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# Retrospectives
# On the Genius Behind David Ricardo's 1817 Formulation of Comparative Advantage

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This feature addresses the history of economic terms and ideas. The hope is to deepen the workaday dialogue of economists, while perhaps also casting new light on ongoing questions. If you have suggestions for future topics or authors, please contact Joseph Persky, Professor of Economics, University of Illinois, Chicago, at jpersky@uic.edu.

## Introduction

David Ricardo's formulation of comparative advantage is one of the oldest analytical results in economics. In a famous paragraph in the trade chapter of his *Principles of Political Economy and Taxation*, Ricardo (1817 [1966], pp. 134–135) employed what Paul Samuelson (1969) referred to as "Ricardo's four magic numbers":

> The quantity of wine which she [Portugal] shall give in exchange for the cloth of England, is not determined by the respective quantities of labour devoted to the production of each, as it would be, if both commodities were manufactured in England, or both in Portugal. England may be so circumstanced, that to produce the cloth may require the labour of 100 men for one year;

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> and if she attempted to make the wine, it might require the labour of 120 men for the same time. England would therefore find it her interest to import wine, and to purchase it by the exportation of cloth. To produce the wine in Portugal, might require only the labour of 80 men for one year, and to produce the cloth in the same country, might require the labour of 90 men for the same time. It would therefore be advantageous for her to export wine in exchange for cloth.

As far back as Samuelson (1948), the four magic numbers have inspired the basis for numerous textbook treatments of the principle of comparative advantage. Following the lead of James Mill's (1821) reading of Ricardo's famous passage, these numbers have been interpreted as fixed unit labor requirements and have served as a powerful pedagogical device to illustrate the idea of comparative advantage and the gains two countries realize when they move from autarky to trading with each other.

But in a few key respects, the approach Ricardo followed in developing his argument appears at odds with the modern textbook treatment of comparative advantage. Instead of a comparison between autarky and trade, his canonical example starts with the evaluation of an existing trading relationship between England and Portugal. If the numbers are interpreted as labor requirements per unit of output, all four numbers are needed for a relative cost comparison between England and Portugal. However, Ricardo draws a conclusion about England's pattern of trade and its gains from trade based only on the magic numbers for England; he then draws a conclusion about Portugal's pattern of trade and its gains from trade based on the magic numbers for Portugal. His discussion makes no statement about the terms of trade between wine and cloth.[1] The contrast between Ricardo's presentation of comparative advantage and the labor unit requirement interpretation of his thinking has led to a debate in the history of thought literature discussed in Aldrich (2004) as to whether Ricardo really understood his principle.

The recent 200th anniversary of the publication of Ricardo's 1817 statement of comparative advantage offers an opportunity for revisiting the concerns of Ricardo and his contemporaries that motivated his development of the concept of comparative advantage. Our discussion offers a deeper reading of the fundamentals of Ricardo's logic, which viewed trade in goods as equivalent to workers moving across borders. From this perspective, the four magic numbers pertain to the amount of labor embodied in trade. Our account starts with mercantilism and the emergence of the "18th century rule" more than a century prior to the publication of the *Principles of Political Economy*.

[1] By contrast, if one assumes a terms of trade of one between cloth and wine, as Eaton and Kortum do in their recent discussion of Ricardo (in this journal, 2012), then the four numbers become both the labor value of trade and the unit labor coefficients.

## Identifying Why Trade Is Advantageous: From Mercantilism to the 18th Century Rule

The voyages of discovery of the late 15th and 16th centuries that opened up the European conquest of the Americas and the seaborne trade routes to Asia ushered in an era of unprecedented commercial rivalry among the great European powers of the era: England, the Dutch Republic, Spain, Portugal, and France. The trade was conducted either by large monopoly companies such as the British East India Company or by independent merchants. It focused on sugar, tobacco, and indigo from new colonies in the Caribbean and North America; gold and silver from Latin America; and products of the East such as spices, cotton cloth from India, and raw silk from China. The rivalry prompted one-and-a-half centuries of theorizing about how to maximize the benefit that states received from that trade—and finance the extraordinary military expenditures required to successfully compete. The doctrine that emerged and the policy recommendations of the period have become known as "mercantilism." Viner (1937) and Heckscher (1935) are classic attempts to characterize the theory and policy recommendations of mercantilism.

Mercantilist thought was pro-trade, but for mercantilists, the gains from trade emanated from an excess of exports over imports in enough branches of trade to allow the accumulation of the gold and silver bullion required to finance other areas (Irwin 1996, pp. 32–33).[2] The incentives of private traders were not always aligned with those of the state. Both as a response to concerns about overpopulation and a belief that exports of goods that embodied a substantial amount of domestic labor were the best means to secure a surplus, mercantilist trade policy favored exports that absorbed large amounts of labor (Grampp 1952, pp. 467–72; Tucker 1750). That meant promoting exports of manufactures that were among the most labor-intensive industries of pre-industrial economies. The main British export of the early mercantilist period—woolen cloth manufactured from English wool—fit the bill. Mercantilist policy focused on reducing imports of competing manufactures, unless they contributed to enhancing the productive capacity of the state. Instead, imports that used the least amount of labor, such as raw materials or foodstuffs, increased the balance of exported labor and the gains from trade: "When two countries are exchanging their produce or manufactures with each other, that nation which has the greatest number employed in this reciprocal trade; is said to receive a balance from the other; because the price of the overplus labor must be paid in gold and silver" (Tucker 1750, p. iii, as quoted in Viner 1937, p. 53). By contrast, imports of luxuries (French silks or lace) consumed only by the wealthiest classes were to be discouraged since they resulted in a *net* importation of embodied labor.

The idea that imports—not exports—could generate gains from trade first appeared in Henry Martyn's (1701) *Considerations of the East India Trade*. Martyn's

[2]Wilson (1949) notes that England's ongoing construction of a large naval fleet required importation of wood and iron from the Baltic for which it paid with gold and silver bullion.

argument, which appears to have gained few adherents at the time, would re-emerge a century later as a core element of Ricardo's conceptualization of the gains from trade. During the last decades of the 17th century, the British East India Company was importing cotton cloth (calicos) from Bengal, primarily for re-export to the continent and the American colonies. The cotton cloth imports threatened the domestic English woolen industry and prompted a backlash of tariffs and eventually a prohibition on the consumption of any all-cotton cloth in England. In the midst of a debate over how to limit these imports, Martyn argued that imports of cotton cloth freed up resources that could be deployed better elsewhere in the English economy. Martyn was the first to enunciate what Jacob Viner (1937, p. 440) termed the "eighteenth-century rule" (p. 440–41) that overturned the standard mercantilist view of how trade benefitted the national economy, a rule which Viner summarizes as: "[I]t pays to import commodities from abroad whenever they can be obtained in exchange for exports at a smaller real cost than their production at home would entail" (p. 440).

Seventy years after the 18th century rule appeared as part of an unsuccessful attempt to fend off an import prohibition, Adam Smith (1776) invoked it in the *Wealth of Nations*. Smith's perspective that trade could enhance the wealth of a country via specialization also reflected a world where the scarcity of productive means meant that savings (and gains) could be achieved with specialization and exchange: "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).

The ongoing British struggle against Napoleon in the first decade of the 19th century prompted the clearest expression of the 18th century rule by the early classical economists. The 1807 Orders of Council imposed a severe trade blockade on Napoleon's Europe and of course, on British exports to the continent. In response to arguments in some quarters that Britain should pursue a policy of self-sufficiency, James Mill (1808) and Robert Torrens (1808) argued forcefully for the advantages that accrued to a trading nation. In particular, Torrens (1808, p. 37) offers a remarkable and strikingly modern account that captures the gains that England had secured from its trading relationship with France:

> If I wish to know the extent of the advantage, which arises to England, from her giving France a hundred pounds of broad cloth, in exchange for a hundred pounds of lace, I take the quantity of lace which she might, at the same expense of labor and capital, have acquired by manufacturing it at home. The lace that remains, beyond what the labor and capital employed on the cloth might have fabricated at home, is the amount of the advantage which England derives from the exchange.

Torrens recognized that the advantage from trade is realized on the imports side and also that the evaluation involves a comparison between the (counterfactual) amounts of English labor and capital that would have been necessary to

produce the import (in this case, lace) in England with the (actual) amounts of English labor and capital embodied in the production of the export (in this case, woolen broad cloth). Robbins (1958, p. 22) argues that in his definitive articulation of the 18th century rule about when trade was beneficial, Torrens had presented "one-half of the principle of comparative [advantage]." But as Robbins notes, "it was only one-half," since Torrens and the 18th century rule were silent on the role cross-national differences in productivity played in trade and the gains from it.

## Ricardo's Labor Value Formulation of Comparative Advantage

It was left to David Ricardo to enlist the 18th century rule in the effort to develop a full statement of the sources of gains from trade and comparative advantage. One task of Ricardo's *Principles* was to elucidate the two additional steps required to achieve this goal: a theory of value and an explicit recognition of the distinction between domestic and international terms of trade.

In an insightful paper, Ruffin (2002) offers a narrative account of Ricardo's discovery of comparative advantage and brings attention to Sraffa's neglected interpretation of Ricardo's numbers as labor embodied in trade (Sraffa and Einaudi 1930).[3] Ruffin (2002, p. 736) reports on Ricardo's correspondence from the period when he was writing the *Principles*. In February 1816, Ricardo wrote "If I could overcome the obstacles in the way of giving a clear insight into the origin and law of relative or exchangeable value I should have gained half the battle." In the opening paragraph of his chapter seven on foreign trade, Ricardo recognized that the actual valuation of "foreign goods is measured by the quantity of the produce of our land and labor, which is given in exchange for them" (Ricardo 1817 [1966], p. 128). However, abstracting from other factors of production and focusing on labor alone offered him insight into the origin and law of relative and exchangeable values.[4] It can be argued that employing labor units alone as the sole metric for the relative valuations of goods opened the door to his comparative advantage statement.

As with the passage from Torrens (1808) quoted above, Ricardo's famous passage starts with an existing trading relationship between England and Portugal: "The quantity of wine which she (Portugal) shall give in exchange for the cloth of England is not determined by the respective quantities of labor devoted to the production of each, as

[3] Ruffin's rediscovery of Sraffa's insights has launched a reread of Ricardo among historians of economic thought. Recent writers like Maneschi (2004) and Faccarello (2015) are now in agreement that the textbook version of the one-factor fixed labor coefficient model is based on John Stuart Mill's (1852) misreading of Ricardo via his father James Mill (1821).

[4] In his seminal article, Stigler (1958, p. 361) points out that Ricardo's labor theory of value was based on empirical reasoning: "Ricardo believed that the changes brought about in the relative values of commodities by fluctuations in wages and profits were very small relative to those brought about by fluctuations in the quantity of labor (direct and indirect)."

it would be if both commodities were manufactured in England, or both in Portugal" (Ricardo 1817 [1966], pp. 134–35). Unlike Torrens, Ricardo's labor theory of value permitted him to employ labor units as a metric for evaluating the "real costs" in the context of the 18th century rule of the advantage of trade.

Ricardo next considers a configuration where the English cloth exported in exchange for the imported wine required the labor of 100 men; England in turn would have required the labor of 120 men to produce an equivalent amount of wine. Because the latter number is larger than the former, Ricardo applied the 18th century rule to conclude that England would "find it in her interest to import wine, and purchase it by the exportation of cloth."

After having established the advantage of trade for England, Ricardo follows up with a parallel 18th century rule statement for Portugal. He chooses numbers that indicate higher labor productivity in Portugal for both goods. The export of wine would require only the labor of 80 men; the cloth purchased with the exported wine would have required the labor of 90 men. Ricardo (1817 [1966], pp. 134–35) notes that Portugal's relative productivity in both goods poses a puzzle not resolved by simply invoking the 18th century rule: "This exchange might even take place, notwithstanding that the commodity imported by Portugal could be produced there with less labor than in England." Ricardo (p. 133) resolves the puzzle by asserting that "the same rule which regulates the relative value of commodities in one country, does not regulate the relative value of the commodities exchanged between two or more countries." His labor theory of value permits him to demonstrate the difference in the rules that govern international exchange: "[Within England] the labour of 100 Englishmen cannot be given for that of 80 Englishmen, but the produce of the labour of 100 Englishmen may be given for the produce of the labour of 80 Portuguese, 60 Russians or 120 East Indians" (p. 135).

By noticing that in domestic exchange, the labor of an Englishman in domestic cloth production is always given one for one for the labor of an Englishman in any other branch of production, Ricardo's formulation anticipates the ultimate source of the gains from trade in the neoclassical framework: the difference between the domestic and international terms of trade. In this formulation, the magnitude of the gains from trade stems from a benefit minus cost calculation: the benefits are on the import side and the costs are on the export side. Although Ricardo only considers the case of two goods and two countries, the logic extends in a straightforward manner to higher dimensions. In the many goods case, the labor needed to produce all import goods is subtracted from the labor needed to produce all export goods. Because the workers could be of different skill types, the formulation is not restricted to a single factor.

Table 1 summarizes Ricardo's logic. It also illustrates the separation property: that is, gains from trade can be calculated for each country separately. In addition, Ricardo's formulation does not require data on the technologies used by the trading partner. The amount of domestic labor actually embodied in a country's exports and imports—as a counterfactual—contains all the relevant information about the gains from trade for a given country.

*Table 1*
**Ricardo's Labor Value Formulation of Comparative Advantage**

| | *Exports (workers, actual)* | *Imports (workers, counterfactual)* | *Gains from trade (in workers)* |
|---|---|---|---|
| *England* | 100 Englishmen | 120 Englishmen | 20 Englishmen |
| *Portugal* | 80 Portuguese | 90 Portuguese | 10 Portuguese |

*Source:* Numbers are from Ricardo (1817 [1966], p. 135)
*Note:* Ricardo compares the number of a country's workers embodied in its exports with the counterfactual workers that would have been needed to produce its imports and implies the 18th century rule to determine the gains (in terms of workers) for each country separately.

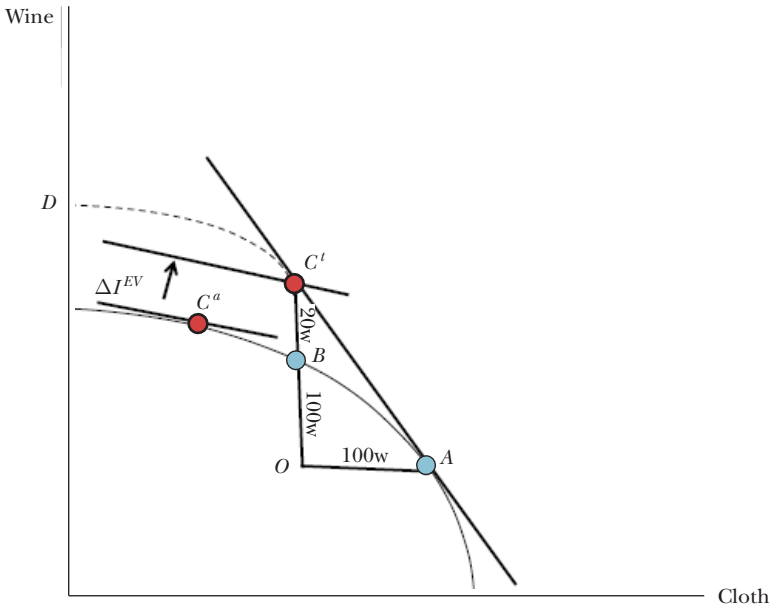
## Ricardo meets Haberler

Because Ricardo's formulation of comparative advantage was so tied to his labor theory of value, it lost its prominence later in the 19th century and into the 20th century in tandem with the loss of prominence of the labor theory of value. In a path-breaking paper that reformulated comparative advantage in terms of opportunity costs, Haberler (1930) "revolutionized the theory of international trade… [and] laid the foundation for Ohlin's theory, as well as … Samuelson's" (Chipman 2008, p. 812). Although Haberler's formulation encountered some initial resistance, his diagrammatic representation became a major tool for the neoclassical synthesis between the classical emphasis on production costs and the utilitarian emphasis on consumer utility as a source of relative prices (or value).[5] Over time, Haberler's diagram established itself as what Robert Baldwin (1982, p. 142) has labelled the trade economist's "sacred diagram." It became a main textbook diagram for depicting the logic of comparative advantage and the corresponding gains from trade. This opportunity cost formulation of comparative advantage has allowed trade economists (and textbook writers) to view the Ricardian model and the Heckscher–Ohlin model as special cases pointing to alternative sources of comparative advantage: differences in relative productivities or endowments.

Figure 1 depicts Haberler's bowed-out production possibilities frontier diagram, with cloth on the horizontal and wine on the vertical axis, which serves as a useful tool for putting Ricardo's logic into a modern context. Because the standard textbook treatment of Ricardo is based on the assumption that Ricardo's numbers pertain to fixed unit labor requirements, the production possibility frontier of the canonical Ricardian model would have a linear slope, with the empirically stark prediction that international trade completely wipes out the comparative disadvantage sector

[5]Haberler's original paper was published in 1930 in German in *Weltwirtschafliches Archiv* and was not translated into English until 1985. Haberler's formulation reached the English-speaking audience in his 1936 English translation of his 1933 textbook on international trade. See Viner (1937, pp. 516–526) for his critical comparison between the opportunity cost approach and his favored real cost approach.

*Figure 1*
**Ricardo's Gains-from-Trade Formulation in the Modern Production Possibilities Frontier Diagram**




*Source:* Authors.
*Note:* Ricardo's gains-from-trade logic is depicted in the standard textbook production possibilities frontier. Starting from the trade equilibrium with production at point $A$ and consumption at point $C^t$, Ricardo compared a counterfactual domestic exchange of 100 workers along the segment $AB$ on the production possibilities frontier with the international exchange of 100 workers embodied in exports $OA$ for 120 workers embodied in imports $OC^t$. In Ricardo's formulation, trade is equivalent to a labor augmentation of 20 workers, depicted by the outward shift of the production possibilities frontier to $DC^t$. In Samuelson's formulation, autarky consumption $C^a$ is the starting point and trade is equivalent to an income increase of $\Delta I^{EV}$ to the economy's representative consumer allowing that consumer to afford the trade consumption point $C^t$ at autarky prices.

for at least one country. When we recognize that Ricardo's numbers pertain to units of labor embodied in a country's imports and exports, Ricardo's logic is compatible with a bowed-out production possibilities frontier, diminishing returns to labor, and incomplete specialization. Because of Ricardo's intuitive use of the separation property of comparative advantage, we can just focus on the trading equilibrium for England and compare his gains-from-trade formulation with the versions found in standard textbook presentations and in Torrens (1808).

The standard textbook formulation starts out with an autarky equilibrium and expresses the gains from trade as a comparison of (economy-wide) consumer utility or consumption between autarky and free trade. In Figure 1, England's autarky consumption point is depicted by point $C^a$ on its production possibilities frontier. Under autarky, the economy's consumption point must coincide with its

production point. The slope of the tangency at point $C^a$ measures the autarky price of cloth relative to wine. Assume now that when opening up to international trade, England faces a relative world price of cloth greater than the relative price of cloth in autarky. This provides an incentive for English resources (labor, capital, or land) to move into the production of cloth, which will drive up the relative price of cloth in England until it coincides with the world price of cloth at the free trade production point *A*. Exporting English cloth for imports of foreign wine will enable the English economy to reach a free trade consumption $C^t$ somewhere on the terms-of-trade line, but outside its autarky-based production possibilities frontier. Thinking about the line through $C^t$ as an income line under autarky prices (and invoking the assumption of a single consumer), the gains from trade can be expressed as the increase in income (denoted by $\Delta I^{EV}$) that must be given to English consumers in order to achieve the free trade consumption point under autarky prices. An attractive feature of this gains-from-trade formulation is that it holds under very general settings.[6] A major limitation is that an empirical assessment of this formulation requires data on autarky prices for a market economy.[7]

Unlike the textbook formulation, the starting point for both Torrens and Ricardo is a statement about the quantities of England's exports and imports, which are represented in Figure 1 by the trading vector $AC^t$. Their application of the 18th century rule to find the gains from trade means that both compare the resources embodied in the economy's exports with the domestic resources that would have been necessary to produce the economy's imports. In Ricardo's formulation, the exports of cloth ($OA$) correspond to a resource cost of 100 English workers (labeled 100w on the figure), while the imports of wine ($OC^t$) would have required 120 English workers (the labels 20w and 100w) if they were produced in England. In Ricardo's formulation, the issue of the gains from trade can be separated into two questions: 1) Are there gains from trade? And 2) if gains exist, how large are they? He addresses the existence question by noting that in domestic exchange, 100 workers embodied in cloth production must also be exchanged for 100 workers embodied in wine production. In terms of Figure 1, if the 100 English workers engaged in the production of cloth exports were domestically reallocated to domestic wine production, they could have produced only $OB$ units of wine. The movement between points *A* and *B* along an economy's production possibilities frontier (PPF) depicts this "no trade" scenario. Turning to the case of international trade, 120 workers is

[6] Paul Samuelson (1939), who was Haberler's student, formally proved the existence of the gains from trade. Although the production possibilities diagram is restricted to two goods, Samuelson showed that the underlying gains-from-trade logic holds for any number of goods or factors. Samuelson's gains-from-trade formulation assumes a representative consumer who follows the weak axiom of revealed preference; he introduced the axiom in his foundational consumer theory paper (Samuelson 1938).

[7] In Bernhofen and Brown (2005), we exploit data from Japan's 19th-century opening up from a market-based autarky economy to a trading economy as a natural experiment compatible with the theory's ceteris paribus assumptions. Using detailed autarky prices, we provide an upper bound on $\Delta I^{EV}$ that was the equivalent of about 6–9 percent of Japan's GDP at the time.

greater than 100 workers, so the gains from trade are positive. The gain of $BC^t$ units of wine corresponds to a gain of 20 English workers.[8]

We can embed Ricardo's formulation in the standard general equilibrium framework by recognizing that these 20 workers are the additional counterfactual workers that would be needed to attain the free trade consumption point $C^t$ through domestic production capabilities. In this formulation, the "compensation" measure that formally captures the gains from trade is in terms of the augmentation of the economy's labor endowment. Trade is equivalent to the economy gaining 20 fictitious workers who would enable the economy to produce the free trade consumption point $C^t$ through domestic production. These 20 workers can be thought of as extending the economy's production possibilities frontier in Figure 1 along the segment $DC^t$.

Ricardo's gains-from-trade formulation has several attractive features. First, the gains from trade can be illustrated without knowledge of the economy's autarky equilibrium consumption $C^a$ or autarky prices. The exchange of factor services embodied in the economy's actual trading vector is—to use modern terminology—a sufficient statistic for identifying the existence and the magnitude of the gains from trade.[9] Second, the gains from trade are formulated in terms of a cost–benefit comparison. The costs of trade are the workers lost to the production of exports; the gross benefits from trade are the domestic workers that would have been needed to produce the imports; and the net benefits (the gains from trade) are the difference between the gross benefits and the costs. Third, Ricardo's logic does not require any restrictive assumptions on the consumption side of the economy (like a representative consumer).

Finally, Ricardo's benefit–cost characterization of the gains can be helpful for illustrating the role trade costs play in the existence and magnitude of trade. For tractability, assume that each country incurs trade costs by using its own workers to ship its export good abroad. For example, if 25 English workers are needed to export the English cloth in Ricardo's example, trade is not expected to take place even if the relative autarky price of cloth is lower in England than in the rest of the world. Interestingly, under these circumstances a uniform increase in labor productivity across all activities (cloth manufacture, wine production, and shipping) will not make trade beneficial. For trade to occur would require an increase in labor productivity in shipping *relative* to other domestic production activities.[10]

[8] In Torrens's (1808) formulation of the 18th century rule, the gains are formulated in the units of imports, which would be $BC^t$ units of imported lace. Although the formulations of Ricardo and Torrens are isomorphic in the case of two goods, Ricardo's formulation has the considerable advantage that it can be generalized to multiple goods and factors.

[9] Fundamentally, the advantage of trade can be thought of as a refutable proposition. For example, if the domestic labor content of imports were revealed (by the data) to be lower than the domestic labor content of exports, the gains would be negative. Assuming that the "invisible hand" would not permit this to happen in a completely free market, this outcome could still occur from export subsidies distorting the law of comparative advantage.

[10] Krugman (2010) uses this line of reasoning to speculate that the productivity gains associated with the steam engine disproportionately influenced trade costs relative to costs of production and thus played a key role in ushering in the dramatic growth of world trade between 1870 and 1913. Given that piracy

## A Gains-from-Trade Formula Based on Ricardo's Numbers

Ricardo's framework suggests an algebraic gains-from-trade expression. The expression can be viewed as a special case of the influential gains-from-trade formula developed in Arkolakis, Costinot, and Rodríguez-Clare (2012), which we will refer to as the ACR formula. In their recent discussion in this journal, Costinot and Rodríguez-Clare (2018) provide a unifying perspective of the ACR formula by considering a trade equilibrium that is characterized by an international exchange of factor services.[11] Their approach is reminiscent of Ricardo's view of international trade as an exchange of labor services.

To see this, assume that England and Portugal are operating in a trading equilibrium where the terms of trade are normalized to be one, such that one bottle of wine is exchanged for one unit of cloth. The gains from trade for each economy can then be formulated as:

$$\text{Gains from trade} = \frac{IM(L_{IM} - L_{EX})}{\bar{L}}.$$

The numerator in this expression gives the factor augmentation that would be equivalent to the suspension of international trade and it depends on two factors: the quantity of imports $IM$ multiplied by the difference between the (counterfactual) average number of domestic workers needed to produce one unit of imports, $L_{IM}$, and the average number of domestic workers needed to produce one unit of exports, $L_{EX}$.[12] In Ricardo's example, $120 = IM \times L_{IM}$, $100 = IM \times L_{EX}$, and the labor augmentation equivalent of trade is 20. In order to evaluate whether 20 is a big or small number, the labor augmentation needs to be divided by the economy's labor force $\bar{L}$. This gains- from-trade formula measures the augmentation as a percentage of the economy's labor force.

Costinot and Rodríguez-Clare (in this journal, 2018) argue that measuring the gains from trade in the ACR formula involves two questions: 1) How large are imports of factor services in the trade equilibrium? And 2) How elastic is the relative demand for imported factor services in the counterfactual move from trade to autarky? In an analogous manner in Ricardo's example, the gains from trade for England would be larger, or a counterfactual move to autarky would cost more, the higher the per capita consumption of foreign wine, $IM/L$. The difference $(L_{IM} - L_{EX})$ can be interpreted as capturing the degree of substitutability between

raises trade costs by requiring manpower to protect cargo, Ricardo's gains-from-trade characterization helps to illustrate how improvements in the rule of law on the high seas can stimulate trade. See also North (1968), who found a significant role for the decline in piracy in productivity improvements of ocean shipping prior to 1850.

[11] The discussion of Costinot and Rodriguez-Clare (2018) in this journal is based on the formal model and estimation procedure developed in Adao, Costinot, and Donaldson (2017).

[12] In order to guarantee that each country will produce both goods in a trading equilibrium, one needs to assume diminishing marginal products for labor which implies that $L_{IM}$ and $L_{EX}$ are not constant and will depend on $IM$.

foreign and domestic labor in the transition from trade to autarky, where domestic workers now produce the goods that would have been imported. A higher value of $L_{IM} - L_{EX}$ corresponds to a lower degree of substitutability between foreign and domestic workers and implies larger gains from trade. In a Ricardian world, the larger the relative productivity differences of workers, the lower will be their degree of substitutability.

## A Final Note on Ricardo's Genius

Ricardo's breakthrough formulation of comparative advantage and the gains associated with it stem from his insight that if countries ship goods across borders, it is as if their workers move across borders. Hence, Ricardo's reasoning anticipated the general idea of the factor content of trade, which has proven itself to be a useful analytical tool for generalizing the Heckscher–Ohlin model, among others. In fact, Deardorff and Staiger (1988) provide a formal proof that the reasoning behind a Haberler-style Figure 1 is a special case of a general equilibrium analysis of a neoclassical economy with an arbitrary number of goods and factors (like labor, capital, and land). Starting from a trade equilibrium, they show that if trade were suspended, but if the economy were given the labor, capital, and land embodied in its imports minus the labor, capital, and land embodied in its exports, then the economy would be able to obtain the same consumption level as through international trade.[13] In this way, our discussion provides further evidence for the continuity of economic thought from the classical economists onward and the decisive break they represented with mercantilist thinking. As Haberler (1977, p. 1) observed 160 years after the publication of the *Principles*: "[T]here is an unmistakable family likeness between the modern theories … and the early classical theories, just as there is between a modern jumbo jet and the Wright brothers' contraption."

■ *We thank Gordon Hanson and Timothy Taylor for insightful comments and suggestions.*

[13] Deardorff and Staiger (1988) use the term "equivalent autarky equilibrium" for the situation when trade is suspended but the economy is compensated through the factor augmentation. However, they do not link the factor content of trade to the aggregate gains from trade. Extending Ricardo's gains-from-trade logic to a multifactor framework and employing detailed data on 19th-century Japan, in Bernhofen and Brown (2012) we calculate the factor augmentation equivalents of trade in the case of five factors: female labor, skilled male labor, unskilled male labor, capital, and arable land.

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