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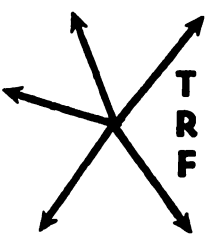

TRANSPORTATION RESEARCH FORUM

The Foreign Trade Econometric Model

by Jerome Gilbert; Nai-Ching Sun*; Amos Ilan* and Michael C. Bunamo**

ONE OF THE CHIEF responsibilities of the Port Authority of New York and New Jersey is the development of marine and aviation facilities to accommodate the flow of foreign trade through the nation's largest port and international airport complex. In order to guide its investment policy in this broad development program, the Port Authority has pioneered a number of long-range planning techniques which represent uniquely new advances in the field of port economics. The foreign trade econometric model, presented in this paper, reveals how long term port investment decisions can be aided by the application of a planning instrument that not only provides trade forecasts but also a thorough explanation of the anatomy and interplay of those forces shaping the foreign trade environment.

In approaching this task, it became evident during the late 1960's that a new analytical methodology was needed for forecasting general cargo foreign trade for planning purposes. The New York-New Jersey Port, for example, witnessed some dramatic changes in the complexion of its foreign trade flows. On one hand, import volumes increased much faster than outbound shipments, while the air cargo industry evidenced dynamic growth in the face of a modest expansion of the oceanborne trade. These trends are illustrated in the following table:

The Port of New York's Foreign Trade, 1958 vs. 1970 (thousands of long tons)

	1958	1970	Growth Rate
OCEANBORNE			
Exports	5,297	6,098	1.1%
Imports	6,784	9,856	2.9%
AIRBORNE			
Exports	12	178	23.0%
Imports	11	131	21.0%

Given these developments, simple extrapolations of the demand for terminal facilities were unsatisfactory for decision making purposes. Extrapolations project past behavior into the future without isolating the key factors shaping and influencing these trends. As such it is not possible to determine whether these factors are subject to change or modification.

Time series extrapolations, however, were unacceptable on a number of other counts. Most important, simple extrapolations could lead to forecasts greater than each mode's true potential. By projecting historical growth rates, the air mode would handle more foreign trade cargo than ocean carriers by the year 1990. In addition, these time series forecasts are devoid of analytical content. They are unable to isolate forces influencing foreign trade activity, evaluate their impact, quantify the effect of interport rivalry or evaluate the impact of intermodal competition. The foreign trade econometric model, however, overcomes all of these shortcomings.

The foreign trade econometric model has two goals: (1) to provide a detailed analysis of the major forces affecting the nation's and the Port of New York's foreign trade; and (2) to obtain reasonable long term forecasts of the bistate Port's foreign trade volume by mode of transportation. These forecasts provide background information for decisions to expand, upgrade or alter the Port Authority's cargo handling facilities. Given the proprietary nature of these forecasts, however, this paper stresses the technical methodology used in developing the actual forecasts.

The model is built up in three sequential phases. Phase I is concerned with analyzing U.S. foreign trade flows and adopts those variables suggested by demand theory—income and price—in estimating this first econometric model. Phase II analyzes New York's participation in U.S. general cargo trade. In this phase, a regression model was developed to analyze changes in the bistate Port's competitive position according to changes in the commodity composition of trade, its geographic orientation and its relationship to economic changes in the Port's hinterland. Phase III's objective was to specify the Port's trade by the ocean and air modes. This was accomplished by conducting a detailed examination of the economic forces that caused changes in the competitive share of air freight in the New York-New Jersey market. It should be noted that bulk cargoes such as grains and petroleum products are excluded from this study because they are highly subject to the influence of non-eco-

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†This article expresses the views of the authors. It does not necessarily represent the views or policy of the Port Authority of New York and New Jersey.

nomic forces such as international politics and worldwide weather cycles.

In its totality, the analysis, and its resulting simulations, incorporate the international, national, regional as well as the modal influences that affect the movement of foreign trade cargo through the New York-New Jersey port. In addition, the model incorporates statistical testing and validation procedures, the flexibility to make periodic adjustments, and the ability to answer "what if . . . ." type of questions regarding the trade environment. Following is a concise report on the methodology and technical analyses developed in the full study. It is believed that this presentation will provide the reader with a sharp focus of the study's major ideas and allow the reader to assess its results and potential.

PHASE I
AN ANALYSIS OF UNITED STATES FOREIGN TRADE VOLUMES

The task of analyzing the level of U.S. foreign trade activity during the past 12 years is, in reality, an attempt to estimate the foreign demand for U.S. exports and the domestic demand for imports. The main objective of this section is to zero in on the major variables that shape the nation's foreign trade and analyze them in a mathematical fashion that is capable of capturing the essence of past trends and projecting them into the future.

The two major explanatory variables recognized by traditional economic theory and utilized in the aggregate econometric functions are (1) world income, and (2) relative prices. There are many other minor variables that are known to influence the level of trade activity, particularly in the short run, but these are either unquantifiable or statistically insignificant. Their exclusion does not reduce the validity of this analysis.

Accordingly, separate econometric formulations were created to estimate the demand for the nation's general cargo export and import movements. These functions were tested for their forecasting accuracy of past trends, and then projected through the year 1990. All estimates were made on the basis of least square multiple regressions.

Exports

The export submodel was estimated by first postulating a functional relationship between the dependent variable, U.S. general cargo exports, and two independent variables, aggregate world demand and relative price. In short,

$$Xusg = f(Yw, P)$$

where,

Xusg = U.S. general cargo exports
Yw = World income
P = Relative prices

Time series data for the three variables were developed for the 1958-1969 period and are presented in Table 1.

Data Used in Estimating the U.S. General Cargo Export Model

Year	Xusg[1]	Yw[2]	$\frac{Pxus}{P10}$[3]
1958	21,092	71.48	.938
1959	23,343	76.18	.975
1960	30,789	82.63	.976
1961	33,462	89.70	1.000
1962	31,050	93.83	1.000
1963	35,730	100.00	1.000
1964	41,971	109.07	.978
1965	39,635	113.78	.988
1966	42,184	120.94	.995
1967	48,453	130.31	1.030
1968	56,339	142.42	1.031
1969	62,277	152.32	1.071
		(1963 =1.00)	(1963 =1.00)

Sources: (1) Port Authority tabulation of U.S. Dept. of Commerce data (thousands of long tons).
(2) United Nations Statistical Office, "Statistical Yearbook," (New York: U.N. Publishing Services), 1971.
(3) U.S. Department of Commerce, Bureau of the Census, "Statistical Abstract of the United States," (Washington, D.C.: U.S. Government Printing Office), 1971.

TABLE 1

The dependent variable measures U.S. general cargo export volumes during the 12-year period. This variable is measured in physical terms since the theory of demand suggests that quantity is the appropriate specification of the dependent variable. Analysis of the data reveals that U.S. general cargo exports have increased by 195.3% between 1958 and 1969.

The world income variable, Yw, reflects the ability of foreign nations to buy American goods. This variable was estimated by constructing a trade weighted index of real GNP for the major trading partners of the United States. According to Table 1, world GNP grew at an annual compound rate of 6.5% from 1958 to 1969. Generally, the higher foreign incomes, the greater their demand for U.S. exports.

$\frac{Pxus}{P10}$

The relative price index, $\frac{Pxus}{P10}$, measures the competitiveness of U.S. exports in the world market. This variable was estimated by comparing U.S. export prices relative to a trade weighted average of the United States' major trading partner's export price indices. The data reveals that U.S. price com-

petitiveness eroded during this period as U.S. export prices outpaced world export prices by 7.3% between 1958 and 1969. According to demand theory, the higher the relative price ratio the less inclined foreigners are to purchase U.S. general cargo commodities.

Multiple regression analysis of the above variables employed both linear and log linear equations. The results are as follows:

(1) $Xusg = 12.84 + .489\ Yw \underset{(8.19)}{} - 26.38\ P \underset{(-.372)}{}$

$R^2 = .963$ D.W. = 1.38

(2) $\log Xusg = .414 + 1.37 \log Yw \underset{(7.43)}{} - .812 \log P \underset{(-.396)}{}$

$R^2 = .954$ D.W. = 1.44

where, Xusg = U.S. general cargo export tonnage
Yw = Real world income
P = U.S. export price/ world export price
R^2 = Adjusted Multiple Correlation Coefficient
D.W. = Durbin – Watson statistic
( ) = t statistic

These results are, as expected, statistically significant. The adjusted R^2, indicating goodness of fit, ranges from .954 to .963. All regression coefficients have the correct signs. According to the t-test, the world income variable exercises the major independent influence on the dependent variable. Relative prices, however, do not enter as expected in influencing general cargo trade flows. Further, auto-correlation is not a serious problem. Most important, the forecasting accuracy of each equation is very precise. This can be seen in Table 2 where the estimates for U.S. general cargo export volumes always lie within 10% of their actual value.

Imports

The mechanics of estimating the U.S. demand for general cargo imports is much the same as in the case for the export model. U.S. general cargo imports are influenced by U.S. income and the relative price of foreign products. Thus,

$$Musg = f\ (Yus, P)$$

where,
Musg = U.S. general cargo imports
Yus = U.S. income
P = Relative prices

Table 3 presents the time series data for each variable used in the import model.

U.S. general cargo imports are once again measured in terms of physical volume. During the 1958-1969 period, this nation's import volumes more than doubled. Real U.S. income, measured by constant dollar GNP, reflects the ability of the U.S. to buy foreign commodities. This variable, which is positively related to the level of imports, showed a compound annual rate of growth of 4.3% during the observed period. In addition, the second explanatory variable, relative prices, measures the price competitiveness between domestic products and foreign imports. The actual price index, the ratio of import prices to U.S. wholesale prices, is inversely related to import volumes. Over the 1958-1969 period, a gradual erosion in U.S. price competitiveness was witnessed as the

The Forecasting Accuracy of the United States General Cargo Export Equation
(thousands of long tons)

Year	Xusg: Actual	Xusg: Predicted	Residual	Percentage Difference
1958	21,092	21,253	— 161	.8
1959	23,343	24,958	—1,615	6.9
1960	30,789	27,690	3,098	10.0
1961	33,462	31,770	1,692	5.1
1962	31,050	33,554	—2,504	8.1
1963	35,730	36,058	— 328	.9
1964	41,971	38,793	3,178	7.6
1965	39,635	41,228	—1,594	4.0
1966	42,184	44,538	—2,354	5.6
1967	48,453	50,094	—1,641	3.4
1968	56,339	55,185	1,153	2.0
1969	62,277	61,200	1,077	1.7

TABLE 2

Data Used in Estimating the U.S. General Cargo Import Model

Year	Musg[1]	GNP[3]	Pmus[2] / Pdus
1958	24,102	$447.3	100.00
1959	29,669	475.9	98.10
1960	28,382	487.7	99.60
1961	27,332	497.2	98.23
1962	30,538	529.8	96.00
1963	32,765	551.0	96.60
1964	34,619	580.0	98.35
1965	40,509	614.4	95.47
1966	45,255	658.1	98.32
1967	46,405	675.2	96.90
1968	57,279	707.2	95.04
1969	53,245	727.1	94.71
		(billions $)	(1958 =100)

Sources: (1) Port Authority tabulation of U.S. Dept. of Commerce data.
(2) United Nations Statistical Office, "Statistical Yearbook," (New York: U.N. Publishing Services), 1971.
(3) U.S. Department of Commerce, Bureau of the Census, "Statistical Abstract of the United States," (Washington, D.C.: U.S. Government Printing Office), 1971.

TABLE 3

rate of inflation in the U.S. surpassed that of its overseas suppliers.

Regression results were generally good, and the test for forecasting accuracy was satisfactory. The following equations were used for analytical purposes:

(3) $Musg = -10.4 + 1.79\ Yus \quad (12.596) \quad - .074\ P \quad (-.577)$

$R^2 = .955 \quad D.W. = 1.67$

(4) $\log Musg = -.543 + 1.37 \log Yus \quad (11.26) \quad - .807 \log P \quad (-2.013)$

$R^2 = .962 \quad D.W. = 1.67$

where,

Musg	=	U.S. general cargo import tonnage
Yus	=	Real U.S. GNP
P	=	Ratio of import prices to domestic wholesale prices
R^2	=	Adjusted multiple correlation coefficient
D.W.	=	Durbin - Watson statistic
( )	=	t statistic

In sum, the explanatory power of all regression equations is very high, most variables are statistically significant and enter with the correct signs. The forecasting accuracy, as can be verified in Table 4, is excellent.

Forecast Methodology

Forecasting U.S. foreign trade volumes was based directly on the equations generated in the previous section. Simulation runs were made under various assumptions for the independent variables. High and low forecasts were generated by simulating a range of assumptions ranging from reasonably favorable to the U.S. to reasonably unfavorable to the U.S. These simulations form the basis for the projections made in Phase II and III. It should be noted that these simulations can be periodically updated to reflect changes in the foreign trade environment.

PHASE II
AN ANALYSIS OF NEW YORK'S SHARE OF UNITED STATES FOREIGN TRADE

Having isolated the factors which influence foreign trade activity at the national level, Phase II focuses on the specific variables which determine trade flows through a particular port.

The Forecasting Accuracy of the U.S. General Cargo Import Equation
(thousands of long tons)

Year	Musg: Actual	Musg: Predicted	Residual	Percentage Difference
1958	24,102	22,801	1,301	5.4
1959	29,669	26,186	3,483	11.7
1960	28,382	27,217	1,165	4.1
1961	27,332	28,588	—1,256	4.6
1962	30,538	32,628	—2,090	6.8
1963	32,765	34,740	—1,975	6.0
1964	34,619	37,380	—2,761	7.9
1965	40,509	41,028	— 519	1.3
1966	45,255	45,746	— 491	1.1
1967	46,405	47,928	—1,523	3.3
1968	57,279	51,828	5,451	9.5
1969	53,245	54,030	— 785	1.5

TABLE 4

This phase of the analysis represents a step into an area that was relatively unexplored, and almost totally devoid of econometric application. Once again, this section focuses on the technical methodology employed in the analyses.

There are two distinct sets of factors which influence the flow of foreign trade cargoes through a port. The most important are exogenous—regional, national and international in character—which provide the direction and magnitude of the long term competitive trends. Three major forces fall into this category:

1. The commodity composition of the port's foreign trade. A port's competitive position improves if a commodity or a group of commodities in which it specializes become relatively more active in foreign trade than other commodities. And conversely, a port's competitive position deteriorates when it fails to participate in handling the nation's major growth commodities. This variable is termed "the commodity effect."

2. The size and strength of the Port's hinterland as a source of exports and as a market for imports. A port's position is greatly enhanced when located in a dynamic hinterland that registers better than average gains in production and consumption. This variable is termed the "domestic base effect."

3. The geographical alignment of the nation's trading partners. An individual port achieves a distinct advantage if its location provides the shortest route to a rapidly growing foreign trading bloc. This variable is termed "the trading partner effect."

The secondary factors are those related to the ability of the port to perform its basic functions of transferring goods. Among these are inland rail rates; port terminal rates and charges; adequacy and physical condition of terminal facilities; frequency of sailings; field solicitation of trade; availability of forwarding, banking and consular services, etc. These factors, unlike the primary factors, can be influenced in varying degrees by the program and activities of port management.

Although the secondary factors do exert some indirect influence on the level of demand for port services, they have not been explicity incorporated into the model. The main reason for this is that only by measuring true demand unrestricted by any lack of supply can one forecast the future need for facilities and services. In this context then, the model incorporates the implicit assumption that port management working in a competitive environment, undertakes all programs necessary to service the port's flow of trade. It must also be noted that an analysis that does incorporate the secondary factors would seriously suffer from the lack of suitable data and the fact that many of the variables are not quantifiable.

The port's share analysis, therefore, proceeded to estimate the functional relationship between the three primary demand variables and New York's share of the nation's exports and imports.

Export Share

The basic quantitative relationships used in estimating New York's export share model is as follows:

$$\frac{Xnyg}{Xusg} = S\ (C, D, T)$$

where,

$\frac{Xnyg}{Xusg}$ = New York's share of U.S. general cargo exports
C = The commodity effect
D = The domestic market effect
T = The trading partner effect

Table 5 presents the annual observations of each variable used in estimating the model for the 1958 to 1969 period.

Data Used In Estimating New York's Export Share Model

Year	Xnyg[1] / Xusg	Xma[1] / Xusg	Xmh[2] / Xmus	IPe[3] / IPj
1958	.250	.080	.214	1.618
1959	.214	.068	.215	1.404
1960	.196	.059	.215	1.254
1961	.171	.055	.216	1.169
1962	.188	.061	.216	1.058
1963	.164	.054	.216	1.000
1964	.152	.051	.212	.927
1965	.144	.051	.208	.917
1966	.147	.049	.204	.845
1967	.127	.041	.196	.723
1968	.105	.035	.189	.662
1969	.091	.032	.181	.634

Sources: (1) Port Authority tabulation of U.S. Department of Commerce data (percent).
(2) U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports Series MA-161 (69), "Survey of the Origin of Exports of Manufacturing Establishments: 1969," (Washington, D.C.: Government Printing Office, 1970) (percent).
(3) United Nations, Statistical Office, "Statistical Yearbook," (New York: U.N. Publishing Services, 1971) (1963 = 1.00).

TABLE 5

New York's share of the nation's general cargo exports is once again defined in physical terms. The data reveals that the Port's competitive performance declined steadily over the ob-

served period from 25.0% in 1958 to 9.1% in 1969.

In the case of general cargo, the commodity effect, $\frac{Xma}{Xusg}$, is defined as the ratio of U.S. machinery and automobile exports to the nation's general cargo exports. Since the Port of New York is a strong performer in this important group, any meaningful decline in the ratio is detrimental to New York's share. Actual performance between 1958 and 1969 shows a gradual decline in this variable reflecting the gradual erosion in the comparative advantage of the U.S. in producing manufactured goods.

The domestic base effects, $\frac{Xmh}{Xmus}$, is defned as the ratio of the value of manufactured exports produced in the Mid-Atlantic states (New York, New Jersey and Pennsylvania) relative to the U.S. Clearly, the lower this ratio the lower the export potential of the Port's hinterland. Between 1958 and 1969 this variable registered a very minor decline.

The trading partner effect, $\frac{Ipe}{Ipj}$, is defined as the ratio of Western Europe's (EEC) industrial production to that of Japan. This variable captures the relative strength of the nation's two leading trading blocs, with the underlying assumption being that New York is in a better position to serve Europe than Japan. Therefore, any decline in the ratio is unfavorable to New York. This is indeed the reality of the situation which reflects the fact that Japan has been the most dynamic of the two over the observed period, causing a shift in the trade axis to the West Coast.

Multiple regression analysis was performed in order to estimate the coefficients of each independent variable. Following are the regression estimates, which were found to be statistically significant:

$$(5) \quad Snyg = -.035 + \underset{(4.011)}{2.312C} + \underset{(.572)}{.146D} + \underset{(1.91)}{.043\ T}$$

$$R^2 = .986 \qquad F = 229.7$$

where,

- Snyg = New York's share of U.S. general cargo export tonnage
- C = U.S. exports of machines & automobiles/ U.S. General Cargo Exports
- D = Hinterland's export production/U.S. export production
- T = EEC Industrial production/Japanese industrial production
- R^2 = Adjusted multiple correlation coefficient
- F = F value
- ( ) = t statistic

The explanatory power of the least squares fit is very high; the regression coefficient have signs which conform to theoretical expectations; and the forecasting accuracy of the equation is very precise as indicated in Table 6. It is interesting to note that the commodity effect has the highest level of statistical significance in the model followed by the trading partner effect.

The Forecasting Accuracy of New York's Share of U.S. General Cargo Export Equation
(per cent)

Year	Xnyg / Xusg: Actual	Xnyg / Xusg: Predicted	Residual	Percentage Difference
1958	.250	.252	—.002	0.8
1959	.214	.215	—.001	0.5
1960	.196	.188	.008	4.1
1961	.171	.175	—.004	2.3
1962	.188	.184	.004	2.1
1963	.164	.165	—.001	0.6
1964	.152	.154	—.002	1.3
1965	.144	.153	—.009	6.2
1966	.147	.145	.002	1.4
1967	.127	.120	.007	5.5
1968	.105	.105	—	—
1969	.091	.093	.002	2.2

TABLE 6

Import Share

New York's share of the nation's general cargo import tonnage declined from 28.6% to 18.4% from 1958 to 1969. The three controlling variables — C, D and T — were again utilized in estimating the equations that explain the observed change in the bi-state Port's import share. Although the theoretical rationale for each variable is the same, the variables are redefined when the reverse flow of trade is analyzed. Table 7 presents the time series data for the period under consideration.

Data Used In Estimating New York's Import Share Model

Year	Mnyg[1] Musg	Mmf[1] Musg	Yh[4] Yus	EJ[3] Eeec
1958	.286	.302	.227	.828
1959	.273	.364	.224	.812
1960	.271	.398	.221	.838
1961	.266	.357	.221	.859
1962	.265	.376	.218	.946
1963	.235	.446	.215	1.000
1964	.217	.434	.215	1.070
1965	.207	.426	.212	1.246
1966	.208	.439	.211	1.338
1967	.198	.453	.211	1.294
1968	.186	.504	.209	1.374
1969	.183	.502	.208	1.316

Sources: (1) Port Authority tabulation of U.S. Department of Commerce data (percent).

(2) U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports Series MA-161 (69), "Survey of the Origin of Exports of Manufacturing Establishments: 1969," (Washington, D.C.: Government Printing Office, 1970) (percent).

(3) United Nations, Statistical Office, "Statistical Yearbook," (New York: U.N. Publishing Services, 1971) (1963 = 1.00).

(4) U.S. Department of Commerce, Bureau of the Census, "Statistical Abstract of the United States," (Washington, D.C.: U.S. Government Printing Office, 1971) (percent).

TABLE 7

In the import submodel, the commodity effect, $\frac{Mmf}{Musg}$, was measured by the ratio of U.S. imports of manufactured goods to U.S. imports of general cargo. Since New York is more specialized in handling semi-processed general cargoes—coffee, sugar, lumber, etc.—than manufactured goods, an increase in this ratio would affect New York's share adversely. Between 1958 and 1969, this ratio rose from 30% to 50%. This reflects the fact that manufactured goods depend on income whereas non-manufactured depend mainly on population increases. In this period, income increased at a much faster rate than population.

The domestic base effect, $\frac{Yh}{Yus}$, which measures the strength of the hinterland's markets for consumption of foreign goods, is estimated by the ratio of total income in the Mid-Atlantic states to total U.S. income. This variable is positively related to New York's share, meaning that this share is expected to increase the higher the region's income relative to the nation's income as a whole. Between 1958 and 1969 the region's share of national income declined from 22.7% to 20.8%, as population continued to move away from the Port's hinterland.

The trading partner effect $\frac{Ej}{Eeec}$, is measured by the ratio of Japan's manufactured exports to the U.S. relative to Western Europe's manufactured exports to the U.S. Generally, the higher the ratio the smaller New York's share of the nation's import tonnage. Over the observed period Japan continuously outperformed Western Europe, causing a shift in the trade axis to the West Coast.

The multiple regression analysis produced the following result:

$$(6) \quad Snyg = .931 - .448C + 1.836\,D \quad (-3.16) \quad (.82) \quad -.108\,T \quad (-2.59)$$

$$\bar{R}^2 = .942 \qquad F = 99.5$$

where,

- Snyg = New York's share of U.S. general cargo import tonnage
- D = Income in Mid-Atlantic states/U.S. income
- T = Japan's exports of manufactures to U.S./Europe's exports of manufactures to U.S.
- C = U.S. imports of manufactures/U.S. general cargo imports
- $\bar{R}^2$ = Adjusted multiple correlation coefficient
- F = F value
- ( ) = t statistic

This equation, as verified by Table 8, was found to be significant and suitable for forecasting.

Forecast Methodology

The equations generated in the previous sections were tested for accuracy in forecasting of past trends, and generally produced superior results. Simulation runs were conducted using various assumptions about the future behavior of all three independent variables. High and low forecasts were ob-

The Forecasting Accuracy of New York's Share of the U.S. General Cargo Import Equation
(per cent)

Year	Mnyg Musg: Actual	Mnyg Musg: Predicted	Residual	% Difference
1958	.286	.288	—.002	.7
1959	.273	.270	.003	1.0
1960	.271	.263	.008	2.9
1961	.266	.269	—.003	1.1
1962	.265	.259	.006	2.3
1963	.235	.233	.002	.9
1964	.217	.234	—.017	7.8
1965	.207	.219	—.012	5.8
1966	.208	.205	.003	1.4
1967	.198	.198	—	—
1968	.186	.167	.019	10.2
1969	.183	.184	—.001	.5

TABLE 8

tained by simulating conditions that ranged from reasonably favorable to New York to reasonably unfavorable to New York. In contrast, time series projections of New York's share, conducted for comparison, were found to be totally meaningless as in some cases New York's share was driven to zero before the year 1990. Having obtained New York's share projections, tonnage forecasts for U.S. exports & imports were recalled from Phase I and provided the base to forecast New York's foreign trade tonnage.

PHASE III
ANALYSIS OF NEW YORK'S FOREIGN TRADE BY MODE OF TRANSPORTATION

This phase of the study deals with the allocation of New York's general cargo foreign trade tonnage between the air and ocean transportation modes. The prime objective of this phase is to derive long-term forecasts of export and import tonnages for each mode through the year 1990. The analysis employed in this chapter primarily focuses on the historical trend in the rate of air penetration (the air mode's tonnage share) and the economic forces that affect this rate. Table 9 presents the data used in the analysis which spans the 1958 to 1970 period.

The modal split approach to forecasting foreign trade tonnage is unique in that most analyses to date have generally utilized independent projections for each of the modes. The latter approach fails to recognize the strong interrelationship between the two modes so that competitive factors are neglected. As a result, the sum of the two independent projections frequently exceeds the true traffic potential that can be generated for the port.

For example, if New York's export tonnage were to be projected independently for each mode using a constant rate of growth derived from the average increases during the period 1962-1970, airborne volumes would actually surpass oceanborne volumes by 1990. Such results are totally unrealistic. The advantage of the modal split approach, therefore, lies in the fact that it creates a defined transportation environment, that cannot be exaggerated by the mathematics.

Methodology

The analytical approach to the modal split forecast of New York's foreign trade takes the view that the overall trend in export and import rates of air penetration can be statistically explained by the economic forces that shape the demand for services of the two modes. By selecting those variables which proved to have a significant explanatory relationship to the rate of air penetration in the past, it was possible to construct econometric equations suitable for forecasting purposes.

Time series data for the dependent variable, the rate of air penetration, roughly approximates the time span within which the air cargo industry became a viable competitor through the introduction of the commercial jet in overseas cargo operation. Rates of air penetration during the period increased exponentially, with the export rate rising more than 12-fold and the import rate more than 8-fold.

The primary reason for this take-off performance is attributable to the strong demand by shippers for a speedy, efficient and relatively damage-free transit of cargo. Significantly, however, not all shippers could enjoy the advantages offered by the air mode, mainly because the price disparity between air and ocean tariffs, although diminishing, remained extremely high. Generally, only those shippers whose commodities were of high value, whereby transportation charges constituted a small fraction of the total shipment value, could economically use the air mode. To some extent, perishable and other urgent shipments also took advantage of this mode, but the vast majority of the low-value commodities could regularly and feasibly rely only on the ocean mode.

This historical development indicates that two powerful factors influence the bi-modal demand for overseas transport. The first is shipment value, the second, price competitiveness between the modes. Although other factors such

Data Used In Estimating The Port of New York-New Jersey's Rate of Air Penetration For Export and Import General Cargo Shipments

Year	P: Export (percentiles)	P: Import (percentiles)	Export: Deflated VPP 1958 = 100	Import: Deflated VPP 1958 = 100	C
1958	.22	.16	.383	.262	100.0
1959	.34	.16	.396	.264	92.0
1960	.34	.20	.382	.271	81.2
1961	.40	.26	.406	.267	81.7
1962	.47	.26	.420	.272	68.4
1963	.60	.33	.427	.283	65.5
1964	.83	.41	.441	.309	58.8
1965	1.60	.60	.519	.320	52.5
1966	1.70	.61	.537	.344	48.3
1967	1.94	.72	.530	.341	46.8
1968	2.50	.90	.574	.354	44.0
1969	3.24	1.38	.592	.363	42.3

Sources: Port Authority tabulations of U.S. Department of Commerce data.

TABLE 9

as port accessibility, congestion and frequency of service, may have some influence on the rate of penetration, their impact is generally considered minor. Moreover, no reliable data base can be generated for these factors.

In mathematical terms, the rate of air penetration is expressed in the following functional form:

$$P = f(V, C)$$

where,

P = The rate of air penetration
V = The value per pound of exports or imports
C = The relative cost of shipping index

Table 9 presents the time series data used in estimating both the export and import models.

The first independent variable, V, the average value-per-pound of air shipments, is a broad indicator of the Port's commodity composition. The higher the value-per-pound, the more highly processed and technologically advanced are the commodities a Port handles. The upward movement in this variable over time exerts an upward push on the rate of air penetration since high value commodities can more easily absorb the higher cost of the air freight movement. Using constant 1958 dollars, the average VPP of an export shipment rose from 38¢ in 1958 to 58¢ in 1970, while imports' VPP rose from 26¢ to 37¢ over the same period.

The second independent variable, C, measures the relative price competitiveness between the air and the ocean modes. It is defined as the ratio of revenue-per-ton-mile of the air mode to that of the ocean mode. This index is fairly representative of the actual trends in average tariff rates of the two modes, and closely reflects the average transport costs incurred by the shipper. Since the air mode is represented in the numerator of the index, this variable is inversely related to the rate of air penetration. In simpler terms, this would mean that the rate of air penetration increases as the relative cost of shipping by air decreases.

Historical data for this variable covering the 1958-70 period show that although the absolute costs of shipping by air remains much higher than that of the ocean mode, the relative cost of shipping by air was cut by more than half as compared to shipping by vessel during the observed period. The actual index stood at 43.3 in 1970 as compared to the 1958 base of 100.

An interesting feature of this unique index is the fact that its declining trend is not characterized by a constant rate, but rather by a diminishing rate. This means that the air mode continually gained a competitive edge over the ocean mode, but this edge has gradually shrunk in magnitude.

Multiple regression analysis in the logarithmic form was utilized in estimating the relationship between the rate of air penetration and the two independent variables. Following are the export and import equations derived for forecasting purposes:

Exports

$$(7)\quad \text{Log } P = 7.7569 + \underset{(5.8147)}{3.1704}\ \text{Log } V$$

$$- 1.329 \text{ Log } C$$
$$(-4.3926)$$
$$R^2 = .992 \quad F=692 \quad D.W.=2.19$$

Imports

$$(8) \quad \text{Log } P = 7.0736 + 3.6559 \text{ Log } V_1$$
$$(2.9451)$$
$$- .8708 \text{ Log } C$$
$$(-1.6201)$$
$$R^2 = .968 \quad F=156 \quad D.W.=1.76$$

where,

P = Rate of air penetration
V = Deflated value-per-pound (exports)
V_1 = Deflated value-per-pound (imports)
C = Relative cost of shipping index (Air RPTM/Ocean RPTM)
R^2 = Multiple correlation coefficient
F = F value
D.W. = Durbin-Watson statistic
( ) = t statistic

For both exports and imports the results were highly significant. Variables V and C were found to have an important role in shaping the level of air penetration.

Forecast Methodology

Simulation techniques were utilized in forecasting the independent variables by applying various assumptions about their future trends. The forecasts of air penetration rates were finally made under the most realistic assumptions that past trends in the V and C variables will generally persist through 1990. These rates were then applied to the general cargo forecasts derived in Phase II to generate the tonnages moving by the ocean and air mode of transportation.

Conclusion

The in-depth analysis of the past patterns of foreign trade developed in this econometric model sheds new light on the primary forces that are changing the complexion of this nation's trade flows. These forces, which bear direct significance on the future role of U.S. ports, may be summarized as follows: 1. The shift in the relative importance of the nation's trading partners with the Far East assuming a greater role vis-a-vis Europe; 2. The shift in the geographic concentration of production and consumption from the eastern United States to the West and South; 3. The change in the export and import commodity composition of this nation's general cargo foreign trade; and 4. The rapid growth in the air cargo industry and its ability to achieve significant penetration into oceanborne cargo.

One of the most important contributions of this model is that it captures the essence of the evolutionary economic and demographic forces that are influencing the flow of foreign trade cargoes through the nation's ports. By respecifying the explanatory variables to fit the particular economic realities of various U.S. ports, this model is sufficiently operational and flexible to explain and be used as a forecasting tool of the competitive performance of any U.S. port district. As such, it provides a new rational basis for planning investments in port facilities.