



**US Army Corps  
of Engineers**  
Engineer Institute for  
Water Resources

---

# **Literature Survey of Induced Traffic Due to Transport Cost Savings**

June 1985

**Working Paper 85-WP-1**

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 85-WP-1	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Literature Survey of Induced Traffic Due to Transport Cost Savings		5. TYPE OF REPORT & PERIOD COVERED Working Paper
		6. PERFORMING ORG. REPORT NUMBER 85-WP-1
7. AUTHOR(s) Patricia Malone Dr. L. Goerge Antle		8. CONTRACT OR GRANT NUMBER(s)
		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
9. PERFORMING ORGANIZATION NAME AND ADDRESS Water Resources Support Center Institute for Water Resources-Navigation Division Casey Building, Ft. Belvoir, VA 22060-5586		12. REPORT DATE June 1985
11. CONTROLLING OFFICE NAME AND ADDRESS Water Resources Support Center Institute for Water Resources-Navigation Division Casey Building, Ft. Belvoir, VA 22060-5586		13. NUMBER OF PAGES 30
		15. SECURITY CLASS. (of this report) Unclassified
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
		16. DISTRIBUTION STATEMENT (of this Report) Unlimited
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Induced traffic, benefit-cost analysis, discriminant analysis, optimization		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The purpose of this paper is to review the literature that is currently available on induced movement benefit. The reviewer focused on coal and grain trade. A wide range of sources were consulted and read in order to find any research that had been done on induced movement benefit. Findings are summarized, and future research topics on feasible models were identified.		

LITERATURE SURVEY OF INDUCED  
TRAFFIC DUE TO TRANSPORT COST SAVINGS

Navigation Division  
Institute for Water Resources

June 1985

Working Paper 85-WP-1

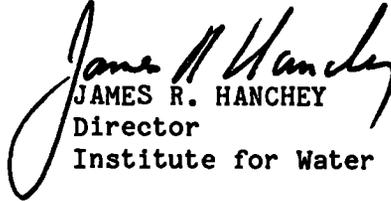
LITERATURE SURVEY OF INDUCED TRAFFIC  
DUE TO TRANSPORT COST SAVINGS

TABLE OF CONTENTS

	PAGE
I. PREFACE .....	iii
II. INTRODUCTION .....	1
III. LITERATURE REVIEW FINDINGS .....	1
IV. FUTURE INDUCED BENEFIT MEASURES .....	5
V. CONCLUSIONS .....	7
VI. REFERENCES .....	9
VII. APPENDIX A .....	11

## PREFACE

This report was prepared by Patricia Malone, an economist and research assistant on the IWR Navigation Division Staff. Other professional economists of the IWR Navigation Division added to and edited the results so the report is a corporate responsibility. We believe that the potential for developing projection procedures to estimate induced traffic exists. The major issue is whether enough credible induced traffic benefits can be generated to warrant the costs of developing this analysis. Without prejudging the outcome, additional work appears to be warranted.

  
JAMES R. HANCHEY  
Director  
Institute for Water Resources

## INTRODUCTION

The purpose of this paper is to review the literature that is currently available on induced movement benefit. The reviewer focused on coal and grain trade. A wide range of sources were consulted and read in order to find any research that had been done on induced movement benefit. Findings are summarized, and future research topics on feasible models were identified.

Induced (or new) movement benefit is defined by the 1983, "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" as the increase in producer and consumer surplus. It results from new traffic that is due to reductions in transport costs that permit a commodity to be produced and shipped if a port or channel is deepened. The underlying assumption is that the transport demand function shifts outward as a result of increased consumption or of increased production (Antle, 1979). The Corps is required to measure new movement benefits when they are doing a cost-benefit analysis of a proposed project. It is also, however, one of the least documented benefits.

Although induced movement benefit has proven difficult to measure, it can be an important benefit of navigation improvements. A producer will respond to a price change. If the cost of transporting his or her product has been reduced, the producer will increase production, consumers will increase consumption, and transporters will ship the increase in trade. The effects, however, will be a function of demand elasticities. The more elastic the demand, the greater the induced movement benefits of a navigation project. Thus, induced movement traffic can be a major benefit of a project, and it should be included in a navigation cost-benefit analysis if the effects are great enough.

## LITERATURE REVIEW FINDINGS

Many navigation cost-benefit analyses have been conducted. Few of these analyses have included a measurement of induced movement benefit. In the typical analysis of port-deepening benefits, it is believed that the majority of benefits are transportation savings associated with the use of deep-draft colliers. Induced movement benefits are ignored because they are assumed to be negligible. This may or may not be a logical assumption, but nevertheless, new movement benefits have rarely been included in a cost-benefit analysis.

There have been a few exceptions to this general rule, however. One of these exceptions is the "Deep River Study Lower Mississippi River" that was conducted by Booz, Allen, and Hamilton, Inc. with the aid of Pyburn and Odom, Inc. for the Governor's Task Force on Deep Draft Vessel Access the Lower Mississippi. The port of New Orleans has been the subject of channel-deepening proposals for many years. It is a major through-port for grains and Southern Appalachian coal. Interested groups have felt that the port of New Orleans could capture a greater share of the coal and grain export trade if the present channel depths of 40 ft were deepened to 55 or 60 ft. The increased channel depth would allow the lower Mississippi River to accommodate deep-draft vessels of 100,000 dwt or more (Booz, etc.).

The Governor's Task Force hired Booz, Allen, and Hamilton to assess the feasibility of deepening the lower Mississippi River channels. Booz, Allen, and Hamilton conducted engineering, economic, environmental, and financial studies. Included in the economic study was an analysis of the induced traffic in coal and grains. To determine the induced traffic benefits for grain, a weighted average of the export grain elasticities for wheat, corn, and soybeans was developed from data of the USDA Extension Service at Purdue University. The decline in ocean freight rates and in the average delivered price of U.S. grains was calculated. These figures were used to determine the percent change in the induced grain tonnage. Results indicated that induced grain tonnage benefits were negligible and were excluded from the study.

The percent change in induced coal tonnage was determined differently. The researchers were unable to identify a U.S. steam coal price elasticity source after conducting a thorough literature review. As an alternative to using price elasticities, the researchers used two facts about the U.S. coal export market to develop a linear extrapolation. An average price of \$9.00 to \$10.00 per ton more for U.S. steam coal over other world suppliers and a constant 25% share of the world export coal market suggests a generally inelastic market (Booz, et al.). To develop the linear extrapolation, the researchers established a maximum U.S. market share of 50% (due to non-price factors) at a price of \$38.50 per ton for U.S. steam coal. A minimum market share of 25% at the current U.S. steam coal price of \$54/ton was established as the second end point (Booz, et al.). The researchers then did a linear extrapolation between these two endpoints; the resulting relationship was used to estimate the potential induced coal tonnage levels. Using this approach, the researchers estimated that channel deepening could induce coal exports, and the total export tonnage would increase by 10% to 22% (Booz, et al.).

Although the researchers did obtain an estimate of the induced coal tonnage, the method used was "quick and dirty." There are several criticisms of the method. First, as even the researchers pointed out, steam coal demand is not just a function of market conditions. Among the non-economic factors that influence coal importers are the following:

- 1) the perception of the U.S. as a cooperative trading partner;
- 2) the security and reliability of the U.S. coal supply;
- 3) the prime position of the U.S.' vast coal resources.

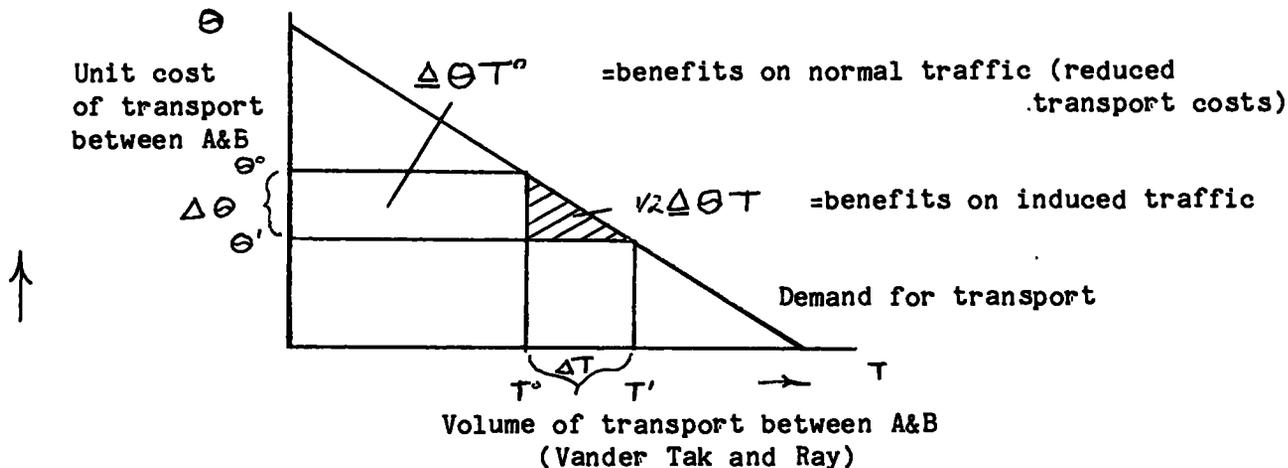
These factors will affect the extrapolation's upper and lower bound.

Second, coal demand is derived. It is a function of coal use in other industries such as steel, electrical generation, and cement. The market for these goods will affect coal use and, ultimately, coal demand. It is not theoretically correct to assume that coal demand is simply a function of coal price and quantities. Any estimate of induced coal export tonnage should deal with the derived coal demand and its resulting elasticities.

Herman G. Vander Tak and Anandarup Ray deal theoretically with benefit measurement of road transportation projects in a paper entitled "The Economic

Benefits of Road Transportation Projects." The authors' goal was not to generate actual benefit measurements; rather, their purpose was to show how these benefits relate to changes in supply and demand for transported commodities. This expository paper provides an analytical framework for benefit measurement. A key idea dealt with in the paper was induced benefits.

Figure 1, the transport demand function, illustrates two kinds of transportation project benefits.



The first, indicated by  $\Delta\theta T^0$ , are the transport savings that accrue to normal traffic with a price change. It is the sum of the consumer's cost savings and the producers' increased profits. The triangle,  $1/2\Delta\theta T^0$ , is a measure of induced traffic benefits; it is the sum of A's consumer surplus and B's producer surplus. This theoretical measure of induced benefits does not, at first, appear to agree with the Army Corps of Engineers' definition of new movement benefits. However, if the demand curve represents total transportation demand rather than waterway transportation demand, it becomes valid. The Corps uses a demand curve for waterway transportation that defines the triangular area ( $1/2\Delta\theta T$ ) as traffic diverted from another mode.

Transport demand, in this model, is not a direct demand measure. The authors derived the transport demand curve from the volume of trade between the points A and B. The demand curve is actually the locus of different equilibrium trade volumes; it is a scalar transformation with mileage held constant. This demand curve reflects the supply and demand conditions in regions A and B.

Therefore, the transport demand curve's slope and elasticity depend upon specific commodity demand and supply functions in the two regions. It follows that transportation improvements lead to lower transport costs, production and consumption changes, and more trade and transport between A and B. Part of the increase in trade will be induced movement as producers and consumers respond to a transport price change. Induced movement benefits are relatively more important to a transportation project cost-benefit analysis the larger the percentage decrease in transport costs and the more elastic the transport demand.

The authors conclude that the social surplus measure (producer plus consumer surplus) is intuitively simple to measure. Unfortunately, it is difficult to apply in a real situation. Gains and losses associated with a transport project have to be weighed, and the benefit measure estimation requires knowledge of the factors that affect supply and demand for the transport mode and its services. Thus, induced benefits can be measured, but it is a difficult task requiring both caution and ingenuity.

## FUTURE INDUCED BENEFIT MEASURES

The literature review revealed few examples of attempts to actually measure induced movement benefits. In the majority of navigation project cost-benefit analyses, new movement benefits are rarely considered. The one study (Booz, et al.) that did attempt to calculate new movement benefits in this review was theoretically shaky. The "Principles and Guidelines" state, however, that induced movement benefits are to be measured when conducting deep- and shallow-draft navigation cost-benefit analyses.

The question, then, is how are we to develop a theoretically sound, relatively simple method of measuring these benefits? In this section of the paper, research directions in derived demand will be reviewed in an attempt to answer this question.

Whenever we deal with transportation demand, we must estimate derived demand curves for various transportation modes. Transportation is an input into a final good, such as steel or electricity, and it is the demand for the final good that determines input demand. Discriminant analysis is one method used to estimate a derived demand curve. The study, "An Application of Discriminant Analysis to the Division of Traffic Between Transport Modes", by Lloyd G. Antle and Richard W. Haynes is an operational application of discriminant analysis to transportation modes. Antle later estimated demand curves for waterway traffic on the Ohio and Arkansas rivers (1979). The procedure was advocated in the substantial research project conducted at Northwestern University in 1970.

Discriminant analysis statistically weighs transportation characteristics to determine their influence on choice of mode. The first step is developing a function by dividing normally distributed mode populations into groups that minimize classification errors. This function reflects the defining characteristics of each mode. Using the function, the next step is to estimate transportation demand for each mode by holding all characteristics, except rate, constant and iterating through rate increases until traffic drops to zero (Antle). The demand curve could then be used to calculate demand elasticity measures for a given transportation mode.

The empirical studies by Antle showed that demand for waterway transport was generally price inelastic to a substantial degree, except where unit trains could operate easily. Existing work has focused on tracing the demand schedule above current barge rates, although estimates of induced benefits could be generated by simulating downward adjustments in barge rates. However, the case of new transport users does not necessarily follow since existing users are the base.

Another method was developed by Lenze and Goodman to measure export coal demand elasticities. The thrust of the paper was determining the importance of supplier diversification and deriving transportation service demand. Using economic theory to establish the relationships in coal export demand, the authors developed a matrix algebra model.

To estimate coal export demand for U.S. coal, the authors considered the identity that the exports (X) of a country are equal to total demand over (i) buyers in its export market minus the amount of demand met by other suppliers (j).

$$X = \sum_i D_i - \sum_j S_j \quad (1) \text{ (Lenze and Goodman)}$$

Differentiating this equation with respect to the U.S. coal price yields demand and supply elasticities. Finally, the authors ran regression analyses of their theoretical models.

The authors' results indicated a price-responsive long-run demand for coal and a very moderately elastic demand for port services. The implication of these elasticity measures is that port improvements have the potential to generate sufficient extra coal demand to make some improvements worthwhile.

Several user models have been developed by the Corps in an attempt to measure project benefits. The Ohio River Division Model (ORD) and the General Equilibrium Model (GEM) are optimization models using linear and non-linear techniques to arrive at waterway equilibrium optimal use solutions. They do not, however, provide an explicit measure of new movement benefits.

The Multi-Regional Multi-Industry Model (MRMI) and the Multi-Regional Variable Input/Output Model (MVIO) are user models developed for the Corps that incorporate modified input-output analysis. These models evaluate regional and national development impacts of various waterway related activities (Liew and Liew). Among these activities is the transportation cost savings. A study of transportation cost savings between barges and the next best alternative needs to be conducted. The savings are divided by shipment values on each trading route, and a percentage of transportation cost savings is computed. This percentage enters the models to evaluate regional and national development impact of the waterway (Liew and Liew). Thus, these models do not measure new movement benefits, but they can evaluate a waterway's impact if such a measure were to be provided.

One could use economic development impact models to generate an estimate of induced economic development due to lowered transport costs. The family of models developed at IWR all offer a procedure based on economic production and consumption by sector and by region to generate impact estimates due to transportation costs reductions. While induced traffic has not been studied thoroughly via these models, it was traced in studies of the Coosa River Waterway. Potential induced traffic was found to be rather modest in that case, since the demand curves of the water competitive traffic is not substantially price elastic (aggregates for instance), although modal diversion potential is relatively substantial. Further exploration is warranted before any substantial conclusions can be reached.

## CONCLUSIONS

Very little research has been conducted on induced movement benefit measures. Most cost-benefit analyses have not dealt with it in even the most cursory manner. However, there is theoretical work that indicates that new movement benefits could be quite significant. Why is there a seeming reluctance to deal with new movement benefits? Part of the reason is theoretical in nature. Coal and transport demands are derived demands. This poses problems in developing a simple, workable method of measuring induced movement benefits. A second reason is the continuing debate about the significance of induced movement benefits. Some economists hold out that the benefits are insignificant. Other economists feel that new movement benefits are an important part of a cost-benefit analysis. The truth probably lies between these two extremes.

One of the reasons that induced movements have not been claimed in many deep port studies is the unusual setting of the world coal and grain markets. The U.S. holds a substantial share of these world markets with a price considerably higher than production and shipping costs of competing countries. This U.S. share would not exist if the market is dependent solely on offered price. Political stability, a dominant currency, and ample supplies guarantee the U.S. share. The induced benefits issue is how much more can the U.S. sell if we could reduce costs (in our case, transport costs). Because of the U.S. market strength, competing nations extract economic rent from the market, by selling coal and wheat at prices substantially above their cost of products, but only slightly lower than the U.S. price. One argument is that they would follow U.S. cost reductions by exactly the same policy pursued now, reduce prices and rent but maintain the same relative equilibrium. In this case, the U.S. share may not change, but total world consumption of coal and grain would increase to the degree that total demand is price elastic. Given this case and the available evidence, fairly small quantities of added U.S. sales would result. This conclusion would change dramatically if total U.S. costs (products, land haul/water haul) could be decreased before competing nations, so that the U.S. share could be increased. To date, most studies have followed the logic advanced above and have not claimed induced traffic benefits.

The countering argument to this logic is that it accepts, analytically, a policy which reflects at least some degree of monopoly pricing. A more aggressive policy stance which deliberately pursues vigorous price competition is more in keeping with the rhetoric of the U.S. free trade, vigorous competition model. If we follow this argument, then the analysis follows a belief that cost and price reduction is the heart of development of strong markets; therefore, an estimate of induced traffic would be vigorously sought.

If we accept the proposition that new movement benefits are significant, how can we measure them? It is possible. Ultimately, what we need is the export demand elasticity of coal or the demand elasticity of the transportation mode. The discriminant analysis model, economic development models, and Lenze and Goodman's matrix algebra model described earlier are possible approaches. Other methods exist as well, and they could be used to develop a method of measuring new movement benefits.

In conclusion, induced movement benefits can be measured. There are several theoretical approaches that can be used to develop measurement techniques. We must, however, ask ourselves the following question; will our measurement method be simple and economic to use? In choosing to develop new movement benefit techniques, we must decide if the advantages of developing new methods will outweigh the disadvantages. Information has a cost, and we must consider the expense associated with attaining it. That is, after all, what any economic analysis asks us to consider.

## REFERENCES

- Antle, Lloyd G. and Richard W. Haynes. "An Application of Discriminant Analysis to the Division of Traffic Between Transport Modes," prepared for the Institute for Water Resources, May 1971.
- Antle, Lloyd G. "The Demand for Water Transportation Application of Discriminant Analysis to Commodities Shipped by Barge and Competing Modes In Ohio River and Arkansas River Areas," Doctoral thesis at the University of Cincinnati, published at the Institute for Water Resources, 1979.
- Booz, Allen, and Hamilton, Inc. "Deep River Study Lower Mississippi River," State of Louisiana Governor's Task Force on Deep Draft Vessel Access to the Lower Mississippi, July 1983.
- Chong K. Liew and Chung J. Liew. "Regional Development Impacts Multi-Regional Variable Input/Output Model (MVI0)," prepared for the Institute for Water Resources, September 1982.
- "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." U.S. government publication, March 10, 1983.
- Energy Information Administration. "Port Deepening and User Fees: Impact on U.S. Coal Exports," DOE/EIA - 0400, Washington, D.C., May 1983.
- Lenze, David and Allen Goodman. "Theory and Estimation of the Demand for Export Coal," presented at TRB meetings, January 20, 1983.
- "The Multi-Regional Multi-Industry (MRMI) Model of the U.S. Economy: User Manual for Evaluating Regional Development Impacts of Water Resource Projects." Prepared by Urban Systems Research and Engineering, Inc. for the Institute for Water Resources, Cambridge, MA, September 9, 1982.
- "Proceedings from a Workshop on Economic Analysis of Inland Navigation and Port Projects." Held by the Institute for Water Resources, March 15-16, 1984.
- Vander Tak, Herman G. and Anandarup Ray. "The Economic Benefits of Road Transport Projects," in Benefit-Cost and Policy Analysis, 1972, Chicago: Aldine Publishing Co., pp. 132-168, 1972.

**APPENDIX A**

## ANNOTED BIBLIOGRAPHY

Alcamo, Joseph. Resources and Energy, "Water and Fire: Water Needs of Future Coal Development in the Soviet Union and the United States," V. 6, No. 2 (1984) pp. 77-105.

American Waterways Operators, Inc. "Waterways Economics," Vol. II-IV, January 1970.

Antle, Lloyd G. "An Overview of the Impact Study of the McClellan-Kerr Multiple Purpose Arkansas River System," prepared for the Institute for Water Resources, July 1975.

Antle, Lloyd G. and Richard W. Haynes. "An Application of Discriminant Analysis to the Division of Traffic Between Transport Modes," prepared for the Institute for Water Resources, May 1971.

This is a study of the operational application of discriminant analysis to transportation modes. Although this method is not used to measure induced traffic benefits, the procedures used could be useful for the following reason: discriminant analysis is a method that can be used to estimate a demand schedule for a given transportation mode.

In dealing with the demand for coal or transportation, we are facing derived demand curves. Coal and transportation are inputs in a final good, and it is the demand for that good, be it electricity or steel, that will determine coal demand.

Discriminant analysis statistically weighs modal characteristics to determine their influence on choice of mode. The first step in the analysis is to develop a function by dividing mode populations (assumed to be normally distributed into groups) that minimize classification errors. This function reflects the defining characteristics of each mode. With this discriminant function, the authors estimated the transportation demand for each mode by holding all characteristics except rate constant. There has been other research conducted along similar lines. Among the references reviewed that deal with discriminant analysis is the following:

Antle, Lloyd G. "Demand for Water Transportation: Application of Discriminant Analysis To Commodities Shipped by Barge and Competing Modes in Ohio River and Arkansas River Areas" prepared for the Institute for Water Resources, August 1980.

This report developed demand functions for barge transportation of various commodities using discriminant analysis. Also included in the report is background on policy issues and the current benefit-cost analysis requirements. The author also spends time reviewing the theory of demand for freight transportation. Included in the review are Marshall's theory of derived demand and the more specific theory of derived transportation demand by Moses, Lave, and Allen. Also discussed are econometric characteristics of the models reviewed. The final part of the report is devoted to an application of a discriminant analysis model of transport demand in the Ohio and Arkansas River regions.

Appalachian Regional Commission. "Briefing on Appalachian Coal -- Summary of Materials, December 17, 1981.

Appalachian Regional Commission, "Revised Market Guide for Coal Exports from the United States," June 1984.

A.T. Kearney, Inc. "National Waterways Study -- Commercial Water Transportation Users," Prepared for the Institute for Water Resources, July 1981.

Bagge, Carl E. "The Samurai and the Cowboy on the Road from Norfolk," presented at the Fourth United States-Japan Coal Conference, San Francisco, May 21, 1984.

Bonsall, P.W. and Others, "Transport Modeling: Sensitivity Analysis and Policy Testing," in Progress in Planning, V.7, Part 3, 1977.

Booz, Allen, and Hamilton, Inc., and Pyburn & Odom, Inc.  
"Deep River Study Lower Mississippi River,"  
State of Louisiana, Governor's Task Force on Deep Draft Vessel Access to the Lower Mississippi, July 1983.

The "Deep River Study" analyzed the feasibility of deepening the channel of the lower Mississippi to accommodate deep-draft vessels. Engineering, economic, environmental and financial studies of the proposal were conducted. Alternatives were developed, and recommendations were made.

Included in the economic study was an analysis of the induced traffic in coal and grains (Refer to Appendix B, pp. III-56 to III-59 of the study). A weighted average of the export grain elasticities for wheat, corn, and soybeans was determined from data of the USDA Extension Service at Purdue University. Then the decline in ocean freight rates and in the average delivered price of U.S. grains was calculated. These figures were used to determine the percent change in the induced grain tonnage. The results were that benefits from induced grain tonnage were negligible and were excluded from the study.

A different approach was used to determine induced coal tonnage. The authors found that a thorough review of the literature didn't identify sources for U.S. steam coal price elasticities. However, two facts, an average price of \$9 to \$20 per ton more for U.S. steam coal over other leading suppliers and a constant 25% of the world coal market share belongs to the U.S., suggests a generally inelastic market. Establishing a maximum U.S. market share of 50% (due to non-price factors in the coal market) at a price of \$38.50 for U.S. steam coal and a minimum market share of 25% at the current U.S. steam coal price of \$54, the researchers did a linear extrapolation between these two points. This relationship was used to estimate the potential induced coal tonnage levels. Using this approach, the researchers estimated that channel deepening could induce coal exports and increase total export tonnage by 10 to 22 percent.

Chase Manhattan Bank, N.A. "World Coal Outlook the Year 2000: Opportunities and Uncertainties," October 1981.

Churchward, Victor & Others. "National Waterways Study: Overview of the Transportation Industry," prepared for the Institute for Water Resources, August 1981.

Comptroller General of the United States. "Improvements Needed in Making Benefit-Cost Analysis for Federal Water Resources Projects," Report to the Congress, September 20, 1974.

Data Resources, Inc. "Transportation Review," Fall 1983. Vol. 5, No. 3.

Dravo Corporation. "Coal Export Study," prepared for the Appalachian Regional Commission, January, 1982.

Drewry Shipping Consultants, LTD. London. "Coal Trade and Shipping in the 1980s," NO. 116, November 1983.

Drewry Shipping Consultants, LTD. London. "Ocean Shipping of Coal-Sea Transportation Methods, Constraints and Costs," Survey No. 24, October 1981.

Econometrics Center. "Cost-Benefit Analysis for Inland Navigation Improvements," prepared for the Institute for Water Resources, Vol. 1 of 3, October 1970.

"Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." U.S. government publication, March 10, 1983.

The purpose of this research was an effort to improve the benefit estimation of inland waterway projects undertaken by the Army Corps of Engineers. The main contribution of the research has been in the area of transportation demand analysis. The researchers developed a transportation demand curve as a function of producers' demands for goods and services and equal to the final product's market value less transportation costs less marginal production costs adjusted for time using net present value. The first volume is a summary report of the research effort. The second and third volumes of the report cover demand and cost analysis and the effects of regulation on transportation demand.

Energy Information Administration. "1982 International Energy Annual," DOE/EA--0219(82), September 1982.

Energy Information Administration. "Coal Data: A Reference," DOE/ETA-0121(82/1Q), August 1982.

Energy Information Administration. "Port Deepening and User Fees: Impact on U.S. Coal Exports," DOE/EIA - 0400, Washington, D.C., May 1983.

Energy Information Administration. "Prospects for Future World Coal Trade," DOE/ETA-0363, December 1982.

Energy and Environmental Analysis, Inc. "Use of Appalachian Coal in Industrial Boilers," prepared for the Appalachian Regional Commission, Vol. I & II, June 1981.

Energy Information Administration. "U.S. Coal Exports: Projections and Documentation," DOE/ETA-0317, March 1982.

Energy Information Administration. "Quarterly Coal Report," DOE/ETA-0121 (82/1Q), August 1982.

Energy Information Administration.  
"1983 Annual Outlook for U.S. Coal,"  
DOE/EIA-0333(83), Washington, D.C.,  
Nov. 1983.

The "1983 Annual Outlook for U.S. Coal" provides a brief historical overview of the coal industry. The report then looks at future trends for coal including demand projections for 1985 to 1990 and at trends in coal supply. Finally, the report looks at factors affecting coal's outlook.

Included among these factors are exports. Current U.S. port capacity is expected to be sufficient to handle future coal exports. However, most U.S. ports cannot accommodate the more cost-effective deep-draft (100,000 dwt) colliers. This could be a possible constraint on increased future U.S. coal exports. The EIA conducted an economic analysis of port-deepening (refer to DOE/EIA-0400). The conclusions of the analysis were the following:

- U.S. coal exports are unlikely to decrease if user fees are imposed to cover port operations and maintenance costs,
- U.S. coal exports will only rise slightly if port deepening occurs.

Induced benefits were not analyzed because the focus of the paper was not on the economic benefits of port-deepening.

F.R. Schwab & Associates. "Project Status Report No. 1 -- Forecast of Steam Coal Demand in Selected Countries," Department of Energy, July 21, 1980.

Gladstone Associates. "Potentials for a Delaware Deepwater Port," prepared for Delaware State Planning Office, October, 1970.

Gramlich, Edward M. Benefit-Cost Analysis of Government Programs, New Jersey: Prentice Hall, Inc., 1981.

Harmon, Pat. "Water Transportation Commodities and the World Economy - U.S. Grain," National Waterways Foundation, presented at International Inland Waterways Conference, August 26-28, 1983, Louisville, Kentucky.

Hartley, Joseph R. Indiana University: Bureau of Business Research, 1957.

- Heiberg III, E. "Recent Port Planning Developments in the United States: Status of Channel Deepening Proposals for Major United States Harbors," 8th International Harbor Congress, Antwerp, June 13-17, 1983.
- Highway Research Record. "Freight Transportation," No. 82, 1965.
- Highway Research Record. "Use of Economic, Social and Environmental Indicators in Transportation Planning," No. 410, 1972.
- Irland, Lloyd C. "The Impact of a Louisiana Offshore Oil Port," for the Ecology Center of Louisiana, Inc., September 1973.
- Kim, Ungsoo, and Others. "An Application of the Interregional I/O Model for the Study of the Impact of the McClellan-Kerr Arkansas River Project," prepared for the Institute for Water Resources, March 1975.
- Kim, Ungsoo, and Others. "An Application of the Interregional I/O Model for the Study of the Impact of the McClellan-Kerr Arkansas River Project," prepared for the Institute for Water Resources, March 1977.
- King, Bonnie L. "International Coal 1983," National Coal Association, 1984.
- Kirby, Isley Edwin. "The Impact of Proposed Inland Waterway User Charges on Grain Transportation and Marketing: The Case of the Illinois Waterway," Unpublished Dissertation from University of Notre Dame, August 1977.
- Kraft, Gerald. "The Role of Transportation in Regional Economic Development," Toronto & London: Lexington Books, 1971.
- Krutilla, John V. & Others. "Economic and Fiscal Impacts of Coal Development: Northern Great Plains," Baltimore & London: Johns Hopkins University Press, 1978.
- Lenze, David and Allen Goodman. "Theory and Estimation of the Demand for Export Coal," presented @ TRB meetings, January 20, 1983.

This paper develops a model to measure export coal demand. Using matrix algebra and regression analysis, the researchers estimated the demand for U.S. export coal with a special emphasis on delivery reliability. They show the importance of supply diversification, and they use it to derive transportation service demand. The results indicate that export coal demand is price-responsive (elastic) in the long-run and that the demand for port facilities is slightly elastic.

Although this paper did not deal with port improvement benefits, it is important because it was an effort to derive the demand for export coal. By estimating coal export demand elasticities, the researchers can bring us a step closer to estimating induced traffic benefits for port-deepening proposals.

National Coal Association. "Coal Markets in the Future," March 1984.

National Coal Association. "Coal Demand and Transportation Policies," A Seminar Presented in New Orleans, Louisiana, September 18-20, 1983.

Office of Technology Assessment. "Coal Exports and Port Development -- A Technical Memorandum," April 1981.

Pegrum, Dudley F. Transportation Economics and Public Policy, Homewood, Illinois: Richard D. Irwin, Inc., 1968.

"Potential Role of Appalachian Producers in the Steam Coal Export Market," prepared for the Appalachian Regional Commission, November 1981.

The President's Commission on Coal, "Coal Data Book," Washington, D.C., February 1980.

Robert R. Nathan Associates, Inc. "U.S. Deepwater Port Study." Prepared for the Institute for Water Resources, Vol. 1 of 5, August 1972.

The "U.S. Deepwater Port Study" focuses on the benefits, costs, and alternatives associated with deepwater ports. The researchers defined measured benefits as the difference between total ocean shipping costs under each alternative and under the base situation. Induced traffic benefits were not measured or even discussed.

Rooijen, M.J. "Water Transportation Commodities and the World Economy - Case for Coal," Presented at International Inland Waterways Conference, August 26-28, 1983, Louisville, KY.

Taylor, Phillip H. & Others. "Regional Response Through Port Development: An Economic Case Study on the McClellan-Kerr Arkansas River Project," prepared for the Institute for Water Resources, August, 1974.

Thompson, Duane A. "Factors Affecting Coal Traffic on the Tennessee-Tombigbee Waterway," Congressional Research Service, July 17, 1981.

"Transportation Economics." A Conference of the Universities-National Bureau Committee for Economic Research, New York & London: Columbia University Press, 1965.

Transportation Research Record. "Application of Economic Analysis to Transportation Problems," No. 550, 1975.

Transportation Research Record. "Cost-Benefit Analysis and Other Economic Analyses of Transportation," No. 490, 1974.

U.S. Army Corps of Engineers. "New York Harbor and Adjacent Channels Study Economic Analysis, Stage 1," prepared for U.S. Army Engineer District New York, September 27, 1982.

This economic analysis had three major levels of investigation:

1. Develop a European coal import forecast for 1990-2040.
2. Determine U.S. share of world coal trade.
3. Divide U.S. steam coal exports among Atlantic and Gulf Coast ports.

After reaching these levels of investigation, port and channel-deepening benefits were measured. Vessel operating costs to Europe and vessel sizes were developed and incremental unit benefits were calculated. These unit benefits were multiplied by coal exports to determine annual benefits of each harbor depth alternative. Average annual equivalent benefits were also calculated.

Induced traffic benefits were not calculated. It was apparently assumed that the majority of benefits were transport savings associated with deep draft bulk carriers.

United States Army Corps of Engineers. "Norfolk Harbor and Channels, Virginia Deepening and Disposal-Feasibility Report," September 1979.

This Corps feasibility study measures the benefits of deepening Hampton Roads harbors and channels. The analysis derived benefits for 55-, 45-, and 40-, foot channel improvements. The transportation savings were computed from vessel operating costs and current lightering rates. The cost savings were computed per unit tonnage and converted to reflect January 1979 price levels. These figures were used to calculate the annual benefits for 1985, 2000, 2035. These annual benefits were then converted to equivalent average annual benefits.

Individual traffic benefits were not considered in this analysis. It was assumed that the majority of benefits would be transportation savings that would accrue to users of large bulk carriers. The price response of coal suppliers was not felt to be a major benefit of deepening the Hampton Roads Port.

U.S. Department of Energy. "Energy Projections to the Year 2000," DOE/PE-0029, July 1981.

U.S. Department of Energy. "Interim Report of the Interagency Coal Export Task Force," draft for public comment, DOE/FE-0012, January 1981.

Energy Information Administration.

"Port Deepening and User Fees: Impact on U.S. Coal Exports," DOE/EIA-0400, Washington, D.C., May 1983.

The major focus of this report was an economic analysis of the impact of user-fees on U.S. coal exports. The report also discussed world port development activities and U.S. port development proposals.

The user-fee analysis calculated cost estimates by applying various cost-sharing formulas. The decreased transportation costs connected with using larger vessels offset these costs by decreasing per tonnage shipping costs. The researchers calculated that the net transportation savings would

result in a slight (3 to 4 percent) increase in U.S. coal exports. Induced benefits were not measured because they were not considered a factor in the analysis. The final results of the analysis concluded that

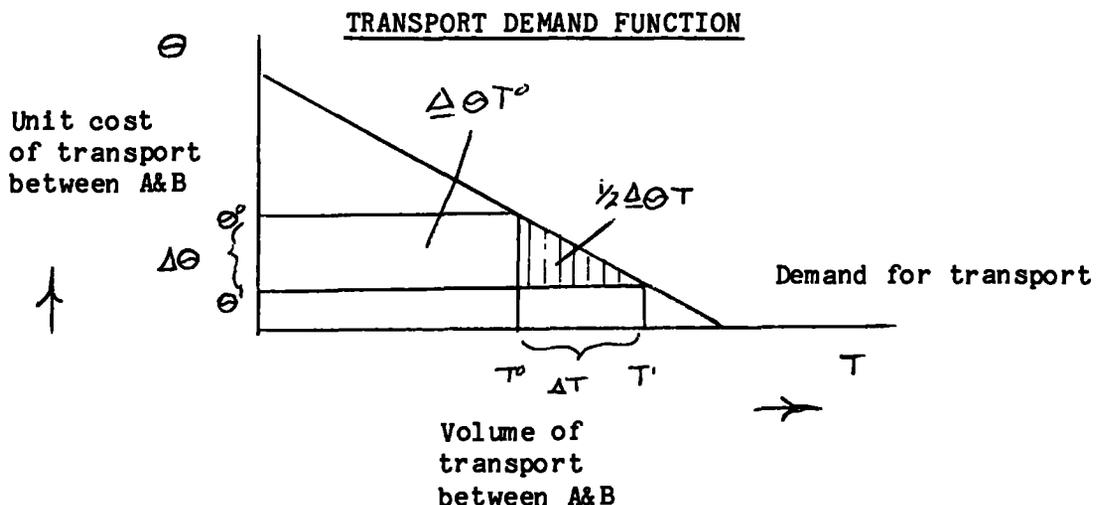
- o U.S. coal exports are unlikely to decrease if user fees are imposed;
- o U.S. coal exports are expected to rise only slightly if port deepening occurs.

The analysis assumed that participants in the coal market choose to purchase least-cost quality coal. However, noneconomic factors will also affect importers' buying decisions. These factors could include 1) the perception of the U.S. as a cooperative trading partner; 2) the security and reliability of a U.S. coal supply; and 3) the prime position that vast coal resources will place the U.S. in the future.

Vander Tak, Herman G. and Anandarup Ray "The Economic Benefits of Road Transport Projects," in Benefit-Cost and Policy Analysis, 1972, Chicago: Aldine Publishing Co., pp 132-168, 1972.

The purpose of this theoretical paper is to analyze the benefits that can be expected from road transportation projects. The authors constrain their analysis with various types of market imperfections to show how these benefits relate to changes in supply and demand for transported commodities. The paper is expository and provides an analytical framework; its purpose was not to generate actual benefit figures.

One of the key ideas the authors looked at was induced benefits.



The above figure illustrates two kinds of transportation project benefits. The first, indicated by  $\Delta\theta T^0$ , are the benefits of transport

savings that accrue to normal traffic. In other terms, it is a measure of the sum of the consumers' cost savings and the producers' increased profits. The triangle  $1/2\Delta\Theta T$  is a measure of induced traffic benefits; it is the sum of A's consumer surplus and B's producer surplus.

In the authors' model, transport demand is not a direct measure of demand. Rather, the demand curve has been derived from the volume of trade. The demand curve is a scalar transformation of introducing a constant mileage, and it is the locus of different equilibrium volumes of trade. This is a reflection of the supply and demand conditions in regions A and B. Therefore, the transport demand curve's slope and elasticity depend upon specific commodity demand and supply functions in the regions. It follows that transportation improvements lead to lower transport costs, production and consumption changes, and more trade and transport between A and B. Finally, induced benefits are relatively more important to a transportation project the larger is the percentage decrease in transport costs and the more elastic the transport demand.

In the rest of the paper, the authors introduce market imperfections into the model to observe its effects on the social surplus measure. They conclude by saying that although the social surplus measure is intuitively simple to measure, it is difficult to apply in a real situation. Gains and losses will have to be weighed, and the estimation of this measure requires knowledge of the factors that affect supply and demand for the transport mode and its services. Thus, induced benefits can be measured, but those undertaking the measurement must exercise caution and ingenuity.

Winters, Tobey L. Deepwater Ports in the United States -- An Economic and Environmental Impact Study, New York, London: Praeger Publishers. 1977.

World Coal Study. Coal-Bridge to the Future, Cambridge: Ballinger Publishing Company, 1980.

World Coal Study. "Future Coal Prospects--Country and Regional Assessments," Cambridge: Ballinger Publishing Company, 1980.

Zimmerman, Martin B. "The U.S. Coal Industry: The Economics of Policy Choice," Cambridge: MIT Press, 1981.

This book examines different aspects of the U.S. coal industry. Topics covered include the coal environment, consumption and production trends, pollution, health and safety, and other policies that affect the coal industry.

Included is a section that develops a coal demand model. The author adapted the Regional Electricity Model (REM), originally developed at MIT by Martin Baughman, Paul Jaskow, and Philip Kamat, to suit their needs. The model first estimates the demand for energy using an econometric equation that considers energy demand per capita as a function of a weighted average of energy prices, incomes, and population. The industrial sector is similarly treated. Regulatory impacts in the electric utility sector are also considered. Then transmission and distribution requirements are added. Finally, metallurgical and export coal are added into the model.

The author's general coal demand model could prove useful in developing a derived demand model for export coal. As it currently stands, the model will not provide coal export elasticities which could be used to measure induced traffic benefits. However, it does provide us an illustration of how to estimate coal demand.