Abridgment
Projecting Commodity Movements for Inland Waterways Port Development

Charles O. Branyan and George D. Mickle, Memphis State University

The inland waterways are receiving greater interest as an energy-efficient, low-cost mode of transportation in a national economy of future energy shortages. As these advantages come to bear on the decision of both shippers and transportation planners, water transportation will likely assume a greater role in the total transportation infrastructure.

Water transportation along the inland waterways has shown significant increases over the past years. As an example, internal domestic waterborne commerce for the United States increased from a total of 173.1 million Mg (190.8 million tons) in 1950 to 361.6 million Mg (398.6 million tons) in 1967 and to 475.4 million Mg (524.0 million tons) in 1976. This represents a 174.6 percent increase between 1950 and 1976 and a 31.5 percent increase between 1967 and 1976.

To accommodate such increases, inland waterway ports are faced with the necessity of planning for port development. Any such planning must consider future commodity movements. This study is one such effort to project such commodity movements for the specific port of Louisville, Kentucky.

THE PROBLEM

In order to plan for port development, it is necessary to project commodity movements for the future. This study was specifically designed to project such commodity movements to the year 2030, starting with a projection for 1985 and projecting tonnages each 5 years thereafter until the year 2000 and each 10 years thereafter (a total of eight projection periods). It was desired to make such projections by major commodity groups as well as for total tonnage estimates.

PRELIMINARY ANALYSIS

The investigators decided to use both time series and regression analysis in attempting to project commodity tonnages. Use of these two approaches required the collection of both historical data pertaining to commodity movements and historical and projected data for any factors that could be considered to be possibly related to commodity movements.

The first step was to identify and define the commodity groups that would be used in the projection process. The framework used in this classification was based on the Commodity Classification for Shipping Statistics of the U.S. Army Corps of Engineers (1). Six commodity groups were selected for both incoming and outgoing waterborne commerce moving through the Port of Louisville facilities. These include (a) coal and lignite; (b) crude petroleum; (c) gas, jet fuel, and kerosene; (d) fuel oils; (e) aggregates; and (f) general cargo.

Collection of historical data followed. U.S. Army Corps of Engineers data were obtained for the period 1950 through 1976 (1). Before 1949, the Corps did not compile data on waterborne commerce on an individual principal port basis. The year 1950 rather than the year 1949 was chosen to allow for the resolution of any possible first-time reporting discrepancy in port statistics for 1949. Selection of these years as the historical base provided 27 years of data.

An analysis of Louisville commodity totals indicated that barge shipments of crude petroleum were lost to pipelines in 1974. Coal and lignite shipments were either nonexistent or of minimal value be-

fore 1965. Therefore, shipments of crude petroleum were not considered further. Since the base of historical data for shipments of coal and lignite did not include a sufficient number of years where data were available for the dependent variable, only a time series equation was computed for this commodity group.

The next step in the preliminary analysis was to identify a set of independent variables that could logically have some relation to commodity movements through the Port of Louisville. In selecting these independent variables, it was necessary to consider whether a reliable forecast value of any variable selected would be available for the term of the projections desired. Variables were desired that would include such economic indicators as population, employment, and income. Independent variable data were obtained from Bureau of Economic Analysis (BEA) projections of regional economic activity for the United States, the state of Kentucky, and the Louisville-Indiana Standard Metropolitan Statistical Area (SMSA). These data were compiled from two reports. The first BEA report was published in 1972 for the U.S. Water Resources Council. The second publication (2) was prepared by BEA under contract with the Tennessee Valley Authority (TVA). On the recommendation of BEA representatives, the TVA statistics were chosen over the earlier figures. In some instances, a series of area statistics appearing in the 1972 report were not duplicated in the latter report. In these cases, the earlier reported series was used. Since the latter publication is, in effect, a disaggregation of the 1972 BEA regional report where the majority of the national figures remained the same in both publications, it was believed that no serious bias would be injected into the data. Projected data for the years 1995, 2010, and 2030 were missing. At the suggestion of BEA staff members, the missing values were interpolated on the assumption of exponential growth.

A total of some 14 such series of data were identified. Six of the variables dealt with income variables, five with population variables, and three with employment variables, as given below:

Variable	Area
Total personal income	United States
	Kentucky
	Louisville-Indiana SMSA
Per capita income	United States
	Kentucky
	Louisville-Indiana SMSA
Population	United States
	Kentucky
	Louisville-Indiana SMSA
	Kentucky portion of Louisville-Indiana SMSA
	Jefferson County
Total employment	United States
	Kentucky
	Louisville-Indiana SMSA

In addition, two more variables were added: time and gross national product (GNP).

DETAILED ANALYSIS

The first step in the detailed analysis was to compute a series of time series equations based on the 27 years of historical data available for the 12

commodity classes selected for analysis. Four equations were computed: a straight line; a second degree curve; an exponential curve; and a second-degree exponential curve.

Based on the equations, forecast values were computed for each of the 12 classes, a total of four sets of projected values for each commodity group. As expected, some of the equations were obviously inappropriate for forecasting to the year 2030 and were discarded. Of the 52 sets of forecast values, 31 were retained for further evaluation.

The next step in the analysis was to consider a series of multiple and simple regressions. Historical data for the selected independent variables were available only for the years 1950 and 1960 through 1976, a total of 18 years. Three groups, previously mentioned, were not considered in the multiple regression analysis, which left 12 groups to be considered. The BMD stepwise regression computer program was used in the analysis.

An initial run was made for all 15 selected independent variables. Values of the multiple coefficient of determination (R^2) ranged from a low of 0.5916 for total local movements to a high of 0.9918 for receipts, gas, jet fuel, and kerosene, with six having values of 0.95 or higher, three with values between 0.90 and 0.95, and only three less than 0.90.

The independent variables exhibited a high degree of multicollinearity. The lowest value of a simple coefficient of correlation between independent variables was 0.796. The highest was 1.0. Of the 105 possible simple coefficients of correlation, 31 had values equal to or greater than 0.99, 20 had values between 0.98 and 0.99, 27 had values between 0.95 and 0.98, 15 had values between 0.90 and 0.95, and only 12 had values less than 0.90. The existence of such multicollinearity casts doubt on the reliability of the individual regression coefficients. In this run, of the total of 106 regression coefficients, 64 or 60.38 percent were considered to be not statistically significant because of the high values of the standard errors as compared with the values of the regression coefficients.

The next step was to structure the regression equations in such a manner as to diminish the effects of multicollinearity as much as possible. This step resulted in five separate computer runs in addition to the initial run. Computer runs 1 through 3 are multivariable equations, and runs 4 and 5 are essentially simple regressions. GNP is the independent variable in run 4; the independent variable in run 5 depended on the initial computer selection of the one variable to be entered into regression.

Computer run 1 was made by using only three independent variables, one each from the variable groups of income, population, and employment. The three variables used were selected on the basis of least simple correlation to each of the other two variables. Variables selected were total personal income in the Louisville-Indiana SMSA, population of Jefferson County, and total employment in Kentucky.

Computer run 2 used selected independent variables from the initial run. In an attempt to restrict the inclusion of highly intercorrelated variables, the F-level test of significance for inclusion was set at a more restrictive 0.5 as compared with the level of 0.01 for the initial computer run. This resulted in the selection of seven independent variables. These independent variables were again used in computing regression equations for each of the 12 commodity groups.

Run 3 was essentially a modification of run 2. In this run, a maximum of three independent variables was included in the regression equations. The stepwise program was allowed to continue to the maximum of three variables only if the next selected independent variable was from a group (income, population, or employment) not already included. This meant that equations might have only one or two independent variables.

Run 4 was a simple regression that used only GNP as the independent variable. This run generally resulted in higher values of R^2 for the receipts groups than for the shipments group of commodity classification.

Run 5 used the results of the initial computer run and all 15 independent variables but stopped after the first step. In essence, this was a simple regression that used as the independent variable only the first variable entered into the program for each commodity group.

Forecast values were then computed for each commodity group by using the equations computed in each computer run. This resulted in several sets of forecast values for each commodity group. Between 7 and 10 sets of forecast values were obtained for the various commodity groups including the time series equations retained for further evaluation and the regression equations. The range of forecast values for the earlier years is not excessive since, for example, forecast values for receipts of gas, jet fuel, and kerosene for 1980 range from a low of 3.033708 to a high of 3.69907, a range of 0.665362. This represents a variation of 9.9 percent maximum from the midpoint of the extreme values. However, for the year 2030, the same relative variation is 31.7 percent. These results are not surprising since we are trying to forecast values for 55 years ahead based on a data set of only 18 observations. The range of values of total megagrams for a few selected periods is given below:

Range	1980	1990	2000	2030
High	11.916 82	16.798 74	23.650 15	54.953 98
Low	4.667 64	9.390 39	10.690 73	13.243 92

Up to this point the analysis had been a computational approach relying on mathematical methods to obtain forecast values. Beyond this point, nonmathematical procedures based on the knowledge and judgment of the analyst are necessary inputs.

In this stage of the analysis, such factors as the values of R^2 and the standard error of the estimate, the proportion of Louisville tonnage to national tonnage, the proportion of each commodity group to the total Louisville tonnage, and other forecasts available on a national basis were considered. Based on this analysis, a forecast equation was selected for each receipt category, for each shipment category, and for local movements. These values were aggregated to predict total receipts, total shipments, and total tonnage. The projections selected are given in Table 1.

The projections presented are made on the basic assumption that the economic activities experienced by the Louisville area between 1950 and 1976 will continue into the future. Of course, any projections made into the future for a period of 55 years are subject to extensive revisions as such economic activities may change. Therefore, in using the projected values, a relatively high degree of confidence can be placed in the projected values for the early years, but forecasts for the latter years of the projection should be viewed with caution.

CONCLUSION

The methods used in this analysis are not new or exotic. The investigators made no attempt to force a set of data into any preconceived model for analysis. Rather, the procedures used have ensured an

Table 1. Projected waterborne commerce at the Port of Louisville between 1980 and 2030.

Commodity Group	Megagrams (000 000s)							
	1980	1985	1990	1995	2000	2010	2020	2030
Total receipts	8.766 37	11.535 99	13.124 39	15.316 25	17.278 37	22.503 28	29.873 89	39.019 26
Coal and lignite	1.561 02	2.193 26	2.560 73	3.300 19	4.249 78	6.553 63	10.290 95	15.421 67
Gas, jet fuel, and kerosene	3.272 26	4.013 07	4.278 91	4.753 89	5.212 92	6.341 30	6.378 89	6.394 28
Fuel oil	0.778 64	1.042 56	1.358 12	1.725 32	2.144 16	3.136 75	4.335 89	5.741 58
Aggregates	1.505 82	1.996 95	2.219 68	2.361 69	2.200 13	2.265 44	3.475 35	4.747 41
General cargo	1.648 63	2.290 15	2.686 95	3.175 16	3.471 38	4.206 16	5.392 81	6.714 32
Total shipments	1.125 05	1.407 93	1.694 62	1.983 77	2.274 41	2.857 76	3.442 06	4.029 98
Coal and lignite	0.706 20	0.976 11	1.246 04	1.515 95	1.785 87	2.325 71	2.865 54	3.405 38
Gas, jet fuel, and kerosene	0.021 07	0.011 70	0.006 13	0.003 03	0.001 42	0.000 25	0.000 04	0
Fuel oil	0.081 45	0.072 97	0.064 47	0.055 98	0.047 49	0.030 51	0.013 54	0
General cargo	0.316 33	0.347 15	0.377 98	0.408 81	0.439 63	0.501 29	0.562 94	0.624 60
Total local movements	0.095 01	0.101 75	0.110 65	0.121 69	0.134 89	0.167 74	0.209 20	0.259 25
Total	9.986 43	13.045 67	14.929 66	17.421 71	19.687 67	25.528 78	33.525 15	43.308 49

Note: 1 Mg = 1.1 tons.

orderly collection and analysis of the factors considered relevant to the study as limited by the availability of projected values for the selected factors. It is believed that these study methods could be applicable to other, similar studies that may be undertaken in the future.

REFERENCES

1. Waterborne Commerce of the United States: Part 2--Waterways and Harbors, Gulf Coast, Mississippi River System and Antilles. U.S. Army Corps of Engineers, 1950-1976.
2. Projections of Economic Activity in Kentucky: Series E--Population. Bureau of Economic Analysis and Tennessee Valley Authority, Dec. 1975.

Abridgment
Statewide Waterborne Commerce and Port Development Planning

Rodger P. Kester, Missouri Department of Transportation

The majority of our country, both in geographic territory and population, is accessible via its inland, coastal, and Great Lakes waterway system. Yet the approaches to port development of the states possessing elements of this vast transportation system vary from benign neglect to extensive funding, construction, and operation of ports and port facilities. This paper briefly describes Missouri's approach.

The state of Missouri is strategically located on the nation's 40 322 km (25 000 miles) of navigable waterways. The Mississippi River system comprises almost 14 516 km (9000 miles) of this total, with over 1613 km (1000 miles) being either within or bordering on the state of Missouri. Missouri's waterway system is complemented by good highway and rail networks covering the state. On this waterway system, Missouri possesses in St. Louis the largest inland waterways port in annual tonnage. Yet, even possessing this complete transportation system and large

port, most port development has just happened in Missouri instead of being created.

Missouri's involvement in port development began with the new Missouri Department of Transportation (DOT), created in July 1974 as one of the 14 state departments under reorganization. Within the state DOT, the plan of organization is based on modal divisions, including the Division of Waterways. In addition to the constitutional and legislative powers of the department, the division is responsible for the administration of Missouri's port legislation concerning the creation of port authorities.

Under this legislation, cities and counties situated on or adjacent to or embracing within their boundaries a navigable waterway are authorized to create port authorities. On approval by the Missouri Transportation Commission, these port authorities become political subdivisions of the state and possess the powers granted by these statutes. Additionally,