# *Chapter* 1

# Comparative advantage: The theory behind measurement

*by*
Alan V. Deardorff[1]

*Three approaches that have been used empirically, each represented in this volume, are reviewed in this chapter to provide information about the patterns and causes of comparative advantage. Revealed comparative advantage, factor content of trade and the gravity model of trade each provide useful information, even if none of them is capable of fully delineating either the nature of comparative advantage or its causes. They can illuminate comparisons across countries that may be suggestive of directions for further research.*

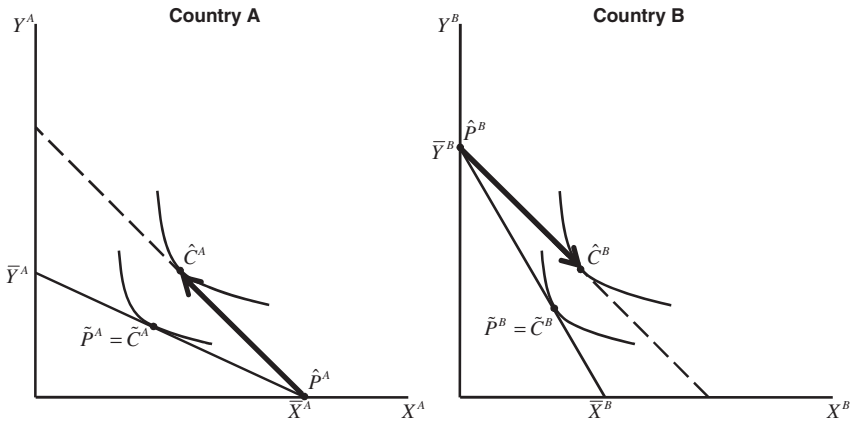
From the earliest days of economic science, economists have sought to explain why countries engage in international trade as well as what they trade – that is, which goods (and, more recently, services) they export and which they import. Fundamental to that understanding has been the concept introduced by Ricardo (1815) of comparative advantage. Ricardo recognized that, while differences in countries' abilities to produce goods – productivity – lie at the heart of international trade, it is not absolute differences but relative differences that matter. That is, a country will not necessarily be unable to export a good just because some other country is able to produce it more efficiently, using less labour, say, per unit of output. If in spite of its low productivity in that particular good the country has even lower productivity in all others, then its wage will be low enough to offset its productivity disadvantage. It will export the good successfully (assuming costs of trade, such as transportation, are low enough that there is any trade at all).

This insight lies at the heart of much of the international trade theory that has appeared in the two centuries since Ricardo wrote. Other explanations of trade do exist (economies of scale, product differentiation, etc.) and undoubtedly help to explain the rich variety of international trade that exists in the world. But most advances in international trade theory have built upon, rather than dispensing with, the concept of comparative advantage. Most notably, the Heckscher-Ohlin theory of international trade due to Heckscher (1919), Ohlin (1933), and Samuelson (1948) elaborates the causes of comparative advantage in terms of factor endowments and factor intensities, thus giving a better understanding than Ricardo was able to provide of why countries have comparative advantage in the sectors that they do. Other researchers have gone on to identify, both theoretically and empirically, many other contributors to comparative advantage, going well beyond factor proportions.

## The Ricardian trade model

Closely associated with Ricardo's insight, and indeed intimately connected with its validity, is the proposition that countries gain from trade. Both are illustrated most starkly in the standard diagrammatic depiction of the Ricardian trade model shown in Figure 1.1. Here two countries, A and B, are each able to produce two goods, X and Y, using a single factor of production, labour. Because each country has a fixed endowment of labour and a fixed (but different) quantity of labour required per unit of output, their production possibilities are represented by the straight lines $\overline{X}^I\overline{Y}^I, I = A,B$. The line for country A is drawn flatter than the line for country B, indicating that the relative cost of good X is smaller in country A than in country B, and thus that country A has a comparative advantage in good X. That this need not reflect absolute advantage can be seen from the fact that the countries' labour endowments do not appear in the figure. Country A may have a much larger amount of available labour than country B, and thus require more of it per unit of either good than country B, an absolute disadvantage in production of both goods. We cannot know that from the figure, and it does not matter, neither for the direction of trade nor for the gains from trade.[2]

**Figure 1.1. Ricardian comparative advantage and gains from trade**




In autarky, each country must consume only what it produces. Using indifference curves to represent preferences for the goods, the countries produce and consume at the points labelled $\tilde{P}^I = \tilde{C}^I, I = A,B$. Their autarky relative prices are only implicit in the figure, given by the relative marginal costs of the goods and thus by the slope of the production possibility curve at the point of production. This slope, in absolute value, gives the relative price of good X, which is therefore lower in country A than in country B.

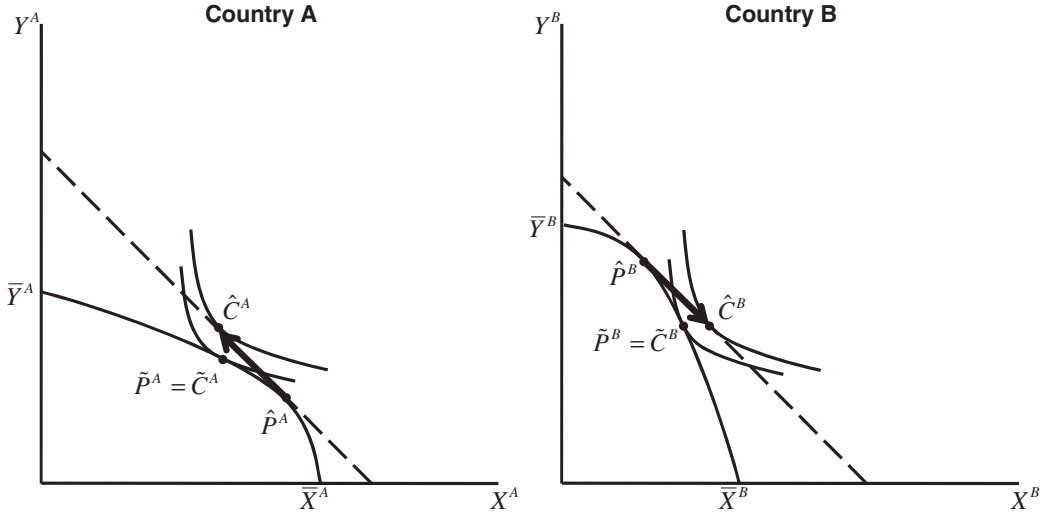
If the countries are now given the opportunity to trade freely, they will necessarily face the same prices, and producers in each country will reallocate resources toward the sector with a higher relative price. Since a common price must lie between the two autarky prices (else both would produce only the same good), free trade leads country A to specialize in good X and country B to specialize in good Y at $\hat{P}^I, I = A,B$, each producing only the good in which it has a comparative advantage. Each country then trades part of its output for the other good and reaches the consumption points $\hat{C}^I, I = A,B$. To be in equilibrium the two vectors of trade from production to consumption, shown in the figure by the heavy arrows, must have the same length. The free trade relative price—which is the common slope of these arrows—is determined by this need to clear markets.

This is the basic Ricardian result. Note that it seems to imply that each country also gains from trade. In fact, however, the causation is the reverse. That is, in order to gain from trade, the countries' trade must conform to comparative advantage, which is therefore a necessary but not a sufficient condition for gains from trade. This will appear more clearly later when we leave the simple Ricardian model and also consider policies that may distort trade.

## A variable-cost trade model

Although Ricardo's insight about comparative advantage is very general, the specific model that we now call the Ricardian Model is very special, with its constant labour productivities. A more general model is shown in Figure 1.2, where the production possibility frontiers (PPFs) are labelled as before but are now curved, bowed outward. This curvature could reflect several causes, including diminishing returns in a specific-factors model, but it is most often taken to represent the interaction of factor endowments and factor intensities in a multi-factor Heckscher-Ohlin model. Thus with, say, two factors capital and labour, country A may have a relative abundance of capital and therefore production possibilities that favour the capital intensive good, X. However, as it shifts more and more of both factors into the X sector, it must rely increasingly on labour, which is less productive in producing X, and the relative cost of X rises.

**Figure 1.2. Comparative advantage and gains from trade with variable costs**




The variable-cost model continues to provide the implication that each country will export the good in which it has a comparative advantage, so long as that advantage is measured from relative costs (and therefore prices) in autarky. However, the model has two implications that are quite different from the simple Ricardian model. One is that the countries are much less likely to specialize in producing a single good (the Ricardian model required at least one of them to do so under free trade). The second implication is that the relative cost differences that define comparative advantage, and are the source of trade, disappear once one reaches equilibrium with free trade. That is, the two countries in the trading equilibrium in Figure 1.2 are both operating at points on their PPFs where the slope is equal to the common world relative price. Thus comparative advantage cannot be observed, in a free trade equilibrium, from relative marginal costs.

It is the gains from trade that imply that trade conforms to comparative advantage, rather than the other way around. Thus the gains from trade are at the heart of various efforts to demonstrate the more general validity of the "Law" of comparative advantage. I and others[3] have shown in much more general models than the one here that trade will conform to comparative advantage in an average sense across industries and countries,

without any restriction on the numbers of factors, goods, and countries, and with almost unlimited natural and policy barriers to trade. The main restriction is that policies must not play too large a role in subsidizing a trade pattern that contradicts comparative advantage.

Note that this more general model is consistent with any of a great many theories of the cause of comparative advantage. The Heckscher-Ohlin model would attribute comparative advantage only to differences across countries in relative factor endowments, although this is open to many interpretations as to exactly what those factors are – labour, capital, human capital (or labour of various skills), land, various natural resources, etc. The Ricardian explanation of trade seemed to attribute it to differences in technology. These too are consistent with the variable cost model, and indeed have found considerable empirical support alongside the factor proportions explanation. But in addition to these two major stories about the sources of comparative advantage, recent work has introduced other sources, such as differences in institutions of various sorts, differences in climate, differences in culture, and so forth (see also Chapter 6). Thus the concept of comparative advantage has continued to be central to international trade theory, even though it has been elaborated and explained in a great many ways.

## Measuring comparative advantage

Given this theoretical underpinning, one might have hoped that the measurement of comparative advantage would be straightforward. In fact it is not, and for reasons that are readily understood from the theory. The best definition of comparative advantage is in terms of autarky relative costs, and of course these are almost always impossible to observe, since countries have long been engaged in trade.[4] Observable relative costs in the presence of trade either have been equalized as a result of trade, as in Figure 1.2, or they differ as a result of trade costs in ways that primarily indicate those costs. Therefore direct observation of relative costs has seldom been successful as a measure of comparative advantage.[5]

Several other approaches have therefore been used, none of which get exactly at comparative advantage, but each of which is nonetheless informative in various useful ways. The approaches taken in the subsequent chapters of this volume illustrate this diversity, and they will be discussed here individually. They are: revealed comparative advantage; factor content of trade; and the gravity model of trade.

### *Revealed Comparative Advantage (RCA)*

The idea here is simply to assume that trade conforms to comparative advantage and use trade itself to indicate what comparative advantage is. This was suggested, named, and defined by Balassa (1965), comparing a country's share of world exports in a sector to its share of exports overall:

$$RCA_{ij} = 100\frac{X_{ij}/X_{wj}}{X_{it}/X_{wt}}$$

where $X_{ij}$ and $X_{wj}$ are exports of good $j$ by country $i$ and the world, and $X_{it}$ and $X_{wt}$ are their total exports. In words, this ascribes to comparative advantage the fact that a country exports more of a good than one might expect based on its and the world's total exports.

This is an intuitively appealing idea that has never been formally shown to be valid within a theoretically consistent trade model, largely because those models have rather extreme implications for specialization, as illustrated in Figure 1.1 for the Ricardian model. Heckscher-Ohlin models retain some of that property when expanded to many goods and factors, especially when the number of goods exceeds the number of factors as is necessary to conform to plausibly available data.[6]

This difficulty might be overcome with the more recently developed modelling approach of Eaton and Kortum (2002), who allow a continuum of productivities to exist within a country and industry and who therefore generate a prediction for trade that varies more smoothly with prices and wages than more conventional models. Indeed, this approach has recently been taken to both modelling and measuring comparative advantage by Levchenko and Zhang (2011) in what promises to be a more direct approach to measuring comparative advantage than the RCA approach. However, it seems plausible to me that this Eaton-Kortum approach might be used to derive something very like the RCA prediction under free and undistorted trade.

Unfortunately, if trade is distorted by policies, then the actual trade flows included in RCA may reflect those distortions as much as or more than any underlying comparative advantage. This limits the usefulness of RCA.

What can RCA measurements be used for? Certainly they can be used for the descriptive purpose of identifying in which sectors a country exports more or less than average (e.g. Chapters 3 and 4 in this volume). The comparison to world exports in the formula for RCA serves the useful purpose of normalizing the trade data for the sizes of sectors and countries, which otherwise might give misleading impressions of the importance of a sector and country in international trade.

RCA can also be used, together with other data, as a guide to what causes actual trade patterns, whether these are driven by comparative advantage or not. Thus RCA indexes could be correlated with additional data on factor endowments and factor intensities to learn whether the Heckscher-Ohlin explanation of trade has significant explanatory power. This is done to a certain extent in Chapter 3 where developments in RCA indices are analysed for separate product groups classified according to the intensity with which they use unskilled labour, human capital or technology across a group of OECD and non-OECD countries. To the extent that differences in total factor productivity can be measured, these could also be related to RCA to see if a more strictly Ricardian explanation of trade patterns plays an important role.

Finally, since policies can influence trade patterns, data on trade policies could be combined with RCA to determine whether trade patterns are correlated with trade policies. For this purpose, the fact that RCA normalizes trade flows by total trade might make it a more accurate indicator than gross trade flows. Similarly, other policies that may not be intended to influence trade, but that might do so unintentionally, could also be correlated with RCA in this way.[7] In both of these policy cases, one should not assume that a causal relationship extends from policy to trade, rather than the reverse or the possibility that both are influenced by some third cause.

Another use of RCA might be to identify sectors that gain or lose from trade, perhaps in order to target assistance to those affected. Presumably sectors with an RCA of less than 100 might be viewed as more vulnerable to displacement by imports in response to trade liberalization than those for which RCA suggests a comparative advantage. This

would be useful to know when configuring policies to deal with hardship in industries on an industry-specific basis.

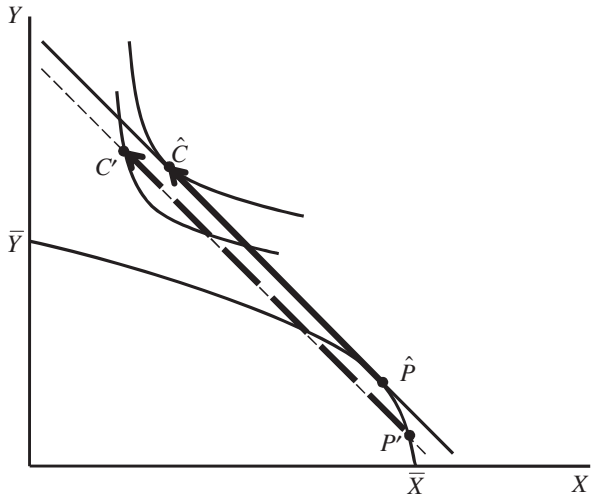
Some might be tempted to use RCA as an indicator of which industries should be the target of export promotion policies, such as subsidizing production and/or exports. To the extent that policy makers accept that trade in accordance with comparative advantage is beneficial, they are likely also to believe that increasing the amount of trade increases those benefits. This, however, is problematic.

First, the conclusion is even potentially valid only if RCA provides a correct diagnosis of the sectors in which a country has true comparative advantage. But as already discussed, this is not necessarily the case. Existing policies can easily distort trade and cause a country to record an RCA index greater than 100 in spite of a true comparative disadvantage. This is most obviously possible of policies that, say, subsidize production of what would otherwise be high-cost goods – not an uncommon practice, especially in agriculture. It is also possible, however, without subsidies. If taxes or other impediments happen to be highest in the sectors where true comparative advantage lies, then exports there will be depressed, leaving other comparative-disadvantage sectors to dominate the RCA index.

In either case, then, export promotion policies targeted on the basis of RCA would be expected to make the country worse off. Their effect would be to reallocate resources from relatively low-cost sectors to relatively high-cost sectors. That cannot be good.

On the other hand, even if RCA were known to correctly diagnose comparative advantage, one should be wary of any policy implications. A subsidy to increase exports of a good, even though it is a good in which the country has comparative advantage, will actually lower welfare. This is shown in Figure 1.3 where, starting from free trade, an export subsidy causes welfare to fall.

**Figure 1.3. Effects of an export subsidy to the comparative-advantage good, X**




In the figure, a small country starts with free trade, producing at $\hat{P}$, consuming at $\hat{C}$, and trading along the heavy solid arrow. A subsidy to exports of good X raises its price within the country, causing production to move to $P'$, consumption to $C'$, and trade to

the dashed arrow. Welfare falls from the higher to the lower indifference curve. Thus, even though the country has a clear comparative advantage in good X, it loses by subsidizing its exports. So even if RCA were successful in identifying comparative advantage correctly, it would not serve as a useful guide to policy in this case where trade is already free and therefore optimal.

One might argue that, even though trade may be free, there are costs of trade such as transport costs that prevent a country from achieving the optimum shown at $\hat{C}$ in Figure 1.3. In that case, surely, if RCA can identify the comparative advantage good, then subsidizing its exports would be beneficial.

This is not the case. Although I will not attempt the rather messy analysis here, if trade is reduced by the presence of real trade costs, then that reduction is in fact optimal. To artificially promote trade with an export subsidy would force the country to bear those trade costs excessively, and welfare would again fall.

One might also object to other assumptions made in Figure 1.3. What if the country is not small, but instead large? That just makes the subsidy worse, since it will push down the world price of the export good, worsening the country's terms of trade.[8] What if the policy were a production subsidy rather than an export subsidy? That would indeed be better than an export subsidy, since it would not distort consumer choice. But production would still move to a point like $P'$, reducing the value of the country's output at world prices and making even undistorted consumers worse off.

In short, even if RCA can correctly identify the sector or sectors in which a country has comparative advantage, it is not clear that this information can be useful for policy purposes. If a tool exists that can identify true underlying comparative advantage even when it is not reflected in actual trade, then that might be useful as a guide to removing whatever barriers prevent comparative advantage from being exploited. But RCA by its nature only captures comparative advantage if it is already reflected in trade. And in that case it is not clear that there is anything more to do with policy.

### *The factor content of trade*

A second method of learning something about comparative advantage empirically is to measure the factor content of trade. Most simply, this consists of first ascertaining the quantities of the various $m$ factors of production that are used to produce one unit of each of the $n$ goods that enter into international trade, in the form an $m \times n$ matrix, $F$. This matrix is then multiplied by the $n \times 1$ vector $T$ of net trade in goods (exports minus imports) to obtain the amounts of each factor used to produce exports minus those used to produce imports. The Heckscher-Ohlin-Vanek version of the Heckscher-Ohlin Theorem, due to Vanek (1968) says that this vector will be positive for those factors with which the country is relatively well endowed compared to the world, and negative for others. Thus, rather than identifying goods in which the country has comparative advantage, it identifies its relatively abundant factors that, in the Heckscher-Ohlin model, underlie its comparative advantage.[9]

As an indicator of comparative advantage, this is arguably more useful than information about goods, just because there are so many more goods than there are factors. By learning that a country has comparative advantage in goods that are, say, relatively capital intensive, we may gain a better understanding of trade than if we were simply given a list of comparative-advantage goods or sectors.

The factor content of trade may also be useful for another purpose. Deardorff and Staiger (1988) showed that, under somewhat restrictive assumptions, the factor content of trade is indicative of the effects that trade has on factor prices. Thus one might infer, for example, that a country that is a net exporter of, say, capital in factor-content terms has had its return to capital increased by trade above what it would have been in autarky. Likewise, a change over time in the factor content of a country's trade may indicate how trade has altered factor prices over time.

This approach to relating trade to factor prices has been used frequently by both trade and labour economists to diagnose the extent to which trade may have contributed to the rising premium paid to skilled workers compared to unskilled workers in the United States since about 1980.[10] Some trade economists – especially Leamer (2000) – have criticized this approach as requiring assumptions that are too restrictive to be meaningful.

### *Gravity models*

A final empirical approach to analyzing comparative advantage builds upon the gravity model of trade. In its original form, the gravity model dealt only with total trade, not its composition, and the focus was on how bilateral trade varied with country size and distance. The simplest gravity equation takes the form

$$T_{ij} = AY_iY_j / D_{ij}$$

where $T_{ij}$ is a measure of trade between country $i$ and country $j$, $Y_i$ and $Y_j$ are the countries' incomes, and $D_{ij}$ is the distance between them, with $A$ a constant. Taking logs and allowing the three explanatory variables to enter with elasticities other than one, the equation becomes

$$\log T_{ij} = \alpha_0 + \alpha_1 \log Y_i + \alpha_2 \log Y_j - \alpha_3 \log D_{ij}$$

This equation routinely fits the data remarkably well, and it does even better if a few additional explanatory variables are included, such as population (or per capita income) and dummy variables for such things as a common border or common language. Although the gravity equation did not originate with any particular theoretical model of trade, it is consistent with several of them, as discussed in Deardorff (1998).

The gravity-type model has also been derived for trade by sector, including additional explanatory variables on the right-hand-side to capture determinants of comparative advantage (e.g. Chor, 2010). The latter include relative factor endowments of countries interacted with sector factor intensities in order to capture the Heckscher-Ohlin mechanism as well as other variables that might be thought to influence comparative advantage, such as institutional variables.

This approach is somewhat *ad hoc*, since the precise estimating equation is unlikely to be derivable from a complete theoretical model of trade. In that sense it is subject to the same criticisms as early attempt to test the Heckscher-Ohlin Model such as by Baldwin (1971). On the other hand, by building on the theoretically sound gravity-equation structure, it can at least control properly for the roles of income and distance.[11] In any case, this gravity-model approach provides very useful descriptive information about the correlates of sectoral trade, and at least a suggestion of what institutions and other features of economies may influence the pattern of trade. Chapter 6 in this volume builds on Chor (2010) and on other insights from the literature on specific sources of

comparative advantage to quantitatively assess their relative importance for bilateral trade patterns at the industry level, with particular focus on policy and institutional factors.

## Conclusions

Three approaches that have been used empirically, each represented in this volume, are reviewed in this chapter to provide information about the patterns and causes of comparative advantage.

Revealed Comparative Advantage gives the most explicit information about which products a country exports either more or less than average, and it thus provides quite a complete mapping of what a country's patterns of trade actually are. This does not tell anything about what the underlying forces generating that trade may be, however, unless one is certain that no such forces are operating except true comparative advantage. If that were the case, then further information about comparative advantage might not be needed or useful. Nonetheless, RCA is a useful tool for describing trade, and it can illuminate comparisons across countries that may be suggestive of directions for further research.

The factor content of trade, in contrast, focuses exclusively on one particular source of comparative advantage: factor proportions. By measuring the quantities of factors embodied in exports and imports, factor content calculations allow us to see the role that factor endowments and intensities have played in forming trade patterns. This approach is particularly useful as a guide to how trade, and changes in trade, may alter factor prices. The latter in turn are fundamental for understanding changes in the distribution of income.

The gravity model provides a third approach to studying trade patterns, one that has not until recently been used for this purpose because most gravity estimations have been done at the aggregate level. By disaggregating trade and then incorporating various hypothesized determinants of comparative advantage in a gravity equation, however, one is able to gauge the contributions that these determinants may make to the pattern of sectoral trade.

Thus each of these methods provides useful information, even if none of them is capable of fully delineating either the nature of comparative advantage or its causes. The chapters in this volume, accordingly, provide a wealth of information that will be useful both for policy makers and for future researchers on trade. One might even hope that this information will provide both clues and stimulus to further research that will ultimately help us better understand the true patterns and causes of comparative advantage.

## *Notes*

1. Associate Dean, Gerald R. Ford School of Public Policy, University of Michigan, Ann Arbor, Michigan, United States. The views expressed are those of the author alone and are not meant to represent the views of the OECD or any of its members.
2. Although it certainly matters for the real wage, and thus the income, of the country. But the low wage implied by low productivity does not interfere with the fact that the real wage will rise with trade. Quite the opposite: it is the low wage that makes both trade and the gains from trade possible in the presence of low productivity.
3. See Deardorff (1980), Dixit and Norman (1980).
4. An exception is the work of Bernhofen and Brown (2004), which used data from Japan's historical opening to international trade to confirm the role of comparative advantage.
5. Early research by MacDougall (1951) and Stern (1962) had some success looking at labour costs.
6. This is one of the problems discussed in my Nottingham and Graham Lectures, Deardorff (2005, 2006).
7. Chapter 6 in this volume addresses the role of broad policies in influencing comparative advantage and trade patterns.
8. In Figure 1.3, the price line would become flatter while still tangent to the PPF. This pushes the country to an even lower indifference curve.
9. An attractive feature of this approach is that it incorporates intermediate inputs fairly easily by use of an input-output matrix (see also Chapter 5).
10. For an early example, see Borjas, Freeman, and Katz (1991).
11. Distance should not be captured quite that simply. As noted in Deardorff (1998) and stressed by Anderson and van Wincoop (2003), trade between two countries depends not only on the distance between them, but also on their combined distance from the rest of the world, i.e. their remoteness.

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