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The Structure of Ocean Transport Charges

ABSTRACT: This paper attempts to estimate the commodity structure of ocean transport charges: the relation between the characteristics of commodities and the charges for shipping them. The purpose is to provide a method of estimating such charges for use in models of world trade, to explain which goods will enter international trade, and how much trade will take place in the commodity in general and between particular countries. Because comprehensive transport price data are not available we have used actual charges for individual shipments to construct a model of commodity differences in rates. ¶ We find that the main determinants of rates, which make up our estimating equation, are the value per ton of a commodity, its bulkiness (cubic ft. per ton), the distance over which it is shipped, the prevalence of small individual shipments, and the possibility of shipping the product by tanker. We found no evidence that rates on exports from the United States were higher than on exports of other developed countries, once commodity and route characteristics were taken into account. There was some weak evidence that products shipped mostly by liner carried relatively high charges and that an export surplus on a shipping route led to lower rates on imports than on exports.

INTRODUCTION

This paper[1] attempts to give some empirical content to the idea of a commodity structure of ocean transport prices that helps to determine which goods will enter international trade, what proportion of the total output of a commodity will be traded, and which countries will be exporters and which will be importers of each commodity. There are no comprehensive, publicly available data on actual transport charges in international trade.[2] Requiring such information as an element in the explanation of the pattern of trade, by commodity, we have attempted to quantify the main factors underlying commodity differences in the price of transport and thus to provide a method of estimating the price of ocean transport for each commodity. We have done this by examining two bodies of data on actual transport charges and generalizing from them, as well as we can, about the determinants of these charges. However, we were not primarily interested in the factors determining the level of ocean transport charges or changes in that level over time, differences among routes or among ports, or the effect of shipping conferences on rates.

Several empirical models of international trade flows, attempting to explain the volume of total trade between two countries, have used distance as a proxy for various barriers to trade, of which transport cost is one. A study by Tinbergen, for example, explained the size of the trade flow between any two countries by the GNP of each and the distance between them, assuming that distance was a rough measure of transport cost, although it could also stand for an index of the amount of information on export markets.[3] Distance proved to be a significant variable, with the appropriate negative sign in almost all of his equations.

Linneman, in a much more elaborate study that included income, population, and several variables for various preferential trading arrangements, also found distance to be an important and significant negative influence on the amount of trade between countries.[4]

Several other similar models of trade based at least partly on distance, but including other variables such as income, membership in preferential market areas, and the total level of each country's exports and imports, have been described by Taplin and by Leamer and Stern.[5] The only instance we found of an attempt to introduce cost rather than distance was in a study by Beckerman in which a crude ordering of country pairs by the cost of transportation between them, based on differences between exporters' valuations (excluding transport and insurance charges) and importers' valuations (including transport and insurance charges), was used to explain trade patterns within Europe.[6]

DETERMINANTS OF THE PRICE OF TRANSPORT—THEORETICAL CONSIDERATIONS

Most theoretical explanations of the structure of ocean transport charges deal with supply elements, listing the factors that determine the cost of producing these services. Some of these relate to commodity characteristics and others to characteristics of particular shipping routes. We are mainly interested in the former but we have attempted to introduce the latter, where possible, to insure that their presence will not bias our estimates of the effects of the commodity characteristics.

Among the commodity characteristics are the stowage factor (that is, the number of cubic feet of shipping space taken up by one ton of a commodity); the possibilities of shipping the product in bulk using specialized vessels, or for using tramp rather than liner shipment; the ease of loading or unloading; the fragility of the product or its susceptibility to deterioration; and the average size or shipping weight per shipment. Size of shipment is important because small shipments require additional labor costs, such as extra handling, for a given amount of weight.

Among the route characteristics are the distance of shipment, the costs of loading and unloading in particular ports, the degree of competition among shipping lines, and the extent of any imbalance of trade between outbound and inbound shipments.[7] The significance of the last factor is that it might cause severe competition for freight, and therefore lower charges, in the direction of less trade.

If the shipping industry were perfectly competitive and we were willing to treat shipping services as homogeneous, at least within liner or tanker shipping, we could ignore demand factors, since we are interested primarily in the structure of rates at one time rather than in changes over time. However, it is well known that the unit value (value per ton) of the commodity to be shipped is an important determinant of ocean transport charges. It is difficult to explain a strong positive relationship between the unit value of commodities and transport charges per ton by any cost factors. The only clearly positive relationship between the unit value and the cost of producing transport services is based on the cost of insurance, which is included in our measure of transport cost. Insurance cost may appear either as a specific payment or as the need for stronger guarantees of the quality of service necessary to obtain the business of shipping valuable commodities. However, the cost of insurance is only a small part of transport cost, and since it depends on many factors other than unit value, one would not expect the relationship between unit values and insurance cost to account for a large part of the variability of transport charges. In fact, evidence from the United Nations' Latin American freight rate study,[8] referred to below in the section on comparisons with other results, indicates that insurance charges could account for no more than .02 or .03 of unit value coefficients which we found to be in the neighborhood of .50.

If shipping is subject to monopolistic pricing, mainly through the operation of shipping conferences and barriers to entry, a positive relationship between unit values and transport charges could result from price discrimination since the demand for transport services is likely to be more inelastic for higher-valued commodities than for cheaper ones. That is, if one commodity is more expensive per ton than another, a given rise in transport cost per ton will add less in percentage terms to its price than to that of the cheaper product. If the elasticity of final demand is the same for both commodities, then sales, and therefore the purchase of transport services, will decline less for the more expensive product. Thus, the elasticity of the derived demand for transport services will be lower for the expensive product, and the difference in the elasticities provides the opportunity for discriminating carriers to charge higher freight rates on the more expensive products.

Our model of the determination of transport charges in a cross-section of commodities and trade routes therefore assumes that these charges are a function of a variety of cost elements on the supply side and of the elasticity of demand for ocean transport, the unit value of the commodity being the determinant of the demand elasticity. To our data on transport charges for particular shipments we have thus fitted equations using unit value and several other characteristics of commodities and those of trade routes. The basic data are from a Census Bureau study of the differences between two methods of valuation for U.S. imports: the official valuations (those reported on customs documents, chiefly value at the point of shipment, excluding freight and insurance) and the value at the point of entry into the United States, including freight and insurance. The difference between these two values, with some adjustments, is our measure of transport charges. Supplementary data, referred to hereafter as "bidding data" and used as a check on the Census data, are from an earlier National Bureau study of international price competitiveness. Both data sets are described more fully in the appendix. Since the Census data are broader in commodity coverage, they are the basis for most of the conclusions that follow.

TRANSPORT PRICE ESTIMATING EQUATION

The basic estimating equation for the price of transport, based on Census data for U.S. imports, treats the transportation charge per ton as a function of the unit value, the distance shipped, the stowage factor for the commodity, a dummy variable for products that are at least to some extent shipped by tanker, and a dummy variable for small shipments, which we define as shipments under one ton in weight. All the coefficients for these variables were statistically significant at the 5 per cent confidence level and all had the signs that would be expected. Some other variables that were tested, but not finally accepted for the estimating equation, are discussed below.

The estimating equation,[9] with all variables in logarithmic form, is:

$$\text{(1)}\quad FR = -3.53 + \underset{(57.35)}{.52UV} + \underset{(13.51)}{.30DI} + \underset{(18.18)}{.35ST} + \underset{(6.22)}{.30SW} - \underset{(12.25)}{.51TA}$$

$$\bar{R}^2 = .81$$

where *FR* is the transport charge (in \$ per ton), *UV* is unit value (\$ per ton), *DI* is distance (nautical miles), *ST* is stowage (cubic feet per ton), *SW* is a dummy variable for a shipment of less than one ton, and *TA* is a dummy variable for a product that was in some instances imported by tanker. Figures in parentheses are *t*-values for the coefficients.

The equation states that a long distance from origin to destination, bulkiness (volume per ton), and smallness of a shipment all add to the price of transport per ton, presumably by raising the cost. The feasibility of shipment by tanker reduces the price. High value per ton raises the price of transport, and this is the strongest relationship of all.

The degree of our success in matching the actual determinants of transport charges can be seen in Table 1, which compares the rates estimated from equation (1) with the reported charges for those Standard International Trade Classification (SITC) groups in which we had at least thirty observations. Some wide discrepancies are evident, and for a few of them explanations come readily to mind. For example, we have no variable to take account of fragility or likelihood of damage in shipment, except to the extent that value per ton serves as a proxy for these characteristics; and that omission probably accounts for the underestimates of transport charges on glassware and pottery and possibly for those on alcoholic beverages and toys and games.

For some purposes interest in transport costs is centered not on the freight rate (cost per ton) but on the freight factor: the ratio of total freight payments to the total value of the shipment. The freight factor may be a better measure than the freight rate of the influence of transport costs as a barrier to trade and would be useful also for estimating aggregate transport costs if value data, but not tonnage data, were available.

An equation for freight factors could presumably be estimated directly, but in these logarithmic equations, freight rate and freight factor equations are both linear, differing only in one coefficient.

TABLE 1 Reported and Estimated[a] Transport Charges: Averages by Commodity Groups[b] (dollars per metric ton)

SITC[c]		Average of Reported Charges	Average of Estimated Charges
011	Meats, fresh, frozen, etc.	87	66
013	Meats in containers, meat prep., etc.	50	64
031	Fish, fresh, frozen, etc.	69	65
051	Fruit, fresh, and nuts, fresh or dried	24	27
061	Sugar and honey	8	10
071	Coffee	40	52
081	Feeding-stuff for animals	25	20
112	Alcoholic beverages	64	50
231	Crude rubber	51	44
262	Wool and other animal hair	90	103
281	Iron ore and concentrates	2	2
283	Ores and concentrates, non-ferrous	5	4
331	Petroleum, crude and partly refined	2	3
332	Petroleum products	2	2
422	Fixed vegetable oils, exc. soft	15	29
512	Organic chemicals	31	30
631	Veneers, plywood board, etc.	39	34
653	Textile fabrics, woven, exc. cotton	87	105
664	Glass	33	29
665	Glassware	173	87
666	Pottery	92	60
674	Iron and steel plates and sheets	19	14
732	Road motor vehicles	130	109
841	Clothing	254	260
851	Footwear	196	171
861	Scientific, medical, etc., inst. and appar.	319	311
894	Toys, games, sporting goods, etc.	270	189
899	Manufactured articles n.e.s.	201	169

[a]Estimated from equation (1).
[b]Averages are geometric means.
[c]All groups with thirty observations or more. Some of the SITC titles are abbreviated here.

Thus, if the freight rate equation is

$$\log FR = a + b \log UV + c \log DI + d \log ST$$

implying, in arithmetic form:

$$FR = aUV^{b} DI^{c} ST^{d}$$

the freight factor equation is

$$\log FF = a + (b - 1) \log UV + c \log DI + d \log ST$$

implying, in arithmetic form,

$$FF = aUV^{b-1} DI^{c} ST^{d}$$

and our estimating equation for freight rates can easily be transformed into an estimating equation for freight factors. This is, in fact, how we derived the freight factor equation used for Table 2, which lists the actual and estimated freight factors. We can use these estimated transport costs of individual commodities as a variable to explain trade flows or, as an alternative, we can use them to turn price relationships among exporting countries at the point of export, excluding transport charges, into delivered price relationships, including transport charges. A number of studies have used export unit values to represent prices of exporting countries,[10] and some more recent work has involved the calculation of actual price levels for goods offered in international trade.[11] In both cases the comparisons involve prices exclusive of transport charges. However, one would expect that purchase decisions are based on delivered prices, so that equal U.S. and U.K. export prices, for example, would mean that the U.S. supplies Canada but the U.K. supplies Ireland.

The equations derived in this paper permit the analyst to transform prices or price ratios excluding transport charges into delivered prices or ratios applicable to individual markets by inserting the appropriate values for the independent variables. Even if no relative price data exist, the freight factors derived from these equations provide estimates of that part of differences in relative delivered prices that could be accounted for by transport charges, if these costs are borne by purchasers. Thus if we assumed that prices from different suppliers to one market were identical before transport charges were added, w could estimate the relative difference in delivered prices between one supplier and another. If we assumed that delivered prices in a market were identical, we could estimate relative differences in prices at the point of shipment.

TESTS OF THE ESTIMATING EQUATION

Comparisons with Bidding Data

Since the structur of transport charges in U.S. import trade, to which the Census data relate, could be quite different from that on other trade routes, we are fortunate to have a completely independent ource of data, for different years and different routes, with which we can compare the results

TABLE 2 Reported and Estimated[a] Freight Factors: Averages by Commodity Groups (percentage of value of shipment)

SITC[b]		Average of Reported Freight Factors	Average of Estimated Freight Factors
011	Meats, fresh, frozen, etc.	11	8
013	Meats in containers, meat prep., etc.	4	5
031	Fish, fresh, frozen, etc.	7	6
051	Fruit, fresh, and nuts, fresh or dried	13	15
061	Sugar and honey	7	8
071	Coffee	5	6
081	Feeding-stuff for animals	18	14
112	Alcoholic beverages	9	7
231	Crude rubber	13	11
262	Wool and other animal hair	5	6
281	Iron ore and concentrates	26	29
283	Ores and concentrates, non-ferrous	14	11
331	Petroleum, crude and partly refined	15	19
332	Petroleum products	14	16
442	Fixed vegetable oils, exc. soft	6	11
512	Organic chemicals	4	4
631	Veneers, plywood board, etc.	16	14
653	Textile fabrics, woven, exc. cotton	6	7
664	Glass	14	12
665	Glassware	11	6
666	Pottery	12	8
674	Iron and steel plates and sheets	11	8
732	Road motor vehicles	9	7
841	Clothing	5	5
851	Footwear	7	6
861	Scientific, medical, etc., inst. and appar.	2	2
894	Toys, games, sporting goods, etc.	9	6
899	Manufactured articles n.e.s.	9	8

[a]Estimated from equation (1).
[b]All groups with thirty observations or more. Some of the SITC titles are abbreviated here.

from the Census data. The equation from bidding data, which covered exports by the United States and other developed countries mainly to less-developed countries, particularly in Latin America, during 1953–64, was

$$(2)\quad FR = -4.95 + \underset{(28.23)}{.70UV} + \underset{(6.93)}{.34DI} + \underset{(13.08)}{.50ST} \qquad \bar{R}^2 = .59$$

The variables for small shipments and tanker shipment do not appear in this equation because no such shipments were included in these data. The other three variables were statistically significant, as in the Census data, and had the same sign. However, the coefficients were all higher in the bidding data, .70 against .52 for unit value, .34 against .30 for distance, and .50 against .35 for stowage.

We pooled the two sets of data to test whether the level and the structure of rates implied by the bidding data were significantly different from those derived from Census data. An equation containing only a dummy variable for bidding data, implying that the other coefficients were assumed to be identical in the two sets of data, was (in logs):

$$(3)\quad FR = -3.61 + \underset{(63.71)}{.53UV} + \underset{(21.26)}{.37ST} + \underset{(14.80)}{.30DI} + \underset{(5.96)}{.27SW} - \underset{(12.15)}{.48TA} + \underset{(23.52)}{.67B} \qquad \bar{R}^2 = .81$$

where B is a dummy variable for bidding data and the other variables are those defined for equation (1). The level of rates, on the a sumption that the coefficients for UV and other variables are identical in the two data sets, is significantly higher in the bidding data than in the Census data. However, the other coefficients can be tested by inserting cross-product variables, multiplying B by each of the others. The cross-product term for distance did not appear to be significant and was dropped, leaving as the resulting equation:

$$(4)\quad FR = -3.56 + \underset{(60.46)}{.52UV} + \underset{(19.14)}{.35ST} + \underset{(15.24)}{.31DI} + \underset{(6.57)}{.30SW} - \underset{(12.89)}{.51TA} - \underset{(4.11)}{1.11B} + \underset{(5.41)}{.17(B \times UV)} + \underset{(2.77)}{.14(B \times ST)} \qquad \bar{R}^2 = .81$$

which implies that both the unit value and the stowage coefficients were significantly higher in the bidding data than in the Census data, whereas the constant term was significantly lower.

The bidding data thus confirm the choice of variables but suggest different values for some coefficients. A number of possible interpretations of these differences are discussed below.

Tests with Independent Unit Value Data

A basic problem in our estimating equation is that the freight rate and the unit value are both variables that have the weight of the shipment in their denominator; that is, freight rate is computed by dividing the total freight cost by the weight of the shipment, and unit value is computed by dividing the total value of the shipment by the weight of the shipment. If there were significant errors of measurement in the weight variable, they could have biased both the unit value coefficient and the correlation measure. The extent of the bias would depend on the characteristics of the errors; for example, the correlation between the errors and the true values of the variables. To check for possible bias from this source, we collected published value and quantity data and calculated independent unit values for the commodities and countries in our transport charge data, as described in the appendix, matching the SITC categories in our transport charge data to those of the published value and quantity data. The number of independent unit values was, of course, smaller than the number of our original observations because the independent unit values represented whole commodity groups rather than individual shipments.

We then calculated regressions with the logarithms of the independent unit value, distance, and the stowage factor as independent variables, as well as, in the Census data, dummy variables for small weight and tanker shipment, and the logarithm of the transport charge as the dependent variable. These results are compared with the original equations in Table 3.[12]

We were concerned that our unit value coefficient obtained from the whole data set might be biased by errors in the measurement of weight, but as noted in Table 3, the magnitudes and signs of these coefficients based on the two sets of unit value observations are very similar. In the Census data the unit value and distance coefficients are almost unaffected by the substitution of the independent unit values (they change from .52 to .50 and .30 to .32) and the stowage coefficient is unchanged. Only the small shipment and tanker coefficients are altered substantially. The small shipment coefficient may pick up some of the variation artificially excluded from the unit value variable because the unit values from the published data, matched only to the country and commodity of each freight rate, are identical for several observations.

The bidding-data coefficients change more significantly, the coefficients for unit value and stowage declining and becoming closer to those from the Census data and that for distance increasing and differing by more than originally from the Census results. We suspect, from the change in the unit value coefficient, that some bias from measurement errors may have been present in the initial result. It is not surprising that the bidding data were more subject to this defect because many of the shipping weights were estimated, whereas those used for the Census equations were part of the original data set.

The adjusted $\bar{R}^2$ decreased in each case, as we would expect, since we substituted the average unit value of a commodity group for unit values specific to individual shipments. In this way we ignored some known

TABLE 3 Comparison between Regression Coefficients Based on Original Unit Values and Coefficients Based on Independent Unit Values

Equation	Intercept	*UV*	*ST*	*DI*	*SW*	*TA*	$\bar{R}^2$
			Census Data				
(1)	−3.53	.52	.35	.30	.30	−.51	.81
		(57.35)	(18.18)	(13.51)	(6.22)	(12.25)	
(5)	−2.34	.50	.35	.32	.72	−.57	.75
		(42.33)	(15.29)	(12.50)	(13.53)	(11.82)	
			Bidding Data				
(2)	−4.95	.70	.50	.34			.59
		(28.23)	(13.08)	(6.93)			
(6)	−4.30	.68	.49	.28			.58
		(26.38)	(12.29)	(5.12)			
(7)	−4.93	.58	.44	.45			.47
		(19.64)	(9.56)	(7.33)			

(1) Original data, 2,889 observations.
(2) Original data, 835 observations.
(5) Independent unit values.
(6) Original data for which matching independent unit values were available, 756 observations.
(7) Independent unit values.

variation in the independent variable that we knew was associated with some of the variation in the dependent variable.

On the whole, then, the Census-data equations passed this test quite successfully, and we feel fairly safe in proceeding on the assumption that the problem of biased coefficients is negligible in the Census data and is of some, but not major importance, in the bidding data.

Non-Linearity and Heteroscedasticity

We have fitted linear equations in logs although there is no strong theoretical basis for the linear form. The recent UNCTAD study, described more fully below, used linear arithmetic equations that we found to produce a much poorer fit and unstable coefficients. It is quite possible, of course, that a more complex function would give a still better fit than the log linear function, and to examine that possibility we tested the estimating equation for signs of non-linearity. The method was to split the sample in half according to the ranking of several variables, asking, first, whether the coefficient for a variable among the observations with larger values for the variable was significantly different from the coefficient among the observations with smaller values, and second, whether coefficients for independent variables differed significantly between commodities carrying lower transport charges and those bearing higher rates. The most convenient way to perform the tests was to assign a dummy variable to that half of each distribution which contained the larger observations and introduce into the equation cross-product terms between that dummy variable and each independent variable. Thus, for example, if we defined *LU* as the dummy variable for large unit value (that is, higher than the median unit value), we introduced a term (*LU*) (*UV*) into the equation. A positive and statistically significant coefficient for (*LU*) (*UV*) would indicate that a given percentage difference between two unit values was associated with a larger percentage difference in freight charges among more expensive goods than among the cheaper products.

The results of these tests, summarized in Table A3 in the appendix, suggest that there were some statistically significant differences in coefficients, but that permitting slopes to vary in the two halves of the distributions would, in most cases, produce little improvement in the fit of the equation and change the coefficients only slightly.

The separation by size of unit value (equation 26) has comparatively little effect on the coefficients but indicates that a given percentage change in unit value adds less to the freight charge at higher unit values than at lower ones. The breakdown by stowage factor (equation 27) suggests that the impact of bulkiness on freight rates is greater among bulky commodities than among less bulky ones. The distance breakdown (equation 28) indicates that the effect of a given percentage change in distance is smaller among long voyages than among short ones. In none of these cases did the addition of the dummy variable raise the $\bar{R}^2$ substantially, even though all the dummy variables were statistically significant at the 5 per cent level.

A greater effect on the coefficients was produced by separating the group into high and low transport rates, the dependent variable (equation 29). The higher $\bar{R}^2$ is meaningless since transport cost was, to some extent, being placed on both sides of the equation. The equation does suggest that stowage affected transport charges much more among commodities with high rates than among those with low rates.

One reason for the differences in coefficients that appear when observations are divided into transport rate groupings is suggested by our tests for heteroscedasticity. We tested for heteroscedasticity, using Bartlett's test and a four-way division of the observations, with orderings by transport charge, unit value, stowage, and distance. The latter two orderings did not produce a rejection of the hypotheses of homoscedasticity at the 5 per cent level, the unit value ordering indicated a rejection at the 5 per cent level but not at the 1 per cent level, but the ordering by transport charges produced very strong evidence of heteroscedasticity. It may be, then, that the differences in coefficients between high- and low-transport charge groups reflect this heteroscedasticity rather than any true non-linearity in the relationships.

Some Experiments with the Transport Price Equations

Since the bidding data cover a period of several years, we could presumably use them to measure changes in the structure of transport prices, although the observations become fairly thin when they are divided by periods of time. If we fit an equation (in logs) to the bidding data for 1959–61 and 1962–64 using a dummy variable, *E*, for observations for 1959–61, and adding the cross-product terms for 1959–61 for each variable, we obtain:

$$\text{(8)}\quad FR = -2.89 + \underset{(15.85)}{.69UV} + \underset{(5.83)}{.40ST} + \underset{(1.53)}{.14DI} - \underset{(2.64)}{2.81E} + \underset{(1.46)}{.08(E \times UV)}$$

$$- \underset{(.40)}{.03(E \times ST)} + \underset{(2.63)}{.29(E \times DI)} \qquad \bar{R}^2 = .60$$

The equation implies that there was no unambiguous shift in the level of rates, since the coefficient for *E* is negative; but the cross-product terms for unit value and distance are positive. It would be possible to calculate the implied transport charges for different types of commodities in the two periods and to weight these in any proportions considered appropriate to produce an index of transport charges.

Another possible source of information on changes in transport charges is the comparison between bidding- and Census-data equations, since the bidding data referred to an earlier period. The equation with only a single dummy variable for bidding data showed a considerably higher level for the earlier period. The more complete equation was also more ambiguous, since the dummy variable for bidding data was negative, although the cross-product terms for the unit value and stowage coefficients were positive. The two equations suggest that although the level of transport charges was probably lower in general in the Census data, there might be some products, with low unit value and low storage factors, for which the Census data equation implied higher charges.

There are several possible reasons for the difference in level between equations for the two data sets, since the bidding data differ from the Census data in several respects other than just the method of collection. One is that the Census data relate entirely to U.S. imports, whereas the bidding data cover mainly shipments from the United States and other developed countries to less-developed countries, particularly in Latin America. Another is that the bidding data cover mostly the years 1960–64, but the Census data are all for 1966. Still a third difference is that the

Census data cover a much larger number and variety of commodities than the bidding data.

A possible explanation of the difference is that transport charges declined between the early 1960s and 1966, in the sense that in 1966 they were lower than the levels implied by the bidding-data equation, taking account of unit value, distance, and stowage factors. If transport charges per ton for each commodity on each trade route increased, but not so much as our equation predicted, given a rise in unit values, we would consider that transport charges had fallen.

There are at least two alternative explanations for the difference between the two transport charge levels: (1) that transport charges into the United States are lower, given the commodity characteristics of trade, than those on shipments out of the United States and out of other developed countries, or at least lower than on those countries' shipments to Latin America; (2) that the amount of discrimination by shipping firms, as indicated by the extent to which they charged higher rates for more valuable commodities, was greater in the earlier period than later, or greater on the exports of the United States and other developed countries, at least those to Latin America, than on U.S. imports.

These data thus do not rebut the claim that transport charges favor U.S. imports as compared to U.S. exports, but because of the differences in timing and commodity coverage between the sources we cannot draw any firm inference on this issue. A related claim that transport charges on U.S. exports are higher than on the corresponding exports by other countries is not supported by a test in which the bidding-data dummy variable used for equation (3) is replaced by separate variables for U.S. exports and exports by other countries. The coefficients for the two origins of exports are almost identical, a fact that suggests that transport charges, taking account of product mix, were not significantly different.

A factor not included in our equations is the possibility of shipping a product other than the tanker products by some method other than liner, including the use of specialized bulk cargo vessels or tramp ships. Several versions of this variable were tried: the percentage of tonnage shipped by liner, a dummy variable if any of the product was imported by non-liner (other than tanker) shipment, and a dummy variable for products of which more than 10 per cent of imports was by non-liner shipment. These variables had the expected sign: positive for percentage shipped by liner and negative for the two dummy variables. However, none of the coefficents was statistically significant at the 5 per cent level and we therefore omitted these variables from the basic estimating equation. An example of one of these coefficients is given in equation (9), where *NL* is a dummy variable for a commodity of which non-liner imports were 10 per cent or more of total imports into the United States. If one takes the coefficient at face value, it seems to imply, as one might expect, that shipment by tramp steamer or other non-liner mode is cheaper than by liner or that the possibility of such shipment lowers even the liner rates for the affected products.

$$(9)\quad FR = -3.47 + \underset{(54.83)}{.52UV} + \underset{(18.08)}{.35ST} + \underset{(13.49)}{.30DI} + \underset{(6.25)}{.30SW} - \underset{(11.97)}{.54TA} - \underset{(1.70)}{.05NL} \qquad \bar{R}^2 = .81$$

It has also been suggested that transport charges are affected by the balance of tonnage on a route. The hypothesis is that, if outbound tonnage exceeds inbound tonnage on a route, outbound rates will be comparatively expensive and inbound rates will be cheap, as the surplus of capacity for inbound shipping induces price-cutting among carriers. Using some data on shipments along particular trade routes, we classified origin-destination combinations into twenty-seven routes and calculated the ratio of export tonnage to import tonnage and the difference between them for each route. The coefficients for the balance on liner shipment, non-liner shipment, and both combined proved of no statistical significance in any of the equations we tried, and often had the wrong sign. However, a cross-product term for $(NL)\left(\frac{X_{NL}}{M_{NL}}\right)$, where $\frac{X_{NL}}{M_{NL}}$ is the ratio of non-liner exports to non-liner imports on a trade route, although it was not significant at the 5 percent level, did have a t-value greater than 1 and the expected negative sign, as in equation (10).

$$(10)\quad FR = -3.55 + \underset{(56.69)}{.52UV} + \underset{(18.17)}{.35ST} + \underset{(13.59)}{.31DI} + \underset{(6.22)}{.30SW} - \underset{(12.31)}{.53TA} - \underset{(1.51)}{.006}(NL)\left(\frac{X_{NL}}{M_{NL}}\right) \qquad \bar{R}^2 = 81$$

If the coefficient is taken as given, it implies that an export surplus on non-liner trade on a route lowers the transport charge for non-liner imports on that route. The relationship is not strong, but it is in the expected direction and does give some support to the role of the trade balance.

COMPARISON WITH OTHER FINDINGS

Our results agree with earlier studies[13] in identifying the unit value as the most important determinant of freight rates. However, none of these authors calculated any coefficients for the other variables we include and find to be significant, or estimated a significant, specific relationship between freight rates and unit values. With better data we are able to estimate the separate influence of distance, stowage, and size of shipment on freight rates. Furthermore, our results suggest that the omission of any of these variables may cause the others to be miscalculated, as there is significant and positive correlation between unit values and distance and between unit values and stowage factors. That omission of variables may account for the difference between our estimate of the unit value coefficient and those calculated by Moneta, which ranged between .23 and .29. However, other explanations for the difference are possible. The Moneta data were calculated from grouped observations rather than from individual shipments, the distance variable was taken into account in a crude manner by dividing the observations into five exporting areas, and the data referred to a period much earlier than ours.

Benjamin Chinitz, in a 1956 study, examined the freight rate structure of two conferences that had published rates covering commodities exported from the United States to Colombia.[14] His major purpose was to investigate whether conference rates implied rate discrimination in ocean transport. Holding constant the stowage factor, he found the correlation between the published conference freight rate and the unit value for each commodity to be quite low, and thus unlike the strong relation in our equations.

The most elaborate study of the structure of transport charges is a recent ECLA volume on transport charges for exports from Latin America.[15] The data are quite different from ours, the rates being derived from conference tariffs and thus confined to liner trade and to official rates. The approach was also different, separating the elements of transport charges into two components. One was what the authors referred to as the structure of rates, which involved differences among commodities with regard to transport charges on a single route. The other involved what they called the level of rates: differences among routes for transport charges on individual commodities. The results, however, were similar to ours in several respects. Unit value and stowage were almost always significant variables and explained a high proportion of transport rate variation among commodities. Handling costs and risks of damage and pilferage were statistically insignificant or of small importance. Distance was a significant element in determining transport rate variation among routes, as we also concluded, and two other variables for which we had no data, the number of lines serving a route and the level of port costs, were also significant. The degree of imbalance of trade on a route appeared to be insignificant. In general, the explanation of commodity differences in transport charges was much more successful than the explanation of route differences.

On the whole, despite the wide differences in sources and methods between our study and the ECLA report, the conclusions appear to be reasonably in agreement.

CONCLUSIONS

We find that there is a commodity structure of transport charges in which the main determinants of these rates are similar over fairly different time periods and trade routes. The main elements we identify as determinants on the cost side are the stowage factor (the bulkiness of the commodity), the distance over which it is shipped, the size of individual shipments, and the possibility of shipping the product by tanker. The other main element in transport charges, which we identify with discrimination by shipping companies in rate-setting, is the unit value, or value per ton of the commodity. With these variables we were able to derive an equation that could be used to estimate transport charges for whole classes of commodities, as a step in explaining the commodity composition and direction of international trade.

On other issues related to the determination of transport charges the evidence was weak or ambiguous. A comparison of two different sets of data indicated that either (1) transport charges fell between the early 1960s and 1966; or (2) rates on imports to the United States were lower than on exports from the United States and other developed countries; or (3) charges on U.S. imports were lower than on Latin American imports. We could find no evidence in our data that rates on exports from the United States were higher than on exports from other developed countries, once commodity and route characteristics were taken into account.

We found some evidence that products shipped mostly by liner carried relatively high transport charges and still weaker evidence that an export surplus on a route led to lower transport charges on imports than on exports. The weakness of the trade balance effect, as well as the strength of the unit value effect, suggests that the shipping conferences may have been highly successful in reducing competition.

Several interesting questions are raised by the results here but would require additional data collection or further analysis for an authoritative conclusion. One is whether the structure of transport charges differs substantially among routes or areas of the world. Another is whether the growth of container shipment has increased competition sufficiently to alter the structure of rates, particularly the relation of unit value to transport charges. Still another is whether the same type of analysis could be used to explain and forecast the growth of air transport as a substitute for ocean transport.

There are quite a few additional sources of transport price data that are newly available or were for other reasons not employed in our analysis, but could contribute to a fuller study of the transport market. One is the Census Bureau data for U.S. imports in the years after 1966, including those on air shipments, which are superior to our sample because the actual value at the point of shipment was collected for each shipment, in addition to the official value. Another source is the extensive collection of transport charges for the United Nations report cited earlier, and still another is the voluminous information on conference freight rates such as was published in various congressional hearings.[16] Major shippers of bulk commodities, particularly products such as petroleum in which intra-company shipments are important, could probably provide much better transport cost data than our official records, which are not reliable for these cases. These data would enhance the accuracy of our estimates and enlarge the time, mode, product, and geographical coverage. They would thus, among other advantages, provide a better opportunity to distinguish between effects of changes over time and of differences in cost among countries of origin and among destinations.

APPENDIX

Our data on transport costs come from two sources. One is the underlying data from a Census Bureau study of the difference between official and c.i.f. (cost, insurance, and freight) valuations for U.S. imports, and the other is the price collection that was part of the National Bureau's study of international price competitiveness.[1]

Census Data

The main body of data, and the basis for our estimating equation, was the Census Bureau study of U.S. imports. This had, as its main purpose, measurement of the difference between c.i.f. values, which include insurance and transport charges, and the official value of imports as reported by the Census Bureau. The latter are mainly f.a.s. (free alongside ship) or f.o.b. (free on board) but also include some other bases of valuation such as American selling price. These data consisted of information on about 5,000 import shipments into the United States during the calendar year 1966 from a probability sample of U.S. imports.

The information collected by the Census Bureau included the value reported in the official data and, in addition, the c.i.f. value, the shipping weight, and a detailed commodity classification by both the SITC (Standard International Trade Classification) and the TSUSA (Tariff Schedules of the United States Annotated). Using these classifications we estimated the stowage factors from the sources described below. The difference between the official value and the c.i.f. value is what we call transport cost, except in the cases described later.

Not all of the more than 5,000 observations from the Census Bureau's survey were suitable for our purpose. Since we were interested in ocean transport costs, we eliminated all shipments other than by vessel and all shipments loaded or originating in Canada or Mexico, about 1,900 altogether. Also dropped from the sample were all observations showing zero transport cost or zero shipping weight, and all for which we could not estimate a stowage factor. After all these eliminations, the final sample contained 2,889 observations.

These Census data are widely distributed among the commodity groups, as can be seen in the following table.

SITC	Commodity	Number of Observations
0	Foods	545
1	Beverages & tobacco	65
2, 61–65	Crude materials, excl. petrol., and mfrs. of animal or vegetable origin	782
3	Petroleum	153
4, 5	Fats, oils, and chemicals	308
66, 812	Stone, glass and clay products	187
67, 68, 69	Metals and manufactures, n.e.s.	178
71, 72	Machinery	118
73	Road motor vehicles	126
83, 84, 85	Clothing and shoes	231
82, 86, 89	Miscellaneous	203

The Census data have some drawbacks. The classifications, detailed as they are, do not identify particular articles, and it is therefore likely that the assignment of stowage factors to particular shipments was imperfect. There are also ambiguities in the officially reported valuation, as mentioned earlier. For example, in some cases the official value was the American selling price (ASP), which was not related to the actual f.a.s. value and could even be higher than the c.i.f. value. This created no problems for the Census Bureau's own study, which was directed toward measuring differences between official values, however calculated, and c.i.f. values, but was troublesome to us because we were measuring transport cost. Some, but not all, of these anomolies were removed by an adjustment we carried out for those products subject to ASP valuation. The official values were multiplied by the ratio of f.o.b. value to official value, calculated from the 1970 Census Bureau survey.[2] The information on f.o.b. values was not available in the 1966 survey we used.

However, even where ASP valuations were not reported as the official values, there were cases of what appeared to be unbelievable unit values. We made no attempt to remove these observations because we lacked the information needed to decide which were incorrect. Many cases of improbable unit values, and also of improbable or impossible transport charges, were for commodities in which a high proportion of shipments were intra-company transactions. In such transactions the unit values are subject to the vagaries of transfer-price accounting, in which tax considerations may play an important role, and may therefore be far from true market prices. When the ships are also company-owned, as is often the case for petroleum imports, it is not at all clear what the reported transport charge means. In this case too, the allocation of costs among the stages of production, transportation, marketing, etc., could be quite arbitrary or reflect the structure of taxation.

Bidding Data

The data from the price competitiveness study, which we refer to here as bidding data, are derived mainly from formal bids by firms in developed countries to supply machinery and equipment to less-developed countries. The basic information supplied by each bidding document included the f.o.b. or f.a.s. price of the particular product being offered, and, in the cases used here, the c.i.f. price as well. Occasionally, other information was provided, such as the division of the f.o.b.-c.i.f. differential among insurance, ocean freight, and other costs, and data on the weight of particular shipments or on their bulk. The information on bulk was used for calculating stowage factors. What we have called "transport charge" is the difference between the c.i.f. and f.a.s. values. Where we could, we added inland freight to f.o.b. values to convert them to f.a.s. values, but we did not remove insurance even when it was reported separately.

Only a small part of the total observations included both weight and bulk, and one or the other therefore had to be estimated in most cases, often on the basis of data from other sources. For transformers, weight and stowage factors were estimated from separate equations relating them to the capacity of the transformer.[3] There were no more than 100 observations on weight and about 70 on stowage, mainly from shipping documents associated with bids on projects for U.S. government agencies, particularly the TVA, but including several others. The bids used for this purpose were not necessarily or usually the ones that provided the shipping-cost data. They were from the collection acquired for the price competitiveness project, and they covered the same type of product.

The shipping-cost data for railway locomotives also did not include weight, but did provide detailed specifications. A logarithmic regression equation of weight on horsepower, with dummy variables for wheel arrangement and type of service (such as road, switching, or combination), was derived from data published in various issues of *Railway Age* magazine,[4] and this equation was then used to estimate the weights for locomotives in the sample.[5]

Data on aluminum cable were indentified by type of cable (e.g., Quail, Flicker, Drake) and type of reel used. Using this information, we obtained both weight and the stowage factor from a catalogue listing the weight and volume of each type of cable and reel.[6]

The commodity distribution of the bidding data is not representative of United States or world trade, because it was determined by the needs of the price competitiveness study and the availability of data. That study was confined to machinery, transport equipment, metals, and metal products, which accounted for a little under half of the value of exports of the United States and of the OECD countries in 1963. They accounted for a smaller share of world trade and, since these are relatively expensive products for which freight cost is comparatively low as a percentage of value,[7] for a still smaller share of total expenditures on ocean freight.

Even within the three-digit Standard International Trade Classification commodity groups included in the data, the observations were very unevenly distributed because the bids, which were the source of most of the observations, were concentrated in certain products. Of 835 observations containing information on both weight and stowage, as given in the sources or estimated, the main groups covered were:

SITC	Product	Number of Observations
693.13	Aluminum cable	143
718.42	Graders & dozers	54
722.1	Transformers	526

The other 112 observations were scattered among various types of semi-manufactured metal products, iron and steel tanks and drums, several types of electrical and non-electrical machinery, automobiles, and trucks.

These data include observations in years ranging from 1953 through 1965, but were mainly concentrated in the period 1960 through 1964, as can be seen in the following tabulation:

Year	Number of Observations
1953	1
1954	7
1955	0
1956	0
1957	0
1958	20
1959	53
1960	195
1961	30
1962	156
1963	222
1964	144
1965	7

As noted, almost all the observations represent the cost of shipments from developed to less-developed counties. The origins of the shipments are as follows:

Origin	Number of Observations
U.S.	156
Canada	35
urope	563
Japan	75
Other	6

and the destinations:

Destination	Number of Observations
Mexico	156
South America	611
Asia	50
Other	18

Thus the data are strongly dominated by exports to Latin America.

Independent Unit Value Data

Estimates of value per ton, or unit value, independent of our main data on transport charges, could not be obtained for individual shipments. However, they could be calculated for each commodity group from published data. We collected the value and tonnage data for exports of OECD countries other than the United States and Canada (which do not use tonnage as a universal quantity unit) to match the bidding-data unit values.[8] To match the Census data for each commodity, we collected values and shipping weights reported in the published statistics on imports by method of transportation.[9]

Stowage, Distance, and Shipping Characteristics of Commodities and Routes

Stowage factors for products other than electrical equipment and aluminum cable were assigned on the basis of information in several books on freight stowage, although the commodity lists there did not cover all the items in our sample.[10] Distance, the other principal variable involved in our equations, was also not provided in the bidding data, but the ports of shipment and destination usually were given. We used shipping distances for these ports or the ones closest to them.[11]

The characteristics of trade routes—the balance of liner, non-liner, and tanker trade—were derived from a report of the U.S. Maritime Administration.[12] The origins and destinations in our Census data were classified into twenty-seven trade routes and the balance of trade on each route (e.g., U.S. Atlantic ports and East Coast of South America) imputed to all the origin-destination combinations included in the route.

Several shipping characteristics of commodities in U.S. import trade were calculated from the same source. One characteristic was whether the commodity was ever imported by tanker. Another was the share of liner imports, for those products that were never imported by tanker; a third was whether a commodity (other than those sometimes shipped by tanker) was ever among non-liner imports; and a fourth was whether non-liner imports were more than 10 per cent of the sum of liner and non-liner imports of a commodity. These commodity characteristics were calculated for all trade routes combined, and used that way in the equations.

Basic Data

The average values of each variable in the Census data are shown in Table A1 for every SITC group containing at least ten observations. The values for these variables are not necessarily characteristic of the whole group, particularly in groups with small numbers of observations, since they were assigned on the basis of the characteristics of the particular observations that appeared in the sample.

TABLE A-1 Average Values of Variables in Census Data

										Liner Trade		Trade Other Than Liner or Tanker	
SITC[a]	*FR*	*UV*	*ST*	*DI*	*SW*[b]	*TA*	%*L*	*NL* > 0	*NL* > 10	$\frac{X}{M}$	*X* − *M*	$\frac{X}{M}$	*X* − *M*
11	87	825	82	6882	0.0000	0	92	1	0	126	36	165	325
13	50	1231	60	4496	0.0000	0	100	0	0	65	−618	310	3120
31	69	1025	80	4668	0.0000	0	60	1	1	112	47	394	2194
32	51	764	60	6597	0.0000	0	100	0	0	165	307	514	6018
51	24	184	113	3242	0.0000	0	57	1	1	208	327	365	−2228
53	34	300	59	7196	0.0667	0	77	1	1	136	−33	783	8652
55	40	349	62	4854	0.0000	0	100	0	0	175	166	678	6718
61	8	117	43	4112	0.0000	1	0	0	0	0	0	0	0
71	40	806	65	4221	0.0000	0	100	1	0	150	25	172	−1625
72	35	372	68	3670	0.0000	0	100	0	0	123	45	105	−2175
75	99	1945	79	8020	0.0000	0	100	0	0	111	106	376	125
81	25	140	65	3715	0.0000	0	38	1	1	87	−203	136	392
99	50	533	65	4301	0.0000	0	4	1	1	73	−781	550	7461
112	64	732	65	4250	0.0213	0	100	0	0	96	−585	560	6447
121	66	1416	100	5160	0.0000	0	100	0	0	102	−155	648	4879
211	62	1482	75	5786	0.0000	0	100	0	0	127	70	515	1889
221	19	196	87	5939	0.0000	0	19	1	1	120	357	1038	19074
231	51	404	63	8466	0.0000	0	94	1	0	120	102	551	390
243	30	140	45	4467	0.0000	0	97	1	0	122	74	381	3873
262	90	1659	103	6622	0.0172	0	100	0	0	101	−112	228	1210
266	50	613	97	5751	0.0000	0	100	0	0	114	−442	668	9212

TABLE A-1 (continued)

										Liner Trade		Trade Other Than Liner or Tanker	
SITC[a]	*FR*	*UV*	*ST*	*DI*	*SW*[b]	*TA*	*%L*	*NL* > 0	*NL* > 10	$\frac{X}{M}$	*X* − *M*	$\frac{X}{M}$	*X* − *M*
276	14	107	33	6463	0.0000	0	5	1	1	148	92	590	4203
281	2	8	14	2594	0.0000	0	16	1	1	214	366	30	−7113
283	5	34	22	3002	0.0000	1	0	0	0	0	0	0	0
291	100	4480	89	5289	0.3182	0	89	1	1	105	−420	624	5746
292	53	937	74	6123	0.0345	0	100	0	0	159	264	886	4983
331	2	16	41	2788	0.0000	1	0	0	0	0	0	0	0
332	2	14	30	1906	0.0000	1	0	0	0	0	0	0	0
421	34	660	39	3919	0.0000	1	0	0	0	0	0	0	0
422	15	261	39	7828	0.0000	0	100	0	0	147	170	674	9972
512	31	727	60	4529	0.0625	1	0	0	0	0	0	0	0
513	26	358	43	4306	0.0000	1	0	0	0	0	0	0	0
514	28	203	46	5193	0.0000	0	9	1	1	137	−293	571	7013
515	71	19877	18	7685	0.0000	0	9	1	1	78	−78	0	−470
531	126	8351	68	3500	0.2308	0	100	0	0	61	−1286	663	9309
541	293	22000	64	4473	0.2727	0	100	0	0	65	−958	655	8805
551	215	8679	78	5456	0.5000	0	100	0	0	96	−140	627	4747
581	57	1339	69	4668	0.2308	0	70	1	1	90	−819	690	9945
599	35	681	72	4171	0.0625	0	100	0	0	107	−570	529	6873
611	128	4484	97	4787	0.2500	0	100	0	0	102	−441	604	4702
629	46	1081	117	4484	0.0435	0	100	0	0	129	−346	664	7787
631	39	240	75	6986	0.0000	0	67	1	1	141	269	840	13646

632	86	680	84	5485	0.1429	0	100	0	0	91	−288	735	9917
641	17	176	92	4744	0.0000	0	70	1	1	67	−577	371	4500
651	118	2361	126	5279	0.0500	0	100	0	0	80	−561	628	7883
652	81	1573	103	6956	0.1034	0	100	0	0	134	−177	911	9127
653	87	1528	89	8486	0.1566	0	61	1	1	188	383	1109	8024
656	136	2752	108	6947	0.4000	0	100	0	0	85	−459	728	10429
657	148	1217	150	8238	0.0500	0	100	0	0	157	220	1129	11374
662	27	215	42	6356	0.0000	0	100	0	0	123	55	788	11934
664	33	239	65	4609	0.0545	0	100	0	0	102	−460	681	10082
665	173	1551	73	4542	0.3636	0	100	0	0	90	−564	679	8619
666	92	788	69	5400	0.1781	0	100	0	0	130	−97	835	13190
673	17	93	14	6213	0.0000	0	38	1	1	236	586	612	8778
674	19	173	11	6351	0.0000	0	27	1	1	153	4	766	12043
678	24	274	55	7123	0.0769	0	45	1	1	187	410	789	12147
682	22	1030	24	4388	0.0000	0	100	0	0	59	−595	230	1751
687	52	3589	9	9765	0.0000	0	100	0	0	99	−121	759	8044
698	102	3943	65	4979	0.5000	0	85	1	1	94	−644	671	9803
714	176	5694	121	3664	0.0000	0	100	0	0	66	−1022	656	9142
715	110	1685	79	4790	0.0000	0	100	0	0	84	−631	594	7628
719	139	4231	55	4349	0.3077	0	100	0	0	65	−712	569	8448
723	144	1578	56	5188	0.1250	0	100	0	0	144	204	913	14727
724	188	5734	198	6387	0.1600	0	100	0	0	101	−6	938	16127
729	243	7842	117	4833	0.1818	0	100	0	0	104	−309	822	12928
732	130	1519	185	4751	0.0094	0	37	1	1	113	−404	671	9442
821	115	1227	120	4069	0.3043	0	100	0	0	83	−671	585	6749
831	288	2852	177	6973	0.4118	0	100	0	0	92	−296	902	14768
841	254	4850	202	7766	0.2988	0	100	0	0	98	−253	858	12844
851	196	2930	205	5173	0.1600	0	100	0	0	109	−154	766	8481
861	319	3011	83	6340	0.4194	0	100	0	0	94	−415	818	12629
862	117	4231	80	3818	0.0909	0	100	0	0	63	−1208	682	9676

TABLE A-1 (concluded)

										Liner Trade		Trade Other Than Liner or Tanker	
SITC[a]	*FR*	*UV*	*ST*	*DI*	*SW*[b]	*TA*	%*L*	$NL > 0$	$NL > 10$	$\frac{X}{M}$	$X - M$	$\frac{X}{M}$	$X - M$
891	273	3744	141	6145	0.1905	0	100	0	0	109	−38	849	12803
893	116	1209	141	7714	0.0000	0	100	0	0	112	−152	888	14371
894	270	3026	206	6072	0.2778	0	100	0	0	91	−271	805	12119
899	201	2220	191	7028	0.3947	0	100	0	0	124	−42	833	12534

[a]SITC groups with ten or more observations.

[b]Figure below multiplied by 100 is percentage of observations or groups with indicated characteristic.

FR = Transport charge, in $ per ton.
UV = Unit value, in $ per ton.
ST = Stowage factor, in cubic feet per ton.
DI = Distance, in nautical miles.
SW = Small weight dummy for shipments of less than one ton.
TA = Dummy variable for commodity group sometimes imported into the U.S. by tanker.
% *L* = Percentage liner. For products never imported by tanker, liner imports as percentage of sum of liner and non-liner imports.
$NL > 0$ = Non-liner greater than 0. For products never imported by tanker, dummy variable for some non-liner imports.
$NL > 10$ = Non-liner imports greater than 10 per cent. For products never imported by tanker, dummy variable for non-liner imports more than 10 per cent of sum of liner and non-liner imports.

$\frac{X}{M}$ = Ratio of export to import tonnage: average for trade routes in commodity group, in percentage.

$X - M$ = Difference between export and import tonnage: average for trade routes in commodity group, in thousands of long tons.

TABLE A-2 Estimating Equations for Transport Charges: Alternative Equations for Use when Some Variables Are Missing

Equation	Intercept	*UV*	*ST*	*DI*	*SW*	*TA*	$\bar{R}^2$
(1)	−3.53	.52	.35	.30	.30	−.51	.81
(11)	−4.42	.56	.38	.35	.25		.80
(12)	−3.54	.54	.35	.29		−.49	.81
(13)	−1.08	.54	.35		.25	−.62	.80
(14)	−2.50	.59		.31	.28	−.59	.79
(15)	−4.40	.58	.37	.34			.80
(16)	−1.66	.60	.39		.18		.79
(17)	−3.46	.65		.37	.23		.78
(18)	−1.16	.56	.35			−.60	.80
(19)	−2.52	.61		.30		−.57	.79
(20)	−0.02	.61			.23	−.70	.78
(21)	−1.71	.61	.38				.78
(22)	−3.44	.66		.36			.78
(23)	−0.57	.68			.15		.76
(24)	−0.10	.63				−.68	.78
(25)	−0.62	.69					.76

All variables except *SW* and *TA* are in logs.
For definitions of variables see Table A1.

TABLE A-3 Tests for Non-Linearity in Basic Estimating Equation

Equation	Intercept	*UV*	*ST*	*DI*	*SW*	*TA*	(*LU*)(*UV*)	(*LS*)(*ST*)	(*LD*)(*DI*)	(*LF*)(*UV*)	(*LF*)(*ST*)	(*LF*)(*DI*)	$\bar{R}^2$
(1)	−3.53	.52	.35	.30	.30	−.51							.81
		(57.35)	(18.18)	(13.51)	(6.22)	(12.25)							
(26)	−3.57	.55	.36	.29	.30	−.49	−.02						.81
		(39.52)	(18.41)	(12.64)	(6.35)	(11.70)	(2.88)						
(27)	−3.38	.52	.30	.30	.29	−.50		.02					.81
		(57.24)	(11.02)	(13.57)	(6.14)	(11.95)		(2.44)					
(28)	−4.39	.52	.35	.41	.29	−.50			−.02				.81
		(55.88)	(18.37)	(10.56)	(6.14)	(11.95)			(3.49)				
(29)	−2.11	.43	.16	.26	.23	−.53				−.005	.17	.01	.84
		(31.19)	(5.95)	(11.35)	(5.06)	(13.43)				(0.24)	(4.76)	(0.43)	

FR (dependent variable) = Transport charge, in $ per ton.
UV = Unit value, in $ per ton.
ST = Stowage, in cubic feet per ton.
DI = Distance, in nautical miles.
SW = Small weight dummy, for shipments of less than one ton.
TA = Dummy variable for commodity group sometimes imported into the U.S. by tanker.
LU = Low unit value (below the median).
LS = Low stowage factor (below the median).
LD = Low distance (below the median).
LF = Low transport cost (below the median).

NOTES AND REFERENCES TO TEXT

1. This analysis of ocean transport charges is a by-product of a study of interrelations between international investment and trade, financed partly from grants to the National Bureau by the National Science Foundation and the Ford Foundation. Benjamin Chinitz, J. Royce Ginn, Hal B. Lary, Donald S. Shoup, Raymond J. Struyk, and a refereee assisted us with valuable suggestions on both content and presentation, as did Frank Boddy, Emilio G. Collado, Douglass North, Willard Thorp, and Donald Woodward who read the manuscript as members of the Bureau's Board of Directors. We are indebted to Susan Tebbetts and Marianne Rey for research assistance and programming and to the U.S. Bureau of the Census for some of the data on transport cost. For a description of the study see Robert E. Lipsey and Merle Yahr Weiss, "The Relation of U.S. Manufacturing Abroad to U.S. Exports—A Framework for Analysis," *1969 Business and Economic Statistics Section Proceedings of the American Statistical Association.*
2. The most extensive sets of data available are conference rates published in various congressional hearings, particularly those of the Joint Economic Committee on *Discriminatory Ocean Freight Rates and the Balance of Payments.* See, for example, 88th Congress, 1st and 2nd Sessions, Parts 1 through 5, June 20 and 21, 1963, October 9 and 10, 1963, November 19 and 20, 1963, and March 25 and 26, 1964; and 89th Congress, 1st Session, Parts 1, 2, and 3, April 7 and 8, 1965, May 27, 1965, and June 30, 1965. It is uncertain, however, how closely these match the rates actually paid. Furthermore, they cover only certain trade routes and certain commodities. The commodity descriptions usually do not match those of trade data, being sometimes too specific and sometimes too broad. There are also many rates not given in terms of tonnage or value and not easily translated into those terms. The information is in such cases almost impossible to relate to trade data without a separate study of each commodity.
3. Jan Tinbergen, *Shaping the World Economy* (New York: Twentieth Century Fund, 1962), Appendix VI, p. 263.
4. Hans Linneman, *An Econometric Study of Trade Flows* (Amsterdam: North-Holland, 1966).
5. Grant B. Taplin, "Models of World Trade," *International Monetary Fund Staff Papers,* November 1967; Edward E. Leamer and Robert M. Stern, *Quantitative International Economics* (Boston: Allyn and Bacon, 1970), Chapter 6.
6. W. Beckerman, "Distance and the Pattern of Intra-European Trade," *Review of Economics and Statistics,* February 1956, pp. 31–40.
7. For a discussion of the determinants of cost differences among shipping routes see Walter Oi, "The Cost of Ocean Shipping" in *The Economic Value of the United States Merchant Marine* (Evanston, Illinois: The Transportation Center, 1961).
8. *Maritime Freight Rates in the Foreign Trade of Latin America,* United Nations, Economic Commission for Latin America, Joint Transport Programme, November 1970.
9. One of the main intended uses of the equation is for estimating transport charges if specific data are not available. Since not all the variables in our equation are always obtainable, we have listed, in Table A2 of the appendix, several variants of the equation that omit one or more of these variables.
10. For example, A.L. Ginsburg, *American and British Regional Export Determinants* (Amsterdam: North-Holland, 1969).
11. Irving B. Kravis and Robert E. Lipsey, *Price Competitiveness in World Trade* (New York: NBER, 1971).
12. We also re-ran our bidding equation for the subset of our observations that matched the independently collected unit values (Equation 6 in Table 3). The omission of shipments for which we could not collect independent unit values did not affect the Census equations significantly and we therefore have omitted these calculations.

13. See, for example, Herman F. Karreman, *Methods for Improving World Transportation Accounts, Applied to 1950–1953* (New York: NBER, Technical Paper 15, 1961); and Carmellah Moneta, "The Estimation of Transport Costs in International Trade Accounts," *Journal of Political Economy*, February 1959, pp. 41–58.
14. Benjamin Chinitz, "Rate Discrimination in Ocean Transportation," (unpublished Ph.D. dissertation, Harvard University), April 1956.
15. *Maritime Freight Rates in the Foreign Trade of Latin America*, United Nations, Economic Commission for Latin America, Joint Transport Programme, November 1970.
16. See, for example, the Joint Economic Committee's hearings on *Discriminatory Ocean Freight Rates and the Balance of Payments*.

NOTES AND REFERENCES TO APPENDIX

1. "C.I.F. Calculations Add 9 Percent to Import Figures, Special Study Shows," Census Bureau release, December 20, 1966; and Kravis and Lipsey, *Price Competitiveness in World Trade* (see Chapter 4 for a description of data sources).
2. The ratio was virtually identical to the average of 1968–70. The results of these surveys were reported in *Highlights of U.S. Export and Import Trade* (FT 990), U.S. Bureau of the Census, March 1969, July 1970, and April 1972.
3. The equation for weight was:

$$\text{log weight (pounds)} = \underset{(10.67)}{3.2802} + \underset{(26.31)}{.7755} \text{ capacity } (KVA)$$

and the equation for stowage was:

$$\text{log stowage (cubic feet per ton)} = 42.06 - \underset{(4.08)}{.03} \text{ capacity } (KVA/1{,}000)$$

Numbers in parentheses are *t*-values of regression coefficients.

4. *Railway Age*, January 18, 1960; January 15, 1962; January 20, 1964; Simmons-Boardman Publishing Corp.
5. The equation was:

$$\text{log weight (pounds)} = \underset{(54.07)}{7.79} + \underset{(29.76)}{.65} \log HP + \underset{(3.20)}{.09}CC - \underset{(4.80)}{.24}B$$
$$- \underset{(11.82)}{.38} \text{ Gen'l Purpose} - \underset{(8.27)}{.27} \text{ Rd. Switch}$$
$$- \underset{(5.73)}{.27} \text{ Freight} - \underset{(10.52)}{.45} \text{ Misc. Purpose}$$

in which *HP* is horsepower, CC and *B* are wheel arrangements, and General Purpose, Road Switching, Freight, and Miscellaneous describe the type of service for which the locomotives were built. Numbers in parentheses are *t*-values of regression coefficients.

6. *Alcoa Product Data: Aluminum Electrical Conductors, Stranded-Bare, December 1, 1966* (Pittsburgh: Aluminum Co. of America).
7. For empirical evidence for this statement see Moneta, "The Estimation of Transport Costs . . ."
8. Data were taken from *Commodity Trade: Exports*, Series C, January–December 1964, OECD.
9. U.S. Bureau of the Census, *U.S. General Imports-Geographic Area, Country, Schedule A: Commodity Groupings, and Method of Transportation*, Report FT 155, Annual 1967, Washington, 1968.

10. The stowage factors were taken from R.E. Thomas and O.O. Thomas, *Stowage: The Properties and Stowage of Cargoes* (Glasgow: Brown, Son & Ferguson, Ltd., 1968); from *The Stowage Red Book* (New York: Traffic Publishing Co., 1944); and from G.P. Lewis, *Handy Guide to Stowage* (London and St. Ives Hunts: Imroy, Laurie, Norie & Wilson, Ltd., 1962).
11. See the *Marine Distance and Speed Table* (New York: Edward W. Sweetman Co., 1965), and *Table of Distances Between Ports* (U.S. Navy Department, Hydrographic Office, 1943).
12. *Essential United States Foreign Trade Routes,* Maritime Administration, U.S. Department of Commerce, Washington, 1969.