produce at either of the points given above or at any point on the line connecting those points, so both countries have linear PPFs. We graph these PPFs below.

We can see that the US has the absolute advantage in the production of both wheat and cars, since it can make more of both goods. In order to find out who has the comparative advantage in the production of each good, we must find the opportunity costs in each country. We know that the absolute value of the slope is the opportunity cost of producing the good on the x-axis, and the reciprocal of the absolute value of the slope is the opportunity cost of producing the good on the y-axis. This yields the chart below.

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC of 1 car is 2 wheat</td>
<td>OC of 1 car is 2/3 wheat</td>
<td></td>
</tr>
<tr>
<td>OC of 1 wheat is 1/2 car</td>
<td>OC of 1 wheat is 3/2 cars</td>
<td></td>
</tr>
</tbody>
</table>
From this chart, we can see that the opportunity cost of producing cars (in terms of wheat production forgone) is lower in Japan than in the US, and the opportunity cost of producing wheat (in terms of car production forgone) is lower in the US than in Japan. Thus, the US has the comparative advantage in producing wheat, and Japan has the comparative advantage in producing cars.

If both countries devote half of their resources to producing each good and that there is no trade between the US and Japan. Then the US will produce 200 bushels of wheat and 100 cars, and Japan will produce 50 bushels of wheat and 75 cars. Now imagine instead that the US produces 3 fewer cars and Japan produces 3 more cars, and they agree to trade 1 bushel of wheat for 1 car. The new production levels are in the table below.

<table>
<thead>
<tr>
<th></th>
<th>US Production</th>
<th>US Consumption</th>
<th>Japan Production</th>
<th>Japan Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Trade</td>
<td>200</td>
<td>200</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Wheat Cars</td>
<td>100</td>
<td>100</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>With Trade</td>
<td>206</td>
<td>203</td>
<td>48</td>
<td>51</td>
</tr>
<tr>
<td>Wheat Cars</td>
<td>97</td>
<td>100</td>
<td>78</td>
<td>75</td>
</tr>
</tbody>
</table>

Here, we see that both countries are better off after trading. They consume the same number of cars as before, but both now have more wheat. This additional wheat is the gain from trade for both countries. The key lesson here is that in order for both countries to benefit from trade, they must specialize according to their comparative advantage. In this case, the US produced more wheat, which is the good in which the US has a comparative advantage. Similarly, Japan produced more cars, the good in which Japan has a comparative advantage. This specialization allowed both countries to enjoy more consumption than they could in the world without trade – note that the points (100,203) and (75, 51) are outside the PPFs of the US and Japan, respectively.

The last thing we want to consider is the terms at which the countries agree to trade with one another. Specifically, what will be the price of wheat (in terms of cars) when they trade? In order to figure this out, we need to remember that a country won’t trade unless trading makes it better off – that is, it can consume at least as much after trading as it could without trading at all. We know that in this case, because the US has the comparative advantage in wheat production, that Japan will be buying wheat when the countries trade. So how many cars is Japan willing to give up for a bushel of wheat? Well, we know that the most cars Japan would be willing to give up is 3/2. This is because their opportunity cost of making a bushel of wheat is 3/2 cars, so they can always get a bushel of wheat at this price simply by shifting their own production. Similarly, what’s the least number of cars the US would be willing to accept in exchange for a bushel of wheat? Again, we know that that fewest cars the US would accept is 1/2. The US opportunity cost of making a bushel of wheat is 1/2 of a car, so they could always get 1/2 a car for a bushel of wheat simply by shifting their own production. Putting these two facts together, we know that the price of a bushel of wheat has to be somewhere between 1/2 and 3/2 cars. However, this is the best we can do at pinning down the price – we only know that it must be somewhere in this range, but we cannot figure out exactly what it will be. The actual price which the countries will settle on depends on things which are difficult to quantify, such as the relative bargaining abilities of each side. For example, if
the US has a very good negotiator and Japan has a very poor one, then they will settle on a price of wheat close to 3/2, as higher prices are good for the US. So while we can figure out the range of prices in which trade can occur, we cannot determine the exact price at which the two countries will trade.

International Trade
An alternative way to think about the effects of international trade is to consider markets for individual goods and services. We want to compare a closed economy (one in which trading with the rest of the world is forbidden) with an open economy (one in which individuals may trade with the rest of the world as much as they want). When looking at the effects of opening up the economy on both consumers and producers, we use consumer and producer surplus as our measuring stick. To make things simpler, we also assume that opening up the economy to trade has no effect on the world price of any product. This means that the world price is fixed, and both consumers and producers in our domestic market take the world price as given.

We illustrate the closed economy in the picture below. Since all trade with other countries is prohibited, this country has only its domestic demand and domestic supply of goods in this market, so equilibrium is currently at the point \((P^*, Q^*)\). With this equilibrium, we know that consumer and producer surplus are given by the appropriate shaded areas below. The closed economy represents our baseline case. When we open the economy, we will see how the amounts of consumer and producer surplus compare to their closed economy levels. \(WP1\) and \(WP2\) represent two possible world prices. The important thing here is that the world price is not the same as the domestic equilibrium price, so opening up the economy will benefit either producers or consumers. \(WP1\) and \(WP2\) illustrate the two cases we’re interested in – whether the world price is higher or lower than \(P^*\).
If the world price is at WP1, then any domestic supplier who enters the market at a price higher than WP1 will not produce anything, since domestic consumers will be able to buy as much as they want at price WP1. This scenario is pictured below.

Since the world price is fixed at WP1, this means that total domestic supply of this product is $Q_{SD}$, while the total amount demanded by domestic consumers is $Q_{DD}$. This means that the amount of imports by domestic consumers in this market is $(Q_{DD} - Q_{SD})$. 
If instead the world price is at WP2, we have the situation shown above. Now, domestic producers know that they can always sell their product for WP2, since there are a large number of foreign consumers willing to buy at this price. Since all producers are unwilling to sell below price WP2, domestic consumers demand only $Q_{DD}$ units, while domestic suppliers produce $Q_{SD}$. This means that the total amount of domestic exports in this market is $(Q_{SD} - Q_{DD})$.

When the world price is WP1, we see that a low world price benefits domestic consumers, since they now have access to low cost imports, and harms domestic producers, who must now compete with foreign suppliers who can provide the product at a price lower than the domestic equilibrium. This means that CS rises greatly when the economy opens to trade, while PS falls. When compared to the closed economy, the rise in CS is larger than the fall in PS, so society as a whole is better off when the economy is open. When the world price is WP2, the high world price benefits domestic suppliers while harming domestic consumers. But again, when compared to the closed economy, the rise in PS is larger than the fall in CS, so society as a whole is still better off when the economy is open. Thus, no matter whether the world price is higher or lower than the domestic equilibrium, society is better off with an open economy than a closed one.

Of course, while economy as a whole benefits from trade, there are still winners and losers. In our analysis above, we have assumed that when the government opens the economy, it allows free trade – producers and consumers may buy and sell with no government regulations or taxes. However, when the world price is WP1, consumers get large gains while producers lose out. In this situation, domestic firms will often lobby the government for some sort of protection from foreign suppliers in an effort to recapture some of their lost producer surplus. There are two policies which the government might use to reduce imports and increase domestic producer surplus: tariffs and quotas.

Tariffs

Tariff: an excise tax imposed on imports.

A tariff is simply a type of tax. However, it only applies to foreign goods, so we do not analyze it in exactly the same way. Here, it is useful to think of the world price line as an international supply curve, representing the large number of foreign suppliers who are all willing to sell at price WP1. We know that a tax placed on suppliers should simply shift the supply curve up by the amount of the tax. Since a tariff is a tax only on the foreign suppliers, it should only shift the foreign supply curve up by the amount of the tariff.

The figure below illustrates the effects of the tariff on an open economy with world price WP1. Imposing a tariff of $T per unit imported raises the world price line to WP1 + T. At this new price, domestic consumers demand $Q_{DDT}$, and domestic suppliers produce $Q_{SDT}$ units, so imports are now $(Q_{DDT} - Q_{SDT})$, which is less than $(Q_{SD} - Q_{DD})$. We see that imposing the tariff does raise producer surplus compared to the situation under free trade, which was the original goal of the policy. Just like other taxes, a tariff generates both tariff revenue and deadweight loss. The revenue raised by the tariff is the rectangle with width equal to the total amount of imports and height equal to the amount of the
tariff, so $\text{Tariff Revenue} = T \times (Q_{DDT} - Q_{SDT})$. So while a tariff does succeed in helping domestic producers by raising producer surplus, the deadweight loss generated by the tariff means that society as a whole is not as well off as it would be under free trade.

Quotas
Quota: a legal maximum on imports.

Under a quota, the government allows individuals to import the good freely until the quota is reached, and then no further importing is possible. Here, it is again useful to think about the world price line as an international supply curve. In order to analyze the effects of a quota on the market for a good, we're going to construct a new supply curve based on the prices at which suppliers are willing to enter the market and provide their product to consumers. Since there's a portion of the domestic supply curve below the world price, these domestic suppliers are the first people to be included in our new supply curve, since they are willing to supply output at the lowest prices. We then travel up the domestic supply curve until we hit the world price, $WP_1$, and this is the first section of our new supply curve. At $WP_1$, there are a large number of foreign suppliers who are all willing to sell at this price, so we get our supply from these foreign producers at this price. We can keep getting our supply from abroad until we run up against the quota imposed by the government, at which point we must stop importing. This flat section at $WP_1$ is the second part of our new supply curve. So, if the domestic market is still not in equilibrium after getting supply from the very cheap domestic producers and using the entire quota of imports, who can provide the rest of the supply? Well, there are still many domestic producers who are not yet in the market, as they require a price above $WP_1$ to be willing to supply their product. The remainder of our supply curve comes from these domestic firms, so the third part of our new supply curve is exactly parallel to the original domestic supply curve, but shifted over to the right by the amount of the.
quota to reflect the fact that we’ve already imported that amount. The below picture illustrates this new supply curve, $S_Q$, in pink.

On $S_Q$, you can clearly see the three sections of the curve as described above – the first section is the same as the original domestic supply curve, the second runs along the world price line (international supply curve), and the third is parallel to the domestic supply curve, but shifted right by the amount of the quota.

There are several other features of this graph worth pointing out. First, note that the amount of the quota, and therefore the total amount of imports in this market, is the distance ($Q_1 - Q_{SD}$) which we travel along the world price line when finding $S_Q$. Second, now that we have this new supply curve, equilibrium in this market is in the usual place: at the intersection of supply ($S_Q$) and demand ($D$). Thus, equilibrium is $(P_Q, Q_Q)$, where the subscript $Q$ represents that fact that this is the equilibrium under the quota. Third, when defining producer surplus, we must be careful to include only the quantities made by domestic producers. Since imports are $(Q_1 - Q_{SD})$, we know that domestic producers make everything up to $Q_{SD}$, and everything between $Q_1$ and $Q_Q$. So producer surplus only exists over those two ranges, leading to the two separate areas of producer surplus in the graph above. Fourth, we still have deadweight loss from a quota, just like with a tariff. This is because the economy is not at the free trade equilibrium $(WP1, Q_{DD})$, and we can see that there is less total surplus than there would be under free trade.

Lastly, how does a quota raise revenue, and why does it raise the amount in the orange box? The easiest way to think about this is to imagine that when the government sets the quota, it also prints up quota licenses. A quota license is just a piece of paper which entitles the holder of the license to import one unit of the good at the world price, so the quota is enforced by requiring someone who wants to import a unit of the good to hand over their quota license when they do. Once they’ve printed up the licenses, the
government can sell them at an auction to raise revenue. So how much will an individual be willing to pay to get a quota license? Well, if someone has a quota license, then he can import a unit of this good and pay only WP1 for it, then turn around and sell it on the domestic market for P_Q. Thus, the most someone would be willing to pay for a quota license is P_Q – WP1, and since the government is selling the licenses at an auction, this will be the price for every license. So the government will sell (Q_1 – Q_{SD}) licenses for $(P_Q – WP1)$ each, raising Quota Revenue = $(P_Q – WP1) x (Q_1 – Q_{SD})$. This is exactly the area pictured on the above graph.

One major weakness of the above graph is the fact that the producer surplus area is divided up, making some of the quantities that economists are interested in difficult to calculate from the graph. Also, our discussion has suggested that there should be some similarity between the effects of a tariff and the effects of a quota, yet the graphs for each of these policies looks very different. To help make the math and the links between these policies more clear, we can rearrange the areas on the quota graph to look as below:

Here, all we’ve done is move the producer surplus triangle and part of the DWL to the left, while sliding the quota revenue box to the right. This switch has the added benefit of making it a little easier to think about the amounts produced domestically and the amounts imported, as we now have Q_{SDQ} as the total amount produced domestically under the quota, and imports are Q_{DDQ} – Q_{SDQ}, the difference between the quantities demanded domestically and supplied domestically under the quota. Since this is the same quota as before, we know that Q_{DDQ} – Q_{SDQ} must be equal to Q_1 – Q_{SD}.

A final word about tariffs and quotas: perhaps the most important relationship between the two policies is that they are interchangeable. That is, instead of imposing a tariff, a government can impose a quota which will create the same levels of CS, PS, DWL, and revenue as the tariff. Figuring out how to do this is actually simpler than it sounds.
Imagine that the government has in mind a tariff of amount $T$, as pictured in the tariff section. We already know that the total imports under this tariff are \( Q_{\text{DDT}} - Q_{\text{SDT}} \). In order to implement a quota with the same effects as this tariff, the government just needs to set the quota at \( Q_{\text{DDT}} - Q_{\text{SDT}} \). With the same amount of imports coming into the country, the effects on consumers and producers will be exactly the same under either policy, and the government will raise an equivalent amount of money in revenue. This relationship between tariffs and quotas is a popular source of exam questions, but it really does just come down to keeping the level of imports the same under the two policies.

In the real world, there may be some reasons why a country would impose a quota instead of a tariff, but these reasons are often political. Perhaps more interesting is the different long run effects on an industry which can result from using a quota instead of a tariff. In the 1980’s, the growth of Japanese automobile imports into the US created a wave of lobbying for protectionism from the US auto industry. However, the US government did not feel as though putting a tariff on Japanese automobile would be politically prudent, especially given the Japanese government’s threats of retaliation against other US products. Instead, the US and Japanese governments negotiated “voluntary import restrictions”, whereby Japan would agree to limit the number of cars it would export to the US. Obviously, this policy has the same basic effects as a quota. Japanese automakers realized that since they could only send a given number of cars to the US every year, they should send the type of cars which offer the highest profit margins – luxury cars, such as Lexus and Acura models. At the time, there were very few luxury cars made in Japan, but the imposition of the “voluntary import restrictions” spurred Japanese companies to spend time developing and improving these models. In the long run, this led to Japanese manufacturers developing a very high quality luxury car, designed to compete with American brands like Cadillac or European makes such as Mercedes or BMW. In this case, the quota had an effect on the development of the Japanese automotive industry which a tariff would not have had, since a tariff simply charges some fixed fee for every car imported. While a tariff would have provided some incentive for Japanese firms to improve their luxury cars, it would not have been as powerful as the effect of the quota. Thus, while a tariff and a quota may have the same effect on a market today, the long run implications of these two policies can be quite different.