DM/86/35

INTERNATIONAL MONETARY FUND

Research Department

Modeling International Transportation Services

Prepared by Henryk Kierzkowski 1/

Approved by Malcolm D. Knight

May 16, 1986

Summary

This paper develops a model of transportation services that is designed to be consistent with the structure of the World Trade Model. In addition to the specification of the theoretical model and its estimation for ten industrial countries, the paper includes brief reviews of the literature on modeling transportation services and of the relevance of service accounts to the global asymmetry in the current account of the balance of payments.

Most previous work in this field has been based on one of two standard models. The first, developed by Samuelson, treats transportation as a cost directly related to the quantity of goods being shipped; the only effect of the cost of transportation is to reduce the volume of trade, and the model cannot determine who will provide the services. The second, an extension of the Heckscher-Ohlin model, focuses on the role of relative factor endowments in determining the allocation of transportation services, but it has little relevance except in the very long run.

This paper attempts to overcome the shortcomings of earlier approaches by modeling transportation services in the context of a duopoly in which there are two countries, two goods, and two providers of transportation services. Merchandise trade determines the demand for transportation, and the interaction between the two shippers (modeled as a Cournot game) determines the allocation of the market shares.

1/ Graduate Institute of International Studies, Geneva, Switzerland. This paper was written while the author was a consultant in the Research Department. Helpful comments and suggestions made by J. Boughton, R. Haas, and M. Knight led to improvements in the paper. Excellent research assistance provided by Gertrud Windsperger is also gratefully acknowledged. The opinions expressed in the paper are my own.

I. Introduction

International trade in services has been gaining prominence in recent discussions on commercial policy and trade negotiations. For example, it is frequently suggested that future GATT negotiations should involve at least some categories of services. In spite of its importance and the widespread interest that has been accorded to it by policymakers, international trade in services has as yet been the subject of only limited theoretical and empirical work. It is unlikely that a single operational model of trade in services--one that would apply equally well to international transportation, insurance, tourism, banking, data processing, and telecommunication--will ever emerge. The discussion of services that are closely related to transactions in goods--such as shipping, insurance, and certain types of finance--is perhaps most appropriately undertaken by analyzing the determinants of flows. By contrast, stock considerations are often more appropriate to describe the determinants of factor services.

This paper deals with international transportation services. Historically, transportation has been the most important internationally traded service, and even today it is a significant sector of the world economy. Thus an analysis of the determinants of transportation services appears to be an appropriate starting point for expanding our trade models to include services, especially considering close links between this particular type of service and merchandise trade.

The present paper is organized as follows. Section II discusses some "stylized facts" concerning international payments resulting from transportation services. Section III offers a brief review of the existing theoretical work on transportation services and puts forward an alternative to the standard model. In Section IV, this model is estimated for a number of industrial countries, and the results are discussed. Finally, Section V offers a few concluding remarks.

On the theoretical side, the novelty of this work lies in departing from the standard competitive framework and setting the international transportation industry in an environment of monopolistic competition. This approach is intended to offer a dose of realism and to get around some of the well-known and serious shortcomings of the availables statistical data on service transactions. The empirical work relies on such macroeconomic variables as the volume of trade, exchange rates, wage rates, and oil prices and is thus in harmony with most aggregative models of merchandise trade, including the World Trade Model (Deppler and Ripley (1978), Spencer (1984)).

II. Stylized Facts

International transportation, like so many other services, consists of a very heterogeneous collection of economic activities. The IMF

balance of payments statistics divide them into two broad categories: "shipment," and "other transportation." The former class of service transactions covers: "the freight, insurance, and other distributive services (a) performed by residents of the compiling country on merchandise and most other movable goods acquired or owned by nonresidents, and (b) performed by nonresidents on merchandise and most other movable goods acquired or owned by residents." 1/ The latter category is essentially defined as a residual: "... those services not classified in other items that are performed by one economy for another through the operations of carriers and similar equipment..." 2/ It consists of passenger services (mainly fares, but also charges for excess baggage and payments for transportation of personal effects accompanying the passengers, such as automobiles), port services, etc. Port services cover procurement of goods and services by carriers for the purpose of their own operations. However, this second category also covers such miscellaneous services as fees for salvage operations, delivery of letter mail, and so forth. Freight services, provided through the operations of land, sea, and air carriers, constitute the main component of the services of shipment and the transportation of persons. For the purpose of balance of payments recording it is important to determine both where these carriers operate and where their owners reside. Since international transportation services constitute one of the best examples of a "footloose industry" analytical and empirical problems abound, with serious implications for balance of payments statistics.

How important are transporation services in absolute terms and in relation to merchandise trade? Table 1 provides some information on this subject. The total value of world shipment services amounted to SDR 42.8 billion (credits) in 1983, an amount that constituted about 2.8 percent of the value of merchandise trade. 3/ Other transportation services were worth SDR 68.2 billion. Taken together, total transportation services represented 7.3 percent of merchandise trade in 1983. There is some variation in the relative importance of transportation services over time, owing to cyclical factors and to structural and technological influences. There seems to be no doubt that there has been considerable technological progress in the international transportation industry, involving not only

---

1/ Balance of Payments Manual, Fourth Edition, International Monetary Fund, Washington, D.C., p. 87.

2/ Balance of Payments Manual, op. cit., p. 95.

3/ Of course, the value of all services in international trade is very much larger. The value of international shipment services, other transportation, travel, direct investment income, and indirect investment amounted to SDR 429.3 billion (credits), or 28.2 percent of the value of merchandise trade. In addition, there was SDR 178.2 billion worth of transactions in other goods, services and income.

improvements in the efficiency of the existing means of transportation, but also the development of new modes of transportation; the introduction of container ships is a case in point. 1/ Recent deregulation of the transportation industry in a number of countries is also bound to have a significant influence on the volume and the value of international transactions.

In comparing international transportation transactions with other services, it is worth remembering that in 1983 this industry generated balance of payments flows worth more than the total flows of direct investment income: SDR 111 billion against SDR 98 billion. On the other hand, the dramatic expansion of international lending following the first sharp rise in oil prices in 1973-74 resulted in increased flows of income from portfolio investments. From about 1979 onward, these became the most important item in the aggregate service account of IMF member countries (SDR 200 billion in 1983).

Table 1. International Transportation in Relation to Merchandise Trade

(Credits in billions of SDRs and percent)

	1977	1983
Merchandise trade, f.o.b.	870	1,521
Total transportation	64	111
As percent of merchandise trade	(7.3)	(7.4)
Shipment	27	42
As percent of merchandise trade	(2.8)	(3.1)
Other transportation	37	68
As percent of merchandise trade	(4.5)	(4.2)

Source: Balance of Payments Statistics, International Monetary Fund, Volume 35, Yearbook, Part 2, 1984.

According to official statistics, international transportation services are provided mainly by and for industrial countries. The share of these countries in exports of transportable services reached

1/ For a detailed discussion of this issue see Gray (1982).

76.2 percent in 1983, whereas they imported 63.0 percent of world transportation imports. (As the discussion below indicates, however, official statistics can often be very misleading in this respect.) Among the countries that play a crucial role in the world market for transportation services are the United States, Japan, the United Kingdom, the Federal Republic of Germany, the Netherlands, Norway, France, and Italy. Chart 1 presents quarterly data on export and import performance for each of these countries during the period 1970-1984. As can be seen, gaps appear quite frequently in the records of service transactions for countries that otherwise are known for very systematic and reliable statistical information.

Two of the eight industrial countries, namely the Netherlands and Norway, are systematically net exporters of transportation services. Interestingly, the Netherlands is consistently a net importer of shipping services and a large exporter of other transportation services. In the case of Norway it is the other way around--a large net payment surplus for shipment outweighs the deficit on other transportation. Japan, the Federal Republic of Germany, and Italy have consistently recorded subtantial deficits in their balance of transportation services. The overall situation of France is not clear because the data for other transportation services are not available, but France has a large and growing deficit on shipping. As far as the United States and the United Kingdom are concerned, no clear picture emerges with respect to the net position. In recent years, however, both countries seem to be net importers of transportation services on an increasing scale. Behind these aggregate numbers, the United States is consistently a net importer of shipping services; the United Kingdom which was once a substantial net exporter of shipping services, has experienced a sharply declining surplus on this account to a position of near balance in recent years.

In terms of broad, international trends, Chart 1 reveals a rapid rise in the value of transportation exports and imports during the period stretching from 1973 to around 1980. This tendency can be attributed to a rapid increase in the cost of providing transportation services which was triggered off by the two oil shocks and wage explosion in most of the developed countries.

The chart also reveals cyclical movements that appear to have been more pronounced than the fluctuations in merchandise trade. It seems clear that cyclical fluctuations in the value of transportation exports and imports are not perfectly correlated across the countries under discussion. The last turning point occurred around 1980, but not simultaneously.

It would be most desirable to look at the volumes of transportation services, but the data do not permit that option. To work on international services transactions requires not only working with incomplete

and inconsistent data classifications but also having to accept that data on the most important variable to the economist--the price--often do not exist at all; or, when they do exist, they may mean very little. As far as shipment is concerned, there do exist price indices for fuel carriers, as well as conference-rate and tramp-rate indices, but international debit and credit statistics do not distinguish between different types of carriers. With regard to other types of transportation, the airfare index exists, but no price indices are generally available for other components of this category such as repairs of foreign carriers, port charges and fees.

No discussion of the data concerning international transportation is complete without a brief discussion of the problem resulting from the statistical asymmetry. The global asymmetry problem refers to the fact that when balances on current accounts are aggregated for all countries considered in IMF statistics, the world as a whole has a sizable current account deficit. This deficit has grown very rapidly from $5 billion in 1974 to $77 billion in 1983. There are good reasons to believe that a significant portion of this amount can be traced to service transactions. As far as transportation services are concerned, the asymmetry problem is presented in Table 2. It can immediately be seen that this is a very serious problem indeed; the asymmetry on shipment transactions alone rose to a level 73 percent of the total value of credits in 1983. The fact that these asymmetries are consistently biased in one direction suggests that they are not really random errors and that something systematic must be taking place. The relative discrepancy between credits and debits on other transportation transactions is much smaller than on shipments.

A number of factors may lie behind the asymmetry problem. 1/ In the first place, of course, global balance of payments accounting identities hold only for the world as a whole and not for any particular group of countries. Although Fund statistics are quite comprehensive, they do not cover a number of countries, among them most of the East European countries. While the above countries are most likely to be net importers of all categories of services (hence the asymmetry problem may be even more serious), their net position with regard to transportation services is more difficult to ascertain. The existence of fleets flying so-called flags of convenience is believed to be responsible for a significant part of the asymmetry problem. As the countries offering "tax-haven" services do not consider shipping companies that profit from these facilities as indigenous to the economy, they do not enter services provided by these companies as credits in the balance of payments accounts. The problem arises because the countries importing services of fleets flying flags of convenience do record payments for these services.

1/ For a detailed discussion of the asymmetry problem, see World Economic Outlook, 1983.

CHART 1A

EIGHT MAJOR INDUSTRIAL COUNTRIES

SHIPMENT AND OTHER TRANSPORTATION SERVICES

(In billions of U.S. dollars; seasonally adjusted)

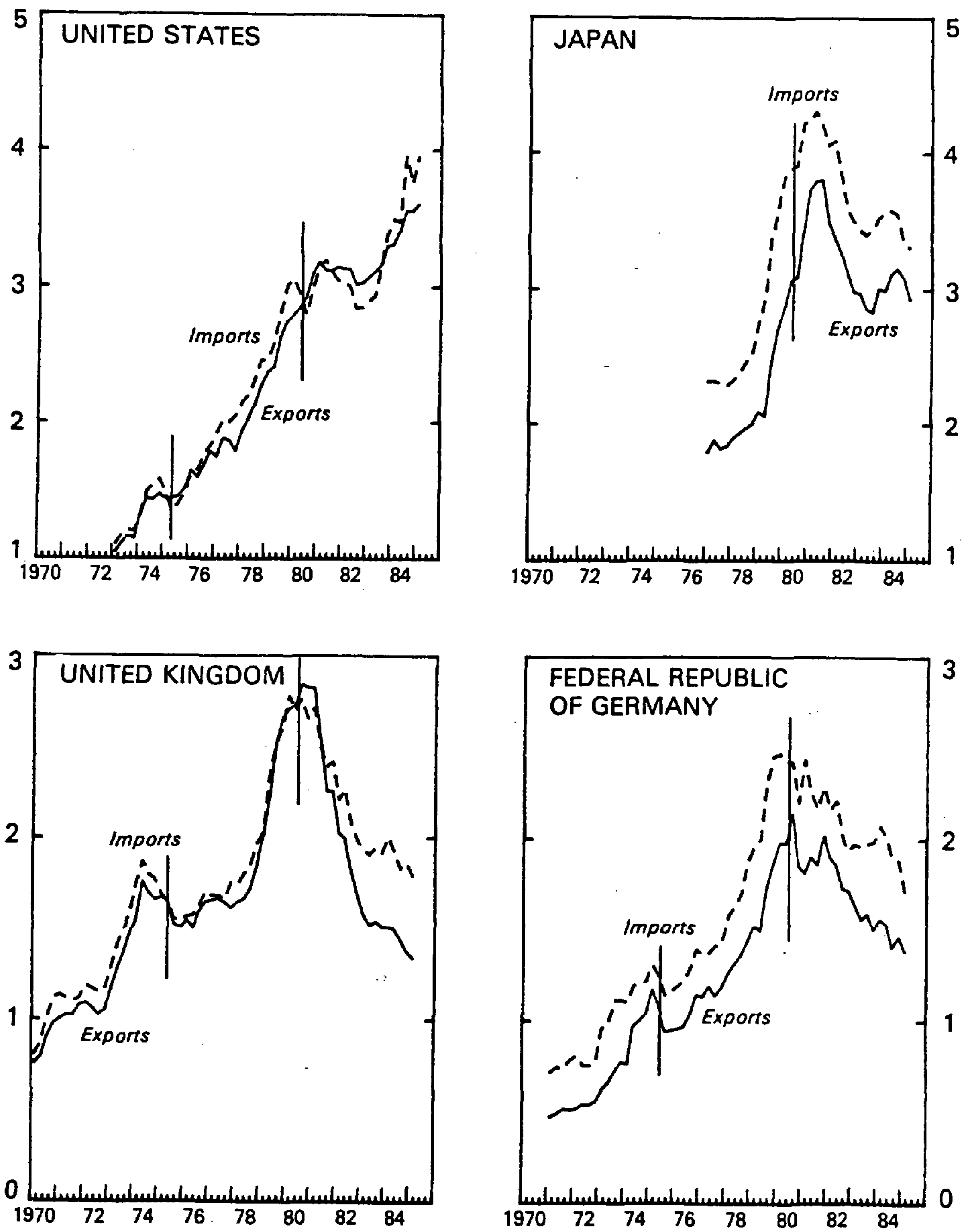
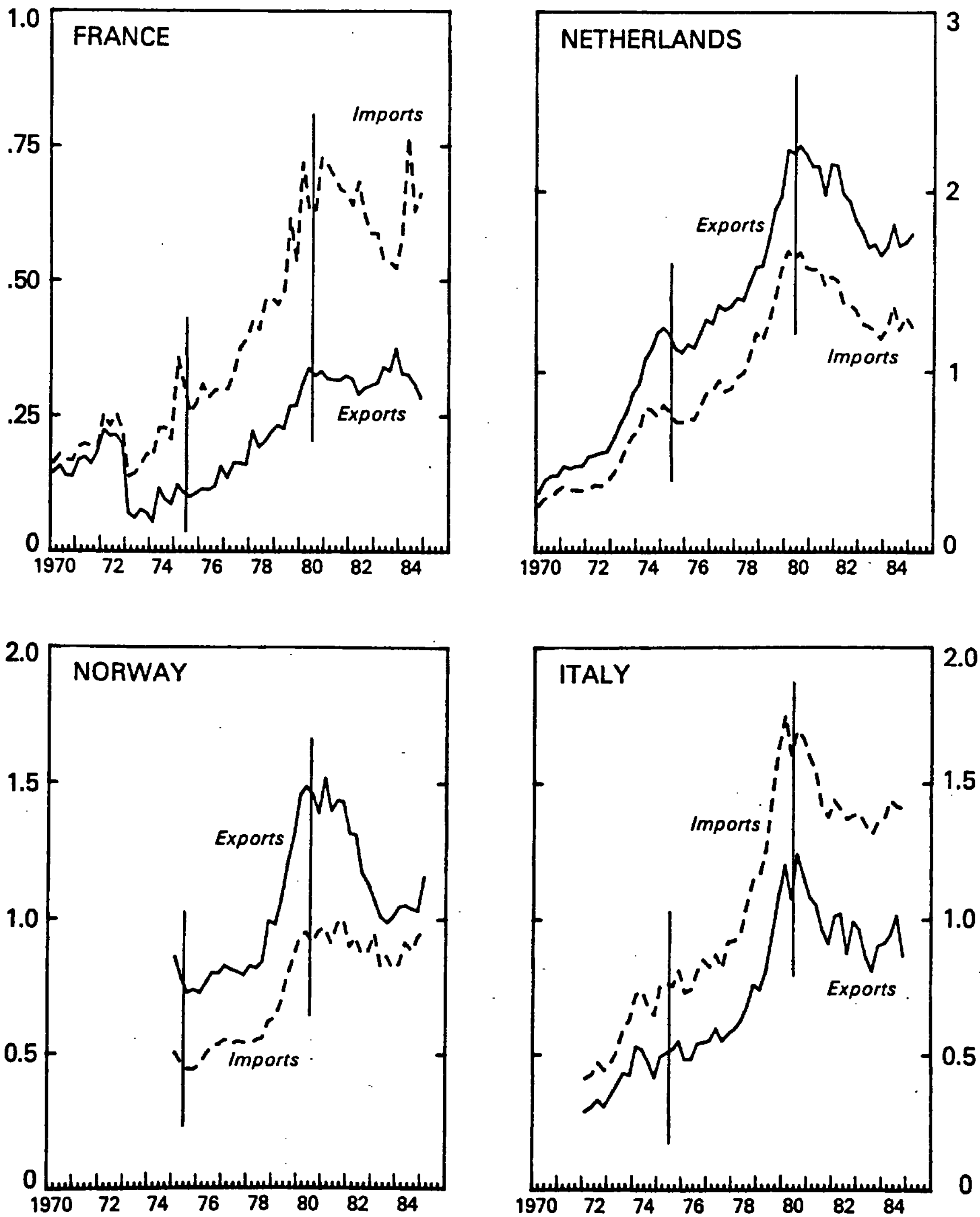


CHART 1B

EIGHT MAJOR INDUSTRIAL COUNTRIES

SHIPMENT AND OTHER TRANSPORTATION SERVICES (CONCLUDED)[1]

(In billions of U.S. dollars; seasonally adjusted)



[1] For France, data on other transportation are not available.

Table 2. Statistical Asymmetry on Shipment and Other Transportation Payments

(In billions of SDRs and percent)

	1977	1978	1979	1980	1981	1982	1983
Discrepancy (Credits Minus Debits)							
Shipment	-18.3	-19.7	-21.6	-24.9	-30.9	-32.0	-31.1
Other transportation	-1.7	-1.3	824	-2.4	-4.5	-2.1	-209
Total transportation	-20.0	-20.9	-22.4	-27.2	-35.4	-33.3	31.4
Discrepancy as Percent of Credits							
Shipment	(67.8)	(69.5)	(62.0)	(59.6)	(68.0)	(70.7)	(72.8)
Other transportation	(4.6)	(3.2)	(1.7)	(3.8)	(6.5)	(3.1)	(0.3)
Total transportation	(1.0)	(30.8)	(26.6)	(26.6)	(31.0)	(29.5)	(28.2)

Source: Balance of Payments Statistics, International Monetary Fund, Vol. 35, and Yearbook, Part 2, 1984.

This discussion of the availability and quality of international statistics on transportation services leads to two practical conclusions with regard to empirical work in this area. First, although it would normally be preferable to specify the model in terms of volumes rather than values, that approach would not be practical here. It is desirable to minimize the extent to which prices enter the theoretical model explicitly, so that its empirical counterpart will be less sensitive to errors in published price indices. This may be a very promising way to deal with one of the main difficulties associated with services in general, not only transportation. Second, given the evidence on the asymmetry problem, it is clearly preferable to work separately with export and import equations, rather than with equations for net flows.

III. *Modeling International Transportation*

Two somewhat different approaches to modeling international shipping and transportation have emerged and currently coexist in the economic literature. The first of these approaches was developed by Paul Samuelson (1954) and has come to be known as the "iceberg" model. The second approach is an extension of the Heckscher-Ohlin model. The great advantage of the iceberg model is its parsimonious analytical structure, which makes it especially suitable for empirical work. The essential idea of the model can be simply stated: "...to carry each good across the ocean you must pay some of the good itself...only a fraction of ice exported reaches its destination as unmelted ice." 1/ In other words, the process of transportation uses factors of production and thereby effectively reduces the factor endowments of the countries involved. It should not come as a surprise that in the simple version of the model the existence of transportation costs does not affect patterns of trade but influences, quite obviously, the volume of trade. 2/

The existing empirical work on international shipping and other transportation services has by and large relied on some version of the Samuelson model, though this reliance is usually implicit and supplemented by other variables. Flows of trade in tangible goods are the crucial explanatory variable; however, there are differences between authors. Rhomberg and Boissonneault (1964), Prachowny (1969), Kenen (1978), and Bond (1978) explained various transportation payments in

1/ Quoted from Samuelson (1954), p. 268.

2/ Alan Deardorff (1983) has extended the simple Samuelson model. Using the basic ieberg model but with many countries and many commodities, Deardorff shows that transportation costs play a crucial role in determining South-South and North-South trade patterns. In the Deardorff model, relatively capital-rich developing countries end up exporting capital-intensive goods to capital-poor developing countries, but at the same time export labor-intensive goods to developed countries.

terms of merchandise imports and transportation receipts in terms of merchandise exports plus a number of other variables. Other authors have postulated that payments for foreign transportation services are influenced not only by imports but also by merchandise exports. Presumably, the same logic should also apply to exports of transportation services. Kwack (1971) separates different services that are usually categorized as transportation expenditures and in particular draws a distinction between freight and passenger fares paid to foreign carriers and port expenditures incurred by domestic carriers abroad. This distinction is quite meaningful, but it necessarily increases the level of disaggregation.

The second strand in the existing research on international transportation attempts to integrate it into the traditional Heckscher-Ohlin model. Falvey (1976) and Cassing (1978) model transport industry as if it were an industry producing goods. Factor endowments and relative factor intensities become, once again, the key to such a model. In the end, grafting transportation on the Heckscher-Ohlin model leads to a set of predictions similar to those tested by Leontief in the context of merchandise trade. The task of testing the Heckscher-Ohlin model with regard to freight and other services was left to Sapir and Lutz (1981). In their study the authors assume that freight services are capital intensive and show that factor endowment does indeed matter in explaining net trade on transportation services. While embedding international transportation services in the Heckscher-Ohlin model is highly desirable, this approach focuses attention on endowments of labor and capital, which tend to be approximately constant in the short run.

It would seem fair to say that models intending to explain the shortrun behavior of international transportation transactions are bound to rely more heavily on the first strand of the literature than on the second. It would be equally fair to argue, however, that the theoretical foundations of the first class of models leave something to be desired. While the approaches outlined above explain the amount of world resources that are needed to make trade possible, they are silent on the question of who will provide the necessary services.

We will now propose an alternative model of international trade in transportation services which will look at the problem from a new perspective. The factors traditionally emphasized by the Heckscher-Ohlin model will be suppressed to a minimum, though they could, in principle, be re-introduced into the model at the cost of substantially increased complexity. The spirit of the specification to be presented here is similar to that of recent models of intra-industry trade under imperfect competition, and can be traced to the work of Brander (1981) Brander and Krugman (1983), Brander and Spencer (1984), and Krugman (1984). Their framework is particularly appealing for the analysis of the problem at hand.

This model treats the world as consisting of only two countries, which will here be called the United States and Europe. There are only two goods in the model and both are traded internationally. The U.S. import demand function is given by equation (1), while Europe's import demand is specified by equation (2).

$$M^{US} = A_o \, Y_{US}^{\varepsilon_y^{US}} \left(P_m^{US} + t_{E,US}\right)^{\varepsilon_p^{US}} \tag{1}$$

$$M^{E} = B_o \, Y_{E}^{\varepsilon_y^{E}} \left(e \, P_m^{E} + e \, t_{US,E}\right)^{\varepsilon_p^{E}} \tag{2}$$

The elasticity of country x's imports with regard to variable z is denoted by ε_z^x; Y_{US} and Y_E stansd for real income in the two countries; P_m^{US} and P_m^E are prices paid by U.S. and European importers, expressed in terms of U.S. dollars. Finally, the transportation costs are denoted by $t_{E,US}$ and $t_{US,E}$; and the exchange rate, e, converts prices and costs expressed in U.S. dollars into European currency.

The two import demand functions have a partial equilibrium flavor, but so far nothing has been sacrificed by this simplification. In fact, for the sake of simplicity, we can also set ε_y^{US} and ε_y^E equal to one. The two income levels, as well as the prices of imported goods, are assumed to be exogenously determined as is the exchange rate. On the other hand, quantities of imports and the transportation rates will be explained by the model. To proceed further, the transportation industry has to be described in more detail.

Assume that there is only one shipping company operating in Europe and only one based in the United States. While the international transportation industry corresponds to the case of duopoly, perfect competition reigns in the market for goods. 1/ The market structure of the shipping industry differs from the classical duopoly situation in that the demand for transportation services is a derived demand. Since the two duopolists know the link between the demand for traded goods and the demand for their services, they must also know that transportation rates obey the following equations: 2/

1/ In fact, we need to assume that there is a large number of producers of the two goods and that the aggregate supply of each good is infinitely elastic at P_m^{US} and P_m^E, respectively.

2/ The two duopolists of our model are assumed to play a one step game. Of course it would be preferable, as is generally the case in the theory of firm, to move to a dynamic framework. However, this extension is rather (To be continued on page 11)

$$t_{E,US} = \left(\frac{M^{US}}{A_o\ Y_{US}}\right)^{\frac{1}{\varepsilon_p^{US}}} - P_m^{US} \qquad (3)$$

$$t_{US,E} = \frac{1}{e}\left(\frac{M^E}{B_o\ Y_E}\right)^{\frac{1}{\varepsilon_p^{E}}} - P_m^{E} \qquad (4)$$

Equation (3) gives the freight rates for transportation of U.S. imports from Europe that are consistent with the U.S. import demand function. Transportation rates for the shipment of goods from the United States to Europe must be governed by equation (4) if the demand for these services is to be exactly satisfied.

Suppose now that it takes α units of transportation services to move one unit of U.S. imports across the Atlantic. This task can be accomplished by either American or European carriers. Denote the number of units of transportation services on the Europe-United States crossing provided by the U.S. industry by $T_{E,US}^{US}$; and, similarly, services rendered on the same route by Europe by $T_{E,US}^{E}$. It must be true then that $T_{E,US}^{US} + T_{E,US}^{E} = \alpha\ M^S$, that is, in equilibrium the supply of shipping services on Europe-United States crossings must be equal to the demand for these services which, in turn, is equal to α times U.S. imports of merchandise goods from Europe. Using this equilibrium condition, one can rewrite equation (3) as follows:

$$t_{E,US} = \left(\frac{T_{E,US}^{US} + T_{E,US}^{E}}{\alpha\ A_o\ Y_{US}}\right)^{\frac{1}{\varepsilon_p^{US}}} - P_m^{US} \qquad (5)$$

1/ (Continued from page 10) difficult to carry out in the present case, especially in the face of special considerations. See Cassing (1975) on this point. Note also that for a truly dynamic model one would require the exact timing of merchandise exports and imports far beyond what is available in the existing statistics. Dynamic considerations can be best captured at the micro level with the use of linear programming. Indeed, one of the first applications of linear programming was to a transportation problem.

Considering the shipment of goods from United States to Europe, assume that it takes β transportation services to move one unit of U.S. exports across the Atlantic. Again this task can be accomplished by either U.S. or European carriers, and for the equilibrium conditions to hold it must be true that $T^{US}_{US,E} + T^{E}_{US,E} = \beta M^{E}$ (the notation is somewhat cumbersome but it should be straightforward). The freight rate of U.S.-Europe crossings that is consistent with Europe's import demand function becomes:

$$t_{US,E} = \frac{1}{e}\left(\frac{T^{US}_{US,E} + T^{E}_{US,E}}{\beta B_o Y_E}\right)^{\frac{1}{\varepsilon^E_p}} - P^E_m \tag{6}$$

Equations (5) and (6) can be interpreted in the following way: Starting from an initial equilibrium, consider a reduction in shipping services provided by the duopolists. As a result, excess demand for imported goods will develop in both countries and their prices will tend to rise. The duopolists operating in the shipping industry can take advantage of the shortages created by their action and increase shipping rates until excess demand is eliminated. The extent to which freight rates can increase is stipulated by equations (5) and (6), and depends crucially on the price elasticities of import demands in the United States and Europe.

Although the international shipping industry is presented as a duopoly, it still remains to be decided what are the relevant policy variables used by the two competitors. Let us assume that no collusion is possible. Following a well-established tradition in this respect, each duopolist is said to play a "Cournot game." The quantities of transportation services are thus the relevant decision instrument. More specifically, the U.S. duopolist will decide on $T^{US}_{E,US}$ and $T^{US}_{US,E}$; and he will expect $T^{E}_{E,US}$ and $T^{E}_{US,E}$ to remain unchanged. The same decision process applies to the European duopolist. 1/

Having gone this far, the profit function of the U.S. duopolist is easy, if somewhat cumbersome, to express. This is done in equation (7),

1/ One could readily criticize the model presented here on the same grounds as one in general criticizes Cournot games. I have no additional defence beyond what is normally said in justifying the use of Cournot models (see e.g., Friedman (1983) for a detailed discussion). With both criticisms and defence being well known, nothing else remains to be said on the subject. It is interesting to note that in spite of numerous objections this is a, if not the, dominant model in the field of industrial organization.

$$\pi_{US} = [(\frac{T^{US}_{E,US} + T^{E}_{E,US}}{\alpha\ A_o\ Y_{US}})^{\frac{1}{\varepsilon^{US}_p}} - P^{US}_m]T^{US}_{E,US} + [\frac{1}{e}(\frac{T^{US}_{US,E} + T^{E}_{US,E}}{\beta\ B_o\ Y_e})^{\frac{1}{\varepsilon^{E}_p}} - P^{m}_{E}]T^{US}_{US,E}$$

$$- [F^{US} - C^{US}_{\alpha}\ T^{US}_{E,US} - C^{US}_{\beta}\ T^{US}_{US,E}] \qquad (7)$$

where F^{US} stands for the fixed cost of the U.S. duopolist, and C^{US}_{α} and C^{US}_{β} represent his average (and marginal) variable costs, both in U.S. dollars, associated with moving one unit of U.S. and European imports across the Atlantic. 1/ A very similar profit function could be written for the European duopolist, but rather than doing this we simply state the first order conditions for profit maximization by the two protagonists. Differentiation of equation (7) with respect to $T^{US}_{E,US}$ and $T^{US}_{US,E}$ yields zero profit conditions:

$$[(\frac{T^{US}_{E,US} + T^{E}_{E,US}}{\alpha\ A_o\ Y_{US}})^{\frac{1}{\varepsilon^{US}_p}} - P^{US}_m] + \frac{1}{\varepsilon^{US}_p\ \alpha A_o\ Y_{US}}(\frac{T^{US}_{E,US} + T^{E}_{E,US}}{\alpha\ A_o\ Y_{US}})^{\frac{1}{\varepsilon^{US}_p} - 1}\ T^{US}_{E,US} = C^{US}_{\alpha} \qquad (8)$$

$$[\frac{1}{e}(\frac{T^{US}_{US,E} + T^{E}_{US,E}}{\beta\ B_o\ Y_E})^{\frac{1}{\varepsilon^{E}_p}} - P^{m}_{E}] + \frac{1}{e\ \varepsilon^{E}_p\ \beta\ B_o\ Y_E}(\frac{T^{US}_{US,E} + T^{E}_{US,E}}{\beta\ B_o\ Y_E})^{\frac{1}{\varepsilon^{E}_p} - 1}\ T^{US}_{US,E} = C^{US}_{\beta} \qquad (9)$$

1/ Note that C^{US}_{α} need not be equal to C^{US}_{β} because very different goods are concerned. The variable cost of shipping one ton of frozen beef from the United States to Europe must surely be different than the variable cost of importing one ton of steel from Europe when in both cases the transportation is done on U.S. carriers. It goes without saying that α and β are likely to differ as well. It should also be noted that in principle the coefficient α (as well as β) could be different for U.S. carriers than for European carriers. One country may use different technology from the other. Pursuing this line of reasoning would render our model Ricardian. For the sake of simplicity it is assumed that the two countries use the same transportation techniques.

Differentiating the (unwritten) analogue of equation (7) for the European duopolist with respect to his choice variables, gives the following:

$$\left[\left(\frac{T^{US}_{E,US}+T^{E}_{E,US}}{\alpha\, A_o\, Y_{US}}\right)^{\frac{1}{\varepsilon^{US}_p}} - P^{US}_m\right] + \frac{1}{\varepsilon^{US}_p\, A_o Y_{US}}\left(\frac{T^{US}_{E,US}+T^{E}_{E,US}}{\alpha\, A_o\, Y_{US}}\right)^{\frac{1}{\varepsilon^{US}_p}-1} T^{E}_{E,US} = C^{E}_{\alpha} \qquad (10)$$

$$\left[\frac{1}{e}\left(\frac{T^{US}_{US,E}+T^{E}_{US,E}}{\beta\, B_o\, Y_E}\right)^{\frac{1}{\varepsilon^{E}_p}} - P^{m}_{E}\right] + \frac{1}{e\, E^{E}_p\, \beta\, B_o\, Y_E}\left(\frac{T_E{}^{US}_{US}+T_E{}^{E}_{US}}{\beta\, B_o\, Y_E}\right)^{\frac{1}{\varepsilon^{E}_p}-1} T^{E}_{US,E} = C^{E}_{\beta} \qquad (11)$$

Note that in the last two first-order conditions for profit maximization, C^E_α and C^E_β are analogous to C^{US}_α and C^{US}_β and are expressed in U.S. dollars. It is also assumed that the European duopolist maximizes his profits in terms of foreign currency, but this assumption has no serious consequences for the analysis or the results. Equations (8)-(11) constitute four reaction functions for the two shipping operators. In principle, they should jointly determine the endogenous variables $T^{US}_{E,US}$, $T^{US}_{US,E}$, $T^{E}_{E,US}$ and $T^{E}_{US,E}$. Once the quantities of transport services to be provided are determined, the corresponding transportation rates come out of the import demand functions (1) and (2), or their transformations (3) and (4). In general, $T^{US}_{E,US}$, $T^{US}_{US,E}$, $T^{E}_{E,US}$ and $T^{E}_{US,E}$ should be jointly determined by the first order profit conditions of the duopolists playing the Cournot game. However, if there are no economies (or diseconomies) of scale in the transportation industry, there is a certain degree of dichotomy in the system of equations (8)-(11). Constant returns to scale technology implies that C^{US}_α, C^{US}_β, C^{E}_α and C^{E}_β are independent quantities of services provided on different routes (but not independent of other economic variables, as will be shortly discussed) and the equations can be solved pairwise.

For instance, take equation (8). It constitutes the reaction function of the U.S. carriers for the westbound traffic stemming from American merchandise imports from Europe. In essence, equation (8) tells us the quantity of services $T^{US}_{E,US}$ that the U.S. oligopolist will wish to provide on this route, assuming that the European oligopolist will maintain his operations, $T^{E}_{E,US}$, unchanged at some initial level. On the other hand, equation (10) gives us, the level of operation that the European shipping company will choose on the westbound routes in order to maximize its profits under the assumption that $T^{US}_{E,US}$ remains unchanged.

The reaction functions given by equations (8) and (10) are depicted in Figure 1; US-US represents the former equation, whereas E-E denotes the latter. The absolute and relative slopes of the reaction functions play a crucial role in determining whether equilibrium exists, and if so, whether it is stable. Differentiating totally equation (8) and rearranging the terms, the slope of the U.S. reaction function can be shown to be:

$$\frac{dT^{US}_{E,US}}{dT^{E}_{E,US}} = - \frac{a + b}{a + b + cT^{US}_{E,US}} < 0 \qquad a,\ b,\ c > 0 \qquad (12)$$

The coefficients a,b, and c are functions of the parameters and variables of the system and are all positive. 1/ It follows immediately that the U.S. reaction function must be negatively sloped and less than unity in absolute slope. This is shown in Figure 1. By comparison, the slope of the E-E curve is:

$$\frac{dT^{US}_{E,US}}{dT^{E}_{E,US}} = - \frac{a + b + cT^{US}_{E,US}}{a + b} < 0 \qquad (13)$$

This reaction function is also negatively sloped, but its slope exceeds unity.

Our duopoly model of the international transport industry displays stable behavior, given the slopes of the reaction functions. Its behavior out of equilibrium can be analyzed by supposing that the European carriers initially decide to supply 0a units of transportation services. Given this quantity, the best response of the U.S. carriers is 0b in Figure 1. With 0b coming from the U.S. side, the best response of Europe amounts to 0c. This, in turn, leads to a U.S. offer of 0d. The adjustment process continues until point Q is reached. Hence the equilibrium is stable; the market is divided between the two competitors. The total supply of transportation services matches the demand, i.e., $\alpha M^{US} = T^{US}_{E,US} + T^{E}_{E,US}$. The freight rates for westbound traffic are chosen in a consistent way; account is taken of the fact that an increase in transportation rates will raise the price of imported goods to U.S. consumers (given P^{US}_{M}) and consequently imports of goods and demand for transportation services will decline.

1/ These coefficients can be quickly untangled by differentiating (8). Nothing is to be gained by writing out full expressions.

The relative position of the equilibrium point Q in Figure 1 with regard to the 45° line indicates which of the competitors has the dominant position in the market for freight transportation services from Europe to the United States. If point Q happened to be located exactly on this line, the market would be equally split between the two duopolists. This would happen if C_{α}^{US} equaled C_{α}^{E}; that is, the average variable costs were the same on U.S. and European carriers. Of course, this need not be the case.

Suppose that transportation is a labor-intensive activity and that labor is the only variable factor of production. 1/ It has already been assumed that it takes α units of transportation services to move one unit of U.S. imports across the Atlantic. If, for the sake of simplicity, one unit of labor was required, whether in the United States or in Europe, to produce one unit of freight transportation services, the average variable costs appearing in equations (8) and (10) would be:

$$C_{\alpha}^{US} = \alpha W^{US} \qquad (14)$$

$$C_{\alpha}^{E} = \alpha W^{E} \qquad (15)$$

where W^{US} and W^{E} stand for the wage rate in the United States and Europe, respectively. 2/ It should now become obvious that, with the same technology available in both countries, equalization of the wages is required for equal division of the market. If the U.S. carriers paid higher wages than their European competitors, the former would provide less than 50 percent of the total transportation activities involved in getting U.S. imports to their final users.

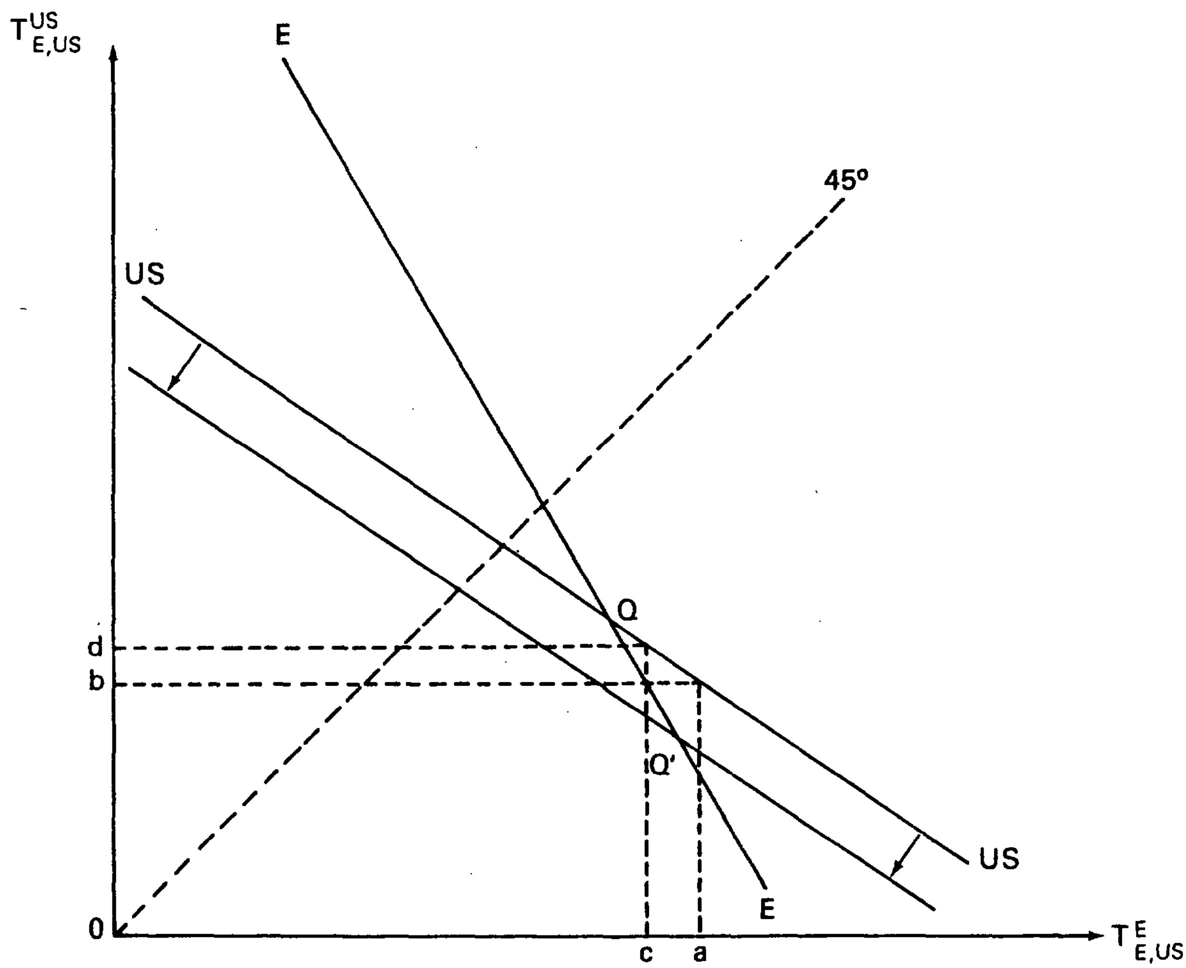
An increase in the U.S. wage rate, ceteris paribus, has the effect of shifting the US-US curve toward the origin and leaving the European reaction function unaffected in its initial position. At a certain wage

---

1/ Shortly we shall also consider oil as another factor of production and indeed argue that the price of petroleum should be an important explanatory variable in determining international freight transportation debits and credits.

2/ If labor was a homogeneous factor of production in Europe and the United States and no distortions were present, there would be only one wage rate in each country. However, labor is not a homogeneous factor, and distortions abound in the labor markets. There are workers of different skills and experience working on ships, and workers employed in ports to load and unload these ships. There is also international rail transportation with yet another set of wages. In the empirical work, we will have to decide which wage rates should be used in the estimation of the model.

FIGURE 1
IMPORTS OF TRANSPORTATION SERVICES IN THE DUOPOLY MODEL



level, U.S. carriers would price themselves out of the market altogether. If policymakers wanted to prevent this from happening, wage subsidies could be used. Indeed, this is what one observes in reality. A moderate increase in the U.S. wage rate would shift the equilibrium point to, say, Q' in Figure 1. Note that at Q' the sum of $T^{E}_{E,US}$ and $T^{US}_{E,US}$ is smaller than at the initial equilibrium; consequently, U.S. imports from Europe must also be smaller. This can be established by the following argument: Draw a line through Q with slope -1. This line represents a given amount of transportation services (i.e., $T^{E}_{E,US} + T^{US}_{E,US}$ = a constant) associated with a given level of M^{US}. The new equilibrium must be on the E-E reaction function southeast of Q. Since the slope of the E-E curve is more than -1, Q' must be somewhere "below" the constant-amount-of-transportation line going through Q. It follows that in the new equilibrium there will be less merchandise imports and less transportation to service U.S. imports. 1/ The decline has been brought about by higher U.S. wages, which have led to an increase in transportation rates. Both duopolists charge more for their services compared with the initial situation.

We now turn to the effects of the above change on the U.S. current account. To begin with the initial situation, the fact that the U.S. carriers transport some U.S. imports across the Atlantic does not have any direct impact on the service account. If importers pay for shipping services, as is usually the case, payments made between U.S. importers of goods and U.S. merchant fleet owners do not enter the U.S. balance of payments accounts, since these are transactions between nationals of the same country. But the increase in the U.S. wage rate affects the amount of transportation services provided by the foreign merchant fleet, and these payments are registered in the U.S. balance of payments accounts. Our analysis showed that the absolute and relative share of the European fleet in U.S. imports of transportation services must increase. Since the freight rates were shown to increase as well, the net effect must be a worsening of the U.S. service account. But with imports of goods being smaller, the trade account should improve to some extent, provided that all other variables in the system remain unchanged. 2/

If wages were to increase by the same amount in both the United States and Europe, the two reaction functions would shift inward in a parallel fashion. The relative shares should be preserved, but less transportation transactions would be effected and freight rates would go up. In this case the net impact on the U.S. service account would be ambiguous. This is a classic instance where quantity and price effects

---

1/ Of course, to trace out all effects on the current account, merchandise exports remain to be considered.

2/ This is asking a lot. Wages, prices, and exchange rates usually change at the same time. But this is the price one has to pay for using a partial equilibrium framework.

work in opposite directions. Nevertheless, a presumption may be formed that, generally, import demand may not be very sensitive to changes in transporation rates, especially if the transportation costs constitute only a small fraction of the prices paid by consumers; therefore the price effect can be expected to dominate in this case.

It is rather unrealistic to assume that labor is the only variable factor of production in international transportation services. Even to a casual observer it is clear that petroleum inputs play a crucial role in shipping and air transport, as well as other forms of transportation. One would expect that with identical "production functions" the marginal and average variable costs to European and U.S. carriers would be affected in similar ways by changes in oil prices. Suppose now that oil prices go up sharply. The immediate effect would be to increase the cost of transportation, and a part of this increase would be passed on to U.S. consumers. As a result, demand for imports--and hence for transportation services--would decline. The two reaction functions would have to shift inward by the same relative distance. The new equilibrium would be located on a ray passing through point Q in Figure 1, but closer to the origin. Thus, while the relative market shares would remain intact, the total amount of transportation services provided by the two duopolists would have to decline. However, the value of imported transportation services could increase.

A very substantial increase in the price of oil, such as the one witnessed by the world in 1973-74, would exert an additional and perhaps more important impact. It may be taken for granted that such an oil shock reduced real income in the United States, as well as in Europe. As the real GNP in the United States declined, so would its level of real imports. The reaction functions contained in Figure 1 would then shift even closer to the origin, but likely by a different extent depending on the vulnerability of a particular country.

It still remains to discuss the effects of exchange rate changes on the services account, but this discussion may well be carried out in the context of flows of transportation services stemming from Europe's imports of goods from the United States. Using the logic of our earlier discussion, the remaining first-order condition for a duopolist's profit maximization, equations (9) and (11), can be jointly solved to determine $T^{US}_{US,E}$ and $T^{E}_{US,E}$. The amount of symmetry built into our model makes our task rather easy and very similar to what has already been accomplished. Once again, when quantities of transportation services are determined, the freight rate will be known as well; consequently, we also know the value of transactions entering the balance of payments accounts. Note that, just as before, sales of transportation services to Europeans by the U.S. shipping industry are jointly determined with sales of these services by the European duopolist even though, from the point of view of the balance of payments, only the former transactions matter.

Figure 2 shows the determination of transportation service flows from the United States to Europe resulting from U.S. merchandise exports. European carriers are shown to capture more than a 50 percent share of the market. If Europe is assumed to have lower wages and the same productivity as the United States, it would become a net exporter of transportation services. For relatively small wage differentials, however, Europe could not drive U.S. carriers completely out of the market. 1/

Comparative static exercises discussed earlier can be readily extended to the case at hand. Once again, it seems useful to distinguish shocks that leave the relative shares unaffected from those that lead to a new division of the market. As an example of the former category, consider an exogenous decline in the "world" price of the U.S. export good. The change will shift both US^*-US^* and E^*-E^* curves away from the origin by the same relative distance. The new equilibrium will be located on the ray passing through point Q^*. Faced with a lower price, Europe imports more, creating an additional demand for transportation services. The expansion of the market is, however, divided between the two duopolists. Changes such as technological progress occurring in the transport industry in the United States or in Europe (but not both at the same rate) or alterations in U.S.-Europe relative wages will affect the total amount of services provided in connection with U.S. exports of goods to Europe as well as their allocation between the competing carriers. It should be kept in mind that shifts which leave relative market shares intact are not necessarily neutral from the balance of payments point of view. An exogenous decline in the world price of goods exported to Europe from the United States will tend to improve U.S. service account.

Many countries seem determined to increase their exports of transportation services through policy interventions. One very powerful instrument of protection of domestic carriers involves the use of laws designed to force commodity importers to use the exporting country's fleet. This type of government intervention can be incorporated into our model without difficulty. To handle this problem one has to distinguish between goods such as, for example, wheat that is reserved for U.S. carriers and other commodities which could be transported using either merchant fleet. This type of policy would tend to shift the US^*-US^* reaction function outward, while the E^*-E^* curve moves inward. The net result would be higher prices paid by European consumers on all

1/ One may be tempted to conclude that from a welfare point of view, it would be desirable to have the most efficient supplier of transportation services dominate the world market. This need not be the case and it would usually be better to keep the inefficient producer in the market as well. The basic reason is that market deviations from Pareto optimum are greater under monopoly then duopoly.

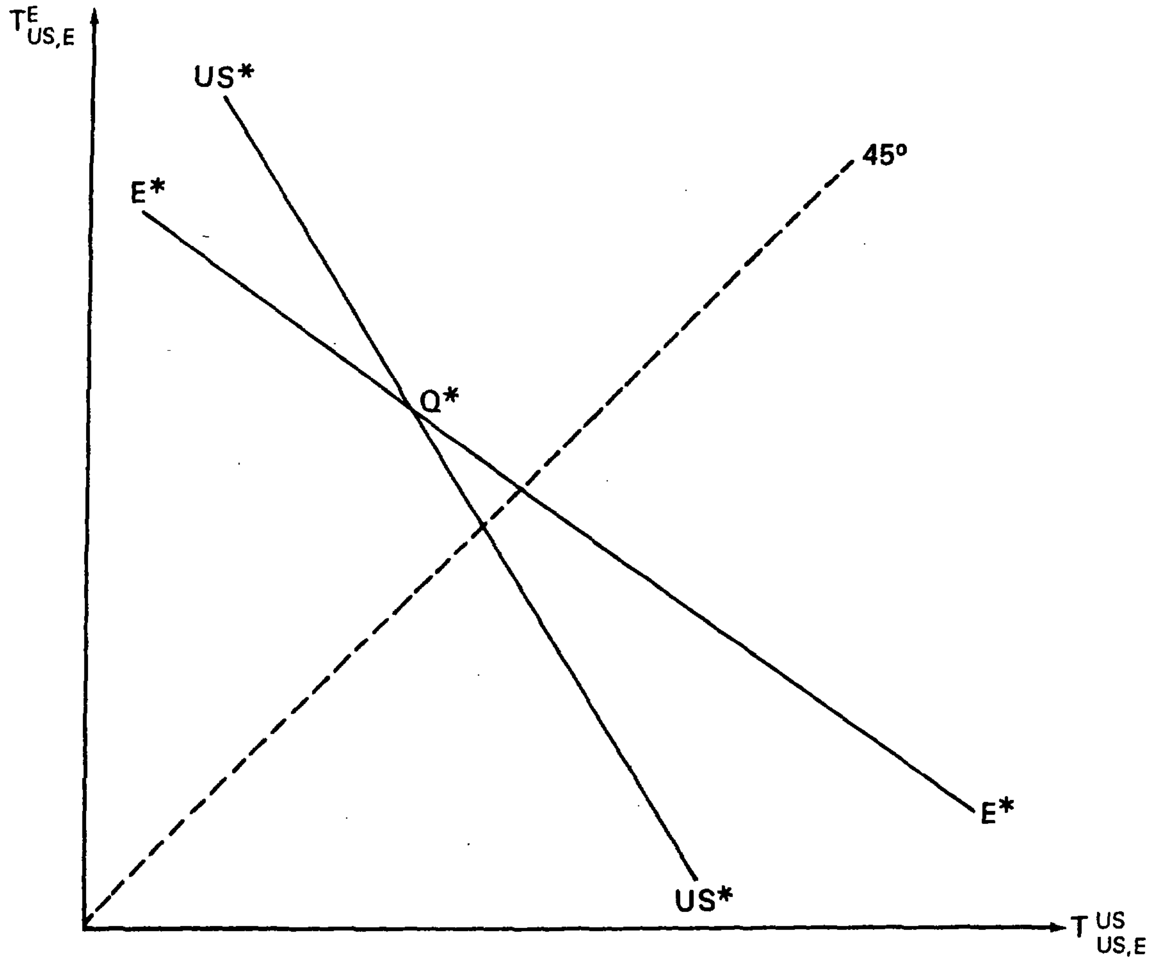
imported goods from the United States due to higher freight rates, smaller exports of goods from the United States to Europe, and finally a higher relative share of the eastbound traffic captured by U.S. carriers.

We now turn to the influence exercised by the exchange rate on international payments for transportation services. The exchange rate appears in all four reduced-form equations for transportation services. The symmetry of our model allows us once more to concentrate only on one of these variables, and we choose to consider Europe's imports of the services in question. Suppose that there is a devaluation of the European currency vis-à-vis the U.S. dollar. The key effect of this change is to reduce the volume of Europe's merchandise imports from the United States. The strength of this effect will depend on the price elasticity of Europe's import demand. From this it follows that the total volume of transportation services to be provided must decline. But there is also the question of the distribution of this amount between the two duopolists. If the costs of transportation services offered by Europe do not increase, she should become more competitive and take some of the business away from the U.S. transportation industry. Furthermore, the freight rates should decline in terms of U.S. dollars. The net result should thus be clearcut; devaluation of the European currency tends to reduce the flow of payments for imports of U.S. transportation services. This analysis accords well with the classical theory of devaluation, indeed it constitutes its corollary. Devaluation reduces merchandise imports and hence the demand to service them. In addition, there is a substitution effect between two alternative sources of supply of shipping services, and this effect tends to work in favor of the devaluing country. The analysis of the impact of devaluation on exports of transportation services should be rather straightforward with regard to their volume. But as in the classical theory of devaluation there is an ambiguous effect on the value of services exports because the price and quantity effects work in opposite directions in this case.

To summarize the results of this section and to put them in perspective, we have attempted to provide more theoretical underpinning than is customarily accorded to the determinants of exports and imports of international transportation services. We started off by putting the shipping industry into a duopolistic setting. Merchandise export and import equations define the extent to which transportation services are needed. Interaction between oligopolistic firms determines how the market is divided. This process of oligopolistic competition creates a feedback onto merchandise exports and imports as the transportation rates are borne by consumers.

In spite of its simplicity, the model presented here has the great advantage of leading directly to the formulation of export and import equations for transportation services in terms of values rather than volumes. This is particularly relevant from the point of view of

FIGURE 2
EXPORTS OF TRANSPORTATION SERVICES IN THE DUOPOLY MODEL



implementing the model empirically, given the the poor quality of price indices. The trick is to endogenize price variables and look directly into cost determinants. Indeed, since the problem of poor quality price indices is endemic to services in general, the approach proposed here might usefully be replicated for other categories of service transactions.

The model developed in this section is, of course, very specialized. But it could be readily extended in a number of directions, making it more general. Moving from the two- to an n-country case would be messy but would present no theoretical difficulties. It is also tempting because it would allow one to discern a realistic case where a third country has no fleet of its own but can import services from other countries. Economies of scale could also be introduced as well. One can see immediately that one of the effects of this would be to introduce a scale variable into the equations representing flows of services.

IV. Empirical Results

In this section, reduced-form equations based on our model are subjected to empirical estimation. It was intended to estimate these equations for as many of the 14 countries covered by the IMF World Trade Model (WTM) as possible. 1/ All the countries included in the WTM are classified as developed market economies, and play a crucial role in world merchandise trade. Estimation of a model explaining international transportation payments would be a first step toward a full specification of the current account transactions in the WTM framework. As the WTM is highly aggregative, modeling of service transactions should also aim at the highest level of aggregation that is still economically meaningful. For this reason it was decided to consider shipment and other transportation jointly. Going to even higher levels of aggregation, say all nonfactor services, would carry the risk of not being able to find an economic theory capable of explaining such an amalgamation of heterogeneous economic activities.

The reduced-form equations derived from our model for the volume of exports of transportation services by country i contain the following explanatory variables:

$$T^{i}_{ij} = h(X_i, P_p, w_i, w_j, e_{ij}) \qquad (16)$$

1/ Deppler and Ripley (1978) and Spencer (1984) provide a detailed description of the World Trade Model.

where X_i represents country i's volume of merchandise exports, P_p is the world price of oil; w_i and w_j are nominal wages in the transportation sector of country i and j, and e_{ij} is the exchange rate. The reduced-form equation for freight rates contains the same exogenous variables:

$$t_{ij} = t(X_i, P_p, w_i, w_j, e_{ij}) \tag{17}$$

It follows that the value of exports of transportation services by country i to j, VTX_{ij}, has the reduced form:

$$VTX_{ij} = f(X_i, P_p, w_i, w_j, e_{ij}) \tag{18}$$

Similar considerations concerning the value of imports of transportation services, VTM_{ij}, lead to the following equation:

$$VTM_{ij} = g(M_i, P_p, w_i, w_j, e_{ij}) \tag{19}$$

As has already been mentioned, there are severe limits on the availability of data on transportation services. Of the 14 countries included in the WTM, suitable quarterly data could be found for only 10: the United States, the United Kingdom, Japan, the Federal Republic of Germany, Canada, the Netherlands, Italy, Norway, Sweden, and Austria. Preliminary results obtained for Sweden were so far out of line with other results that this country was temporarily deleted from our sample, subject to data verification. We thus report results for 9 countries. Although our aim was to estimate the equations of the model in data from the first quarter of 1973 to the fourth quarter of 1983, even that limited task could not be completely accomplished. For some countries the estimation period is considerably shorter; for Japan, for instance, it runs from the first quarter of 1977 to the fourth quarter of 1983.

Our theoretical discussion does not suggest strongly any specific functional form for the equations to be estimated. There is, however, a preference for a log-linear specification because the value equations represent the product of respective quantities and prices. The reduced-form equation for the value of exports of transportation services by country i is specified in log-linear terms as follows:

$$\log VTX_{i,t} = a_0 + a_1 \log X_{i,t} + a_2 \log P_{p,t} + a_3 \log W_{i,t} + a_4 \log e_{i,t} \tag{20}$$

where all the endogenous variables are measured in terms of current U.S. dollars. The exchange rate, $e_{i,t}$, is measured as the number of units of currency of country i per U.S. dollar. 1/ The exact description of the variables and sources is given in the appendix.

With regard to the size of the coefficients, our model predicts that a_1 should be positive. The coefficient on the price of oil; a_2, should be positive as well: an increase in P_p should lead to higher transportation costs and, at a given level of merchandise exports, to higher revenue from exports of transportation services. Depreciation of the exchange rate should lead to an increase in the value of transportation exports as well. The sign of the coefficient on the wage rate is more difficult to ascertain. Our model suggests that in fact the wage rates of the exporting countries, and of importing countries as well, should enter the reduced-form equation. Even in that case there is some doubt as to the net effect of changes in one of these wage rates on export revenue. The ambiguity stems from the fact that the quantity and price effects work in opposite directions.

Even a casual look at wage series for most of the developed countries during the 1973-83 period reveals a large degree of collinearity. It was therefore decided to enter only the wage rate of the respective exporting country. An attempt was made to find wage rate series relevant for the international transportation industry. It is not an easy task, however, for no country apparently has such a high degree of disaggregation for its labor statistics. In assessing the appropriateness of the wage data used in the empirical work here, one should also keep in mind the fact that wage differentials do exist in various service sectors of individual countries, and they may vary over time. Even more important, do Norwegian or Japanese ships, to give an example, use local labor and pay local rates, or do they use foreign labor for which wages are altogether different? If the latter, then wage rates of workers in other countries would be more relevant variables. 2/

1/ In the multi-country world much could be said for using a weighted exchange rates in the estimated equations (leaving aside the problem of appropriate weights). We decided to use, however, bilateral nominal rates against the U.S. dollar (and no exchange rate variable in the U.S. equations) for two basic reasons. First, the value of the endogenous variables are expressed in terms of U.S. dollars. Second, most of the shipping rates are quoted in U.S. dollars. Nevertheless, an attempt was made to re-estimate the model with effective exchange rates. We found this variable statistically insignificant for the United States, and generally to worsen the results in the case of all other countries except Canada.

2/ One should also keep in mind that dock workers (as well as truck drivers) are highly unionized, and their wages may be much higher than for the rest of the industry.

The results of estimation are reported in Table 3. The estimates and general fit of the equations seem to be surprisingly good, given the quality of the data and the relative simplicity of the model. Note that no attempt was made to take account of special events such as dock strikes and the like by introducing dummy variables. In a number of cases, low Durbin-Watson statistics were obtained, revealing serial dependence in the residuals. In all these cases, clearly indicated in Table 3, the original equations were re-estimated using the Cochrane-Orcutt correction method.

The estimates of coefficient a_1 are highly significant and of correct sign for the United States, Japan, Canada, and Italy. The absolute size of this coefficient accords well with the model. Unfortunately, the volume of merchandise exports does not appear to be a significant explanatory variable in the case of the United Kingdom, Germany, the Netherlands, Norway and Austria. For the Netherlands, the United Kingdom, and Norway, all of which are large exporters of transportation services to third markets, it would be preferable to enter an export variable that would recognize the world position of these countries. Ideally, merchandise trade of all the countries to which the Netherlands, the United Kingdom, and Norway export their transportation services would be a suitable variable. The third market should have its merchandise trade weighted in a composite variable according to its relative importance as a buyer of Dutch, British, and Norwegian transport services. This refinement of the model could not be introduced for lack of data.

The price of oil turned out to be a very powerful explanatory variable in all cases but two. Coefficient a_2 has the right sign and ranges in absolute value between 0.10 and 0.68. One could make a conjecture that the variation in the size of this coefficient has something to do with (a) the relative size of shipping in total transportation of a particular country, and (b) the average distance that merchandise exports of the country in question have to travel before reaching their final destination. Petroleum prices are not quite significant in the case of Austria. Note, however, that Austria is the only landlocked country in our sample; its reliance on rail transportation could make it somewhat less susceptible to petroleum price changes.

The wage rate is also significant for most of the countries in our sample. There is no evident explanation for the sign pattern and there is a considerable range in the absolute value of estimates of coefficient a_3. The coefficient is very high for Austria, and it may well be that the wage rate variable tries to pick up all other cost elements in this case as well. (To test for it one could replace the oil price variable with the cost of electricity or coal, for instance.) The sign pattern of coefficient a_3 is not inconsistent with the theoretical model.

Table 3. Regression Coefficients for Exports of Transportation Services 1/

Country	Estimation Period	Constant	log $X_{i,t}$	log $P_{p,t}$	log $W_{i,t}$	log $e_{i,t}$	R^2	D.W.	S.E.E.
United States	1973(1)-1983(4)	-6.55**	0.61**	0.68**	0.99**		0.995	1.66	0.027
		(26.20)	(11.15)	(4.27)	(26.19)				
United Kingdom 2/	1973(1)-1983(4)	7.84**	0.15	0.10*	-0.36	-0.89**	0.965	1.56	0.040
		(1.24)	(1.01)	(2.23)	(1.76)	(6.00)			
Japan	1977(1)-1983(4)	2.10	0.57*	0.56**	-0.68	-0.43**	0.972	1.93	0.041
		(1.70)	(2.35)	(9.37)	(1.89)	(3.12)			
Germany, Fed. Republic of 2/	1973(1)-1983(4)	-4.48**	-0.85	0.10	1.25**	-0.91**	0.976	1.93	0.049
		(4.06)	(0.38)	(1.73)	(4.74)	(6.21)			
Netherlands 2/	1973(1)-1983(4)	5.19**	0.21	0.14*	0.32	-0.65**	0.981	2.04	0.041
		(2.83)	(1.04)	(2.70)	(0.92)	(4.64)			
Norway 2/	1975(1)-1983(4)	5.88**	0.15	0.54**	0.09	-0.94**	0.978	1.81	0.037
		(16.42)	(1.75)	(10.79)	(0.71)	(8.50)			
Canada	1973(1)-1983(4)	3.10**	1.07**	0.51**	-0.90**	1.30**	0.937	1.35	0.074
		(3.30)	(4.94)	(11.82)	(5.92)	(3.07)			
Italy	1974(1)-1983(4)	7.03**	0.50**	0.45**	0.41**	-0.85**	0.967	1.41	0.059
		(7.63)	(3.13)	(6.22)	(3.24)	(7.65)			
Austria	1973(1)-1983(4)	-0.17	0.30	0.07	1.32**	-0.91**	0.976	1.39	0.079
		(0.27)	(1.52)	(1.69)	(7.83)	(8.37)			

1/ The figures under the coefficients are t-ratios. Statistical significance at the 95 and 99 percent level is indicated by one or two asterisks, respectively. S.E.E. is the standard error of the estimate.

2/ The equation estimated with the Cochrane-Orcutt correction for first-order correlation. Adjusted R^2 statistics are error-based at the original level.

Finally, the data reveal a very strong and systematic influence of the exchange rate on the value of export earnings. Note that the equation for the United States does not contain an exchange rate variable, since all exchange rates are in terms of the U.S. dollar. A 10 percent appreciation of the exchange rate increases the value of transportation earnings by between 4.3 percent (in the case of Japan) and 9.4 percent (in Norway). The exchange rate has a powerful influence in the Canadian equation, but the sign of the coefficient is "wrong". 1/ As far as the overall performance of the estimated equations is concerned, they explain a very large part of the variance of the dependent variable.

Turning to imports of transportation services, the following log-linear equation was subjected to empirical estimation:

$$\log VTM_{i,t} = c_o + c_1 \log M_{i,t} + c_2 \log P_{p,t} + c_3 \log \tilde{W}_t + c_4 \log e_t \qquad (21)$$

where $M_{i,t}$ is the volume index of merchandise imports of country i at time t. Once again we faced the problem of choosing a suitable wage variable. As far as the import equations are concerned, it was decided to use a composite wage index whose elements would consist of wages in the transportation sector in major exporting countries. 2/ The precise definition of the wage variable is given in the appendix.

1/ We have re-estimated the equation for Canada using the effective exchange rate instead. The following results were obtained.

$$\log VTX_t = \underset{(4.23)}{6.388^{**}} + \underset{(4.70)}{0.38^{**}} \log X_t + \underset{(10.73)}{0.45^{**}} \log P_{p,t}$$

$$- \underset{(4.77)}{0.59^{**}} \log W_t - \underset{(3.97)}{0.84^{**}} \log e_E$$

$R^2 = 0.945$ D.W. = 1.36 S.E.E. = 0.07

2/ The justification for this decision is straightforward. The recorded statistics of the value of imports of transportation services are very strongly influenced by the shipping rates (and port charges, etc.) posted by exporting countries which, in turn, are directly affected by the cost of labor in those countries. Of course, the cost of labor in an importing country (country i) is relevant because at the margin there is substitution between alternative suppliers of transportation services. But if a transaction actually did take place, as recorded by the balance of payments statistics, it means that labor costs in the exporting country were not found excessively high. And for this reason we selected a composite wage note in major exporting countries as a relevant determinant of the transportation cost. Note also that the same logic influenced our choice of the relevant wage variable in the import equations.

The results are presented in Table 4. The general fit of equation (21) appears good for all the countries considered. As expected, the coefficient on the merchandise import variable is well determined except for the Netherlands and Norway. The reason for this may be similar to that discussed earlier. The elasticity of payments for imports of transportation services is relatively high in the case of the United States and Canada--0.66 and 0.62, respectively. This may reveal something about competition between these two countries in transportation services, or it may suggest that there are binding capacity constraints. The lowest significant value of the elasticity of VMT with respect to M is for Japan and Italy. A 10 percent increase in real merchandise imports of these two countries, increases their payments for transportation services by no more than half as much.

The price of oil variable performs well in all import equations. Japan comes out as the country sharing the heaviest burden of oil price increases. The coefficient on log $P_{p,t}$ for all other countries falls within a range between 0.09 to 0.36.

In general, increases in wages in the major exporting countries cause the importing countries to foot higher bills for imports of transportation services. In the case of Japan and Canada, however, it is the other way around. Two possible inferences can be drawn from this result: one is that merchandise imports of the two countries are highly price elastic; the second is that their own domestic transportation industry is very quick in taking business away from foreign competitors.

The exchange rate effect is, in general, picked up well by the import equations; the sign of coefficient c_4 accords with our model. Devaluation reduces imports of transportation services but the strength of this effect varies from country to country, the strongest being in the Federal Republic of Germany (0.83) and the weakest in Japan (0.22).

V. Conclusions

This paper has attempted to model international transportation services with a greater emphasis on theory than has usually been given in the literature on this topic. While most work on international services has tended to be carried out as a sideline or an offshoot of work on merchandise trade or capital flows, there is a need to face services as a field of research in its own right. The aim here has been to provide a model of international transportation that is consistent with the World Trade Model, in that it will involve a similar degree of aggregation and use similar explanatory variables. An initial investigation of the availability and quality of the data leads to a conclusion that it would be desirable to use a theoretical framework that bypasses the use of price variables. This means trying to

Table 4. Regression Coefficients for Imports of Transportation Services 1/

Country	Estimation Period	Constant	log $M_{i,t}$	log $P_{p,t}$	log $\tilde{W}_t$	log $e_{i,t}$	R^2	D.W.	S.E.E.
United States 2/	1973(1)-1983(4)	-5.22**	0.66**	0.09*	0.62**		0.988	1.80	0.035
		(7.67)	(5.67)	(2.26)	(4.09)				
United Kingdom 2/	1973(1)-1983(4)	3.44**	0.59**	0.16**	0.11	-0.69**	0.966	2.31	0.035
		(3.93)	(4.03)	(4.21)	(0.75)	(5.96)			
Japan	1977(1)-1984(4)	-4.80	0.50**	0.65**	-0.42**	-0.22**	0.986	1.40	0.027
		(0.06)	(4.46)	(23.00)	(6.40)	(3.38)			
Germany, Fed.		-2.96**	0.38	0.13*	0.47**	-0.83**	0.981	1.96	0.039
Republic of 2/	1973(1)-1983(4)	(3.86)	(1.69)	(2.70)	(2.90)	(6.84)			
		2.96*	0.50	0.11	0.49**	-0.79**	0.980	1.84	0.046
Netherlands 2/	1973(1)-1983(4)	(2.10)	(1.89)	(2.01)	(2.22)	(5.00)			
Norway	1975(1)-1983(4)	2.51	0.13	0.36**	0.71**	-0.50**	0.913	1.90	0.088
		(2.03)	(0.51)	(3.72)	(2.87)	(2.96)			
Canada	1973(1)-1983(4)	4.03**	0.62**	0.32**	-0.45**	-1.58	0.894	1.44	0.047
		(6.74)	(6.03)	(10.01)	(4.14)	(0.07)			
Italy 2/	1973(1)-1983(4)	4.26**	0.38**	0.23**	0.13**	-0.77**	0.980	1.89	0.048
		(6.11)	(3.15)	(4.22)	(6.54)	(5.36)			
Austria 2/	1973(1)-1983(4)	0.51	0.27	0.21**	0.11**	-0.73**	0.981	1.71	0.062
		(0.41)	(1.12)	(2.86)	(4.28)	(3.66)			

1/ See footnote 1 to Table 3.
2/ See footnote 2 to Table 3.

endogenize relevant prices and freight rates by looking directly at cost determinants. This may well turn out to be a useful research strategy for other services as well.

Broadly speaking, our preliminary empirical work suggests that the framework of imperfect competition proposed in this paper is indeed suitable for modeling transportation services. Yet it must be recognized that the empirical work does not test alternative hypotheses, owing to the lack of viable alternatives. Nonetheless, the theory provides a bit more justification than has been available in the past for reduced-form equations and explanatory variables.

Derivation of the Data Base

1. Shipment and Transport

The data on shipment were obtained from the IMF Balance of Payments data bank (line 1B.AS4Q for credit and line 1B.BS4Q for debit). The credit entry includes air freight, ocean freight on exports and on other shipments, and other freight. The debit entry includes air freight on imports, ocean freight on imports, and other freight.

The data on transportation were taken from the IMF Balance of Payments data bank (line 1C2AS4Q for credit and line 1C2BS4Q for debit). The credit and debit entries include charters, port disbursements, and "other".

The series for shipment and transportation were seasonally adjusted with the RAL seasonal adjustment routine and converted to U.S. dollars, using the exchange rates listed below (section 5).

2. Volume of Merchandise Exports and Imports

The data on volume of merchandise exports and imports come from IMF, International Financial Statistics, line 72...ZF/DFIFS and line 73...ZF/DFIFS, respectively, and are seasonally adjusted.

3. Wages

The data on wages were obtained from the following sources:
For the United States, series AHERNS, hourly earnings of production workers in the transport, communications, and utility sectors, annual data, from DRI.

For the Federal Republic of Germany, series "Übriger Verkehr and Nachrichtenübermittlung" in Fachserie 16, Reihe 4.3 "Index der Tariflöhne und -gehalter, published by Statistisches Bundesamt, Wiesbaden; and "Index der tariflichen Monatsgehälter in der gewerblichen Wirtschaft und bei Gebiets korperschaften," which includes the sectors railways (excluding) Deutsche Bundesbahn) sea and coastal shipping, sea ports; airlines, airports; transport in pipelines; trucking, storage, and transport agencies.

For data for the United Kingdom, Japan, Netherlands, Norway, Canada, France, and Italy the source is International Labor Office, "Yearbook of Labor Statistics," 1981 and 1984, Table 20, Wages in Transport, Storage, and Communications. For the United Kingdom and Norway, hourly earnings for males and females (adults); for the Netherlands, hourly wages (October of each year, including juveniles); for Japan, monthly earnings of employees

(including family allowances and mid-year and end-year bonuses). For Canada, data for 1971 to 1980 refer to weekly earnings for employees; for 1981 to 1983 percentage changes in the series "urban transit systems" were used to extend the series published in the previous (1981) edition of the ILO Yearbook. For Italy, the data series from 1974 to 1983 is an index of minimum hourly wage rates. For Austria an index for "Tariflohn" for workers in the transport sector published in Statistisches Handbuch fuř die Republik Oesterreich" (various issues) was used. All series were indexed to 1983 = 100.

To derive quarterly series, the annual series were benchmarked on national-source quarterly data of hourly remuneration in the manufacturing sector, IMF Bureau of Statistics.

For Austria, Canada, Italy, and Sweden a composite wage rate was calculated based on wages in six most important exporters of shipping services, as follows:

$$\log \tilde{w}_t = 0.22\ w_t\ \text{(Japan)} + 0.13\ w_t\ \text{(United States)} + 0.18\ w_t\ \text{(Germany)}$$
$$+ 0.16\ w_t\ \text{(Norway)} + 0.21\ w_t\ \text{(United Kingdom)} + 0.10\ \text{(Holland)}$$

The weights used represent 1983 individual shares in the sum of total shipment (credits) of the six countries.

4. Price of oil

The world price of oil (in U.S. dollar terms) is listed in the Statistical Appendix, World Economic Outlook, International Monetary Fund, Washington, D.C., various isues.

5. Exchange Rates

The following exchange rates were used:

Line ..RB.ZF (national currency/SDRs) and line ..RF.ZF (national currency/U.S. dollars), both period averages.

Bibliography

Bond, M., "The World Trade Model: Invisibles," Staff Papers, International Monetary Fund (Washington), Vol. 26 (June 1979), pp. 257-333.

Brander, J., "Intra-Industry Trade in Identical Commodities, Journal of International Economics, Vol. 11 (1981), pp. 1-14.

Brander, J. and B. Spencer, "Tariff Protection and Imperfect Competition in the Presence of Oligopoly over Economies of Scale," in Kierzkowski, (1984).

Cassing, J., "Transport Costs in International Trade Theory: A Comparison with the Analysis of Nontraded Goods," Quarterly Journal of Economics, (November 1978), pp. 535-550.

_____, "Trade Pattern Predictions and Resource Allocation in a Model with Jointly Supplied Transport Services," International Journal of Transport Economics (December 1979), pp. 293-317.

Deardorff, A., "The Directions of Developing Countries Trade: Examples from Pure Theory," a paper presented at a World Bank Conference, Brussels, February 28-March 1, 1983.

Deppler, M. and D. Ripley, "The World Trade Model: Merchandise Trade," Staff Papers, International Monetary Fund (Washington), Vol. 25 (March 1978), pp. 147-206.

Falvey, R., "Transportation Costs in the Pure Theory of International Trade," Economic Journal (September 1976), pp. 536-550.

Friedman, J., Oligopoly Theory (Cambridge: Cambridge Press, 1983).

Gray, P., "International Transportation," in Walter (1982), pp. 11.3-11.18.

Gray, P., "International Trade in Services," in Walter (1982), pp. 14.3-14.22.

Kenen, P., A Model of the U.S. Balance of Payments (Lexington, Mass.: D.C. Heath, 1978).

Kierzkowski, H., ed., Monopolistic Competition and International Trade (Oxford: Oxford University Press, 1984).

Krugman, P., "Import Protection as Export Promotion: International Competition in the Presence of Oligopoly over Economies of Scale," in Kierzkowski (1984).

Kwack, S., "A Model of Transportation Account in the U.S. Balance of Payments, 1960 III - 1967 IV," Journal of International Economics, Vol. 1 (May 1971), pp. 215-26.

Prachowny, M., A Structural Model of the U.S. Balance of Payments, (Amsterdam: North-Holland, 1969).

Rhomberg, R. and L. Boissonneault, "Effects of Income and Price Changes on the U.S. Balance of Payments," Staff Papers (Washington), Vol. 11 (March 1964), pp. 59-124.

Samuelson, P., "The Transfer Problem and Transport Costs; II: Analysis of Effects of Trade Impediments," Economic Journal (June 1954), pp. 264-289.

Sapir, A., "Trade in Non-Factor Services: Past Trends and Current Issues," World Bank Staff Working Paper, No. 410 (1980).

_____, "Trade in Services: Economic Determinants and Development-Related Issues," World Bank Staff Working Paper, No. 480.

Spencer, G., "The World Trade Model: Revisited Estimates," Staff Papers (Washington), Vol. 31 (September 1984), pp. 469-498.

Walter, J., Handbook of International Business (New York: John Wiley, 1982).