Special Papers in International Economics
No. 12, April 1977

"TWO-NESS" IN TRADE THEORY: COSTS AND BENEFITS

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INTERNATIONAL FINANCE SECTION
DEPARTMENT OF ECONOMICS
PRINCETON UNIVERSITY · 1977

This is the twelfth number in the series SPECIAL PAPERS IN INTERNATIONAL ECONOMICS, *published from time to time by the International Finance Section of the Department of Economics at Princeton University.*

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International Finance Section

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Library of Congress Cataloging in Publication Data

Jones, Ronald Winthrop, 1931-
"Two-ness" in trade theory.

(Special papers in international economics; no. 12 ISSN 0081-3559)
Bibliography: p.
1. Commerce—Mathematical models. I. Title. II. Series: Princeton University. International Finance Section. Special papers in international economics; no. 12.
HF1007.J629 382'.01 76-58437

Printed in the United States of America by Princeton University Press
at Princeton, New Jersey

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I. Introduction

The number "two" is undoubtedly encountered more frequently in the theory of international trade than in any other field of economics. It is a large number: two countries provide a more complex setting for analysis than just one. The analysis of two countries trading two commodities, each produced with one or possibly two factors of production, eschews the partial-equilibrium one-thing-at-a-time approach standard in so many areas of economics in favor of general equilibrium. But two is also a small number. It is the smallest number that can be used to describe international trade when countries have genuinely different commodities to exchange with each other.

The basic defense offered in casting so much of trade theory in "twos" is ease of exposition and lack of ambiguity in conclusions. Two dimensions are ideally suited to blackboard diagrams. Koopmans (1957, p. 175) has suggested that "Only unnecessary and self-imposed tool limitations can explain why almost the entire literature on the theory of international trade has been confined to models of two countries trading in two commodities." I suggest there are other reasons. Fundamentally, there exists a belief that most of the useful and valid points in trade theory can be made in the context of two countries, two commodities, and one or two productive factors. If so, there is surely some advantage to using such a streamlined vehicle of communication. Combined with this is the fear that general-equilibrium analysis of higher-dimensional cases cannot be coaxed into yielding definite and unambiguous comparative-statics results.

But can the simple two-by-two models in trade theory be relied upon to provide answers to basic questions that have hopes of generalizing fairly accurately to a world with many commodities, countries, and factors? Listen to some of the critics: Pearce (1970, p. 320), in discussing trade and production models, states: ". . . many textbooks of international trade theory (even the most advanced) lay a great deal too much emphasis upon *propositions which are true only for models with two commodities and two factors of production*" (italics supplied). Hahn (1973, p. 297), in a review of a recent book by Negishi, remarks: ". . . it is well known that an economy with only two goods has a number of important properties which do not carry over to the general case."

Perhaps the clearest note of criticism was that sounded by Frank Graham, whose 1948 volume, *The Theory of International Values*, culminated several decades of pioneering work aimed at setting the pure theory of trade on a much firmer foundation than had been provided by Ricardo, Mill, and Marshall. Graham (1948, p. 284) states explicitly, ". . . one of the very strongest reasons for rejection of the classical doctrines is that the classicists themselves made their analysis in such simple terms (two-country, two-commodity trade) and then erroneously projected their results into complex trading situations." In reviewing Graham's book, Elliott (1950, p. 16) summarizes Graham's attitude toward received doctrine in trade theory by remarking, "In the theory of international trade, classical and neoclassical writers were led astray . . . by generalizing from the case of two countries and two commodities."

The issue I wish to address in this paper concerns the appropriateness of "two-ness" as an assumption in the theory of international trade. I shall start where Graham left off, with a brief analysis of the issue of dimensionality in the classical, or neo-Ricardian, world characterized by constant returns in production to composite units (labor). From there I shall branch more widely into several diverse areas of international trade theory in which standard work has been characterized by the "two-ness" assumption but in which it is also possible to consider the consequences of moving beyond two. To conclude, I shall appraise the post-classical (or modern) approach known as the Heckscher-Ohlin theory in the light of our quest for higher-dimensional truths. In particular, I shall argue that the sharp distinction often drawn between Ricardian "climatic" models and the Heckscher-Ohlin theory can disappear when one heeds Graham's insistence on basing the analysis of trade upon a model with many countries and many commodities.

In my discussion, I shall in large measure (but not exclusively) pick examples from my own work. For the past twenty years I have taken seriously the kind of question concerning dimensionality that was posed so forcefully by Graham. But perhaps I have been more conservative—trying to reveal how the "two-ness" assumption can often be salvaged to play a useful role in expressing basic economic truths. As I shall argue, this defense of the simple models is frequently made possible only after basic concepts are reformulated to take account of economic relations more clearly viewed in higher dimensions.

II. The Classical Trade Model and Graham's Criticism

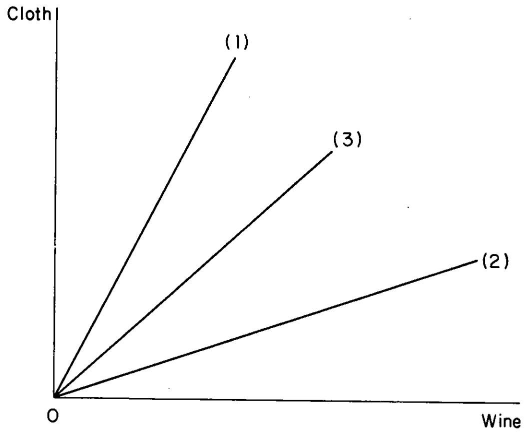
The basic Ricardo-Mill-Marshall model that attracted so much criticism from Graham can be sketched as follows: In each of two countries, fixed labor costs (man-hours) per unit of output would be required to produce one unit each of two commodities (wine and cloth). In the absence of international exchange, each country would supply its own residents' consumption demands and wine and cloth would exchange for each other according to their relative (labor) costs of production. For countries not sharing the same technology (or climate), these costs ratios would differ between countries. Once free trade is made possible, some ratio of commodity exchange is struck between the limits set by the cost ratios in the two countries. Although Ricardo was mute concerning precisely how such terms of trade were established, both Mill and Marshall asserted that the forces of reciprocal demand—in each country for the product in which the other country possessed a comparative advantage—would determine an equilibrium trading ratio.

Perhaps the feature of this solution that most disturbed Graham was the assertion that the terms of trade would lie *between* the cost ratios in either country. With occasional remarks to the contrary, most classical writers illustrated, in their numerical examples, a trading ratio lying *strictly* between the cost ratios in each country. This is what Graham called a "limbo" ratio, one not anchored by costs of production, since each country specializes in a different commodity. The striking feature of such a limbo solution is that changes in tastes cause prices to change but there is absolutely no response in supply.

The alternative, which Graham viewed as "normal," involves terms of trade equilibrated to the cost ratio in one of the countries, with at least one commodity produced in common by more than one country. He provided numerical examples with either more than two countries or more than two commodities, or both, in which an "intermediate" commodity or country served as a link between the two countries' cost structures. Thus, in a three-commodity, two-country case, each country could produce the commodity in which it possessed the greatest comparative advantage as well as the intermediate commodity. Labor costs in each country would then serve to bind the price of the intermediate commodity to each of the other two commodities. In such a world, according to Graham, changes in the structure of world demand could be accommodated by reallocations of labor in each country between the two goods that country produces without any change in the terms of trade.

The role of intermediate commodity thus described could alternatively be played by a third country. To the two-country, two-commodity case now add a third country whose cost ratio is intermediate between the two other countries. Figure 1 illustrates this cost ratio by the slope of intermediate line (3). If the world terms of trade coincide with the cost ratio in the third country, a shift in tastes could serve just to alter production patterns in the intermediate country instead of changing the terms of trade.

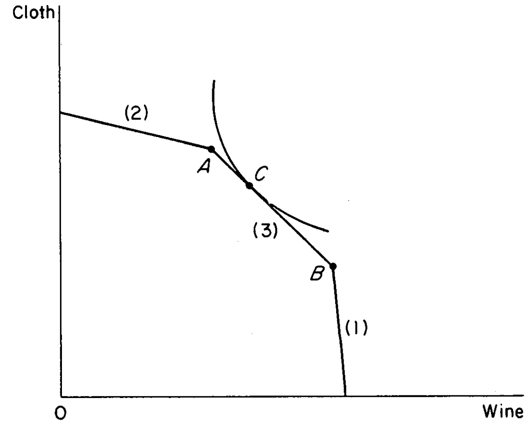
FIGURE 1
COST RATIOS IN A RICARDO-GRAHAM MODEL



Since Graham's work, there has apparently emerged an agreement among writers in this area that an eclectic view is appropriate. In a world of many countries and many commodities, a disturbance to trade may be met primarily by price changes, on the one hand, or production changes, on the other. Limbo price ratios may occur and are not as "unstable" as Graham would have led us to believe. The analytical concept that supports this view is of a world production-possibilities surface which, in the Ricardian world of constant returns to single primary inputs in each country, consists of "flats," "ridges," and "corners" of various dimensions, depending upon the number of commodities and countries.[1] A simple two-commodity, three-country version is illustrated in Figure 2.

[1] This concept was used by Whitin (1953) and McKenzie (1954).

FIGURE 2
THE WORLD TRANSFORMATION LOCUS



The slope of each segment corresponds to the cost ratio in the designated country (as shown also in Figure 1).

Imagine now being able to describe world taste patterns by a set of smoothly bowed-in indifference curves. A point of "tangency" between one such curve and the transformation locus could take place anywhere along the surface. If it takes place at *C* (as illustrated), intermediate country (3) indeed fulfills its Graham role of producing both wine and cloth, leaving country (1) to produce just cloth and (2) to concentrate on wine. But a different taste pattern (not drawn) could easily result in a corner (or limbo) solution such as *A*, with prices strictly between the slopes of (2) and (3).

It is certainly the case that Graham forces us to consider the possibility that the terms of trade will be reflected in the cost ratio of some country that is incompletely specialized. But is it necessary to abandon the simple two-by-two world to illustrate this point? Not at all. Indeed, Graham argued strongly that, even in a world composed of two countries and two commodities, the terms of trade would be unlikely to lie strictly between the cost ratios in each country. More likely, in his view, would be a disparity either in country size or in the relative importance of commodities that would drive one of the countries to produce both commodities.

The appropriate criticism of the two-by-two model, then, is not that it excludes the possibility that the terms of trade may correspond to some country's cost ratio but that it suggests such a possibility is *extreme*. In such a model, there is a whole range of possible equilibrium terms of trade. All the ones "in the middle" are limbo ratios. The solution that Graham terms normal can be found only at one extreme ratio or the other, for example, the slopes of rays (1) or (2) in Figure 1 when country 3 is absent. I refer to this more generally as the phenomenon of the *excluded middle*, a trait of "two-ness" that will show up in other contexts. In general, I submit that, if a wide variety of solutions is possible, some midway solution suggests itself more naturally than an extreme solution. Certainly, Ricardo, Mill, and Marshall found this case seductive in most of their arithmetic examples. The difficulty with the structure of the two-country, two-commodity model is that there is no middle solution that is capable of expressing what to Graham was normal—terms of trade that are a reflection of opportunity costs.

Graham points out as well that the higher-dimensional cases admit a richer variety of possible outcomes than does the two-by-two model. Can a fall in world demand for a nation's export commodity improve that country's welfare? Certainly not in the two-country, two-commodity case. In suggesting the alternative possibility, Graham is stressing that today's exports may become tomorrow's imports. With sufficient commodities and countries explicitly considered, the entire trading (and production) pattern in a country can change when tastes are altered. By contrast, in the two-by-two case each country has only one commodity it can ever export (excluding technical progress).

The criterion for comparative advantage in the two-by-two case involves a double bilateral-ratio comparison: the ratio of labor costs in wine and cloth in one country compared with a similar ratio in the other country. Now enlarge the scope of the model: three countries (America, Britain, and Continental Europe—A, B, and C), each capable of producing three commodities, say corn, linen, and cloth. Some years ago, I analyzed this kind of model and provided a numerical solution in which America was assigned production of linen, Britain production of corn, and Continental Europe production of cloth. With the labor-cost figures chosen,[2] it turned out that each country had a bilateral comparative advantage in the commodity assigned to it relative to either of

[2] See Jones (1961, p. 163). This example was suggested by a diagrammatic illustration in McKenzie (1954). For ease of reference, I reproduce the numerical example here. Each number represents man-hours per unit of output.

	America	*Britain*	*Continental Europe*
Corn	10	10	10
Linen	5	7	3
Cloth	4	3	2

the other countries compared with the commodity assigned to each of them. That is, if a_j^i represents the labor cost (man-hours) in country i per unit output of commodity j,

$$a_{linen}^{A}/a_{corn}^{A} < a_{linen}^{B}/a_{corn}^{B}, \quad a_{linen}^{A}/a_{cloth}^{A} < a_{linen}^{C}/a_{cloth}^{C},$$

and

$$a_{corn}^{B}/a_{cloth}^{B} < a_{corn}^{C}/a_{cloth}^{C}.$$

These are the comparisons suggested by the two-by-two model. However, with the numbers chosen, it turns out that this set of production assignments could never be tolerated in a free-trade competitive world. The criterion that was used in the two-by-two model turned out not to be incorrect, but rather to be *insufficient* in a genuine multilateral world. An alternative assignment (America in corn, Britain in cloth, and Continental Europe in linen) turned out also to satisfy the appropriate bilateral rankings. No comparison between the efficient specialization (America in corn, etc.) and the inefficient one (America in linen, etc.) was possible using just a pair of countries and commodities at a time.

Lest these remarks serve to cast doubt on the generalization of the concept of comparative advantage, I hasten to add that the appropriate general criterion for choosing among production assignments in a Ricardo-Graham model does, of course, reduce to the standard bilateral comparison in the two-by-two case. It just appears in slightly different guise. Both specializations cited above for the three-by-three model involved the specialization of each country in a different commodity (and thus all three commodities were produced—each by a different country). How many patterns of production should be considered? There are six candidates for this "class" of assignments.[3] (There are three choices for corn. Each leaves two for linen, with the remaining country in cloth.) The optimal (or efficient) assignment in this class is the one that *minimizes* the product of labor coefficients. Thus, the second of the two specializations I cited had

$$a_{corn}^{A}\,a_{cloth}^{B}\,a_{linen}^{C} < a_{linen}^{A}\,a_{corn}^{B}\,a_{cloth}^{C} \quad (90 < 100).$$

This minimum-product rule can be translated into the bilateral-ratio rule in the two-by-two case. For example, the first bilateral-ratio com-

[3] As I have defined the term, a "class" of assignments specifies how many countries are to be completely specialized in each commodity. Here there is one country in each commodity (see Jones, 1961, p. 164).

parison cited previously can be written as

$$a^{A}_{linen}\, a^{B}_{corn} < a^{A}_{corn}\, a^{B}_{linen}\,.$$

The criterion in the two-by-two case thus rewritten serves as the appropriate guide for the multilateral case.

This phenomenon will occur again in comparing a model characterized by "two-ness" with a higher-dimensional version: alternative and equivalent criteria in two-by-two cases may not prove equivalent in more general settings. But knowledge of the general case can aid in recasting criteria in the simple model so that it can generalize.

Let me make one final remark about this Ricardo-Graham model before turning to other issues. In general, we can specify two categories of production assignments of countries to commodities. Some assignments are efficient, and, if world prices (or world demands) are appropriate, these production patterns could be observed in a free-trade world. Other assignments are inefficient, so that no conceivable pattern of demand (or prices) could coax them into existence given the competitive pressures of free trade. Indeed, the doctrine of comparative costs should, I think, be viewed as telling us not what *will* be produced (for that depends on demand as well) but what patterns *cannot* be produced in a worldwide competitive framework. Suppose we restrict ourselves to patterns of production in which each country is completely specialized in some one commodity. If there are n commodities and r countries, there are n^r possible assignments of this type. In a two-by-two model there are four.[4]

How many of these assignments are inefficient? In a two-by-two world, only one (each country assigned the commodity in which it has a comparative disadvantage). That is, in the basic two-by-two world the doctrine of comparative advantage can be used to knock out only 25 per cent of the possible production patterns based on complete specializations. In this sense, the two-by-two model does insufficient justice to the power of the doctrine. In a three-by-three world, a full 17 out of 27 (or 63 per cent) of the assignments are ruled out; in a four-by-four world, the percentage of inefficient production assignments rises to 86. Multilateral models of comparative advantage—of the kind considered by Graham—reveal more forcefully than the classical two-country, two-commodity model the ruthlessness with which a regime of free trade requires countries to abstain from inefficient production assignments.

[4] One assignment has both countries producing, say, wine, one has both producing cloth, and two have one country in wine and the other in cloth.

III. New Possibilities in a Multicommodity, Multifactor Setting

A natural formal objection to models characterized by "two-ness" is that they are automatically precluded from displaying compositional features that can emerge in higher-dimensional cases.

To illustrate, consider the relationship between commodity outputs and prices along a smoothly bowed-out production-possibility schedule. Suppose the price of commodity 1 rises, all other commodity prices remaining constant. Output in the first sector must rise. This is a common property of general-equilibrium models that holds regardless of the number of sectors. In a two-sector economy, such output expansion in the first sector must draw resources away from the second. But in a multisector model this condition does not usually generalize to *every* other sector. Some sectors may expand when p_1 rises—those that are complementary to the first sector. Formally, if p_1 rises in an n-sector model (other prices remaining constant), $\sum_{j \neq 1} p_j \, dx_j$ must be negative. But *some* other outputs may expand.

A similar observation can be addressed to demand behavior along smoothly bowed-in indifference surfaces. With real income held constant, a rise in p_1 would induce a fall in demand for commodity 1 (D_1) and a substitution toward *some* other commodities. Indeed, $\sum_{i \neq 1} p_i \, dD_i$ would have to be positive. But not *all* other D_i's need rise. Some may be complements of good 1 in consumption, a feature precluded in the two-by-two models.

This possibility of complementarity lies at the root of a phenomenon discussed recently by Gruen and Corden (1970). In the standard two-commodity model, a country might improve its terms of trade by levying a tariff. A duty on imports, so the argument goes, could serve to depress the world price of imports by artificially creating a reduction in home demand. Symmetry compels the same conclusion to emerge in the case of an export tax: the world price of the country's exports could be bid up. The exception to this result follows in the case in which the home country is too small to be able to exercise any influence over world prices. In this event, a tariff (or export tax) would leave the terms of trade unaffected.

By adding one more commodity (and one more factor), Gruen and Corden provide an example in which a tariff serves to *worsen* the terms of trade. In addition, their example usefully points out how in a multicommodity world a country may be "small" in some markets but not in others. Their example is intended to capture some of the features of the Australian economy. Only one commodity is imported (textiles), and it utilizes capital and labor. Two commodities are exported—wool and grain—and each requires land and labor (but not capital). Of these two export items, wool employs a higher proportion of land to labor than does grain.

This description ensures that wool and textiles are complements in production. Suppose the domestic price of textiles rises because a tariff is levied on textiles and the country is too small in the world textile market to influence world prices. If the prices of grain and wool are (temporarily) held fixed, what resource shifts are induced? Clearly, textiles draw labor away from the export sectors. Wool and grain production together form a subset of the economy in which total land availability is constant (land is not used in textiles), and in which labor supply has been depleted (the departure of workers to the protected textile industry). At constant prices (for wool and grain), the standard Rybczynski (1955, pp. 336–341) result for a two-sector economy asserts that labor-intensive grain output falls but land-intensive wool output actually rises.

Gruen and Corden use the complementarity between textiles and wool in this example to establish their "paradox" by assuming further that, although the country cannot influence grain prices, it can affect the world price of wool. The tariff on textiles has caused local output of wool to rise. If this exceeds any rise in local demand, the world price of wool will be depressed. Thus, the only influence on world prices exerted by the initial tariff on textiles is a lowering of the wool price. A tariff has worsened a country's terms of trade. Complementarity, either in production or consumption (or both), is thus a new feature introduced by moving beyond the world of twos.

There are also *problems* that cannot effectively be posed without introducing more than two commodities, factors, or countries. For example, the theory of customs unions requires at least three countries in order to capture the phenomenon of two or more nations banding together to create a tariff structure that discriminates against other countries in favor of the nations in the union.[1]

At a more basic level, the presence of more than two commodities is required in order to raise the question of optimal tariff *structures*. A simple illustration involves a country too small to affect world prices that imports two commodities (2 and 3) in exchange for exports of another commodity (1). Suppose that the country has imposed a tariff at rate

[1] For recent treatments of the customs-union issue, see Kemp (1969) and Berglas (1975).

t_2 on its imports of commodity 2, and that this rate cannot be changed. (For example, strong trade-union pressure has forced protection in the second industry.) Also, suppose there is required free trade in the market for its exportables. Should this small country levy a duty on its imports of commodity 3? If so, at what level?

The analysis of this case is straightforward. Since the country is small, there are no terms-of-trade effects. Real income is affected only if the volume of trade is altered in any market in which world price (p_j^*) differs from domestic price (p_j). By assumption, no such discrepancy exists in the nation's export market, but it does in the market for the second commodity. A small initial duty on imports of commodity 3 would, if commodities 2 and 3 were substitutes, tend to shift demand toward 2 and production away from 2. On both counts, imports of 2 would rise; this would raise real income, since the local value of the second commodity to home residents is reflected in the domestic price, p_2, which exceeds the cost of obtaining commodity 2 on world markets (p_2^*) by the amount of the fixed tariff rate, t_2. But this reasoning also suggests that further increases in the duty on commodity 3 will introduce some harmful effects on real income as a tariff wedge in the market for good 3 is established and imports of good 3 are reduced.

Formal analysis in this case reveals that, if all goods are substitutes, the small country should impose a duty on the third commodity, but *at a lower rate* than the fixed duty on the other importable. If M_j denotes excess demand for good j, the change in home real income (measured in units of the first commodity) as tariff rate t_3 is increased is given by

$$\frac{dy}{dt_3} = \sum_j (p_j - p_j^*) \frac{dM_j}{dt_3}.$$

Real income reaches a maximum when this expression is zero, or when tariff rate t_3 is given by

$$\frac{t_3}{1 + t_3} = \left[\frac{p_2(dM_2/dt_3)}{-p_3(dM_3/dt_3)}\right] \cdot \frac{t_2}{1 + t_2}.$$

With p_3 the only variable price, and since in the neighborhood of the point of maximum utility the real-income effects of a tariff rise vanish,

$$\frac{dM_j}{dt_3} = \left(\frac{\partial D_j}{\partial p_3} - \frac{\partial x_j}{\partial p_3}\right) p_3^*,$$

where the consumption effect, $\partial D_j/\partial p_3$, reflects only a substitution term. For substitution effects in consumption, $\sum p_j(\partial D_j/\partial p_3)$ equals zero. For movements along the transformation frontier, $\sum p_j(\partial x_j/\partial p_3)$ is also zero.