Commodity Trade and Factor Mobility—Substitutes or Complements? A Case Study of Economic Theorizing

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Abstract
The discrepancy between what is asserted in the economic theory and what really occurs in the economic world always embarrasses economic theorists and prompts debates on economic theorizing among economic theorists and methodologists. The traditional way to deal with this problem is to raise the issue of realism versus theory by focusing on the concern of unrealistic assumptions in economic theories. This paper, by using a case study from international trade theory, argues that, contrary to traditional wisdom, economic theorists’ application of unrealistic assumptions in economic theorizing is not a vice with respect to the empirical tradition; it rather figures in economic theory-building in just the same way as does physicist’s procedure of condition-control in theory-building in experimental physics. According to this view, unrealistic assumptions are introduced into theories to act as controlling devices to safeguard theoretical models against disturbing influences produced by other, less relevant or less important causal factors and to ensure that the main targeted phenomena can be elicited from these shielded theoretical models. The conclusions derived from these shielded theoretical models are the so-called abstract causal laws (or abstract capacity claims). They are the main targets of economic theorists. From this perspective, inaccuracy as a characteristic of economic theories is not surprising. This paper further argues that, economic theorists, by so doing and coupling with their practices of executing theory-concretization, can show us a strong case that what they have done in their economic theorizing or model-manipulation represents an attempt to provide more complete causal accounts of the economic phenomena in question.
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1. **Background: The Heckscher-Ohlin-Samuelson Model and the Factor-Price Equalization Theorem**

It is widely acknowledged by international trade theorists that the Heckscher-Ohlin (H-O) model is highly idealized in that it aims to obtain precise knowledge of the effects of a difference in factor endowments on a country's pattern of international trade under a well-contrived environment. The definite result derived from this model is that a country has a comparative advantage in producing and exporting those commodities that use more intensively the country's relatively more abundant factors. In other words, to use a philosophical term, the difference in factor endowments has the capacity to determine which commodity a country should produce and export.\(^1\)

This definite result is the so-called Heckscher-Ohlin (H-O) theorem.

The H-O theorem is generally used to delineate the relationship between a country's factor endowment and its pattern of commodity trade. In addition to this relationship, international trade theorists are interested in the impact of international commodity trade on real factor prices in both trading countries. Heckscher and Ohlin stated that international commodity trade either definitely equalizes or tends to equalize factor prices. But it was Paul A. Samuelson who established a systematic account, in a series of papers published in 1948 and 1949, of the relationship between international commodity trade and the prices of factors of production.

Let's discuss the gist of Samuelson's account. Note first that Samuelson's account was conducted under the framework of the H-O model. So, as with the H-O model, let's also assume that there are only two countries—nation 1 and nation

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\(^1\) For the idea of “capacity,” I follow Nancy Cartwright by adopting the following subjunctive conditional type of definition: “In methodology, ‘capacity’ is used to mark out abstract facts about economic factors: what they would produce if unimpeded.” (Cartwright 1998, in Davis, Hands, and Maki (eds.), 1998, p. 45)
and two factors of production—in our model, labor and capital—involved in producing two commodities—commodity X and commodity Y. Let's suppose that nation 1 is a labor-abundant country and nation 2 is a capital-abundant country and that commodity X is a labor-intensive good and commodity Y a capital-intensive good. Under the other assumptions stipulated in the H-O model, such as the same production technology and the same tastes in consumption in the two countries, the pre-trade, or autarkic, price of commodity X must be relatively lower in nation 1 than in nation 2 because the relative price of labor is lower in nation 1 (because nation 1 is a labor-abundant country). Similarly, we know that the autarkic price of commodity Y must be relatively lower in nation 2 than in nation 1. The condition of the difference in autarkic prices between the two countries creates a comparative advantage for each country to specialize in producing different commodities. For example, nation 1 will specialize in producing and exporting commodity X in exchange for commodity Y with nation 2, and nation 2 will operate in the opposite direction.

Let us further assume that both factors of production are fully employed in both industries in both countries. It's important to note that as international commodity trade occurs between these two countries and as nation 1 increasingly concentrates on producing commodity X, it must reduce its production of commodity Y in order to release additional factors of production to be used in manufacturing the additional amounts of commodity X called for in international commodity trade. But because commodity X is a labor-intensive good—that is, its production uses more units of labor than of capital—the relative demand for labor will raise faster than the relative demand for capital in nation 1. As a result, the price of labor—i.e., the wage (w)—will increase, and the price of capital—i.e., the interest rate (r)—will fall in nation 1. The same logic applies to nation 2, with the result that the price of capital
(r) will increase and that of labor (w) will fall.

Remember that nation 1 is a labor-abundant country, so the pre-trade wage rate must be lower in nation 1 than in nation 2; and because nation 2 is capital-abundant, the pre-trade interest rate must be lower in nation 2 than in nation 1. Thus, according to the mechanism mentioned above, when international commodity trade occurs between these two countries, this trade will increase the originally lower wage rate and reduce the originally higher interest rate in nation 1, and, conversely, it will reduce the originally higher wage rate and increase the originally lower interest rate in nation 2.

Accordingly, as long as there is a difference in the prices of factors between these two countries, there will be differences in the commodity prices, and there will still be a comparative advantage for each country to continue international commodity trade. The upshot is that the international commodity trade between the two countries will continue until the relative commodity prices are completely equalized. To be more specific, the international commodity trade will stop only when the relative factor prices are completely equalized, the relative commodity prices are then completely equalized, and the condition of comparative advantage no longer exists for the two countries to trade. So a succinct conclusion can be made: International commodity trade tends to equalize the factor prices between nations. This conclusion is the so-called factor-price equalization (FPE) theorem.

From the perspective of complete factor-price equalization, an important corollary can be derived from the FPE theorem. The corollary is that international commodity trade can be regarded as a substitute for factor mobility (or factor migration or factor trade) between nations. That is because, like factor mobility, commodity trade can also bring about a condition of international equilibrium in which all the homogeneous factors earn the same level of reward in both countries.
That is, in the absence of factor mobility between nations, commodity trade between nations can act in the same way as factor mobility between nations to bring about the equalization of the factor prices between nations. It is in this sense that commodity trade is said to be a substitute for factor mobility. (see also Mundell 1957) Let’s call this the corollary of substitutability.

Hereafter I will call the model that derives the H-O theorem and the FPE theorem the Heckscher-Ohlin-Samuelson (H-O-S) model.

2. The Focus of the Case Study
Casual observation of the world economy, however, will immediately indicate that neither factor prices nor commodity prices are equalized between nations. The discrepancy between what is asserted in the economic theory and what really occurs in the economic world always embarrasses economic theorists and prompts debates on economic theorizing among economic theorists and methodologists.

The traditional way to deal with this problem is, first, to raise the issue of realism versus theory by focusing on the concern of unrealistic assumptions in economic theories. To tackle the problem of inaccurate theory means to answer the following two questions: whether theories derived from unrealistic assumptions can actually represent and explain real economic phenomena, and whether these unrealistic assumptions are testable. One prominent example of this approach to economic methodology can be found in a series of discussion papers and responses exchanged among distinguished economists discussing economic methodology published in American Economic Review in 1963-5.

Although these traditional methodological concerns give us an angle to look at the problem of the inaccuracy of a theory when it is used to explain or predict
phenomena of interest in the real world, they are not my main concerns in this case study. As we will see from the ideas presented in the following sections, imprecise economic theories are inevitable. The imprecision of economic theories originates from what I would call the gap of abstractness between the abstract theories and the real phenomena of interest.

To a certain degree, as traditional wisdom would argue, the gap of abstractness can indeed be attributed to unrealistic assumptions. But, contrary to traditional wisdom, the application of unrealistic assumptions in economic theorizing is not a vice with respect to the empirical tradition; it figures in economic theory-building in just the same way as does the procedure of condition-control in theory-building in experimental physics. Unrealistic assumptions are introduced into theories to act as controlling devices to safeguard theoretical models against disturbing influences produced by other, less relevant or less important causal factors and to ensure that the main targeted phenomena can be elicited from these shielded theoretical models. The conclusions derived from these shielded theoretical models are what I would call abstract causal laws (or abstract capacity claims). They are the main targets of economic theorists. From this perspective, inaccuracy as a characteristic of economic theories is not surprising.

But the inevitable inaccuracy of economic theories, which troubles many empirical-minded economists, is not irremediable; the process of concretization is the salvation of the problem. This process attempts to provide additional phenomenal content to the originally highly abstract theory by supplying more complete knowledge of the causal structure of the real phenomenon in question. This additional causal knowledge may come from economists’ observation of the real economic situation, from their reexamination of other relevant economic theories, or from any other reliable sources. The effect of this additional causal knowledge on
the practice of economic theorizing may result in any form of change in economic theories. It may, for example, cause economic theorists to remove the assumptions of their original theories. Or they may replace the production function used in their original theoretical model with other, more pertinent production functions. Or new assumptions may be added to the original theoretical model. In any case, the main concern is no longer whether the gap of abstractness still exists or whether the original highly unrealistic theory can accurately represent the real phenomenon in question.

The main focus of the study of economic theorizing should be, however, to examine whether economists indeed tend to revise their original highly abstract theories to enable them to capture more complete causal accounts of real-world economic phenomena by adjusting the causal structures of their theoretical models when important new causal features are called for. More succinctly, the main focus of the entire study of economic theorizing should more closely mirror the following concern: The focus is indeed not "[the question] of realism in science—i.e. how accurately can the sciences, including economics, represent the world, but rather the question of the range of science—how much of the world can it represent.” (Cartwright, 1999, pp. 318-319)

The following sections present a case study of two models. The case study illustrates the reaction of international trade theorists—who are deeply committed to the abstract capacity claim (i.e., the corollary of substitutability), which is derived from a highly idealized theoretical model—to critics who decry the frequent discrepancy between economic theory and economic reality, calling for economic theorists to adjust their theories. An important finding of the study is that a seemingly empirically refuted capacity claim still figures in these theorists' theory-building. Indeed, a characteristic common feature of these theorists' practice is that, no matter what new theoretical conclusions they may draw from their revised
theoretical models, what is asserted in the capacity claim continues to figure in their theorizing and to reappear in their new conclusions. The only difference involved in the capacity claim is that, given detailed information to explain a discrepancy between their theories and reality, theorists will reexamine the capacity claim under a new theoretical model. In an attempt to accommodate the additional causal knowledge, the new model contains a new causal structure that is revised from the old model. As a result of this reexamination, theorists may make some refinements to the original content of the capacity claim with respect to the features of the new causal structure. For example, if the new causal structure features more complicated interactions among various causal factors, theorists may add a restrictive condition to the original capacity claim to indicate the situation under which the cause stated in the capacity claim will influence the targeted effect in its own specific way. No matter what final conclusions theorists may draw from their new theoretical models, what they have done in their economic theorizing or model-manipulation represents an attempt to provide more complete causal accounts of the economic phenomena in question.

3. Outline of the Controversy

As pointed out in previous sections, for most empirical-minded economists, the status of the corollary of the substitutability between trade in goods and factor mobility—i.e., the corollary to the factor-price equalization theorem—is dubious. These critics' argument is this: The corollary's validity is based on the validity of the factor-price equalization theorem, and the validity of the factor-price equalization theorem depends on the unrealistic assumptions made in the Heckscher-Ohlin (H-O) model. These assumptions include the existence of free trade in goods and factor immobility; the same technology in the two countries; constant returns to scale; perfect
competition both in commodity and in factor markets; and incomplete specialization in production. For these critics, not only are the unrealistic assumptions in the H-O model problematic, but also any observation of the factor prices and commodity prices in the real world raises doubts about the truth of the factor-price equalization theorem. So, according to the argument, the corollary of substitutability is not true in the real world.

Indeed, some economists, by revising some of the unrealistic assumptions in the H-O model, have reached a very different conclusion: Goods trade and factor mobility, to a certain extent, are *complements*. For example, James R. Markusen (1983) pointed out that if we assume identical factor endowments but different factor prices in a world of two countries, any revision of the traditional assumptions of the H-O model results in the conclusion that goods trade and factor mobility are complements between two trading nations.

Let's digest for a moment to clarify the terms "complement" and "substitute" used here. *Complement* here represents the ordinary economic meaning when it is used to describe two goods that are complements (or complement goods): If the purchase of good A induces the purchase of good B, we say that good A and good B are complements. In other words, if good A and good B are complements, good B tends to be purchased when good A is purchased, and vice versa. One example is cups and saucers. On the other hand, if good A and good B are *substitutes*, good B tends not to be purchased when good A is purchased, and vice versa. That is, the demand for good B is replaced by the demand for good A if the two goods are substitutes. One example is coffee and tea. In Markusen's case, commodity trade and factor mobility are said to be complements in that, in the process of heading for factor-price equalization, an increase in the amount of commodity trade will also induce an increase in the amount of factor mobility, and vice versa. In the H-O-S
model, however, in the process of heading for factor-price equalization, an increase in
the amount of commodity trade can occur in the absence of factor mobility, something
that represents an extreme case of substitution.

Other prominent examples involved in the debate about substitutability and
complementarity include Lars E. O. Svensson's 1984 paper and Kar-yiu Wong's 1986
paper and 1995 book. Unlike Markusen, whose model significantly violated most of
the assumptions in the H-O framework, Svensson removed only the assumption of
factor immobility; he retained all other assumptions in the factor-endowments theory.
His goal was to create a model that reflected both the real situation in the world and
the simplicity of a theoretical model. In this work Svensson developed a
middle-ground conclusion: Goods trade and factor trade tend to be substitutes
(complements) if traded and non-traded factors are cooperative (non-cooperative)
after a change in the endowment of the home country.

Kar-yiu Wong, allowing for possible differences in factor endowments, tastes,
and technologies across the two trading countries, avoided the question of
substitutability or complementarity. Instead, he developed necessary and sufficient
conditions for substitutability and complementarity between goods trade and factor
mobility.

These papers represent an active discourse between these trade theorists on the
topic of the nature of the relationship between commodity trade and factor mobility.
Markusen's and Wong's papers are discussed in the following two sections.

4. Markusen's Models

Although the main purpose of Markusen's paper was to argue for an alternative
account of the cause of international trade, the conclusion derived from his argument
can shed light on the question of substitutability. Markusen argued that instead of being substitutes, factor movements and commodity trade are complements. Markusen's work, using some different assumptions, presents several models in which factor mobility leads to an increase in the volume of world trade—i.e., both the volume of factor mobility and that of world trade change in the same direction, which means that they are complements. This work contradicts the corollary of substitutability between goods trade and factor mobility, which is inferred from the H-O-S type of factor-price equalization theorem.

Markusen listed six assumptions (Markusen 1983, p. 342):

(a) Countries have identical relative factor endowments;
(b) Countries have identical technologies;
(c) Countries have identical homothetic demand;
(d) Production is characterized by constant returns to scale;
(e) Production is characterized by perfect competition; and
(f) There are no domestic distortions in either country.

Markusen noted that if assumption (a) is removed and if the other five assumptions are retained, the model conforms to the standard H-O-S model. In fact, Markusen retained assumption (a) and assumption (c) and created four different models, each removing one of the remaining four assumptions. Because all the models retain the assumption of identical relative factor endowments before factor movement (note that this is contradictory to what is assumed in the H-O-S model), the models share the common characteristic that the basis for trade is something other than differences in relative factor endowments (note that difference in relative factor endowments is the cause of international trade in the standard H-O-S model). Table 1 compares the assumptions and the trade bases for the H-O-S model and the Markusen models.
In the H-O-S model, differences in relative factor endowments create trade, and the mechanism described in section 1 results in factor-price equalization with incomplete specialization. In the Markusen models, on the other hand, equalization in relative factor endowments but differences in factor rewards induce factor mobility, which creates a factor proportion basis. Differences in relative factor endowments reinforce the other basis for trade. In the four models, factor-price equalization occurred after at least one nation was completely specialized.

Note that the phenomenon of "distribution of factors" does not matter in the H-O-S model because it assumes differences in factor endowments. This is an important issue for the Markusen models, however, because they assume that the relative factor endowments between two countries are equal before factor movement occurs.

How did Markusen conclude that commodity trade and factor mobility are complements? Let's take one of Markusen's models for illustration. In the model of different production technology (model (i) in Table 1), we see a series of chain reactions due to the removal of assumption (b)—i.e., dropping the assumption of identical production technology across countries. Suppose that, in this model, two countries—h (home) and f (foreign)—use two factors—L (labor) and K (capital)—to produce two commodities—X and Y. Also suppose that X is a labor-intensive commodity and Y capital-intensive, and that there is no factor-intensity reversal. The production function for each industry in each country can be represented in the following form, where the total supplies of L and K are assumed to be fixed and denoted as $\bar{L}$ and $\bar{K}$ (Ibid., p. 343):
\[ Y^i = G(L^i_y, K^i_y); \quad \bar{L} = L^i_x + L^i_y, \]

\[ X^i = \alpha^i F(L^i_x, K^i_x); \quad \bar{K} = K^i_x + K^i_y, \quad \text{where } i = f, h \]

(1)

\( \alpha^i \) is called the *technical efficiency parameter* in producing commodity \( X \).

Let's suppose that \( h \) is more efficient in producing \( X \)—i.e., \( h \) has superior technology in producing \( X \)—so \( \alpha^h > \alpha^f \). Now, under the assumptions of equal relative factor endowments, identical homothetic demand between countries, and fixed amount of factor supplies in each country, country \( h \) apparently has a comparative advantage in producing more \( X \) to exchange for \( Y \) from country \( f \). And, because \( X \) is a labor-intensive good and country \( h \) has a superior technology in producing \( X \), it follows that country \( h \) can be even better off in its already superior efficiency of utilizing \( L \) if it can transfer more \( L \) from the production of \( Y \) to the production of \( X \); then the relative marginal productivity of labor in country \( h \) must be greater than that in country \( f \). Also, under the assumption that production is characterized by perfect competition (recall assumption (e) above), it follows that the reward for each factor must reflect its marginal productivity, so wage \( (w) = \) marginal productivity of labor, and interest rate \( (r) = \) marginal productivity of capital. So it must follow that \( w^h > w^f \).

The same reasoning can be applied to establish that country \( f \) has a comparative advantage in producing \( Y \), and we can conclude that \( r^h < r^f \).

Having outlined the production structures of both country \( h \) and country \( f \) and the effect of a difference in production technology on factor prices in each country, let's now look at what will happen when these two countries allow their factors to move across national borders. Under the factor reward structure derived above—i.e., \( w^h > w^f \) and \( r^h < r^f \)—if the factor mobility between nations is allowed, \( L \) will move from country \( f \) to country \( h \) and \( K \) from country \( h \) to country \( f \). This pattern of factor movement will create a Heckscher-Ohlin basis (or factor-proportion basis)—i.e., country \( h \) will be endowed with (or will accumulate) more \( L \), and country \( f \) will be
endowed with (or will accumulate) more K—to reinforce the existing direction of commodity trade. This pattern of factor movement will continue until at least one country is completely specialized in producing its more advantageous good. When this indeed occurs, the factor prices can also be equalized between nations.

The underlying mechanism of Markusen's model of different production technology can be summarized in the following steps:

[1] Dropping assumption (b) to allow differences in production technology → [2] the factor price structure \( w^h > w^f \) and \( r^h < r^f \), where h (home country) is exporting labor-intensive good X and f (foreign country) is exporting capital-intensive good Y.

If factor movement is now permitted, then, from [2], it follows:

[2] \( \rightarrow \) [3] in country h, K (capital) flows out to country f, and in country f, L (labor) flows out to country h \( \rightarrow \) [4] h will have more L, and f will have more K \( \rightarrow \) [5] forming a factor-proportion basis for commodity trade; this adds a Heckscher-Ohlin basis for trade, which acts to reinforce the existing direction of goods trade \( \rightarrow \) [6] Finally, factor prices can be equalized between countries only if at least one country is completely specialized in producing its more advantageous good.

Note in this flow chart that the factor mobility occurs at step [3], and at step [4], as follows from the previous step, both countries have more of the factors that are used intensively in producing their export goods; at step [5], commodity trade increases. It is the same direction of variation both in step [3] and in step [5] that led Markusen to conclude that factor movements and commodity trade are complements.

One of the main purposes of discussing Markusen's study is to illustrate an extreme case of model-manipulation. It is obvious that the H-O-S model and the Markusen model of different production technology begin with different assumptions: The H-O-S model begins with the assumption of different relative factor endowments...
with or without different factor rewards, and the Markusen model begins with the assumption of equal relative factor endowments and different production technology. These two models produce the two simple causal paths shown in Figure 1.

[Please refer to Figure 1]

Recall our original question: What is the relation between commodity trade and factor mobility; are they substitutes or complements? As shown in Figure 1, the H-O-S model maintains that commodity trade and factor mobility are substitutes because commodity trade increases in the absence of factor mobility. In the Markusen model, however, they are complements because commodity trade increases as factor mobility increases. With respect to our original question, which model is the right one? The answer is that it depends. As I have emphasized in the previous sections, there is no single model that can be used as a general model to answer our original question in every real situation. Which model is the right model to answer our original question depends on which model is better for illustrating the current situation of international trade under a certain causal structure.

Dominick Salvatore's popular international economics textbook presents the general equilibrium framework stipulated in the Heckscher-Ohlin theory. (Salvatore 1999, p. 120) This framework is reproduced in Figure 2.

[Please refer to Figure 2]

In this general equilibrium framework, at least four fundamental economic forces contribute to the formation of commodity prices. These forces are those factors at the bottom of each route in Figure 2: technology, supply of factors (and so
the difference of factor endowment), tastes, and income level. What the H-O-S model has done is to freeze the action of the forces of technology, tastes, and income level and so to rule out their latter influences along routes I, III, and IV. The purpose of this abstraction is to single out the force of the supply of factors (or the difference of factor endowment) in an attempt to see how it will exert its full influence on commodity prices. So, instead of the entire causal system expressed in Figure 2, what the H-O-S model derived is the simplified causal path starting from route II: Supply of factors → Factor prices → Commodity prices. It is from this causal path that the H-O-S model derived the conclusion of substitutability between commodity trade and factor mobility.

In Markusen's model of different production technology, however, route I is singled out by holding fixed all the influences coming from the other three routes. What is new to the general equilibrium system is that the Markusen model brings in a new causal factor from outside this system: factor movements between nations. This new causal factor in turn changes the system in that the original causal route II is now incorporated into route I. Therefore, instead of deriving the original simple causal route I—Technology → Commodity prices—Markusen's model comes up with a more complicated version: (Different) Technology → (Different) Factor prices → Factor mobility → Different supply of factors (or different endowment of factors) → Commodity prices. It is from this causal path that the Markusen model derives the conclusion of complementarity between commodity trade and factor mobility.

Thus, both the H-O-S model and the Markusen model are highly idealized models in that to obtain their results they use numerous assumptions to rule out what many economic theorists thought were less relevant influences. If we are lucky and the causal system of the concrete phenomenon of international trade in question happens to have the same causal structure specified in, say, Markusen's model, we can
readily apply this model to explain the concrete phenomenon. But, most of the time, nature acts in a way that is far more complicated than specified either in the H-O-S model or the Markusen model. If the real causal system is so difficult to grasp, what is the use of these abstract models?

For the question at hand, a simple criterion can be immediately applied: If a theoretical claim is derived from a more complete—i.e., more concrete—causal model, it will generally be a more accurate causal claim and can be used to provide a fuller causal explanation of the targeted real phenomenon.\(^2\) According to this criterion, it seems that Markusen's theoretical claim, asserting that commodity trade and factor mobility are complements, is indeed the more accurate claim compared with the corollary of substitutability. Why? The reason is that Markusen makes factor movement, a prevalent phenomenon in the real world, a part of his model, at the same time incorporating what the H-O-S model called the cause of international trade—the difference in factor endowment—into the model's causal path leading to general equilibrium. But if, based on this, we conclude that Markusen's model is the right model for identifying the relation between commodity trade and factor mobility, it would be a misguided conclusion.

If we assume that the real world operates as depicted in Figure 2, Markusen's model is neither concrete nor complete enough to cover a sufficient part of the entire causal structure and thereby claim the status of the right model compared with Kar-yiu Wong's model, which is discussed in detail in the following section. For our present purpose, it suffices to say that in Wong's model, all the economic factors presented in Figure 2 are released to act to determine whether commodity trade and factor mobility are substitutes or complements. What is derived from this model is a

\(^2\) I have argued elsewhere (Chen (2003)) that this criterion can be regarded as a plausible option to be used to determine the order of accurateness among different causal claims and that of completeness (or concreteness) among different causal models.
list of sufficient and necessary conditions indicating when commodity trade and factor mobility are substitutes or complements. Because all the causal factors mentioned in Figure 2 are included in Wong's model, according to our criterion, it should be more complete than Markusen's.

Note that we make this judgment with respect to the background of the general equilibrium framework depicted in Figure 2. We can make this judgment because we assume that the causal structure of the real world happens to be the same as this general equilibrium framework. If, for any reason, it turns out that the real world does not act in this way, the original judgment will need to be reexamined under a new causal structure that can represent the real world's structure. That is, any judgment of the ordering of the completeness of any two models is made relative to a hypothesized complete causal structure that theorists think can represent the real causal system of an economic phenomenon. When theorists find that this hypothesized complete causal structure can no longer represent the real causal system of the phenomenon in question, they need to construct another complete causal structure to try to represent the real causal system. Economic models are then re-judged for their completeness relative to this newly hypothesized complete causal structure.

One important point is that no single hypothesized complete causal structure can exhaustively list all causal factors of the phenomenon in question. So even if Wong's model is the most complete model relative to the hypothesized general equilibrium system, it is still not the most complete model in general. There is no such thing as the most complete model in general; every model is compared with another model relative to a hypothesized complete causal structure that is thought to represent the real causal system in the world. The most that we can get is the relatively most complete model with respect to a certain hypothesized complete causal structure.
From this perspective, we can say that an abstract model such as the H-O-S model serves as a prototype to guide later theorists such as Markusen and Wong in developing their models so as to retrieve as much phenomenal content as possible from the hypothesized complete causal structure. If we see economic theorizing or economic model-building in this way, we are causal structuralists and will not ourselves commit the same mistake made by the regularists—to seek endlessly for the most general economic model that covers every economic detail in the world.

The next section discusses Kar-yiu Wong's model. This model represents a theorist's effort to try to establish the relatively most complete model under the general equilibrium system stipulated in the Heckscher-Ohlin theory.

5. Wong's Model

Our concern is not to find a model that is the most complete model in general that is readily applicable to explaining a real economic phenomenon. Instead, our goal is to find a model that is the relatively most complete model that can be used to explain the real phenomenon whose causal structure is supposed to be specified under a hypothesized complete causal structure of a general equilibrium system stipulated by economic theorists. Given that, we turn to Wong (1986) for a fresh perspective. Wong developed necessary and sufficient conditions pertaining to the question as to when substitutability or complementarity obtains, thus yielding more general insights into the debate of our concern.

Wong's model allowed differences in three variables: first, in factor endowments (the cause of trade in the H-O-S model but the result of factor mobility in the Markusen models); second, tastes (both in the H-O-S model and in the Markusen models, countries are assumed to have similar tastes); and third, technology (the
H-O-S model assumes the same technology level between two countries, whereas the Markusen model of different production technology allows the technology level to differ between the countries. Wong’s model is to be regarded as more complete than Markusen’s model because Wong introduced an additional causal factor, and from this model he derived a more complete conclusion to the extent that Markusen’s conclusion is to be regarded as one of its special cases.

5.1 Model Specification

Let’s introduce Wong’s method by beginning with the model specification. Let’s define $p$ = prices of good 2, $w$ = prices of labor = wage, $r$ = prices of capital = interest rate, $k$ = the amount of foreign capital in the home country (negative for the amount of national capital in the foreign country), $x_i$ = production of good $i$ by the (national and foreign) factors in the economy, and $c_i$ = the consumption of good $i$ by the nationals ($i = 1, 2$). We denote foreign variables with asterisks. Suppose the following situations obtain (Wong 1986, pp. 27-8):

1. A world of two countries—the home country (h) and the foreign country (f)—initially endowed with a fixed amount of two factors: labor and capital.
2. The home country has a higher rental rate, i.e., $r^h > r^f$.
3. In autarky, both countries produce good 1 and good 2. Good 2 is the cheaper good in the home country (h), assuming a closed economy, i.e., $p^1_h < p^2_h$.
4. Differences are allowed in factor endowments, preferences, and technologies, but technologies are those which exhibit constant returns to scale and no factor-intensity reversal occurs in any prices.
5. The home country’s export (import if negative) of good 1 is

$$E(p, k) = x_1(p, k) - c_1(p, I) - r(p, k)k$$ (2)

where $I =$ national income, defined as total domestic output - payments to
To simplify formula (2), we further assume that in the absence of factor-intensity reversal, a one-to-one correspondence exists between factor prices and commodity prices. Thus, we can write \( w = w(p), \ r = r(p), \) and \( I = I(p; \ L, \ K) = w(p)L + r(p)K, \) where \( L \) and \( K \) are the given labor and capital endowments of the economy. Thus, we can derive simplified (2) when the economy is diversified:

\[
E(p, k) = x_1(p, k) - c_1(p) - r(p)k
\]  

Next, we derive simplified (2) when the economy is completely specialized in producing good 1. Because only good 1 is produced, there will be no effect of the price of good 2 (= \( p \)) on the production of good 1 (\( x_1 \)) and on the price of capital; thus, \( p \) is removed from the production function of \( x_1 \) and the interest rate function of \( r. \) So the simplified function of the home country's export of good 1 when the economy is completely specialized in producing good 1 is as follows:

\[
E(p, k) = x_1(p, k) - c_1(p) - r(k)
\]  

Given that there is no export of good 1—i.e., \( x_1(p, k) = 0 \)—and that the consumption of good 1 (\( c_1 \)) depends upon import, the simplified function of the home country's export of good 1 when the economy is completely specialized in producing good 2 can be derived as follows:

\[
E(p, k) = -c_1(p, k) \text{ where } I = px_2 - pr_2k
\]  

Formulas (2a), (2b), and (2c) are used below to derive the sign pattern of \( E_k = \partial E/\partial k \)—i.e., the home country's export of good 1 when capital is traded.

### 5.2 Outline of Wong's General Equilibrium Approach

Wong's general equilibrium approach examines how the interaction between the world's commodity markets and the world's capital market determines simultaneously the relation between commodity trade and factor trade—i.e., whether they are
substitutes or complements. In this approach, schedule GT, whose slope is denoted as \( S_G \), depicts the equilibrium of the world's commodity markets under all possible combinations of \( E \) and \( k \) on an \((E, k)\) plane. Schedule KM, whose slope is denoted as \( S_K \), depicts the equilibrium of the market in the world's capital—the traded factor—under all possible combinations of \( E \) and \( k \) on an \((E, k)\) plane. We will also see that some necessary and sufficient conditions for substitutability and complementarity between goods trade and factor mobility can be established by observing the behavior of the slope of schedule GT and that of schedule KM simultaneously.

To examine the behavior of the slopes of these two schedules, we must first determine the sign patterns of the slope of each schedule. However, these sign patterns can be determined only after we determine all the sign patterns of the variables that exist in the formula of the slope.

In the following sections, we will first see that Wong examined the condition for capital flow to have negative effects on the volume of commodity trade—i.e., the condition for \( E_k < 0 \). Given that \( E_k < 0 \), Wong then moved on to derive the slope of schedule GT from three equilibrium conditions of the world's commodity markets. By using the same sign pattern of \( E_k \), Wong also derived the slope of schedule KM from three conditions of the world's capital market. Finally, by observing the pattern of the intersection of schedules GT and KM, Wong derived the necessary and sufficient conditions for substitutability and complementarity between goods trade and factor trade.

5.3 Effects of Capital Flow on the Volume of Commodity Trade

Consider under what condition investment from abroad—i.e., the capital inflows from foreign countries—will have negative effects on the volume of commodity trade in
good 1; that is, under what condition the sign of \( E_k = \frac{\partial E}{\partial k} \) is less than zero.

Proposition 1 in Wong's paper (1986, pp. 28) provided a condition for \( E_k < 0 \) in all three cases represented in formulas (2a), (2b), and (2c).

**Proposition 1.** The case in which [if either]
(a) the economy is diversified, or
(b) the economy is completely specialized in the capital-intensive good and is a capital-receiving country, or
(c) the economy is completely specialized in the labor-intensive good and is a capital-sending country[.]
[then] more investment from abroad will, under constant terms of trade [i.e., under constant commodity prices], lead to a smaller export of good 1: \( E_k \) is negative if and only if good 1 is labor-intensive.

The condition for \( E_k < 0 \) is that good 1 is a labor-intensive good. Note that Wong's proposition 1 has already gone beyond the H-O-S model in that the economy in question is allowed to be completely specialized in producing only one good and to have capital inflows from foreign countries but still obtain the similar conclusion that is indicated in the theorem of factor-price equalization—i.e., commodity trade and factor trade tend to have a negative relationship. The purpose of identifying both the sign pattern of \( E_k \), which is negative, and the factor-content of good 1, which is labor-intensive, under the three different cases specified in (a), (b), and (c) of proposition 1, is to attempt to clarify the further conditions that are to be used to ensure the derivation of the sign patterns of the slopes of both schedule GT and schedule KM.

5.4 Equilibrium of the World's Commodity Markets

According to Wong's proposition 1 we assume that (1) good 1 is labor-intensive in
both countries and (2) both countries are diversified. Thus, the equilibrium of the world's good 1 market in the presence of capital movement requires the following three equilibrium conditions (Wong 1986, pp. 29):

\[ E(p, k) + E^*(p^*, k^*) = 0 \]  
\[ k + k^* = 0 \]  
\[ p = p^* \]  

Substituting (4) and (5) into (3), we have

\[ E(p, k) + E^*(p, -k) = 0 \]  

Equation (3a) gives possible combinations of \( E \) and \( k \) that equilibrate the international goods market at the indicated price of good 2. Thus, all these possible combinations of \( E \) and \( k \) construct a schedule (GT) in a coordinate system with \( E \) or \(-E^*\) as the vertical axis, and \( k \) or \(-k^*\) as the horizontal axis.

By, first, totally differentiating (3a) and the export equation \( E = E(p, k) \) and, second, substituting the conclusion of the total differentiation of (3a) into the conclusion of the total differentiation of the export equation, we obtain the formula of the slope of schedule GT:

\[ \frac{dE}{dk}|_{GT} = (E^* k^*) E_p + E_k (E^* p^*) / E_p + E^* p^* \]  

Recall that, from proposition 1, \( E_k \) is supposed to be negative—i.e., \( E_k = \frac{\partial E}{\partial k} < 0 \). Wong pointed out that, in a Walrasian sense, the stability of the system of the international market of good 1 at any level of capital movement requires that \((E_p + E^*_p) < 0\). This inequality brings about two situations: \( E_p < 0 \) and \( E^*_p < 0 \), or either of them is positive but not of a significant magnitude. Thus, Table 2 summarizes the conditions for schedule GT to be negatively sloped—i.e., the conditions for the value of formula (6) to be negative—if good 1 is labor-intensive in both countries.

[Please refer to Table 2]
Based on this information, these combinations of equilibrium $E$ for various values of $k$ are plotted in Figure 3 as negatively sloped schedule GT. The vertical axis in Figure 3 represents domestic export ($E$) or foreign import ($-E^*$) of good 1. The horizontal axis represents the amount of foreign capital in the home country ($k, -k^*$).

[Please refer to Figure 3]

5.5 Equilibrium of the World's Capital Market

In the same manner as we did in section 5.4, we can derive another schedule, KM, to represent the equilibrium conditions of the capital market. The equilibrium of the capital market requires the following three conditions (Wong 1986, 31):

$$E(p(r), k) + E^*(p^*(r^*), k^*) = 0$$  \hspace{1cm} (3b)

$$k + k^* = 0$$  \hspace{1cm} (4)

$$r = r^*$$  \hspace{1cm} (7)

Substituting (4) and (7) into (3b), we have

$$E(p(r), k) + E^*(p^*(r), -k) = 0$$  \hspace{1cm} (3c)

Equation (3c) gives possible combinations of $E$ and $k$ that equilibrate the international capital market at the indicated interest rate. Thus, all these possible combinations of $E$ and $k$ will construct a schedule (KM) in the same coordinate system where GT lies.

By, first, totally differentiating (3c) and the export equation $E = E(p(r), k)$ and, second, substituting the conclusion of the total differentiation of (3c) into the conclusion of the total differentiation of the export equation, we obtain the formula of the slope of schedule KM:

$$\frac{dE}{dk}_{|KM} = E_p p r E^* k^* + E^* p^* r^* E_k / E_p p r + E^* p^* r^*$$  \hspace{1cm} (8)
Recall from proposition 1 that $E_k$ is supposed to be negative—i.e., $E_k = \frac{\partial E}{\partial k} < 0$. Note that because both economies are diversified, $E_k$ and $p$, $E_{k*}$ and $p_{r*}$ always have opposite signs. The Walrasian stability also holds in the international capital market; it requires that $(E_p + E_{p*}) < 0$. This inequality brings about two situations: $E_p < 0$ and $E_{p*} < 0$, or either of them is positive but not of a significant magnitude. Table 3 summarizes the conditions for schedule KM to be negatively sloped—i.e., the conditions for the value of formula (8) to be negative—if good 1 is labor-intensive in both countries.

[Please refer to Table 3]

Figure 4 shows a plot of these combinations of equilibrium $E$ for various values of $k$ plotted as negatively sloped schedule KM. The vertical axis represents domestic export ($E$) and foreign import ($-E^*$) of good 1, and the horizontal axis represents the amount of foreign capital in the home country ($k$, $-k^*$).

[Please refer to Figure 4]

We can now combine Figure 3 and Figure 4 to create Figure 5. (Wong 1986, p. 31, here simplified) Figure 5 depicts the intersection point, point w, between schedules GT and KM. Point w represents the equilibrium of the world's good 1 and capital markets. Furthermore, according to the notion revealed in Figure 5, we can develop the necessary and sufficient conditions for substitutability and complementarity between goods trade and factor mobility by observing the slope behavior of schedules GT and KM.
5.6 Necessary and Sufficient Conditions for Substitutability and Complementarity between Goods Trade and Factor Mobility

In Figure 5, points $E_0$, $k_0$, and $w$ have their own meanings. Point $E_0$, with a coordinate of $(0, E_0)$, represents the level of domestic export of good 1 under free commodity trade but no capital mobility. Point $k_0$, with a coordinate $(k_0, 0)$, represents the level of foreign investment in the home country under free capital mobility but autarky in commodity trade. Point $w$, with a coordinate $(E_w, k_w)$, represents the level of domestic export of good 1 and that of foreign investment in the home country under free trade and capital mobility.

In terms of $E_0$, $k_0$, $E_w$, and $k_w$, we quote the following definitions from Wong's paper (1986, p. 33, with renumbering):

(i) Capital mobility diminishes (augments) goods trade if and only if the volume of trade under free goods trade and capital mobility is smaller (greater) than the volume of trade under free trade but no capital mobility—i.e., if and only if $E_w < (>) E_0$.

(ii) Goods trade diminishes (augments) capital mobility if and only if the amount of capital transfer under free goods trade and capital mobility is smaller (greater) than the amount of capital transfer under free capital mobility but autarky in trade—i.e., if and only if $k_w < (>) k_0$.

(iii) Goods trade and capital mobility are substitutes if and only if they diminish each other.

(iv) Goods trade and capital mobility are complements if and only if they augment each other.

We can connect points $E_0$ and $w$ to form line $E_0w$ (not shown) with slope $S_G$,
and connect points \( w \) and \( k_0 \) to form line \( wk_0 \) (not shown) with slope \( S_K \). \( S_G \) can be calculated as follows. We have

\[
 w = w(k_w, E_w) \quad \text{and} \quad E_0 = E_0(0, E_0)
\]

Thus,

\[
 S_G = (E_w - E_0) / (k_w - 0)
\]

\[\Rightarrow S_G k_w = E_w - E_0 \quad (9)\]

In the same manner, we can obtain \( S_K \) as follows. By transforming \( k_w \) and \( E_w \),

\[
 w = w(k_w, E_w) \rightarrow w(E_w, k_w)
\]

\[
 k_0 = k_0(k_0, 0) \rightarrow k_0(0, k_0)
\]

Thus,

\[
 S_K = (k_w - k_0) / (E_w - 0)
\]

\[\Rightarrow S_K E_w = k_w - k_0 \quad (10)\]

Table 4 summarizes the sign structure among \( S_G, k_w, E_w, \) and \( E_0 \) for depicting the change in the equilibrium levels of goods trade in formula \( 9 \), and Table 5 summarizes that among \( S_K, E_w, k_w, \) and \( k_0 \) for explaining the change in the equilibrium levels of capital flow in formula \( 10 \). (Wong, 1986, p. 34, here rearranged)

[Please refer to Table 4 and Table 5]

Figure 6 depicts the possible maps for conditions (1) and (4), (2) and (5), and (3) and (6) in Table 4 and 5.

[Please refer to Figure 6]

By using definitions (i) through (iv) and conditions (1) through (6), we can infer the
following three outcomes (Wong 1986, p. 34, here rearranged):

(a) The slope of schedule GT (= S_G) and that of schedule KM (= S_K) have the same sign.

(b) Foreign capital will tend to flow in under free trade if \( r_0 \) (home price of capital or home interest rate under free commodity trade but capital immobility) > \( r^*_0 \) (foreign price of capital or foreign interest rate under free commodity trade but capital immobility), and \( k_w \) will be positive; thus, \( (r_0 - r^*_0) \) has the same sign pattern as \( k_w \) does.

(c) \( E_w \) (export of good 1) will be positive if \( p_0 \) (price of good 2 in home country under free capital movement but autarky in commodity trade) > \( p^*_0 \) (price of good 2 in foreign country under free capital movement but autarky in commodity trade)—i.e., \( (p_0 - p^*_0) \) has the same sign pattern as \( E_w \) does.

Finally, by combining definitions (i) through (iv), conditions (1) through (6), and outcomes (a) through (c), we can derive the necessary and sufficient conditions for substitutability and complementarity between goods trade and capital mobility when capital is mobile between countries, which we quote from Wong (1986, p. 34):

**Proposition 2.**

(a) Capital mobility diminishes (augments) goods trade if and only if sign (slope of schedule GT) \( \neq \) \( = \) sign \( (k_w) = sign (r_0 - r^*_0) \);

(b) Goods trade diminishes (augments) capital mobility if and only if sign (slope of schedule KM) \( \neq \) \( = \) sign \( (E_w) = sign (p_0 - p^*_0) \);

(c) Goods trade and capital mobility are substitutes if and only if (i) sign (slope of schedule GT) \( \neq \) sign \( (k_w) = sign (r_0 - r^*_0) \); and (ii) sign (slope of schedule KM) \( \neq \) sign \( (E_w) = sign (p_0 - p^*_0) \);

(d) Goods trade and capital mobility are complements if and only if (i) sign (slope of schedule GT) = sign \( (k_w) = sign (r_0 - r^*_0) \); and (ii) sign (slope of schedule KM) = sign \( (E_w) = sign (p_0 - p^*_0) \).
5.7 Wong’s Empirical Testing and a Summarized Comment

In addition to this systematic theoretical treatment of the issue, Wong conducted, in a 1988 paper (Wong in Robert C. Feenstra (ed.) 1988, pp. 231-50; for a succinct summary of this empirical research, refer to Bowen, Hollander, and Viaene 1998, pp. 244-5), the first empirical research on the effects of factor movements (including labor and capital movements) on the volume of commodity trade and factor prices. In this study, Wong estimated the indirect trade utility function of the United States from the data over the period 1948-83, and then, using the results derived from this estimation, he calculated the elasticities of exports and imports with respect to factor supply to see whether these elasticities are negative or positive and thereby determine whether factor mobility and commodity trade are substitutes or complements. The simple idea is this: In the case of substitutability, elasticity is negative; in the case of complementarity, it is positive.

Wong found that, in the case of the United States during this period, the signs of the elasticities are mostly not only positive but also significantly greater than 0. This means that factor mobility and commodity trade are strongly complement to each other; whenever there is an increase in the foreign factor supply to the United States, this foreign factor supply will cause an increase in the volume of U.S. trade with foreign countries. This conclusion runs directly counter to the conclusion derived from the standard H-O-S model, which states that factor mobility and commodity trade are substitutes. But, as is shown in Wong's theoretical model, this result should not surprise trade theorists because it is a case that is already included in Wong's model—a relatively most complete model with respect to the general equilibrium framework of the H-O-S tradition.

One important conclusion regarding the nature of the method of empirical causal inference can be derived. Consider Wong's empirical test for substitutability or
complementarity between factor mobility and commodity trade. Notice that Wong devises his own approach and criterion, with respect to the real situations he faced, to test for the existence or direction of the influence of the additional causal factors that are originally impounded in the H-O-S model. Wong’s practice has demonstrated that his empirical inference of the direction of the factor’s influence should be regarded as only a part of an entire procedure of economic theorizing. This is a part that is to be used, depending on the knowledge collected from the other parts of this entire theorizing procedure, to test the factor’s influence of a specific case in a specific situation. Recall that Wong could not make definite theoretical conclusions simply by depending on his empirical testing approach, he reached his conclusions with the help of a conglomerate of knowledge, including the knowledge derived from his own empirical testing approach, the background causal knowledge provided by the international trade theories of the H-O-S tradition, and, most importantly, the detailed knowledge of the real situation of the economic phenomenon in question—i.e., in Wong’s case, the knowledge of the estimated indirect trade utility function of the United States over the period 1948-1983. The main import here is that whenever there is a change in the knowledge of some part of the theorizing procedure, the existing empirical method being used to make causal inference may turn out to be inadequate under the condition of this new background knowledge, and the method may be replaced by another, more pertinent method.

As a result, whenever an empirical approach to causal inference has succeeded in identifying the causal influence of a specific cause in a specific economic phenomenon, the case should attest only that this empirical approach is adequate for use only in the case of this specific economic phenomenon—no more and no less. Any attempt to generalize the applicability of this empirical approach beyond the limit of a specific case should itself be tested for validity by other, independent approaches
or ideas.

6. Conclusion

Instead of facing the problem of selecting which main assumptions in the H-O-S model to drop, as Markusen faced in his model-building, Wong chose to sidestep this problem by dropping all assumptions in the H-O-S model and then constructing, under the H-O general equilibrium system, a relatively most complete model whose conclusions can be used to identify when commodity trade and factor mobility are substitutes or complements. The lesson that we learn from comparing the theoretical structures of the H-O-S model, the Markusen models, and the Wong model (for a schematic comparison of these models, refer to Appendix) is this: It is possible for theorists to develop full-fledged causal models with respect to a complete causal system that is hypothesized by these theorists themselves (or by other theorists who are from the same tradition) in an attempt to represent the main causal features of a class of real phenomena.

The entire procedure to produce such fully developed causal models can be summarized as follows: When theorists find that some real causal phenomena, which are originally supposed to be explainable or predictable by the theorists' causal models, cannot in fact be explained or predicted by them, the theorists generally start to think about which assumptions specified in their theories do not hold in the phenomena. These theorists often then regard their causal models as being too simple compared with the causal system that is hypothesized in theories by themselves or their colleagues. They then re-specify their simple causal models to accommodate more causal factors, released from the theoretical assumptions, to make their models more complete and so more concrete. At this stage, they are still
restructuring their causal models within a limited domain—i.e., within their hypothesized complete causal system. These theorists journey toward establishing increasingly complete causal models by adding increasing numbers of causal factors that can be released from the theoretical assumptions. In the end, they may reach the point that all imaginable causal factors presented in their theories are exhausted. When this situation is reached, these theorists' causal models can then be regarded as the relatively most complete causal models relative to their hypothesized complete causal system.

One question arises: Are these relatively most complete causal models models of everything? That is, can these models be used as general models to explain and predict every economic causal phenomenon in the real world? No. Notice that these causal models are relatively most complete only with respect to a specific domain—i.e., only with respect to the hypothesized complete causal system. When new causal factors occur in the real world that are missing from the original hypothesized complete causal system but now involve an economic phenomenon in question, these relatively most complete causal models cannot explain or predict the economic phenomenon in question. What, then, can the theorists do? At this stage, they must employ any possible means to ascertain relevant causal knowledge of the new causal factors. When they have obtained enough background causal knowledge of the new causal factors, they can then proceed to enlarge the domain of their hypothesized complete causal system by adding the factors. Then a new round of causal model structuring and restructuring with respect to a new hypothesized complete causal system runs again. The entire procedure continues infinitely.

People may ask, Does this description of causal modeling suggest that it may be possible to establish a relatively most complete causal model at each stage, but it is not possible to have the most complete causal model in general—one that can be
applied to explain or predict anything in the real world, even in the long run? Yes, this is exactly what I mean. Then isn't this too pessimistic a picture of science? No, not at all. This is an exact picture of what science is for. Science, including economics, continues to exist for the purpose of discovering new causal factors in different stages in an attempt to establish the relatively most complete causal model at each stage. The pleasure of scientists and economists comes from their achievements in establishing the relatively most complete causal model at each stage. Here is what Paul A. Samuelson said in a keynote address presenting an anthology of recent papers on new directions in trade theory (Samuelson in Levinsohn, Deardorff, and Stern (eds.) 1995, p. 22):

A science seeks perfection and closure. But success brings dull complacency. To the degree that challenging problems remain to be solved, a science stays vital and exciting.

By this test, the theory of international trade is young and lusty. Our platter is full of delicious challenges. In science as elsewhere, it is better to travel than to arrive. And [the various new models of international trade] attest that trade theory is very much on its way.

Yes, far from being over, the journey has only begun, and there is still a long way to go. Economic theorizing, like any other scientific theorizing, engages in an endless journey of searching for the relatively most complete causal models in different stages of theory development.
Appendix
Assumptions, Methodology, and Conclusions of the Four Models

The controversy concerning the relationship among factor endowments, the pattern of trade in goods, and factor mobility is rooted in the extensions and reinterpretations made by Markusen, Svensson, and Wong of the two powerful propositions made in the Heckscher-Ohlin-Samuelson model. These propositions are the Heckscher-Ohlin theorem, which posits a strong positive connection between factor endowments and the pattern of trade in goods, and the factor-price equalization theorem, which states that trade in goods equalizes factor rewards completely and thus serves to some extent as a substitute for factor mobility.

The criticisms, however, generally are aimed at the assumptions and methodologies of the Heckscher-Ohlin-Samuelson model, not the model's overall structure. The following comparative analysis delineates the main assumptions and methodologies of the models discussed in this paper. The outline of Svesson's model is also presented, although it is not discussed in detail in this paper.

The Heckscher-Ohlin-Samuelson Model

- Main assumptions: (1) different factor endowments (which forms the trade bases), (2) different or same factor rewards, (3) identical technology, (4) identical tastes, (5) factor immobile, (6) incomplete specialization in production, and (7) 2 countries × 2 factors × 2 commodities, (8) constant returns to scale, (9) strong factor intensity, (10) perfect competition, (11) free trade, (12) no transportation costs.

- Methodology: the orthodox theoretical logic

The Rybczynski theorem $\rightarrow$ the Heckscher-Ohlin theorem $\rightarrow$ the Stolper-Samuelson theorem $\rightarrow$ the factor-prices equalization theorem
is used to establish the following two proposition.

- Conclusion: (1) a strong positive connection between factor endowments and trade in goods and (2) trade in goods and factor mobility are substitutes.

**Markusen's Models**

- Main assumptions: (1) Begin with same factor endowments, (2) identical tastes, (3) factors mobile, and (4) 2 countries × 2 factors × 2 commodities.

- Methodology:
  1. Assume same factor endowments.
  2. Relax each one of the following assumptions, respectively, in the Heckscher-Ohlin model to establish a situation of different factor rewards in each individual model: (i) identical technology, (ii) constant returns to scale, (iii) perfect competition in both product and factor markets, and (iv) free trade.
  3. Different factor rewards drive factors to move between countries, thereby increasing factor mobility.
  4. Thus, a situation of different factor endowments obtains.
  5. A factor-proportion basis is formed to reinforce the other basis for commodity trade.
  6. Accordingly, commodity trade increases.

- Conclusion: Goods trade and factor mobility are complements.

**Svensson's Model**

- Main assumptions: (1) begin with same factor endowments and same factor rewards, (2) identical technology, (3) identical tastes, (4) factors mobile, and (5) 2 countries × 2 factors × 2 commodities.

- Methodology:
(1) Assume same factor endowments and rewards between the two countries.

(2) Before the change in the endowment of the home country, trade in both goods and in some factors is allowed.

(3) The initial equilibrium will be zero trade in goods and factors.

(4) However, the change in home country endowment will result in a different equilibrium with generally nonzero trade in both goods and factors.

• Conclusion: Goods trade and factor trade tend to be substitutes (complements) if traded and nontraded factors are cooperative (noncooperative).

### Wong's Model

• Main assumptions: (1) different factor endowments, (2) different factor rewards, (3) possible different technology, (4) possible different tastes, (5) factors mobile, and (6) 2 countries × 2 factors × 2 commodities.

• Methodology: Assume that there are only two factors in the world—one is internationally mobile and the other one is immobile—to establish Wong's own general-equilibrium system. In this system, two schedules are depicted. One schedule represents the equilibrium of the world's commodity markets, and the other schedule represents that of the world's traded-factor market, under all possible combinations of the level of the home country's export of nontraded factor-intensive good and the level of the amount of foreign traded factor in the home country. By observation of the intersecting point of these two schedules and the behavior of the slopes of these two schedules simultaneously, some necessary and sufficient conditions for substitutability and complementarity between goods trade and factor mobility can be established.

• Conclusion: Necessary and sufficient conditions have been developed for substitutability and complementarity between goods trade and factor mobility.
Summary

From these brief outlines it is clear that even those authors, such as Markusen, who most sharply disagree with the traditional Heckscher-Ohlin-Samuelson ideas, still depend heavily on the conventional theoretical assumptions and logic to develop their own models, although they argue that either the assumptions or the logic can be relaxed. Markusen relaxed the conventional assumptions but retained the traditional theoretical logic to develop a conclusion that differs significantly from the traditional ones. To develop his own middle-ground conclusions, Svensson held all of Heckscher-Ohlin's assumptions except factor immobility and conducted the logic using procedures that differ from those in the traditional model. A more interesting case is Wong's paper. By relaxing all the main assumptions in the Heckscher-Ohlin-Samuelson model, Wong developed the equilibrium system originally stipulated in the Heckscher-Ohlin theory to establish the necessary and sufficient conditions for deciding substitutability or complementarity between goods trade and factor mobility.
References


