Chapter 4

International Trade Theory and Evidence: A Survey

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Introduction

This chapter provides a survey of the major theories examining the causes and consequences of international trade and the evidence supporting them. The discussion begins by presenting the classical theory of trade, as first developed by Adam Smith in his *Wealth of Nations* in 1776 and David Ricardo in his *Principles of Political Economy* in 1917. Both Smith and Ricardo presented views on trade that contradicted the mercantilist policies advocated by many governments at the time. Mercantilism viewed trade surpluses favorably and sought to discourage imports of products that competed with local manufacturers. The resulting protectionism of domestic industries was part of an intricate alliance of producers and governments with the purpose of restricting trade. Smith and Ricardo, by contrast, advocated freer trade and saw international commerce as providing gains that were disrupted by protectionism. Ricardo, in particular, argued that if countries specialized according to their comparative advantage, they would all profit from free trade. The chapter examines these claims and also presents the most recent developments of the Ricardian model as well as the available empirical evidence on it.

The chapter then moves on to examine the factor proportions theory of trade, as originally developed by Eli Heckscher and Bertil Ohlin. While the Ricardian framework focused on how technology differences across countries influence trade, the factor proportions theory argues that it is relative factor abundance — particularly of capital and labor — that determines comparative advantage and patterns of trade across countries. It also concludes that trade provides net gains for all countries involved. This chapter discusses the Heckscher–Ohlin (H–O) theory, its implications, and the empirical evidence on it. Central to the empirical evaluation of the theory is the so-called Leontief paradox, which refers to findings that the US — a presumably capital-abundant country — exports relatively labor-intensive goods, contradicting the simple H–O conclusions. Partly as a response, further theoretical analysis emerged to address these empirical findings. Since the framework was developed in a simple model with two factors (labor and physical capital), two countries, and two sectors of production, the theory was extended to incorporate the complexities of the analysis with many factors of production, many sectors, and multiple countries (most prominently by the economist Jaroslav Vanek), and introduced inter-country differences in technology. Empirical evidence on these modified or "hybrid" Heckscher-Ohlin-Vanek (H–O–V) models is presented in this chapter.

The discussion then turns to examining the more recent theories on the causes and consequences of trade, referred to as the "new international trade theory". These theories recognize that the traditional models do not easily explain a large share of global trade called intra-industry trade. The latter refers to exports and imports of different varieties of products within the same industry, as opposed to the inter-industry trade exclusively discussed by both the Ricardian and the traditional and extended H–O models. The new trade theory focuses the analysis within the context of imperfect competition, including models involving oligopolies and monopolistic competition. There is also an acute interest in examining how internal and external economies of scale affect trade. The chapter surveys both the theory and evidence on these new approaches. The discussion then turns to examine trade within the context of heterogeneous firms, presenting what some have called the "new new theory of international trade". These approaches seek to understand the fact that trade has vastly differential effects on the various firms that compose an industry. The last section focuses on the topic of dynamic comparative advantage, which shows how comparative advantage can differ in the short run versus long run, altering the specialization patterns suggested by earlier trade theories.

The Classical Theory of Trade

The classical theory of trade refers to the path-breaking writings of a set of economists in the late 18th century and 19th century, including Adam Smith (1723–1790), David Ricardo (1772–1823), Robert Torrens (1780–1864), John Stuart Mill (1806–1873), and others.

In his 1776 classic volume, *The Wealth of Nations*, Adam Smith advocated in favor of freer trade, arguing that mercantilism — and its protectionist policies — cannot work at a global level since all nations cannot sustain trade surpluses at the same time. In his analysis, Adam Smith appears to subscribe to the theory of absolute advantage, a popular theory that supports free trade. The concept of absolute advantage looks straightforward: countries that specialize in producing and exporting products in which they have their greatest productivity — that is, their absolute advantage — will gain from such trade. And this means — in contrast to mercantilist and protectionist views — that imports can be positive for a country. As Smith puts it, "If a foreign country can supply us with a commodity cheaper than we ourselves can make it, better buy it of them with some part of the produce of our own industry, employed in a way in which we have some advantage" (Smith, 1776, Book IV, p. 185).

Using the simple framework adopted by classical economists, one can clearly show the gains provided by trade. Table 1 shows the labor productivity in two countries, England and Portugal, in the form of hours of labor required to produce a unit of cloth and wine. In this case, England can produce cloth more cheaply than Portugal — its labor per output coefficient in cloth production, $a_{LC}^{E} = 10$, is lower than that in Portugal, $a_{LC}^{P} = 20$ — and therefore England should specialize in producing and exporting cloth to Portugal. Analogously, since Portugal can produce wine absolutely more cheaply than England — its labor per output coefficient in wine production, $a_{LW}^{P} = 10$, is lower than that in England, $a_{LW}^{E} = 20$ — then it should export wine and import clothing and both countries will gain from this trade. Let us examine this claim.

Suppose, for example, the two countries — England and Portugal — can trade 1 unit of cloth for one bottle of wine and each of them has 30 hours of labor available. The theory of absolute advantage showed that specialization will provide gains not available under autarky, that is, without trade. Consider first the case of England. Under autarky, the country can produce 1 unit of cloth and one of wine with its available resources (30 hours of labor), which would then be available to consumers. Similarly, in Portugal, the country could produce under autarky 1 unit of cloth and one of wine with its available labor and the country's

Table 1. Absolute advantage and the gains from trade.

	Labor-hours per unit	
	Cloth	Wine
England	10	20
Portugal	20	10

consumption would be 1 unit of each. Under free trade, however, if England specializes in producing cloth, it can produce 3 units of cloth. It can then export 1 unit of cloth and import 1 unit of wine from Portugal (at the given terms of trade of 1 unit of cloth for 1 unit of wine). Consumption in England under free trade would thus consist of 2 units of cloth and 1 unit of wine, clearly superior to autarky, where consumption was 1 unit of each. In Portugal, when it specializes in wine, it can produce 3 units of wine (with its 30 hours of labor), and export 1 unit of wine for one of cloth, ending up with a consumption of 2 units of wine and one of cloth, again superior to the autarky consumption of 1 unit of each. Both countries gain from trade.

Note, however, that the gains from trade in the absolute advantage framework are based on the fact that each country has an advantage in producing one product. But what if one country has an absolute advantage in producing the two products considered? Then, according to the theory, there would be no basis for trade since the country with the lowest labor productivities would be able to produce and export both products more cheaply when compared to the other. If, for instance, Portugal can produce both cloth and wine at a lower absolute cost, then it would be able to export both products to England, undercutting the latter's output in both sectors. The economy in England would collapse as a result of the cheap imports. This analysis, of course, echoes the arguments popularly made at the present time suggesting that because China and other developing countries can produce and export almost any product more cheaply than high-income countries, like the US, it is in the interest of high-income countries to protect their domestic industries — and workers — through protectionist measures. From this point of view, trade between high-income and developing countries is "unfair" because of the absolute cost advantages the latter have.

It was David Ricardo in his *On the Principles of Political Economy and Taxation* in 1817, who showed the fallacy in the theory of absolute advantage, proposing instead the theory of comparative advantage, which — at its core — remains the theory adopted by trade economists to the present. Given the apparently common sense nature of the absolute advantage theory and its stubborn persistence in popular discussions, the Ricardian theory of comparative advantage remains one of the pillars of economic theory. Indeed, there is a well-known anecdote about the late Nobel-prize winning economist Paul Samuelson, who was asked by the mathematician Stam Ulam to name one proposition in economics that was both true and non-trivial. Samuelson thought about it for a moment and replied, "Ricardo's theory of comparative advantage."

What would happen, Ricardo asks, if one nation was more efficient in absolute terms at producing both cloth and wine but specializes according to its comparative advantage? Consider the example in Table 2, a modified version of the one first

Table 2. Absolute versus comparative advantage in trade.

	Labor-hours per unit		Opportunity cost per unit	
	Cloth	Wine	Cloth	Wine
England	10	20	1/2 units of wine	2 units of cloth
Portugal	8	5	8/5 unit of wine	5/8 units of cloth

presented by Ricardo. Due to differences in technology, Portugal has the absolute advantage in producing both cloth and wine — one Portuguese worker can produce a unit of either cloth or wine at a lower labor cost than a British worker. Under the theory of absolute advantage, Portugal would export both cloth and wine to England, and England would produce nothing and thus be unable to export.

Instead, Ricardo argued that both nations can gain from trade if they follow the concept of comparative advantage, that is, specialize and export the product in which they have the highest relative productivity or lowest relative cost. For England, the cost of production in cloth relative to wine is $a_{LC}^{E}/a_{LW}^{E} = 10/20$, while in Portugal it is $a_{LC}^{P}/a_{LW}^{P} = 8/5$. This means that England has a low relative cost of producing cloth, while Portugal has a low relative cost of producing wine. Therefore, according to comparative advantage, England should specialize in producing and exporting cloth to Portugal. Analogously, since Portugal can produce wine relatively more cheaply than cloth, then it should export wine and import clothing.

Both countries would gain from trade. Suppose, for example, the two countries can trade 1 unit of cloth for one of wine and that the total labor supply in England is 30 hours of labor and that of Portugal is 13 hours of labor. Consider first the case of England. Under autarky, the country can produce 1 unit of cloth and one of wine with its available resources (30 hours of labor), which would then be available to consumers. Similarly, in Portugal, the country could produce 1 unit of cloth and one of wine with its available labor (13 hours of labor) and the country's consumption would be 1 unit of each. Under free trade, however, if England specializes in producing cloth, it can produce 3 units of cloth (given its supply of 30 hours of labor and the labor requirement of 10 hours of labor per unit of cloth produced). It can then consume 1.6 units of cloth, export the remaining 1.4 units of cloth and import 1.4 units of wine from Portugal (at the given terms of trade of 1 unit of cloth for 1 unit of wine). Consumption in England under free trade would thus consist of 1.6 units of cloth and 1.4 units of wine, substantially superior to autarky, where consumption was 1 unit of each. In Portugal, when it specializes in wine, it can produce 2.6 units of wine (13 hours of labor dedicated to wine production, which requires 5 hours of labor to produce each unit). The country can then consume 1.2 units of wine and export 1.4 units of wine for 1.4 units of cloth from England, ending up with a consumption of 1.2 units of wine and 1.4 units of cloth, again superior to the autarky consumption of 1 unit of each. Both countries gain from trade: trade according to comparative advantage benefits both countries, even when production of both cloth and wine is absolutely more costly in England than in Portugal.

Note that in this analysis, Ricardo does not consider at all the absolute cost of production, in terms of labor-hours, in determining trade patterns. Instead, he focuses on the opportunity cost, in terms of production possibilities, to determine a nation's comparative advantage in production. Since each nation is assumed to have a fixed stock of labor, committing one labor-hour to the production of 1 unit of cloth means there is a sacrifice in the production of wine. If Portugal increases production of cloth by 1 unit, this requires 8 hours of work, which means sacrificing 8/5 units of wine, which is the amount of wine that could have been produced with the 8 hours of work required to produce the 1 unit of cloth. In *opportunity cost* terms, 1 unit of cloth is worth 8/5 units of wine. For England, 1 unit of cloth requires 10 labor-hours to produce, which means a reduction of 10/20 units of wine, which is the amount of wine that would need to be sacrificed in order to raise cloth production by 1 unit. It is therefore more "expensive" for Portugal, in terms of opportunity cost, to produce cloth than it is for England. On the other hand, 1 unit of wine only "costs" 5/8 units of cloth for Portuguese workers, versus 20/10 = 2 units of cloth for English workers. Thus, Portugal has the *comparative advantage* in wine production, and England in cloth production.

Due to the technological differences, under autarky — and assuming perfectly competitive markets — the relative price of cloth (the price of cloth divided by the price of wine) would be lower in England than in Portugal. This difference stimulates trade when autarky (the absence of trade) is lifted; England gets a "better deal" on wine, and Portugal on cloth, by importing from abroad. In order to afford imports, however, both countries must specialize in the production of one good and sell their surplus (what they do not wish to consume domestically) on the world market. In doing so, Portugal and England expand their consumption possibilities to what they can buy from and sell to each other, not just what they can produce autonomously.

Under free trade both countries can consume more than they would under autarky — they benefit from trading and producing in accordance with their comparative advantage. As Ricardo wrote, "under a system of perfectly free commerce, each country naturally devotes its capital and labor to such employments as are most beneficial to each ... [By] increasing the general mass of productions, [this principle] diffuses general benefit ... It is this principle which determines that wine shall be made in France and Portugal, that corn shall be grown in America and Poland, and that hardware and other goods shall be manufactured in England" (Ricardo 1817, Chapter 7). More generally, one of the central takeaways of the Ricardian comparative advantage theory is that any two agents can benefit from specialization and unrestricted exchange with each other, even if one agent is always more efficient in absolute terms than the other.

The Ricardian Theory of Comparative Advantage: Empirical Evidence

What is the evidence supporting the Ricardian theory of comparative advantage? Early statistical studies examined one of the key implications of the theory, as stated by Ricardo. If the labor cost of producing cloth in Portugal relative to wine is higher than in England, that is, if $a_{LC}^{P}/a_{LW}^{P} > a_{LC}^{E}/a_{LW}^{E}$, then Portugal should export wine and import cloth from England. But note that the *a*'s are input–output coefficients, representing the amount of labor hours per unit of output produced, and are therefore the reciprocal of labor productivities, equal to output per hour of labor, *x*, so that $a_{LC}^{P} = 1/x_{LC}^{P}$, $a_{LW}^{P} = 1/x_{LW}^{P}$, etc. Ricardo's theory then suggests that if

$$x_{LW}^{P}/x_{LC}^{P} > x_{LW}^{E}/x_{LC}^{E}, \tag{1}$$

that is, if Portugal's labor productivity in wine relative to cloth exceeds the corresponding labor productivity in England, then Portugal should export wine and England should export cloth. Shifting terms around in Equation (1) implies that if

$$x_{LW}^{P}/x_{LW}^{E} > x_{LC}^{P}/x_{LC}^{E} \tag{2}$$

that is, if Portugal's labor productivity in wine relative to England's exceeds Portugal's labor productivity in cloth relative to England, then it should export wine and England should export cloth.

In a paper published in 1951, G.D.A. MacDougall took data on labor productivities in the UK and in the US for various sectors in 1937, from motor cars and machinery to leather footwear and cement, calculated the ratios of labor productivities in these sectors in the US and UK and correlated them with the amount of exports of the corresponding industries in the US and UK. He found a statistically significant positive relationship between these two variables. In other words, for the US and UK, industries with relatively high-labor productivity tend to be also the industries with relatively greater exports.

Another classic study corroborating the simple Ricardian implications regarding comparative advantage was published in 1962 by Robert M. Stern. He used 1950 data for the UK and the US in a variety of industries, such as pig iron, paper, glass containers, hosiery, etc. He calculated the ratios of labor productivities in the

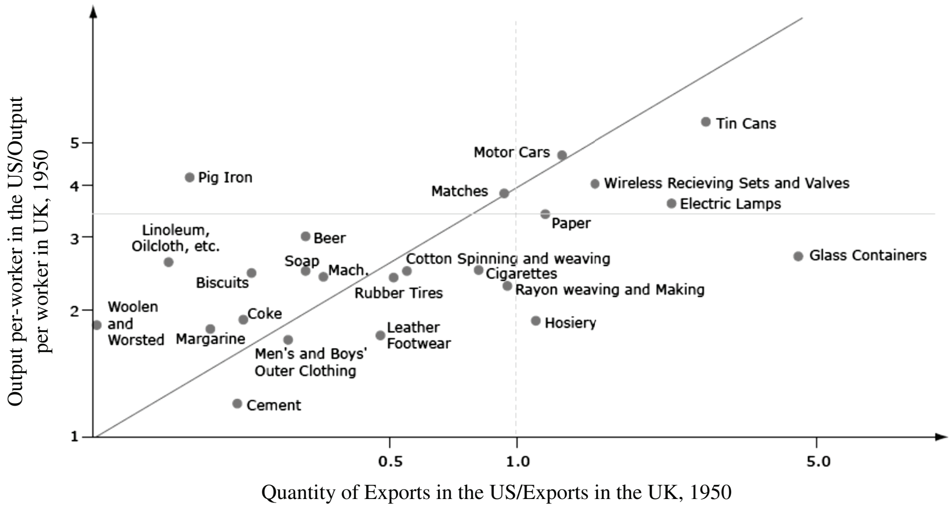


Figure 1. Testing the Ricardian model: Productivity differences and exports in the US relative to the UK.

Source: Stern (1962).

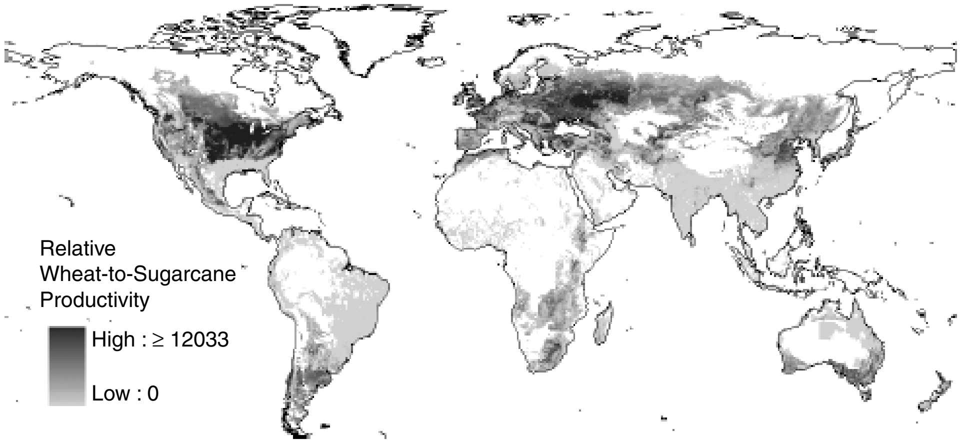
corresponding industries in the US and UK and correlated them with the amount of exports of the same industries in the two countries. The results of this exercise are presented in Figure 1. As can be seen, there is indeed a positive relationship between the ratio of labor productivity in the US relative to that in the UK for various industries and the ratio of the quantity of exports of the US relative to the exports of the UK in the same industries. That is, industries with relatively high-labor productivity tend to be also the industries with relatively greater exports, consistent with the simple Ricardian theory of comparative advantage.

This type of analysis has been carried out for other pairs of countries and industries (see, for example, Golub and Hsieh, 2000). The results are generally consistent with the Ricardian model. There are, however, serious shortcomings to this empirical approach. First of all, the simple Ricardian model is restricted to the analysis of relative comparative advantage between two countries (such as England and Portugal) and a pair of sectors (cloth and wine). Once additional countries and industries are introduced, comparing relative productivities across two specific countries and industries will not necessarily determine patterns of specialization between them because those trade patterns will be affected by the relative productivities, comparative advantage, and specialization incentives vis a vis other countries and industries. More recent theoretical work has extended the Ricardian framework to incorporate more countries and industries. For instance, research by Rudiger Dornbusch, Stanley Fischer, and Paul Samuelson, published in 1977, introduced a continuum of goods, with their various relative productivities, and comparative advantage then determines the range or segment of products each country will export. Other authors, such as Eaton and Kortum (2002), and Costinot *et al.* (2012), have also extended the Ricardian theory. Empirical analysis based on this research still finds results consistent with the spirit of the Ricardian approach, showing that trade based on comparative advantage provides substantial gains for the countries involved (Eaton and Kortum, 2012).

A second issue with the empirical analysis of the Ricardian framework is that it is subject to a significant sample selection bias: if countries specialize according to their relative productivities, then comparatively low-productivity industries would not exist and one would not be able to observe if indeed they are the comparatively low-productivity sectors in the economy. As Costinot and Donaldson (2012, p. 1) put it, "To bring Ricardo's ideas to the data, one must overcome a key empirical challenge. Suppose, as Ricardo's theory of comparative advantage predicts, that different factors of production specialize in different economic activities based on their relative productivity differences. Then, following Ricardo's famous example, if English workers are relatively better at producing cloth than wine compared to Portuguese workers, England will produce cloth, Portugal will produce wine, and at least one of these two countries will be completely specialized in one of these two sectors. Accordingly, the key explanatory variable in Ricardo's theory, relative productivity, cannot be directly observed."

To resolve this problem, an alternative empirical strategy is to find sectors of the economy where data and studies do exist about what productivity would be even if no production actually exists. For instance, in agriculture, studies carried out by agronomists can determine the productivity of various crops — wheat, corn, cotton, soybean, rice, sugar cane, etc. — in various countries and their regions depending on climatic conditions, soil, plant diseases, etc. For these products, then, one can determine (to a large extent) relative productivities even if there is no output of a crop at all. This is the approach followed by Costinot and Donaldson (2016). They find that Ricardian patterns of specialization in farm products within different regions of the US produced substantial economic gains to the American economy in the period examined (1880–1997).

Costinot and Donaldson (2012) also assess Ricardo's theory of comparative advantage at a global level using a dataset that consists of 17 farm products and 55 major agricultural countries. Using this information, they compute predicted output levels for all crops and countries in the sample based on the Ricardian approach and test whether the predictions compare with those that are observed in the data. Their results show that the predictions of Ricardo's theory of comparative advantage are generally consistent with the actual data on worldwide agricultural production. Figure 2, for example, shows the close match of relative productivity in wheat with the actual production of this crop in the world.



(a)

(b)

Figure 2. Relative productivity differences and global production of wheat. (a) Relative wheat–sugar productivity (darker represents comparative advantage for wheat). (b) Production of wheat in the world (darker represents greater wheat production).

Sources: (a) Costinot and Donaldson (2012, p. 4) and (b) International Wheat Association.

Figure 2(a) presents the ratio of productivity in wheat (in tons/hectare) relative to productivity in sugarcane (in tons/hectare). Areas shaded white have either zero productivity in wheat, or zero productivity in both wheat and sugarcane. Areas shaded dark have zero productivity in sugarcane and strictly positive productivity in wheat. Based on Ricardian comparative advantage, then, the dark areas should be the heavier producers of wheat, relative to sugarcane. Figure 2(b) shows the actual production of wheat, in kilograms per hectare, with the white representing zero production and grey areas indicating positive production, ranging all the way to over 1,000 kilograms per hectare in the areas shaded dark grey or black. A visual glance at the figure clearly shows how relative productivity in wheat is indeed matched by greater production.

A third shortcoming of the Ricardian theory of comparative advantage is that it does not specify what forces determine the relative productivities or relative costs of production that the model finds are critical in determining trade patterns. As the example using Table 2 exemplifies, the differences in labor productivity across industries and countries appear to be determined exogenously in the Ricardian framework, a result of differences in existing technologies. But in reality productivity depends on a wide variety of factors, including the intensity of the factors of production used in production (such as physical capital, human capital, and raw materials including fertilizers in agriculture and energy in industry), the scale of production, the quality of management and governance in the private and public sectors, etc. Developments in international trade theory over the years have examined precisely how all these factors shape comparative advantage. The next section begins this discussion.

Factor Proportions and the Heckscher–Ohlin Theory of Trade

The factor proportions theory of international trade focuses on how comparative advantage can arise from differences in the endowments of factors of production across nations. Swedish economist Eli Heckscher (1919) and his student Bertil Ohlin (1933) are broadly accounted for the first detailed treatment of the subject, particularly in Ohlin's book *Interregional and International Trade*, and so the approach has acquired the name of the H–O trade theory. The more modern version of the theory, however, frames it within the context of neoclassical general equilibrium economic theory and grew out of the work of various economists, including most prominently Bhagwati (1967, 1969, 1972), Jones (1956, 1965), Samuelson (1938, 1948, 1949), and Vanek (1962, 1968). This version of the H–O theory is sometimes referred to as the neoclassical model of international trade.

The principal conclusion of the H–O theory is that countries export those goods that require for their production the intensive use of those factors of production that are relatively abundant in the economy. To show this result, the H–O in its classic form adopts a simple analytical framework with two countries, two goods, and two factors of production, often referred to as the $2 \times 2 \times 2$ model. Each good is produced using a production function that is unique for that sector but that is identical across countries (implying identical cross-country technologies). However, each country faces a different endowment of factors of production. For purposes of the discussion, and for comparison with the Ricardian framework, suppose that the two countries involved are England and Portugal, the two sectors of production are wine and cloth, and the two factors of production are land and labor. Suppose also that at any level of output, the ratio of land to labor used in production is higher for wine than for cloth; wine production is relatively *land-intensive*, and cloth production *labor-intensive*. Then, the theory concludes that if England is endowed with relatively more labor than land, and Portugal with more land than labor, England has the comparative advantage in cloth production and Portugal in wine production. Under free trade, therefore, England will export cloth and import wine, while Portugal will export wine and import cloth.

To describe the analytical framework and conclusions of the H–O model, most authors adopt the most popular neoclassical approach, which focuses on capital, K, and labor, L, as the two inputs used in production, with their relative abundance determining comparative advantage. There is output of two products, X and Y, and two economies, domestic and foreign, where the variables for the foreign country are identified by asterisks. We start by describing the economy under autarky. For simplicity, it will be assumed that the domestic and foreign countries are identical in terms of demand (same population and same consumer preferences) but they have different factor proportions: the domestic economy has substantially greater supply of capital relative to labor. The analysis also assumes perfect competition in both the goods and factor markets.

Figure 3 shows the consumption equilibrium for the domestic economy. Consumer preferences are represented by indifference curves. Their budget constraint is given by $P_X X + P_Y Y = I$, where X and Y are the amounts consumed of the two products, P_X is the price of good X, P_Y is the price of good Y, and I is the income available. As a result, consumers face the budget line, $Y = (I/P_Y) - (P_X/P_Y)X$,

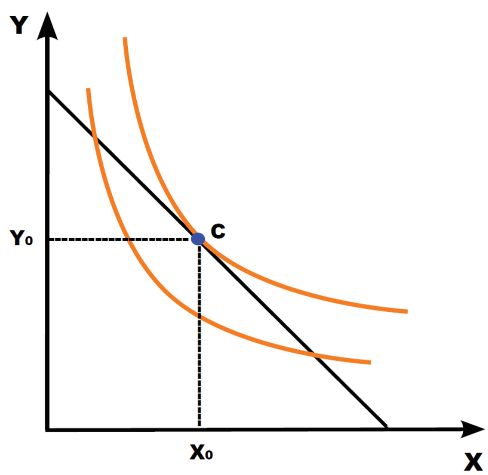


Figure 3. Consumption equilibrium under autarky.

which is also depicted — jointly with the indifference curves — in Figure 3. Consumers in the domestic economy will choose the consumption bundle of X and Y that provides them with the highest utility or satisfaction they can achieve, given the budget constraint. This consumer optimum is therefore reached at point C in Figure 3, at the tangency of the budget line for income I and the highest indifference curve they can reach at that level of income, UU. This specifies the consumption levels X_0 and Y_0. Note that a similar equilibrium will hold for the foreign economy, in all ways similar to the one depicted in Figure 3 since the demand side is assumed to be the same in the two countries (with the same indifference curves).

Note that the consumption equilibrium depicted in Figure 3 is achieved for a given level of income I. But income is derived from production (assuming no other sources of income, such as interest on wealth, remittances from abroad, etc.), which is discussed next.

The production function for each good, X and Y, is assumed to be the same across countries (displaying constant returns to scale, for simplicity) but the technologies differ among the two sectors. Sector X's technology generally uses much more labor relative to capital (it is relatively labor intensive), while sector Y's production requires more capital relative to labor (it is capital-intensive). One could think of sector Y as consisting of capital-intensive industrial goods such as automobiles, airplanes, steel, oil refining, etc., while sector X includes labor-intensive industries such as tobacco manufacturing, apparel, footwear, ceramics, etc. As noted earlier, the key difference between the domestic and foreign economies is that factor endowments differ. It is assumed that the domestic supply of capital relative to labor, K/L, is much greater than the foreign endowment of capital relative to labor, K*/L*.

The production possibilities (PP) curves represent diagrammatically the production side of each economy. These are depicted in Figure 4 by BB, representing the PP curve in the domestic economy, and B*B*, the foreign PP curve. Given the differences in factor endowments (the greater domestic supply of capital relative to labor compared to the foreign economy), the PP curve for the domestic economy, BB, is drawn as shifted toward the relatively capital intensive sector, Y, while the PP curve for the foreign country, B*B*, is shifted toward the production of the relatively labor-intensive good X. In fact, for simplicity, the two PP curves are assumed to be symmetric to each other, with the shift in production in favor of good Y in the domestic economy equal to the shift in favor of good X in the foreign economy.

Given the consumption side presented in Figure 3 and the production side in Figure 4, the equilibria of the two countries under autarky is presented in Figure 5. Consumers in each country seek to maximize utility by choosing the highest indifference curve possible, but subject to the income obtained from production, which is represented by the PP curves. Note that there is just one indifference curve map

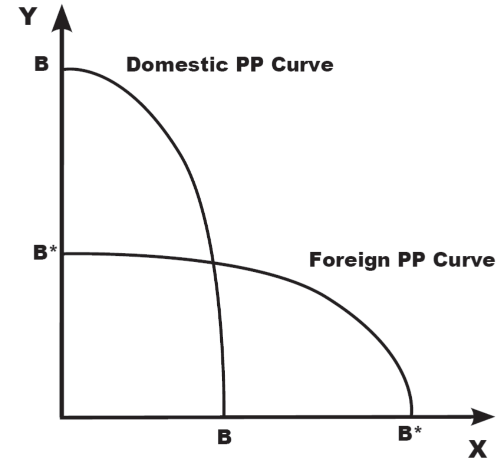


Figure 4. Production possibilities in domestic and foreign economies.

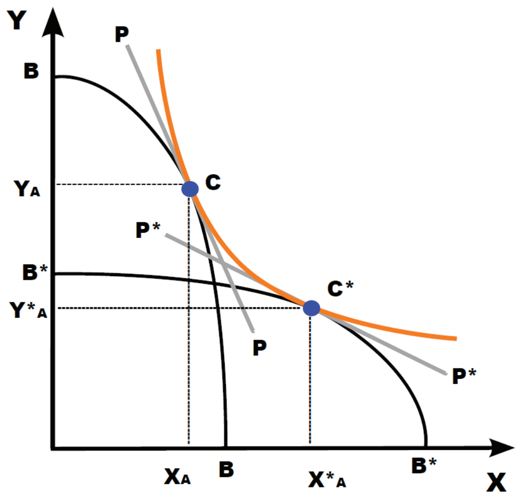


Figure 5. Market equilibrium in the domestic and foreign economies under autarky.

in Figure 5 since consumers in both countries are assumed to have identical preferences. But equilibria in each country vary due to the different relative factor endowments in each country, reflected in the diverging PP curves.

For the domestic economy, the equality of demand and supply occurs at point C, where the indifference curve is tangent to the domestic production possibilities curve, BB. The resulting output of commodity Y under autarky is Y_A and that of commodity X is X_A. The budget line for the domestic economy is depicted by PP in Figure 5, and it is the line that goes through (is tangent to) point C, which represents the equality of demand and supply as determined by consumer preferences (the indifference curve) and the supply side (represented by the PP curve). The equation for this budget line is given by $Y = (I_A/P_Y^A) - (P_X^A/P_Y^A)X$, where P_X^A/P_Y^A is the (absolute value of the) slope of the line PP and it shows the price (opportunity cost) of producing good X relative to Y in the domestic economy under autarky.

For the foreign economy, the equality of demand and supply occurs at point C*, where the indifference curve is tangent to the foreign country's production possibilities curve, depicted by B*B*. The resulting output of commodity Y under autarky is Y_A^* and that of commodity X is X_A^*. The budget line for the foreign economy is then depicted by P*P* in Figure 5, the line that goes through point C*, representing the equality of demand and supply. The equation for this budget line is given by $Y = (I_A^* /P_Y^{*A}) - (P_X^{*A}/P_Y^{*A})X$, where P_X^{*A}/P_Y^{*A} is the (absolute value of the) slope of the line P*P* and shows the price (opportunity cost) of good X relative to good Y under autarky in the foreign economy.

Figure 5 shows that, under no international trade, the equilibrium relative prices of goods X and Y vary across the domestic and foreign economies. The slope of the budget line for the domestic economy, PP, is more steeply negative than that of the budget line for the foreign country, P*P*. In fact, $(P_X^A/P_Y^A) > P_X^{*A}/P_Y^{*A}$, that is, the price of good X relative to good Y is higher in the domestic economy than in the foreign country. Since the demand side has been assumed to be identical in the two economies, the relative price difference between the two countries is based on the supply side differences, a result of the difference in factor proportions. Because the domestic economy has an abundance of capital relative to labor, it can produce relatively more cheaply the capital-intensive product, which is good Y, compared to the labor-intensive product, X. The foreign economy, with an abundance of labor, can produce relatively more cheaply the labor-intensive product, X, compared to the capital-intensive sector Y. These price differences are crucial in understanding the pattern of trade. Once trade is allowed in the discussion, the country that produces the relatively cheaper product (which is determined by relative factor endowments) will export that product and import the other. This is established next.

In Figure 6, the equilibrium of the two economies under international trade is presented. First of all, trade means that domestic prices have now to align to the prices determined by the global market. In Figure 6, the price level under free trade is given by the budget line WW, which is tangent to the PP curves of both countries. The absolute value of the slope of this line is the world market price ratio, P_X^{FT}/P_Y^{FT}, which determines both quantity consumed and that produced in each country.

For the domestic economy, the shift from autarky to free trade means a shift in production from point C, as established earlier, to point E, which is specified by the

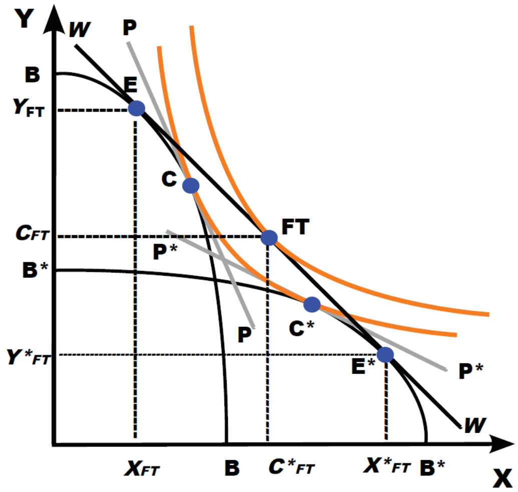


Figure 6. Free trade equilibrium: The H–O model.

tangency of the budget line at global prices (WW) with BB, the domestic PP curve. This leads to an increase in the production of commodity Y, the capital-intensive good, and a reduction in the production of good X, the labor-intensive sector. Under free trade, the domestic production of commodity Y is Y_{FT} and the output of good X is X_{FT}. Consumption is determined by the tangency of the indifference curve tangent to the new budget line, WW, which occurs at point FT. Note that the budget line under free trade is given by: $Y = (I_{FT}/P_Y^{FT}) - (P_X^{FT}/P_Y^{FT})X$ and at point FT, the consumption of goods X and Y in the domestic economy are C_{FT} and C^*_{FT}. The domestic production of good Y exceeds domestic consumption, and the difference between them represents domestic exports of this product, $E_Y^{FT} = Y_{FT} - C_{FT}$. At the same time, the domestic production of good X is lower under free trade, compared to autarky, and domestic consumption now exceeds domestic production, so that the domestic economy imports this product, $M_X^{FT} = C^*_{FT} - X_{FT}$.

For the foreign country, the shift from autarky to free trade means a shift in production from point C*, as established earlier, to point E*, which is specified by the tangency of the budget line at global prices (WW) with B*B*, the foreign country's PP curve. This leads to an increase in the production of commodity X, the labor-intensive good, and a reduction in the production of good Y, the capital-intensive sector. Under free trade, the foreign production of commodity X is X^*_{FT} and the output of good Y is Y^*_{FT}. Consumption is determined by the tangency of the indifference curve with the new budget line, WW, which occurs at point FT. Note that the budget line under free trade is the same as determined earlier for the domestic economy: $Y = (I_{FT}/P_Y^{FT}) - (P_X^{FT}/P_Y^{FT})X$ and at point FT, the consumption of goods X and Y in the foreign economy are C_{FT} and C^*_{FT}. These consumption levels are the same as for the domestic economy, a result of the assumption of identical population and consumption patterns in the two economies. Note that under free trade, the foreign production of good X exceeds consumption, and the difference between them represents exports of this product, $E_X^{*FT} = X_{FT}^* - C_{FT}^*$. At the same time, the foreign production of good Y is lower under free trade, compared to autarky, and foreign consumption now exceeds production, so that the foreign economy imports this product, $M_Y^{FT} = C_{FT} - Y_{FT}^*$.

The analytical framework presented through the help of Figures 3–6 shows the nature of the H–O theorem which states that, in accordance with its comparative advantage, under free trade a country exports the good whose production is intensive in its abundant factor. As in the Ricardian approach, using proceeds from exports, both countries can consume at a higher level than under autarky. The gains from trade for each country under the H–O model are represented in Figure 6 by the higher indifference curve linked to the free trade consumption equilibrium, FT, compared to the autarky equilibria at points C and C*. But in contrast with Ricardo, whose assumption of fixed input–output coefficients implies constant marginal costs of production, and wherein countries specialize completely in the production of one good, the H–O model predicts incomplete specialization. Both countries in Figure 6 continue to produce importables (import-competing products) under free trade, but much less than under autarky.

The Stolper–Samuelson and factor price equalization theorems

Despite the overall gains from trade demonstrated by the Ricardian and H–O theories, both imply significant changes in the economy as it moves from autarky to free trade, changes that can impose serious potential adjustment costs for some firms and factors of production. As depicted in Figure 6, in order to gain from trade — relative to autarky — the domestic economy must reallocate resources from producing good X to good Y. Some firms producing good X will stop operations, releasing workers in the process. They can be re-employed elsewhere, perhaps by firms in sector Y, which is booming under free trade. But if sector Y is concentrated in a particular region, for example, and sector X is concentrated in another region, the adjustments required by trade would involve relocation changes that can be seriously disruptive and painful for workers.

The H–O model also suggests that trade can have major effects on the income received by factors of production. In the neoclassical model described above this means changes in the income of capital and labor. If we denote wage rates by w and the rate of return (sometimes referred as the rental) on capital as r, the implication of the H–O model is that trade can alter sharply the relative factor–price ratio, w/r. These impacts diverge for the two countries. For the domestic economy, a high endowment of capital relative to labor means that under autarky the price of relatively capital-intensive products is low compared to the foreign country. Under trade, the higher international market price of the capital-intensive good Y relative to good X means that the domestic production of the capital-intensive good Y will rise relative to the output of good X and this increases the demand for capital relative to labor, which reduces the wage–rental ratio, w/r. In the foreign economy, the opposite dynamics are being generated by trade. For the foreign country, a high endowment of labor relative to capital means that under autarky the price of the capital-intensive good Y is high compared to good X. Under trade, then, the country faces a lower global price of good Y relative to good X, which is associated with a contraction of the capital-intensive sector Y relative to sector X and this reduces the demand for capital relative to labor, which lowers the wage–rental ratio, w/r. These results have been referred to as the *Stolper–Samuelson theorem* (see Stolper and Samuelson, 1941). They state that, assuming perfectly competitive markets, an increase (decrease) in the relative price of a good leads to an increase (decrease) in the price of the factor used intensely in that good's production and a decrease (increase) in the price of the other factor.

Note that the changes in factor prices just noted imply that international trade tends to reduce differences in relative factor prices across countries. In the example above, wages are relatively low in the labor-abundant country (the foreign country) under autarky and trade tends to raise relative wages. On the other hand, in the capital-abundant country (the domestic economy), wages are relatively high under autarky but tend to drop after the opening to international trade. This tendency for trade to equalize factor prices across countries is referred as the *factor price equalization theorem.*

The conclusions of the Stolper–Samuelson and factor price equalization theorems have been debated over the years. More specifically, the theories have been applied to the impact of globalization in recent decades. If one assumes that the domestic economy in the example above consists of high income, relatively capital-abundant countries, and the foreign economy represents relatively labor-abundant developing countries, then the theorem suggests that increased global trade between these two blocs will lead to the relative rise of wages in developing countries and their relative decline in high-income countries. The economic rationale for these effects is rather straightforward: if developing countries are relatively abundant in labor, then trade — according to both the H–O model and the Stolper–Samuelson theorem — raises the production of relatively labor-intensive sectors in these countries and this increases the demand for labor, pushing up relative wages. The opposite happens in the capital-abundant high-income countries.

Some of the empirical evidence available at a global level appears to be consistent with the implications of the Stolper–Samuelson model in this context.

Consider developing countries. The period of increased trade linked to globalization since the 1990s has been associated with a substantial drop of poverty — in Brazil, China, India, and elsewhere (see Rivera-Batiz, 2013). This fits the Stolper–Samuelson's dictum that trade in labor-abundant countries leads to greater production of labor-intensive goods, which raises the derived demand for labor — particularly unskilled labor — boosting labor income and reducing poverty under globalization. The problem with this birds-eye conclusion, however, is that other major changes have been occurring during the period of discussion. Land and market reforms in China sharply reduced poverty in that country, particularly in the 1980s. In Brazil and other countries social programs acted to reduce poverty as well.

Given the various phenomena occurring simultaneously, in order to determine the impact of international trade on poverty one needs to utilize a multivariate framework where a variety of factors are tested as possible determinants of inequality. The goal is to determine which one(s) are the most significant. Micro-level research carried out using multivariate analyses of the effects of trade liberalization on poverty, which hold constant other variables, are mixed (see, for example, the survey by Harrison, 2007). However, there are a number of careful studies documenting reductions in poverty with trade liberalization. Consider the case of Mexico, which engaged in drastic elimination of trade barriers in the 1980s and early 1990s. Hanson (2007) examines the impact of trade liberalization on poverty in Mexico. He separates regions of Mexico that had greater exposure to globalization and trade from those that had less exposure. He finds those Mexican states with high exposure to globalization had greater income growth and reduced poverty. Similar results are found by Wei (2002) for China, and Porto (2003) for Argentina's trade liberalization under Mercosur.

Another research trend in the literature focuses on examining the effects of trade on inequality instead of poverty. For developing countries, the evidence in this case appears to contradict the Stolper–Samuelson theorem. According to the theory, in low-income countries globalization should have increased the demand for unskilled workers (their relatively abundant factor of production) relative to that of skilled workers, raising their relative wages and inducing a drop of income inequality. The theory also predicts that the effects of trade would reduce the rate of return to capital in developing countries, also contracting the income of the wealthy and reducing inequality. But this has not generally happened. For most developing countries, inequality has risen since the period of trade liberalization in the 1980s and 1990s (se Rivera-Batiz, 2013).

The evidence on rising inequality appears to support the Stolper–Samuelson's predictions for high-income countries, which are relatively scarce in labor — particularly unskilled labor — and would be expected to face a lower output of labor-intensive goods and, therefore lower wages — particularly for unskilled workers — and rising inequality. The slowdown on wage growth in the US and other high-income countries, and rising inequality in these countries, appears to be consistent with the Stolper–Samuelson theorem. Indeed, some studies using data for the US do find that rising competition from imports have had a compressing effect on wages — and therefore boosted inequality (see, for example, Hakobyan and McLaren, 2016; Autor *et al.*, 2013). At the same time, other studies have re-examined these results, finding that increased trade has not significantly affected wages and employment in the US (see Feenstra *et al.*, 2018; Rothwell, 2017, among others).

As in the analysis of poverty, in examining rising inequality — whether in low-income or high-income countries — the problem is that other major economic changes have occurred during the period of trade liberalization accelerating since the 1980s and 1990s and require more complex, multivariate analysis. Studies of this type generally conclude that although trade may explain some of the rising global inequality, it has been the wave of technological changes sweeping through the world economy, not rising trade, that explains the increased inequality (see Bhagwati *et al.*, 2020). As Martin Ravallion has concluded in his survey of the literature, "While there can be little doubt that trade openness and capital mobility have had distributional impacts … the jury is still out on the thesis … that globalization has been the main force jointly creating both features. There has been considerable variance across countries … and trade openness does not seem to stand out as the major generalizable causative factor … Technological change … could well be a much stronger force than expanding trade … Globalization may well be getting too much credit, and being blamed for too much" (Ravallion, 2017, pp. 20–21).

The Rybczynski theorem

There is a third popular implication of the H–O model. It concerns the effects of changes in factor endowments. Consider an open economy trading at a given global relative price of commodity X relative to commodity Y. As before, suppose sector Y is capital-intensive relative to sector X. Let us examine the effects of an increase in the endowment of labor. One suspects that such an increase in the supply of workers should lower wage rates in the economy. But the general-equilibrium framework underlying the H–O model suggests otherwise. As the supply of labor rises, this can indeed put downward pressure on wages. But this raises the relative profitability in the production of labor-intensive goods. As a result, capital shifts from producing capital-intensive goods and into the production of labor-intensive goods. But this raises the demand for labor in the economy and reverses the downward pressure on wage rates. The ultimate consequence is that the increased supply of labor generates a matching increase in the demand for labor, with the new workers being absorbed into the economy without lower wage rates. The motor behind this conclusion is the increase in the relative output of labor-intensive goods as a result of the increase in labor. More generally, *Rybczynski's theorem* states that when the stock of a factor increases, production of the good that more intensely uses that factor increases as well.

The Rybczynski theorem provides a contrasting perspective on the popular view that immigration reduces wage rates and contracts the employment opportunities of workers in the destination countries. It leads instead to the conclusion that immigration may in fact have very little if any effect on wages or the employment opportunities of those already in the recipient country (Rivera-Batiz, 1983). Of course, the conclusion is derived under the assumptions of the H–O model, mainly that there is sufficient inter-sectoral and inter-regional mobility of capital across the economy, so that when lower wages stimulate increased demand for labor in sectors where migrants have moved in, capital will be able to easily move to those sectors, thus generating the employment opportunities noted before. This is a key assumption in the popular version of the H–O model, although there is substantial research examining the theory under conditions of limited inter-sectoral capital mobility, a framework often referred as the Ricardo–Viner approach (see Krugman *et al*., 2012). In addition, the discussion assumes that labor markets are competitive and do not suffer from distortions that generate unemployment. Additional research has shown how the conclusions regarding the impact of immigration vary when these assumptions are relaxed (see Rivera-Batiz, 2018).

Is there any evidence supporting the Rybczynski theorem? Surprisingly, there is significant evidence supporting its results. Two types of empirical studies have been undertaken to examine the impact of immigration on labor markets in recipient countries. First, there are spatial correlations that have looked at whether regions of high immigration are also regions where wage increases have slowed-down, holding other things constant. Probably the best-known of these studies is Card (1990), who examined the impact of the 1980 Mariel Cuban immigrant influx on wages and employment in the Miami area. The background for this influx of migrants starts in April 1980, when a Cuban bus driver and his friends who wanted to exit Cuba ram a bus into the Peruvian embassy and asked for asylum. Thousands of others followed, leading to a crisis that the Cuban government solved by allowing people to leave the island, if they wished, but from the port of Mariel. About 125,000 Cubans left the island between May and October 1980. The great majority moved to and settled in Miami.

Taking advantage of this exogenous increase of immigrants, University of California at Berkeley economist David Card examined the impact of immigration in Miami in his now classic 1990 paper. Card examined data on unemployment and wages of various racial and ethnic groups in Miami and in a set of comparison cities: Atlanta, Houston, Los Angeles, and Tampa. His conclusions were as follows: "this study shows that the influx of Mariel immigrants had virtually no effect on the wage rates of less-skilled non-Cuban workers. Similarly, there is no evidence of an increase in unemployment among less-skilled blacks or other non-Cuban workers. Rather, the data analysis suggests a remarkably rapid absorption of the Mariel immigrants into the Miami labor force, with negligible effects on other groups. Even among the Cuban population there is no indication that wages or unemployment rates of earlier immigrants were substantially affected by the arrival of the Mariels" (Card, 1990, p. 256).

In a recent study, Harvard economist George J. Borjas recently published a paper that appears to contradict David Card's results. He argues that the Mariel immigration did have a negative impact on male high-school dropouts in the Miami area (see Borjas, 2017). The problem with this study is that the dataset used by Borjas is the Current Population Survey (CPS) and the sample of adult working males with less than high school in Miami at the time of the Mariel inflow is extremely small (30–40 persons) and makes the results highly unreliable. Once you take the measurement error bias into account, the results change, as Giovanni Peri and Vasil Yasenov find in a reply to Borjas (see Peri and Yasenov, 2017).

A second type of study simulates the impact of immigration in a labor market by estimating how labor demand and supply in that market are affected, and showing the consequences on wages and unemployment. The research in this area includes Altonji and Card (1991), Rivera-Batiz and Sechzer, (1991), and Gang and Rivera-Batiz (1994a). The results of these studies are mixed, but the predominance of the evidence is that the impact of immigrants on the overall wages and employment of natives is small. For example, Rivera-Batiz and Sechzer (1991), in their simulation of Mexican migration to the US, find that a 10% increase in the US labor force owing to an inflow of Mexican immigrants would have the strongest negative effect on the wages of Mexican workers already in the country; but even this impact is small, equal to a less than 1% drop in wages. More recent research shares these results. Indeed, the most recent and comprehensive study of the impact of immigration in the United States was carried out by a panel of experts assembled by the US National Academy of Sciences. The report was released in 2016 and this is their conclusion: "There is little evidence that immigration significantly affects the overall employment levels of native-born workers."

An innovative recent article also provides support for the conclusions of the H–O model regarding changes in factor endowments. Adopting the strategy followed by Card, Zimrig (2019) uses a natural experiment to study the effects of a large exogenous shock to factor abundance in examining the effects on wages. He uses a historical episode that resulted in the near elimination of commuting from the West Bank into Israel in the year 2000. As Zimrig observes, until that point, around 20% of the labor force in the West Bank commuted to work in Israel on a daily basis. But in October 2000, following the outbreak of the Second Intifada, the number of commuters to Israel was severely restricted by the Israeli government and remained low for many years after. The result of this policy change was to make the West Bank substantially more labor abundant. What impact did this have on wages and employment? These are the conclusions of Zimrig (2019, p. 90): "I find that the changes in production patterns are consistent with the predictions of the Heckscher–Ohlin … model of trade. Moreover, these changes allowed for an absorption of the returning commuters, without relative wage changes, as predicted [by the H–O theory]."

Empirical Evidence on the Factor Proportions Theory

In contrast to the Ricardian approach, which focuses on how given technology or productivity differences across countries explain trade patterns, the factor proportions theory focuses on the role that relative factor abundance has in explaining trade patterns (the H–O theorem).

Factor proportions and trade patterns

Initial tests of the H–O model regarding the pattern of trade were generally inconsistent with its conclusions. But more recent analysis, introducing more extensive data, adopting innovative testing approaches, and incorporating forces other than factor abundance into the discussion have been much more supportive of the theory, prompting Egger *et al.* (2011) to call it "the resurrection of the Heckscher–Ohlin theory".

The Leontief paradox

The first — and perhaps most famous — test of the H–O theory was carried out by Nobel Prize winner Wassily Leontief. Using US data for 1947, Leontief looked at the value of capital and labor requirements in US export sectors and in US import sectors. Based on the H–O theory, one would expect that if the US is relatively capital abundant, then it should export relatively capital-intensive products. But Leontief found that the average value of capital per worker used in US export industries was $13,900, while the value of capital per worker in US import industries was substantially higher, equal to $18,200. He concluded that "an average million dollars' worth of [US] exports embodies considerably less capital and somewhat more labor than would be required to replace from domestic production an equivalent amount of … competitive imports. America's participation in the international division of labor is based on its specialization on labor intensive, rather than capital intensive, lines of production … the widely held opinion." This result has been called the Leontief Paradox in the literature.

Now, Leontief did not conclude that the H–O theory was wrong but instead that the view "that — as compared with the rest of the world — the United States' economy is characterized by a relative surplus of capital and a relative shortage of labor proves to be wrong. As a matter of fact, the opposite is true" (Leontief, 1953, p. 343). He, therefore, adopted the contrarian view of most economists at the time, which believed the US was a capital-abundant, industrial powerhouse relative to other countries.

Leontief's results spurred much further empirical work oriented to determine whether the US is really a capital-abundant country or whether the H–O theory that factor endowments determine trade patterns is wrong. The first issue raised was about the timing of Leontief's analysis, which was based on 1947 data, in the immediate aftermath of WWII, which had seriously disrupted global trade and production. Indeed, given the devastation of the war in Europe, Asia, and other parts of the world, the period following WWII was one of global disequilibrium, with the US displaying massive trade balance surpluses relative to the rest of the world. In 1947, the year of Leontief's analysis, US imports amounted to 37.5% of US exports, but by 1959 this trade surplus had vanished.

Baldwin (1971) finds that the gap in capital per worker between the importable and export sectors in the US shrinks between 1947 and 1962, but he confirms Leontief's Paradox, with US importables still relatively capital-intensive compared to US exports. A more significant challenge to Leontief's vision of US exports as being relatively labor-intensive comes with the rising share of developing countries in global trade beginning precisely in the mid-1960s. No matter what the earlier situation was, at that point one would have to consider global trade between the US and the rest of the world as reflecting a capital-abundant US relative to the labor-abundant developing countries. Indeed, studies using more recent data, even going back to the 1970s, find results that are consistent with the H–O model and indicate that the paradox has vanished (see Stern and Maskus, 1981, for example). The analysis of whether the US or other countries export goods which reflect their relative factor abundance is also influenced by the incorporation of human capital — and other factors of production — into the discussion. Heckscher and Ohlin focused on the relative endowments of physical capital and labor in their analysis, but if one considers instead the role of relative factor abundance in skilled labor in explaining trade, empirical tests have been much more supportive (see Caron *et al.*, 2014). This issue is one of the modifications of the basic H–O model discussed in later sections.

An alternative explanation for the Leontief paradox is that trade patterns are influenced by differences in consumption patterns among trading partners, a topic that was ignored in the simple H–O model, which assumes that consumer preferences are homothetic and identical among countries. As noted earlier, a relatively capital-abundant country has a productive comparative advantage in producing and potentially exporting relatively capital-abundant products since there is a tendency for capital-abundant products to be relatively cheap under autarky (the abundance of capital makes the relative cost of capital cheap), providing the country with a competitive advantage in exporting these products when trade opens up. But if the country also has a strong demand for capital-intensive products, then this might raise the relative price of capital-intensive products under autarky. Despite the relatively abundant supply of capital, the derived demand for capital due to the high consumer demand makes capital relatively scarce, raising the cost of capital and making capital-intensive goods relative expensive. This might suffice to make capital-intensive goods relatively expensive under autarky and therefore products that are imported from cheaper world markets once trade opens up.

There is substantial evidence that consumer preferences are not homothetic and can vary substantially among countries, particularly among rich and poor nations. Recent work focusing on variations in consumer preferences across countries does find that such differences can explain a significant part of the deviations of actual trade patterns from the predictions of the H–O model, the so-called "missing trade" problem (see Markusen, 2013).

The Heckscher–Ohlin–Vanek model

Another set of problems with Leontief's analysis is that he used data for only two factors of production, capital and labor, employed in only two aggregated sectors, exports and importables, strictly produced in the US. This ignores the complications of actual trade in a world involving many factors of production (capital, unskilled labor, skilled labor, raw materials, etc.), many goods (high-tech, low-tech, agriculture, etc.) and many countries or regions. For instance, by focusing on the capital–labor intensity of US exports relative to US *importables* (which, by definition, are produced in the US), Leontief's analysis ignores the fact that many US *imports* are not produced in the US and are not therefore included in Leontief's calculation of the capital-intensity of US exports relative to US importables. Since many of these products, such as coffee or tea, tend to be labor intensive, one suspects that the capital–labor ratio involved in the global production of all US imports would be significantly lower than the capital–labor ratio of importables produced in the US (Leamer, 1980, p. 123).

The analysis of how the H–O theory can be modified and tested in a multi-factor, multi-good world was pioneered by Jaroslav Vanek. Following H–O theory, Vanek suggested that the concept of relative factor abundance in a multi-country world can be specified by calculating the share of the supply of the factor in the domestic economy as a proportion of the total supply of that factor in the world, and comparing this relative factor share to the share of the country's GDP as a proportion of the global GDP. If the factor share in the domestic economy is greater than (less than) the share of domestic GDP on world GDP, then the country is relatively abundant (relatively scarce) in that factor in the world. For instance, suppose the factor of production is capital. If the share of capital in the country as a proportion of all capital in the world exceeds the share of GDP of the country relative the world GDP, the country is relatively abundant in capital compared to the rest of the world.

Vanek then developed the concept of the net factor content of trade. For a factor of production, say capital, a country's net factor content of trade is equal to the quantity of that factor used in the domestic production of exports minus the quantity used by foreign countries in the production of domestic imports. Vanek showed that if a country has a positive net factor content of trade, then in effect that country is abundant in that factor relative to other countries in the world, as defined above. That is, if a country's share of a factor exceeds its share of world GDP, that is, if the country is relatively abundant in that factor, then the net content of trade in that factor should be positive. For instance, if the country is abundant in capital (say it accounts for 20% of the world's capital stock compared to 10% of global GDP) then it should have a positive net capital content of trade, meaning that the amount of capital used to produce exports is higher than the amount of capital used in the rest of the world to produce the country's imports.

The more complex version of the H–O theory presented by Vanek has been referred to as the HOV model. To test whether it holds, one can perform a "sign test", determining whether a factor with a relatively abundant (scarce) factor does indeed have a positive (negative) content of trade for that factor. Leamer (1980) uses the H–O–V approach to re-examine the data on the US collected by Leontief and finds that a calculation of the relative factor content of US *net* exports supports the conclusion that the US is capital abundant, thus arguing that there is no Leontief paradox. However, Bowen *et al.* (1987) extend the analysis to countries other than the US, including 12 factors of production embodied in the net exports of 27 countries in 1967. They find that the sign of net factor exports infrequently predicts the sign of excess factor supplies and therefore does not systematically reveal factor abundance, a result inconsistent with the H–O–V model.

Staiger (1988) uses endowment, trade and income data from 29 countries to examine the link between factor endowments and trade patterns. According to his findings, although factor endowments do explain *some* of the variation in trade, "the strong Heckscher–Ohlin relationship excludes important additional channels through which factor endowments affect the pattern of trade" (Staiger 1988, p. 129). Trefler (1995) similarly finds the standard H–O–V model to be empirically weak at explaining trade patterns. In what Trefler calls the "case of the missing trade," the standard H–O–V model is found to explain only a very small portion of the total variation in trade patterns for 33 of the top trading countries in the world in the 1980s. "Empirically, the HOV theorem … performs horribly. Factor endowments correctly predict the direction of factor service trade about 50% of the time, a success rate that is matched by a coin toss" (Trefler, 1995, p. 1029).

Technology differences and the modified H–O–V model

One of the problems with the H–O–V model is that in deriving its results, it makes a number of strong assumptions, which when relaxed can dramatically change the conclusions of the model regarding how factor endowments explain trade flows. For instance, one of the key assumptions of the H–O framework is that there are no technology differences across countries. It is of course understandable that, in order to focus on explaining trade flows on the basis of differences in factor endowments among countries, the theory ignored differences in technology, which was what Ricardo emphasized in his own analysis of the determinants of trade flows. But technology gaps among countries can in fact reverse the H–O–V conclusions about factor abundance and the factor content of trade. Leontief himself proposed this as an answer to his paradoxical results. For example, the US currently has about 4% of the world labor force but close to 15% of global GDP, which makes labor a relatively scarce factor in the US. However, if technology differences make labor in the US much more productive that in the rest of the world, then the effective labor force is much greater. That is, the greater productivity of the American worker makes its labor force effectively much higher than in the rest of the world, making it an "effective labor" abundant country, which — according to a modified H–O–V model, implies the US should export effective-labor-intensive goods.

Trefler (1993) finds that adjusting for differences in labor productivity among nations can explain for the failure of the H–O–V in predicting trade patterns. Revisiting the Leontief data, Trefler finds that in 1947 the US had 8% of the world's population, but 37% of the world's GDP, implying that the country was scarce in labor. Yet, when he calculates the effective labor endowment of the US (the actual labor endowment augmented by relative US labor productivity) then the US had 43% of the world's effective labor as compared to 37% of GDP, making the country abundant in effective labor. He concludes that "Leontief was right in maintaining that in 1947 the US was labor abundant as measured in productivity-equivalent workers … my results leave intact Leamer's conclusion that there is no paradox" (Trefler, 1993, p. 962).

An alternative approach has been followed by Davis *et al.* (1996), who argue that given the restrictive assumptions of the H–O–V theory at the international level, perhaps it is more appropriate to evaluate the theory to examine the net factor content of trade for regions within a country, where the dissemination of technology may be conducted more freely. They examine whether the net factor content of regions in Japan are consistent with relative factor abundance, as defined by the H–O–V model. Their answer is in the affirmative: once you relax the assumption of equal technology, the sign test for the H–O–V model, as established earlier, holds in over 80% of the regions examined. More recent work, by Davis and Weinstein (2000), tests the implications of a modified H–O–V model that relaxes the assumptions of the "standard model", including those relating to differences in technology. They utilize an extensive database from the Organization for Economic Cooperation and Development's (OECD) which includes input–output tables, gross output, net output, intermediate input usage, domestic absorption, and trade data for 34 industries in 10 OECD countries. Their results also provide evidence that is consistent with a "modified" H–O–V model.

Human capital and trade patterns

Another improvement in the analysis and empirical evaluation of the H–O model is the incorporation of factors of production other than labor and physical capital, such as human capital (skilled labor), land, energy and raw materials, and intermediate products. With multi-factors, however, how relative factor abundance influences trade becomes more complex. For instance, consider a country that is scarce in capital relative to labor in general (low K/L) but it has an abundance of unskilled workers (L_u) in its labor force ($L = L_u + L_s$, where L_s is the supply of skilled labor). Suppose also that unskilled labor is a complementary input to capital. Then, the country may export unskilled-intensive products, for which it has a comparative advantage according to the H–O model, but because of the complementarity with capital, the capital content of its exports may also be relatively high, which implies the capital-scarce country is exporting capital-intensive products, a paradoxical result for the H–O–V model.

In a paper published in the *American Economic Review*, John Romalis differentiates between human and physical capital and relaxes a number of the assumptions of the traditional H–O–V model (including assumptions relating to market structure and transport costs). His analysis derives and tests the predictions of the modified factor proportions model, which he calls a quasi-H–O model. Using bilateral trade data for the US, he finds strong support for the quasi-H–O model. He concludes, "countries that are abundant in skilled labor and capital do capture larger shares of US imports in industries that intensively use those factors. The effect is particularly pronounced for skilled labor" (Romalis, 2004).

Figure 7 shows Romalis's results for Germany and Bangladesh. As can be seen, Germany, with a relatively abundant endowment of skilled labor (the average adult has over 10 years of formal education), accounts for a large share of US imports of skill-intensive commodities, but much smaller shares for commodities that are not intensive in the use of skilled labor. On the other hand, Bangladesh, where skilled labor is relatively scarce (the average adult has just 2½ years of formal education), the opposite trade pattern is displayed with respect to its exports to the US, which are concentrated in commodities that require little skilled labor.

More recently, Stone *et al.* (2011) calculate relative factor endowments of physical capital, skilled and unskilled labor in OECD countries and selected non-OECD countries for the period of 1990–2005. They compute the factor content measures adopted by the H–O–V model, modified to incorporate differences in technology of production in different countries (as given by country-specific input–output tables). They also examine the role of intermediate products. This is an essential issue, as the growth of global value chains (GVCs) has made it clear that traded intermediate goods have become a major part of the global production process. In this case, one needs to measure the number of factors used globally — not

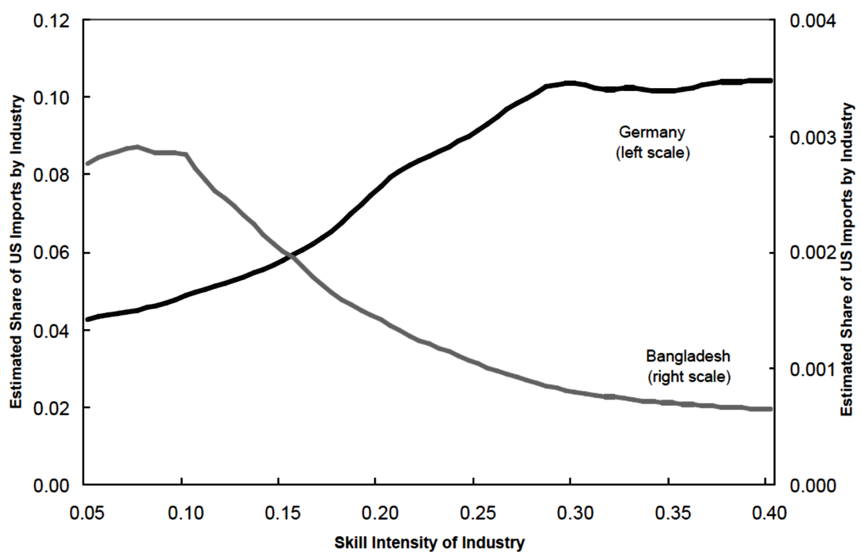


Figure 7. Skill intensity of industry and US imports from Germany and Bangladesh.
Source: Romalis (2004).

just the direct, primary factors of production but also imported intermediate goods produced all over the world — to generate net exports. This stands against the traditional measures of factor content in the H–O–V model, which have generally been based on local, primary factors.

Stone *et al.* (2011) find that, with the measurement refinements of a modified H–O–V model, "factor content is an important determinant of comparative advantage and that comparative advantage, in turn, drives trade patterns. OECD economies as a whole continue to hold the lion's share of capital and skilled labor endowment stocks while selected emerging markets (SEMs) hold more unskilled labor. Overall, measures of factor content of trade reflect these holdings. However, while OECD countries have been shown to be accumulating capital stocks at a rapid rate, over 4% *per annum* for the past 15 years, SEMs have been doing so at an even faster rate, over 11% over the same time period. The same observation can be made for skilled labor; OECD stocks growing at over 3% while SEMs are growing at an annual rate of almost 5%".

As was discussed in the presentation of the H–O theory, economists often examine the conclusions of the theory regarding the role of factor abundance on trade patterns by looking at how the opening of the economy to free trade affects production, consumption, and therefore net exports, relative to autarky. Because truly free (wholly untaxed and unregulated) trade between nations is rare, and because economies seldom, if ever, transition from autarky directly to free trade, analyzing whether trade follows the H–O model, both in terms of trade patterns but also in measuring the gains from trade proclaimed by the theory, constitutes a challenge to measure empirically.

Bernhofen and Brown (2005) use the sudden opening-up of Japan's economy to trade in the 1860s as a "natural experiment", one of the rare instances in which an economy actually transitions from full autarky to relatively free trade over a short period. They take as given (with evidence to support these assumptions) that Japan had a competitive, autarchic market economy before trade and that its patterns of trade after opening up were consistent with Japan's comparative advantages in production at the time. In testing the H–O theorem, they provide values for the factor content of Japan's trade in each year of the early trading period of 1865–1876 and examine the gains from trade relative to the autarkic period from 1850 to 1857. Based on a disaggregation of factors of production into capital, skilled labor, unskilled labor and land, they find that the factor content of Japan's net exports favored its abundant factors while the country was a net importer of its scarce factors, concluding that "our results provide strong empirical support for the general H–O prediction." They also find positive, although modest, gains from trade.

Overall, the empirical evidence accumulated over the years testing the role of factor endowments and technology differences in determining patterns of trade appears to find weaker results when looking at the trade among high-income countries and stronger results when examining trade between high-income and developing countries. It has led the prominent international economists Paul Krugman, Maurice Obstfeld, and Marc Melitz to conclude that "empirical testing of the Heckscher–Ohlin model has produced mixed results … However, the pattern of goods trade between developed and developing countries fits the predictions of the model quite well" (Krugman *et al.*, 2012, pp. 102–103).

Why would trade among high-income countries be more difficult to explain using the Ricardian and H–O theories? This is discussed in the next section.

Market Structure and the New International Trade Theory

Traditional trade theories seek to explain how and why international trade steers countries to produce and export some goods while importing other commodities. In the example from Ricardo, the idea of the model was to explain how and why trade would lead England to specialize in — and export — cloth while Portugal would specialize in — and import — wine. Similarly, the H–O–V model focuses on how factor endowments differences between two countries induce the production and export of different goods in each country. But the problem is that much of trade flows, especially among high-income countries, is not of this type of inter-industry trade, involving exports of the products in some industries and imports of the products of other, different industries. A large share consists of intra-industry trade. Understanding this type of trade, which permeates modern commerce, has been the goal of the so-called new international trade theory.

Intra-industry trade

Intra-industry trade occurs when a country exports and imports products of the same industry. That is the case, for example, when the US exports cars produced by companies such as Chevrolet, Chrysler, Ford, and Tesla, while importing automobiles from firms such as Honda, Toyota, Fiat, Maserati, BMW, Mercedes Benz, and so on, from other countries. Economists have developed indexes to measure the importance of intra-industry trade in different countries and various sectors of the economy. One of the most popular indexes was developed by Herbert Grubel and Peter Lloyd and is referred to as the Grubel–Lloyd index of intra-industry trade, IIT. The index for an industry j is algebraically given by

$$\mathrm{IIT}_j = 1 - [|\mathrm{X}_j - \mathrm{M}_j|/(\mathrm{X}_j + \mathrm{M}_j)], \tag{3}$$

where X_j and M_j are the exports and imports of industry j in a particular country or region. The index is equal to zero if there is no intra-industry trade. In this case, either $X_j = 0$ (no exports) or $M_j = 0$ (no imports) and the right-hand side of the equation is equal to zero. If the country or region exports and imports the same commodity, the index will be greater than zero and will become larger the more significant intra-industry trade is. If, for instance, the value of imports and exports of a given commodity are equal to each other, that is, if $X_j = M_j$, then $IIT_j = 1$. Note that the index is often multiplied by 100.

Any index of intra-industry trade will be related to how narrowly one defines the industry. Overall trade in rubber between two countries might differ sharply from the trade pattern in synthetic rubber or natural rubber. The US is a substantial exporter and importer of rubber, suggesting strong intra-industry trade. However, the US exports synthetic rubber but does not export natural rubber at all, which it imports from abroad. Therefore, if one considers the synthetic rubber industry and the natural rubber industry as separate industries, no intra-industry trade would be observed for the US.

Most countries have data that disaggregate industries into the different sub-industries or products that compose them. Such data are cataloged by assigning numbers to each industry through a method called Standard Industrial Classification (SIC). As each industry is disaggregated and a more specialized industry is considered, an additional digit is added to the industry. For instance, in the US SIC classification system, the manufacturing industry is cataloged by industries 2 and 3. Tobacco manufactures, however, have an SIC classification of 21, leather manufactures have a classification of 31. If one disaggregates some more, a digit is added. For example, motor vehicles have an SIC of 371 while aircraft have a classification of 372, motorcycles 375, etc. More specific categories can be considered, and digits added. Passenger cars have a classification of 3711, while trucks are classified by 3713, truck trailers by 3715, etc. There exist a number of SICs. The best known is the International Standard Industrial Classification (ISIC) produced by the United Nations Department of Economic and Social Activities, but the US utilizes its own SIC as well as a harmonized system with Canada and Mexico called the North American Industrial Classification System.

Intra-industry trade is an essential part of global trade, particularly among high-income countries (see Coeuré, 2020; Lane, 2020). Figure 8 shows the value of the Grubel–Lloyd index for various regions of the world over time. Intra-industry trade has risen for every region. However, note that the value of the index is the highest and has grown the most for trade among high-income countries. For trade between high-income and developing countries, the index has remained low over time.

As Table 3 shows, intra-industry trade varies significantly by industry or sector of the economy. For the US in 2009, the highest value of the IIT index was 0.97 for the metalworking manufacturing, compared to a value of the index of 0.10 for footwear manufacturing (data from Krugman *et al.*, 2012, p. 169).

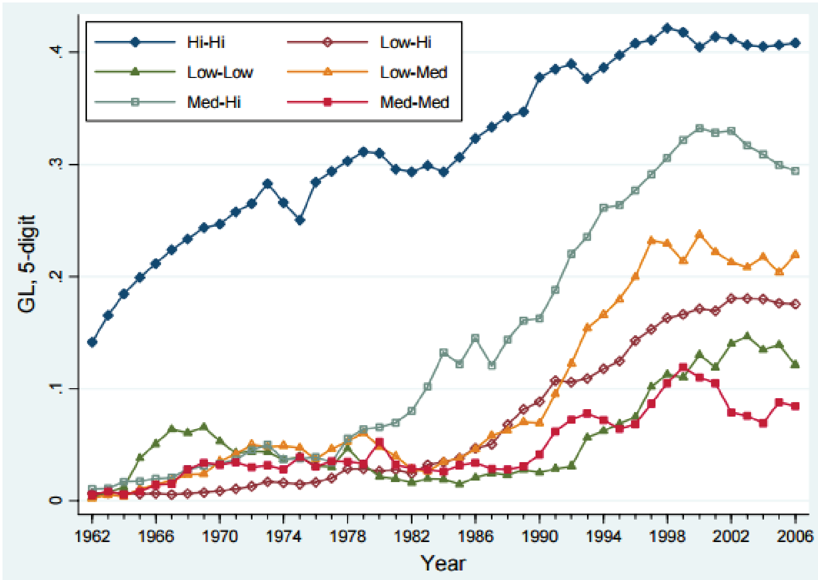


Figure 8. Grubel–Lloyd Index of intra-industry trade, by regions of the world.

Notes: Country grouping according to World Bank categorization.

Source: Brülhart, M. (2008), p. 28.

Table 3. Index of intra-industry trade for US industries, 2009.

Industry	Grubel–Lloyd index
Metalworking Machinery	0.97
Inorganic Chemicals	0.97
Power-generating Machines	0.86
Medical and Pharmaceutical Products	0.85
Scientific Equipment	0.84
Organic Chemicals	0.79
Iron and Steel	0.76
Road Vehicles	0.70
Office Machines	0.58
Telecommunications Equipment	0.46
Furniture	0.30
Clothing and Apparel	0.11
Footwear	0.10

What explains intra-industry trade? Although technology differences and factor endowments can play a role in explaining intra-industry trade, as in the Ricardian and the H–O models (see Davis, 1995), researchers have recognized that the classical and neoclassical theories of trade are based on assumptions that leave a wide abyss in terms of explaining intra-industry trade. The assumptions are that (1) the market structures characterizing the trading economies are perfectly competitive, (2) production occurs under constant returns to scale, and (3) the goods produced and consumed are homogenous, without any differentiation in product characteristics within each sector (no different brands or varieties, just a generic brand X). Relaxing any one of these assumptions can help explain intra-industry trade.

For example, if instead of perfect competition one assumes the presence of an oligopolistic market structure, then exports and imports of the same commodity can be easily explained. In this case, the profits that are enjoyed by the few producers of the industry in the domestic and foreign economies under autarky provide an incentive for foreign firms to enter the market so as to undercut and share in the profits of the local firms. Since both domestic and foreign firms will seek to enter the other countries' territories, trade in the same product will be generated. This phenomenon, called cross-hauling is the result of profit-seeking by firms in an oligopolistic market structure (see, for example, Brander and Krugman, 1983).

The most popular approach seeking to explain intra-industry trade recognizes that much of this trade involves differentiated products within an industry, not identical ones. The US, for example, imports and exports all types of footwear involving wide varieties of shoes, sneakers, etc. US exports and imports of footwear are thus composed of slightly different goods, even though all form part of the same industry. Sneakers buyers, for instance, have been shown to be highly fashion-conscious, differentiating among brands on the basis of their style, designer names and athlete sponsors, a reason for the growing intra-industry trade of brands like Nike and Converse (US companies), Fila, Testoni and Berluti (Italy), Puma, Adidas and Reebok (Germany) and Asics (Japan), among many others. In these markets, countries specialize in producing particular varieties of goods within the industry, and consumers in each country buy both domestic and foreign brands, generating intra-industry trade on that basis. So we observe US residents buying US converse sneakers as well as importing Adidas, just as Americans import Swiss chocolates, while Swiss residents buy Hershey's, and Italians buy BMWs while Germans buy Fiats.

The hypothesis that product differentiation within certain industries can explain trade has a long history and lies at the center of Swedish economist Staffan Linder back in the early 1960s (see Linder, 1961). Based on his analysis, he hypothesized that countries with similar consumer preferences would develop similar industries producing differentiated products that they would trade with each other. This has become known as the Linder hypothesis. It serves as the basis for much of the new international trade theory, as shown in the next section.

Monopolistic competition and the gains from intra-industry trade

The market structure that best describes the characteristics of intra-industry trade is monopolistic competition. Markets under this category are extremely competitive (as opposed to monopoly or concentrated oligopolies) and free entry places stringent restrictions on the monopoly power — and thus profits — of each firm. At the same time, a certain degree of monopoly power does exist, as the differentiated nature of each producer's good provides it with an ability to influence at least some consumers to buy its product relative to others.

In order to have a market structure where product diversity — that is, the presence of different kinds or varieties of products in a given industry — is important, consumers in the economy must value such diversity. In other words, consumer behavior must be such that it allows consumers in any given country to prefer greater variety to less. Traditionally, such tastes toward variety were not taken into account: consumers in the traditional Ricardian and H–O–V models are assumed to value only quantity consumed of a product. Using a standard Cobb–Douglas utility function for the domestic economy, consumers in the traditional trade models only care about the quantities consumed

$$U = U\,(C_1, C_2) = C_1^{\alpha}\, C_2^{1-\alpha}, \tag{4}$$

where U is utility, C_1 and C_2 are domestic quantities consumed of the two products, 1 and 2, and α is a parameter between 0 and 1, connected to relative tastes toward each product and equal to the share of commodity 1 in total expenditure. Since goods are assumed to be homogeneous, it does not matter — within the Ricardian and H–O–V frameworks — whether there are additional brands or not: they are all the same.

We know, however, that in reality consumers differentiate sharply among brands, even when they are almost identical except for shape, size, or color. Additional varieties are thus welcomed by consumers since they allow them to acquire a variety closer to what they would ideally want. Suppose then that product differentiation is an important issue for consumers of industry 1. One approach to incorporating these tastes toward variety into the analysis is to postulate the following sub-utility function for products in industry 1:

$$U_d = \left(\sum_{i=1}^{n} C_i^{\sigma} \right)^{1/\sigma}, \quad 0 < \sigma < 1, \tag{5}$$

where U_d is a sub-utility function for consumption of the n differentiated products in industry 1, and C_i is the consumption of each different product, where there are n varieties in that industry. This sub-utility function is assumed to be of the CES type, with $0 < \sigma < 1$, a parameter to be interpreted shortly. Note that the sub-utility function U_d replaces the homogenous consumption C_1 in the utility function U presented in Equation (4):

$$U = U_d^{\alpha} C_2^{1-\alpha}. \tag{6}$$

Given the symmetric way in which consumption enters the utility function, and under the simplifying assumption that, from the production side, costs and therefore the prices of the products in the industry are equal to each other, then the amount of each differentiated product consumed in industry 1 is equal for all $i = 1, \ldots, n$. As a result, the aggregate quantity demanded of differentiated products is equal to

$$C_1 = \sum_{i=1}^{n} C_i = nC_i.$$

Equation (5) can then be transformed into

$$U_d = C_1 n^{(1-\sigma)/\sigma}. \tag{7}$$

Inserting this expression into Equation (6) yields a utility function that incorporates product variety:

$$U = n^{\alpha(1-\sigma)/\sigma} C_1^{\alpha} C_2^{1-\alpha}. \tag{8}$$

Equation (8) states that domestic utility is related to the quantities consumed of goods 1 and 2 and, in addition, to the number of different varieties of good 1 consumed in the country, n. That the number of products available in the industry has an effect on utility independent of that of their quantity consumed, C_1, is an outcome of the form of the sub-utility function for products in industry 1 and reflects the presence of product differentiation. As mentioned earlier, a rise in the number of types of good 1 available increases utility, even if the total quantity demanded in the industry remains the same. This is because the goods in sector 1 are different from each other and consumers value the product variety.

The parameter σ is positive, indicating that the sub-utility function U_d is concave and that increased variety in sector 1 results in increased utility $(\partial U/\partial n) > 0$. As the value of σ goes to 1, however, the exponent of the number of differentiated products, n, in Equation (8) approaches zero and the influence of n on U disappears. The reason is that, as σ goes to 1, the sub-production function, U_d becomes the simple sum of the quantities consumed. That is, in this case, the products in sector 1 become perfect substitutes for each other. With homogeneous consumption there is no influence of the number of goods on utility, only total quantity demanded, C_1, has an impact. On the other hand, as the value of σ declines toward zero, the exponent of n in Equation (8) increases, and the importance of diversity becomes more significant (the exponent of n rises).

This framework can be used to examine the nature of the gains from trade when the market structure is characterized by monopolistic competition (see Krugman, 1979; Helpman, 1981), Suppose then, that both under free trade and under autarky, the total quantity consumed of the two industries remains unchanged (and at the same prices). The traditional gains from trade in such a case would be zero. However, if trade increases the number of varieties of industry 1's products available to domestic consumers, then utility still increases, as an increase of n in equation 1 raises utility. In other words, even if the overall quantity consumed by consumers stays the same as it is under autarky, the rise in the number of different goods available for consumption increases the utility of consumers. This makes it clear that international trade provides consumers with extra gains in the form of increased product variety.

There is now substantial empirical evidence showing that the gains from international trade due to rising variety are substantial. Broda and Weinstein (2006) use disaggregated data for US imports to show that the number of imported varieties increased by a factor of 3 in the period of 1972–2001. They compute the gains from trade for the US and conclude that "growth in product variety from US imports has been an important source of gains from trade over the last three decades (1972–2001)." The analysis is extended to a variety of countries by Ossa (2015), which calculates the gains from trade relative to autarky. He finds that the median gain from trade in varieties across all countries in his sample is 55.9% of GDP. The country with the highest gain is Belgium at 505.2% of GDP, reflecting the greater importance of trade in differentiated products for small countries, which do not have much access to local varieties under autarky. The fact is that, for any economy, the gains from trade tend to be greater the larger the proportion of trade in the country's total expenditures. For instance, Ossa also finds that the gains from trade in varieties as compared to autarky are 30.8% of GDP for China, 35.3% for France, and 21.4% for Japan, which are substantial but significantly lower than for Belgium (for additional empirical research on the gains from trade due to increased product variety, see Feenstra, 2010, 2018).

Economies of scale, geography and trade

Traditional trade theory — Ricardo and the H–O–V models — assumed constant costs or constant returns to scale. But one of the building blocks of the so-called new trade theory is to consider how economies of scale can provide an explanation for trade and its potential gains. The underlying idea is that trade increases the extent of the market and, in the presence of economies of scale, countries gain by specializing in producing — and exporting — those products in which they have their own comparative scale advantages. At the global scale, it just does not pay for each country to produce everything because by specializing in a set of different or differentiated products, each country — and the world — can produce everything at a lower average cost. Everybody gains by the increased scale of production implied by specialization in a limited set of products and importing the others from foreign countries.

The nature of the economies of scale facing a country can vary. They can be in the form of internal economies of scale, through which specific firms in an industry achieve lower average costs as they raise their production. The economies in this case may arise because the increased firm size allows more productive technological and organization structures, such as increased division of labor within the enterprise, as displayed, for instance, by assembly plants (see the empirical evidence on the presence of economies of scale by Antweiler and Trefler (2002)). Or the productivity advantages can be in the form of external economies of scale, in which the growth of an industry allows producers within the industry to face lower average costs. This is the case when firms agglomerate in one place, generating the proliferation of business services and specialized workers in that location which can then target the specific needs of the industry, making all firms more productive (see Rivera-Batiz, 1988a,1988b; and the recent survey by Venables, 2019).

The origins of economies of scale may also be linked to historical circumstances or connected to geography. The clusters of high-technology firms in Silicon Valley, Route 128 in Boston, or the Research Triangle Park in North Carolina originate in the universities and the consequent clustering of human capital in those locations (see Saxenian, 1994). The growth of finance in New York City can ultimately be connected to the expansion of this sector linked to the role of NYC as a major port in the US (due to its unique geographical location and enhanced by the construction of the Erie Canal in the 19th century), the associated financial operations generated by world commerce, and the customs receipts deposited in *Wall Street* by the federal government when the city was growing.

The effects of geography on trade are more starkly revealed when one considers the influence of transportation costs. This is an area that has been examined by economists for centuries, going back to Adam Smith. However, research was boosted by economists Walter Isard (1954) and Jan Tinbergen (1962) when they proposed the *gravity model of trade*. As the name suggests, the theory was based on Newton's theory of gravitation and suggests that the bilateral trade flow — exports and/or imports — between two countries i and j is proportional to the economic size of the two economies (their "mass"), M_i and M_j, and inversely proportional to the distance between them, D_{ij}. More specifically, the gravity equation can be represented in its simplest form as follows:

$$T_{ij} = G\ [M_i M_j / D_{ij}], \tag{9}$$

where G is the equivalent of the gravitational constant in the physics theory and represents the influence of forces other than "mass" and distance on international trade. Note that the influence of the economic mass of each country on trade can be represented by income or GDP, and the model thus predicts that higher domestic income or GDP is connected to greater imports, while increased foreign income leads to higher foreign imports (increased domestic exports). Overwhelming evidence exists supporting these predictions, as measured by marginal propensities to import.

The effects of distance on trade are closely connected to the role played by transport costs. Greater distance involves higher costs in transporting goods and services and this discourages both exports and imports (Hummels, 2007). This is magnified when a country is landlocked or does not have close access to navigable rivers or lakes, which further makes trade more costly (Gallup and Sachs, 1999).

But geography is not the only factor that influences transport costs. These can be connected to government policies. As an example, consider a case linked to US policy (the following is based on Bergstresser and Melitz, 2017). The Merchant Marine Act of 1920, often referred to as the Jones Act, requires that shipping between US ports (including Alaska, Hawaii, Guam, and Puerto Rico) occur on US-flagged ships built in the US, owned by US citizens, and carrying a crew of at least 75% US citizens or permanent residents. The US government's rationale for the Jones Act is that these restrictions are security-oriented, to prevent domestic trade disruptions in case of war, which may cause foreign-owned suppliers to cut their US operations. But some believe it is also a policy intended to protect the US maritime sector.

The Jones Act substantially raises the cost of transportation between American ports. For example, according to the Congressional Research Service, the cost of shipping crude oil from Texas to refineries in the East Coast is $5–6 per barrel, way over the $1.20 cost of moving a barrel of crude oil from Eastern Canada to the same refineries, the $1.45–1.70 from Nigeria, or the $1.90 from Saudi Arabia. A study by the Federal Reserve Bank of New York found that, in 2012, the shipping cost for a 20-foot container from Florida to Puerto Rico was $3,063, but only $1,503 for the same container from Florida to the Dominican Republic, which is very close to Puerto Rico. On this basis, the Jones Act makes trade more expensive between the continental US and Puerto Rico, possibly discouraging exports — and economic growth — on the Island.

The connection between trade and transport costs postulated by the gravity model can be obtained from a variety of theoretical frameworks (see Bergstrand, 1985; Anderson, 2011, 2016; Head and Mayer, 2014). And it is also widely supported by the empirical evidence (see, for example, Frankel and Romer, 1999). Figure 9 presents data for France showing the relationship between distance and

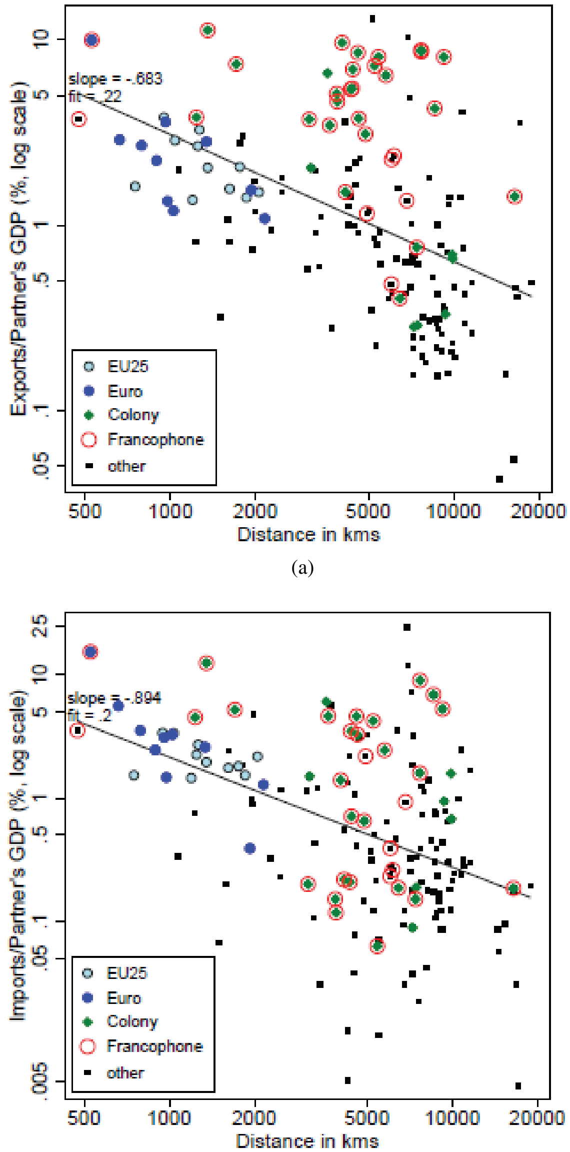


Figure 9. The impact of distance on international trade, France 2006. (a) French exports and the distance of trade partners. (b) French imports and the distance of trade partners.

Source: Head and Mayer (2014).

trade for a sample of partner countries in 2006 (Head and Mayer, 2014). The diagram shows the distance of France from the partner country in kilometers in the horizontal axis. The vertical axis — in a logarithmic scale — shows the share of exports to France as a percent of the partner country's GDP (Figure 9(a)) as well as the share of imports from France as a percent of the partner country's GDP (Figure 9(b)).

The figure depicts the strongly negative relationship between physical distance and trade for France and its trading partners in 2006. It also shows that, holding constant distance, there appears to be more bilateral trade between France and its Francophone trading partners, particularly former colonies. This is one of the factors that would be included in the variable G in the gravity equation, which reflects factors other than distance and "mass" influencing trade.

Governance, institutions and trade

Following the gravity equation, another factor absorbed by the variable G is the quality of public sector governance of the country. The role played by domestic institutions in providing a source of comparative advantage has been noted for a long time. In fact, if one considers the Ricardian model and its assumption that England had a relative productivity advantage in producing cloth, a main reason for this is the fact that government institutions had favored industrial development in that country in the 19th century, thus hosting its industrial revolution.

The quality of government institutions reflects a wide range of virtues and vices. These include the efficiency of government bureaucracies (how quickly they process import and export permits, the grating of licenses, etc.), the rule of law (protection of contracts, property and intellectual rights, the strength of its police and court systems, etc.), the control of corruption, the extent of transparency and accountability, etc. By affecting the costs of production, poor governance can have a devastating impact on an economy (see Rivera-Batiz, 2002). But if there are some sectors of the economy that are more sensitive to the quality of institutions, then governance will also affect the comparative advantage of a country in producing those products. For instance, goods and services that are part of global value chains (GVCs) require an abundance of transactions and contracts involving the shipment and trade of intermediate goods and services, raw materials and final goods. Countries with poor governance would find it costly and cumbersome to export such transactions-intensive products, while countries with good governance would have a comparative advantage in producing them. More formally, Nunn (2007) has constructed an index of "contracting intensity" to focus on those sectors that are more likely to be affected by poor governance. He finds that manufacturing sectors such as aircraft manufacturing, automobiles and heavy vehicles, and electronics have a high contracting intensity, while others such as petroleum refineries, flour milling, coffee and tea manufacturing, have low contracting intensity. Such differences can then explain the comparative advantage of countries and their export patterns.

At the theory level, Levchenko (2007) models the impact of quality of institutions on comparative advantage by introducing it as a domestic distortion. Others — focusing on the role of corruption — have considered poor governance as a tax on domestic business, which can affect different sectors differentially (see Rivera-Batiz, 2002). Yet, others have examined labor market rigidities in determining patterns of comparative advantage (Cunat and Melitz, 2010).

Empirically, various research studies have shown the importance of institutions in determining comparative advantage and trade. For instance, Nunn (2007) uses his index of contracting intensity and finds "that countries with better contracting institutions export relatively more in contract-intensive industries. Quantitatively, these effects of institutions on comparative advantage are greater than the combined impacts of skill and capital endowments." Feenstra *et al.* (2012) use provincial data for China using Nunn's (2007) contract-intensity measure in finding strong effects of contract intensity on inter-provincial comparative advantage and trade. Other authors have used alternative measures of governance in examining how they affect comparative advantage, from surveys and indexes developed by the World Bank, corruption indexes such as the Corruption Perception Index, etc. (Dutt and Traca, 2010; Nunn and Trefler, 2014). They corroborate the significance of governance in determining trade. And Lopez and McQueeney (2020) show how foreign trade facilitation, that is, policies that seek to reduce cumbersome, bureaucratic government controls over commerce, can raise exports.

Firms, productivity and international trade

The traditional view of international trade is that countries produce, consume, and trade final products, from shoes and computers, to wine and cloth. But in reality, only about 30% of all goods and services traded globally represent final goods. Close to 70% of world trade consists of intermediate goods and services, that is, goods and services that are produced but then need to be added to or assembled into final products, which are then sold to consumers.

Figure 10 shows the exports and imports of the European Union (EU) to the rest of the world in 2018, decomposed by the type of product. Close to 50% of exports and over 60% of imports are accounted by intermediate goods, as compared to capital goods, consumption goods, and others.

Within the EU, Figure 11 shows the rising significance of intermediate goods trade between Poland and Germany in the period of 2000–2015. By 2015, exports of intermediate trade goods dominated the volume of exports from Poland to Germany.

This trade occurs through global value chains (GVCs), which link the supply of goods and services worldwide into the assembly of final products. It makes international trade a much more complex phenomenon than the classical and

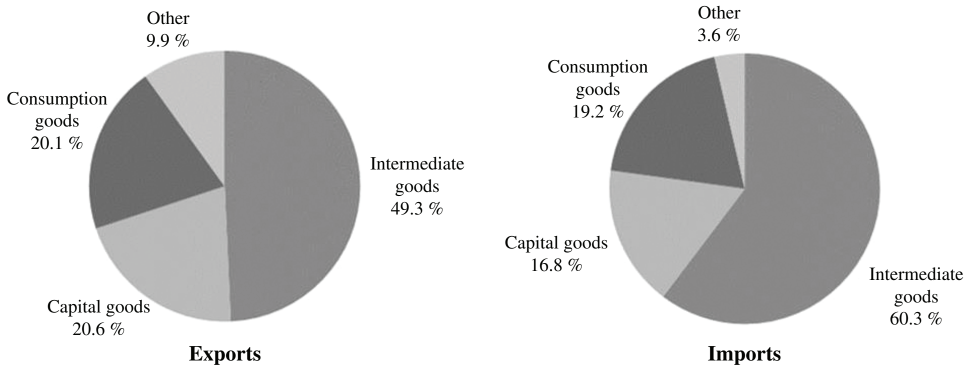


Figure 10. Trade in intermediate goods of the EU-28 with the rest of the world, 2018 (% of total).

Source: Eurostat.

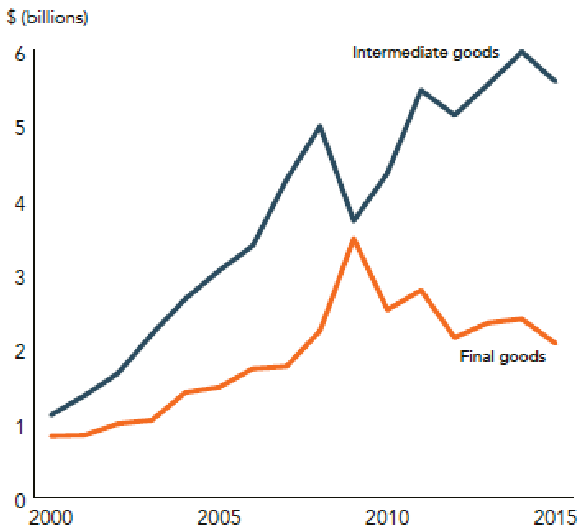


Figure 11. Poland's exports of final and intermediate goods (motor vehicles) to Germany, 2000–2015.

Source: Organization for Economic Co-operation and Development Bilateral Trade in Goods by Industry and End-use database. International Standard Industrial Classification, Revision 4 (2016 edition).

neoclassical theorists ever imagined. And policymakers often fail to understand the complexity of interactions between domestic producers of final goods and the wide array of domestic and foreign suppliers that leads to the final assembly and sale of those products.

Of course, the theories discussed earlier are still highly relevant to the location of economic activity in these global value chains. The location of the different links of those chains often depends heavily on comparative advantage, whether it is connected to technology differences across countries or cheap local inputs connected to factor abundance (see Rotunno *et al.*, 2015). But other forces become significant as well. Geography and efficient transportation links, existing technological infrastructure and internet connectivity, speedy customs clearance and transparency, reduced bureaucracy, all are factors that have greater impact on GVCs, which depend on the back-and-forth movement of intermediate and final goods. Trade in services — and its determinants — becomes essential as well since many of the components in manufacturing production are not just industrial parts but service based.

What is important to recognize of trade through GVCs is that there is a wide variety of countries involved in the production of a final product. The various intermediate goods and services are produced in different countries and each retains some value added and benefit from the chain. It is therefore essential for a country to be connected to these GVCs in order to be involved in the production of final goods. And the thing is that a country's involvement in trade through GVCs is often invisible in traditional trade statistics, which measure gross exports and imports, attaching the full value of a good or service to the last country in the chain that assembled the product and exported it.

GVCs are organized essentially by multinational firms. Therefore, international trade generated by these firms is closely connected to the strategies of multinationals (see the survey by Antras and Yeaple, 2014). This brings out a critical issue that was ignored by traditional trade theory: countries do not export, firms do. Both the Ricardian framework and the H–O–V theory assume that there is just one, homogeneous representative firm in the economy. Recent research has focused on examining the heterogeneity of producers within an industry and the characteristics of export firms. This follows earlier approaches that had studied in detail the strategies followed by firms and governments in oligopolistic markets where market power is a motivator for trade. An outcome of this earlier research was that government policies oriented to provide advantages to domestic firms in global trade, such as production subsidies, could be a strong motivator for protectionism. Such strategic trade policy, as it has become known, does not emerge in the Ricardian and H–O–V models, which assume perfect competition. The game-theoretic behavior of large firms involved in international trade competition has become a staple in the field (see Oliva and Rivera-Batiz, 2013).

The more recent literature on firm heterogeneity provides evidence showing that there is remarkable variation within industries in terms of firm size, productivity, and other characteristics, depending on whether the firms are export-oriented or not. Export firms, for example, tend to be larger, have greater productivity, are more capital and skill-intensive, and pay higher salaries than non-exporters within the same industry (see Bernard *et al.*, 2003, 2004; Melitz, 2003). Furthermore, multinational firms forming the backbone of GVCs, which both import and export products (generally importing components and exporting final goods) tend to display the highest productivity of all (Bernard *et al.*, 2009).

In terms of the impact that trade has on the economy, both the Ricardian and H–O–V theories emphasize the reallocation of production among industries in the economy. But the recent evidence shows that much of the observed reallocation of production in the aftermath of trade liberalization is found to occur among firms within industries (see, for example, Pavcnik, 2002; Bernard *et al.*, 2003; Melitz and Redding, 2014). The focus on firm heterogeneity introduces a new source of the gains from trade: Trade liberalizations are often accompanied by the exit of low productivity firms and the expansion of high-productivity ones, which raises domestic aggregate productivity and national income. This process has been referred as "creative destruction".

As in the inter-industry reallocations of the Ricardian and H–O–V models, the intra-industry reallocation of production among firms means that trade can have significant negative effects on the less-productive firms and their workers. Although the greater overall productivity of the economy means that trade provides net gains, there are still painful adjustment costs for specific firms and workers.

Evidence showing the effects of trade on the distribution of firms within industries has grown over the years. Trefler (2004), for example, examined the impact of NAFTA on Canadian industries. He concludes, "the FTA [free trade agreement] led to large labor productivity gains. For the most impacted, export-oriented group of industries, labor productivity rose by 14% at the plant level. For the most impacted, import-competing group of industries, labor productivity rose by 15% with at least half of this coming from the exit and/or contraction of low-productivity plants" (Trefler, 2004, p. 887).

But what is it about exporting or participating in trade that leads to the reorganization of an industry toward more productive firms? One explanation is the so-called pro-competitive effect of trade, an idea that goes back to Adam Smith. At the theory level, in a market structure of imperfect competition, such as with monopolistic competition, the availability of more competitors — domestic and foreign — reduces the monopoly power of each firm and forces them to reduce the markups they charge in price relative to marginal costs (see Helpman and Krugman, 1989; Helpman and Krugman, 1989, and Rivera-Batiz, 1996, reprinted in Rivera-Batiz and Rivera-Batiz, 2018; Edmond *et al.*, 2015, among others). The empirical evidence on the significance of the pro-competitive effects of trade has been mixed. On the one hand, the research of Edmond *et al.* (2015), Jaravel and

Sager (2018) and Hsu *et al.* (2019), as well as that of others find significant effects of international competition in reducing price markups. On the other hand, Arkolakis *et al.* (2019) report that the evidence is "elusive" in finding such positive effects of trade in their own empirical work.

Another mechanism explaining the positive productivity effects of trade is more dynamic in nature. It suggests that the rivalry and increased competition brought about by foreign producers under free trade force domestic producers to maintain or increase their productivity, as they otherwise would not survive in the global market. As Michael E. Porter concludes in his far-ranging study of how firms are forced to sustain their competitive advantage in the face of foreign competition, "Competitive advantage emerges from pressure, challenge and adversity, rarely from an easy life. Pressure and adversity are powerful motivators for change and innovation … Complacency and an inward focus often explain why nations lose competitive advantage. Lack of pressure and challenge means that firms fail to look constantly for and interpret new buyer needs, new technologies, and new processes … Protection, in its various forms, insulates domestic firms from the pressure of international competition" (Porter, 1990, pp. 170–171 and 665). The economist F.M. Scherer has also noted that "even the most casual observer cannot escape noticing the invigorating effect rivalry commonly has on industrial firms' research and development efforts" (Scherer, 1986, p. 83). Other approaches focus on how trade widens market size and allows firms to spread the fixed costs of investing in new technologies, something difficult to do with the more limited domestic market. And the opening of international trade allows multinational firms to use GVCs to institute new, more productive ways of assembling and exporting final goods through the use of an increasing number of imported intermediate goods (Goldberg *et al.*, 2010).

Recent evidence confirms these hypotheses regarding the effects of trade on innovation. For example, Bloom *et al.* (2016) use panel data from 12 European countries from 1996 to 2007, to conclude that innovation increased within the firms most affected by Chinese imports in their output markets and reallocated employment between firms toward more technologically advanced firms. On the other hand, it is also true that export firms at the lower-end of the productivity distribution may find it more difficult to continue investments in research and development in the face of the lower markups and reduced profits connected to the competition of foreign firms under free trade. The empirical evidence tends to confirm this as well.

Aghion *et al.* (2018) have examined the innovative activities in French manufacturing during the period of 1995–2012. They catalog an exporter as a firm that had exported once in the period of 1995–2012, and an innovative firm as one that had filed at least one patent application in the same time period. The paper

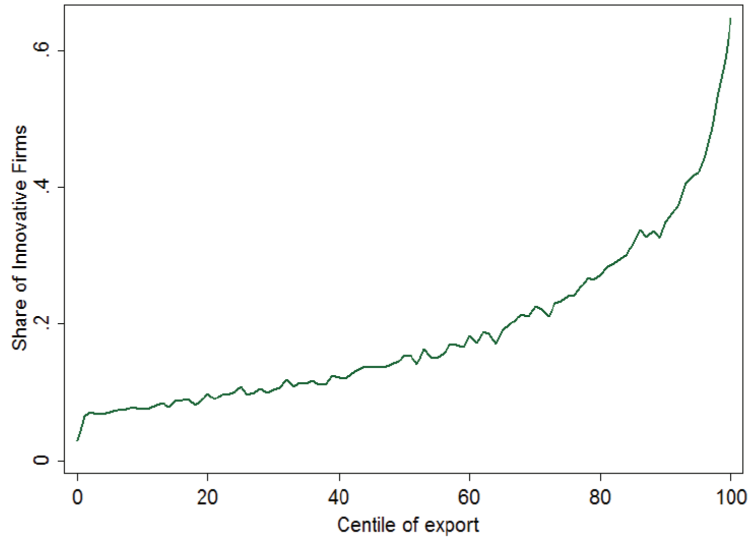


Figure 12. Exports and innovation: France manufacturing firms, 1995–2012.

Notes: Centiles of exports are computed each year from 1995 to 2012 separately and then pooled together. For each centile, we compute the share of innovators. Each centile contains the same number of firms, except for centile 0 that contains all the firms with no export. Manufacturing firms only.

Source: Aghion *et al.* (2018).

specifically seeks to determine a causal connection between increased exporting and innovation, that is, a causality going from higher exports to more innovation, not the other way around, as their statistical analysis is oriented to establishing this causal effect. Figure 12 shows the connection between firms that are higher in the distribution of exports in French manufacturing (have a higher percentile in the export distribution) and the share of those firms in that percentile that are innovators. It shows that there are more innovators among the export-intensive firms. Based on their empirical analysis of patent, customs, and production data covering French manufacturing firms, Aghion *et al.* (2018) conclude, "patenting robustly increases more with export demand for initially more productive firms. [But] this effect is reversed for the least productive firms."

It should be emphasized that once economies of scale, product market imperfections and innovation are introduced into the analysis, and given the diversity of firms within industries, the gains from trade become more complex than in the traditional trade theories. The debate on these issues goes back even to economists Frank Graham, Frank Knight, Jacob Viner, and others in the early 20th century. The idea is that the opening to free trade may result in the contraction of domestic firms operating under increasing returns to scale, raising their average cost and causing losses. Similarly, if trade induces countries to specialize in sectors that have naturally very low rates of innovation — such as commodities like crude oil, diamonds, copper, coffee, etc. — then even if in the short run trade generates net gains, the long-run impact may be negative, as the country's innovation rate declines relative to autarky. This point has been made in relation to the natural resources curse, which points to the widespread evidence that countries specializing in exporting natural resources have lower rates of innovation, intra-industry trade, etc., than other countries (see Sachs and Warner, 1995; Frankel, 1999).

The notion of dynamic comparative advantage, the idea that countries should specialize in — or at least diversify into — producing and exporting goods that have greater potential in terms of innovation instead of those that can be produced at a lower relative cost in a static context, has existed for a long time (see Papageorgiou *et al.*, 2020). The case of South Korea is often mentioned. At the start of its development push, the country was considering production of an integrated steel mill and it was felt — even by institutions such as the World Bank — that the infrastructure requirements and the large scale of such a venture made it unfeasible and not an industry in which South Korea had a comparative advantage (Amsden, 1989). Yet, the South Korean government differed and founded the Pohang Iron and Steel Company with substantial investments and subsidies. The company rapidly became one of the lowest cost producers in the world, outcompeting Japan, the US, and most other countries. Columbia University economist Joseph Stiglitz puts it bluntly: "What matters is *dynamic* comparative advantage, or comparative advantage in the long run, which can be shaped. Forty years ago, South Korea had a comparative advantage in growing rice. Had it stuck to that strength, it would not be the industrial giant that it is today. It might be the world's most efficient rice grower, but it would still be poor" (Stiglitz, 2012).

Theories of dynamic comparative advantage have been presented over the years (see, for example, Bruno, 1970; Redding, 1999). The idea that comparative advantage can change over time, both in response to shocks but more importantly due to endogenous forces, including government policies, is widely recognized. It is consistent with the view that technological change is endogenous, responding to a variety of economic forces (Romer, 1990). In the face of endogenous technological change, international trade patterns can both be influenced by such changes in technology but trade itself can also serve as a stimulus to technical change, as it was noted earlier (see also Rivera-Batiz and Romer, 1991; Rivera-Batiz, 1996).

The notion that comparative advantage can be influenced and changed has given rise to the adoption of so-called industrial policies. Industrial policies seek to shift trade patterns from industries that have a static comparative advantage but have minimal growth potential to those that may have a dynamic comparative advantage and therefore strong long-run growth prospects (Stiglitz, 2016). These policies are controversial and the evidence on them is mixed. First, the potential for economies of scale and/or innovation in industries is difficult to predict *ex ante*. The evidence of failed projects of this nature abounds. Furthermore, the economies of scale that produce greater innovation in some sectors may rely on the growth of knowledge networks and other competitive advantages provided by the agglomeration of related firms in a particular location, often an urban area. But these advantages depend on the availability of human capital, infrastructure capital, and supportive technologies (from urban transportation networks to internet connectivity). This brings the discussion back to the issues of technology and factor endowments as determinants of comparative advantage, as emphasized by traditional trade theory, albeit in a more complex environment.

The debate here is best exemplified by the back-and-forth arguments that have been made by the so-called infant industry argument. Used to justify protection for domestic industries in formation, the infant industry argument goes back to Alexander Hamilton, Friedrich List, and John Stuart Mill. The last one, in particular, noted that in the presence of dynamic learning effects, it might benefit a country to protect a new industry so that it can "grow" and reduce its average costs, before it is wiped out by existing, lower-costs foreign imports. Most economists that accept this premise emphasize that the protection must be temporary, as otherwise it may foster long-term dependency and reduce future innovation efforts (a topic discussed earlier), In addition, the protection should involve production subsidies rather than tariffs (which distort consumption and are more costly to impose), and the potential revenues generated by the government investment must exceed its costs (see Baldwin, 1969; Bardhan, 1971; Melitz, 2005).

Conclusions

This chapter has presented a survey of the key theories that have been developed over the years to explain the causes and consequences of international trade and the evidence supporting them.

The classical theory of trade, as presented by David Ricardo, emphasized that relative technological differences between two countries can generate trade on the basis of comparative advantage, and that this trade benefits all the partners involved, raising their economic welfare and national income compared to autarky or restricted trade. This contradicted Adam Smith's theory of absolute advantage, which concluded that trade between two countries can exist only if each country has an absolute productivity advantage in producing some products but not if one country is less productive than the other in every activity. In the Ricardian framework, a country can still gain from trade even if its productivity in every sector is lower than that in the other country. Ricardo showed that if two countries are considering trade in two products and they specialize in producing and exporting the product in which they have their highest relative productivity — in which they have a comparative advantage — then trade will lead to gains for both countries no matter what their productivities are.

Early empirical evidence on the Ricardian framework generally supported it. But the difficulties of extending the theory to a multi-country, multi-product world complicated the empirical work. There is also the fact that, if countries specialize in producing some products and do not produce others as a result, as predicted by the Ricardian framework, then no data can be observed on the productivities of sectors that do not exist and the theory cannot therefore be tested. These problems forced both the theory and the empirical testing of the Ricardian framework to dwindle.

As analysis using the Ricardian framework declined, a new approach gained attention: the H–O theory. The Ricardian theory focused on how relative differences in technology (relative productivity) generate trade. The H–O theory, instead, assumed that technologies across countries are identical but proposed instead that differences in relative factor endowments — in labor and capital specifically — determine patterns of comparative advantage across countries. The H–O theorem stated that under free trade countries with relative abundance of a factor of production would tend to specialize and export products that use that factor intensively.

The H–O theory was challenged by a number of empirical studies that found the data was inconsistent with the conclusions of the theory. Key among these studies is what came to be known as the Leontief paradox. In his test of the H–O theory using data for the US, Wassily Leontief found US exports were relatively labor-abundant, even though the country is relatively abundant in capital. Despite a rash of studies proposing explanations for the Leontief paradox, both at the theory level and in terms of the empirical data, much skepticism was raised over the years about the theory.

But although both the Ricardian theory and the H–O model have been declared dead by economists over the last 50 years, the reality is that these theories follow well the dictum of Mark Twain who, after hearing the rumors that he had died — including a newspaper that printed his obituary — was heard to have said, "The reports of my death are greatly exaggerated."

Both theories remain standing and have been resurrected by recent empirical evidence that supports their insights, once they are extended to incorporate the existence of many factors of production, goods and countries, inter-country variations in production functions, and hold constant other factors that can also explain trade patterns.

The resurgence of the Ricardian and H–O models started with further theoretical analysis that addressed the empirical findings challenging them. Since the frameworks were developed using a simple model with at most two factors of production (labor in the Ricardian model, labor and physical capital in the H–O model), two countries and two sectors of production, various theories extended both the Ricardian and H–O models over time to make them more realistic and to incorporate additional forces affecting trade, such as the complexities introduced by many factors of production, many sectors, and multiple countries. Empirical evidence on these modified or "hybrid" models, such as the Ricardian model with a continuum of goods and the H–O–V model, has grown over the years. As noted in this chapter, the research generally supports the idea that both technology differences and relative factor endowments — of physical and human capital, unskilled labor, etc. — affect trade patterns, particularly between high-income and developing countries.

The chapter also discusses the more recent theories on the causes and consequences of trade, referred to as the "new international trade theory". These theories recognize that the traditional models do not easily explain a large share of global trade called intra-industry trade. The latter refers to exports and imports of different varieties of products within the same industry, as opposed to the inter-industry trade exclusively discussed by both the Ricardian and the traditional and extended H–O–V models. Intra-industry trade is an essential part of global trade, particularly among high-income countries.

The new trade theory seeks to explain intra-industry trade within the context of imperfect competition, including models of oligopolies and monopolistic competition. It also examines how economies of scale affect trade. The nature of the economies of scale facing a country can vary. They can be in the form of internal economies of scale, through which specific firms in an industry achieve lower average costs as they raise their production. The economies in this case may arise because the increased firm size allows more productive technological and organizational structures, such as increased division of labor within the enterprise. Or the productivity advantages can be in the form of external economies of scale, in which the growth of an industry allows producers within the industry to face lower average costs. The origins of economies of scale may also be linked to historical circumstances or connected to geography.

The effects of geography on trade are most starkly revealed when one considers the influence of transportation costs. The chapter discussed the best-known theory on the role of transportation costs on trade, the so-called gravity model. As the name suggests, the theory was based on Newton's theory of gravitation and suggests that the bilateral trade flow — exports and/or imports — between two countries is proportional to the economic size of the two economies (their "mass") and inversely proportional to the distance between them. As discussed in the chapter, empirical evidence on the gravity model overwhelmingly supports it.

The model has also been found to be consistent with a variety of theoretical frameworks.

The assumption of the traditional international trade theory — such as the Ricardian and H–O models — is that countries produce, consume, and trade final products, from shoes and computers, to wine and cloth. But in reality, only about 30% of all goods and services traded globally represents final goods. Close to 70% of world trade consists of intermediate goods and services, that is, goods and services that are produced but then need to be added to or assembled into final products, which are then sold to consumers. The chapter discussed the theory and evidence on trade in intermediate products and the global value chains that integrate their use into the production of final goods. Related to this issue, connected to the many transactions that GVCs must engage in, is the role played by public sector governance in fostering trade and in influencing the comparative advantage of a country in international trade.

The chapter also summarized recent literature examining trade within the context of heterogeneous firms, presenting what some have called the "new new theory of international trade" and the empirical evidence on it. In terms of the impact that trade has on the economy, both the Ricardian and H–O–V theories emphasize the reallocation of production among industries in the economy. But the recent evidence shows that much of the observed reallocation of production in the aftermath of trade liberalization is found to occur among firms within industries. The focus on firm heterogeneity introduces a new source of the gains from trade: Trade liberalizations are often accompanied by the exit of low productivity firms and the expansion of high-productivity ones, which raises domestic aggregate productivity and national income. The recent literature surveyed in the chapter builds on earlier literature that also focused on the strategic interactions among a few firms involved in trade, often using game-theoretic frameworks. This analysis suggests that in oligopolistic markets, governments may have a strong incentive to engage in policies, such as production subsidies, that protect their firms at the expense of those in other countries.

Recent developments in the field examine the notion of dynamic comparative advantage, the idea that countries should specialize in — or at least diversity into — producing and exporting goods that have greater potential in terms of innovation instead of those that can be produced at a lower relative cost in a static context. The case of South Korea is often mentioned, as the government in that country adopted policies of supporting — through subsidies and short-term protection — investments in industrial sectors which from a static viewpoint looked unsustainable but in the long-run displayed substantial cost-reductions and international competitiveness. The use of government policies to support industries that have potentially large future productivity or innovation advantages is controversial but has received support from some empirical evidence.

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